HERE WE DON'T SPEAK, HERE WE WHISTLE.

MOBILIZING A CULTURAL READING OF COGNITION, SOUND AND ECOLOGY IN THE DESIGN OF A LANGUAGE SUPPORT SYSTEM FOR THE SILBO GOMERO.

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DECLARATION

I declare that the work here presented is, to my best knowledge, original unless otherwise acknowledged in the text. The provided text has not been submitted, in its whole or part, for a degree in any other educational institution.

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ABSTRACT

This thesis presents the study of a whistled form of language known as the *Silbo Gomero* (Island of La Gomera, Canarian Archipelago). After fifty years of almost total extinction this form of communication has been revived, shifting from the fields where it was once used by peasant islanders and into the space of the classroom. Here, it is integrated into the curriculum of the island's schools while providing children with a rich cultural platform that instigates linguistic and auditory experimentation. As a response to this transformation, the need to develop didactic materials is presented as one of the main challenges encountered by the community. Taking this condition as the driver of its research, this body of work draws on phonological, bioacoustic and cognitive theories to develop a formal understanding of the *Silbo Gomero* in a way which aims to complement the whistler's own experience and mastery of the language by also developing an ethnographic reading of this indigenous body of knowledge and its characteristic auditory perceptual ecology. The investigation has culminated in the design of a digital application, *El Laberinto del Sonido,* and its active use within the educational community of the island. Finally, emphasising the practice-based nature of the research, this thesis attempts to relocate the question of intangible heritage from a focus on cultural safeguarding and transmission to one of experimentation, where an indigenous body of knowledge not only provides new exploratory paradigms in the design of didactic materials, but also contributes towards the sustainability of culturally situated forms of apprenticeship within contemporary educational contexts.

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I

INTRODUCTION

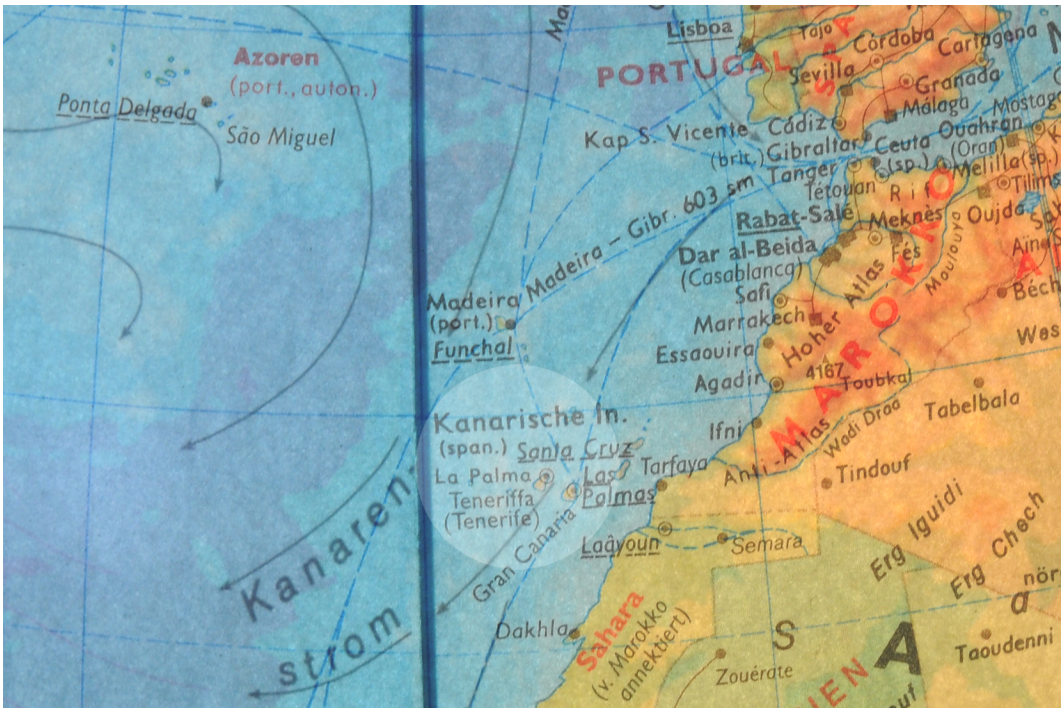
1. The *Silbo Gomero*

A hundred kilometres off the Atlantic coast of Morocco and the Western Sahara one can find the small island of La Gomera[1], the home to a whistled form of language known as the *Silbo Gomero*[2]. Even though the historic origins of this linguistic form are difficult to trace, most islanders attribute this practice to the Guanches, a pre-Hispanic people who were the original inhabitants of this Atlantic region. This may be debatable (García & Villena 2001:198-99), but this ethnic group is commonly associated with Berber tribes that still populate the North African continent. Taking this into account, it has been suggested that this group already inhabited the Canary Islands in the second millennium B.C. (Crosby 1986:80). This thesis, largely based on archaeological findings, is often paired with the idea that the Guanche, due to their apparent isolation, were a part of a Neolithic culture until the Spanish conquest in the XVth century (pp. 80-82). Many native islanders resisted the foreign invasion, but after a long and bloody conquest they were driven to the brink of extinction while the last scattered groups mingled with the newly settled Spanish community (pp. 97-99).

Despite the apparent total isolation of this ethnic group until this time, their linguistic form has much in common with other whistled languages that span the globe, especially in Mexico, Greece, Turkey, Papua New Guinea, Vietnam, Guyana, China, Nepal and Senegal. These places have nothing in common except particular geographical features: all characterised by being either mountainous or densely forested. (Meyer 2005) This geographical diversity tends to suggest that whistled languages are sophisticated linguistic techniques largely used as telecommunication systems (Busnel & Classe 1976:13-31) and bearing a correlation with their local spoken languages (Meyer 2005).

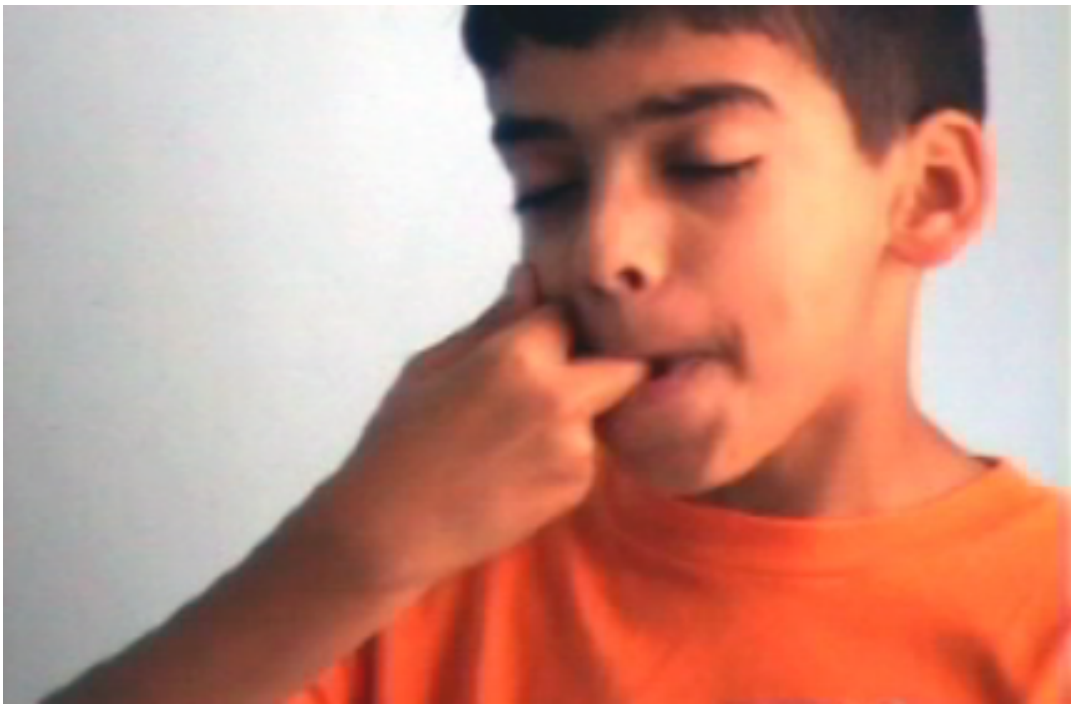
[1] The island of La Gomera is part of the Canary Archipelago, a Spanish territory

[2] Studies of whistled languages, already presented in the XIXth century, refer to the existence of this form of communication in other Canarian islands, particularly in the island of El Hierro and Gran Canaria. (Busnel & Classe 1976:23)



1. Map of a partial view of the North Atlantic region in which La Gomera is to be found.

According to bioacoustician Julien Meyer (2005), who documented the regions, what distinguishes the *Silbo Gomero* from other whistled forms of language across the globe is its active place within everyday life. The *Silbo*, as most Gomerans call it, has slowly, since the 1950's, shifted from the fields where it was once used by peasant islanders into the classroom, something which contributes to safeguarding its position within Gomeran culture. This shift is tied to a continual disappearance of agricultural life, processes of immigration and the introduction of tourism as the main means of economic sustenance. In fact, the attempts that have been made to safeguard this intangible cultural form have led to recent recognition of the *Silbo Gomero* as a significant part of world heritage (UNESCO 2009a). Such recognition not only valorises the linguistic form but has also supported local educational efforts. In fact, this is in line with UNESCO's attempt to recognize the value of infrastructural conditions in order to safeguard intangible forms of heritage. Here, a distinct approach to the safeguard of 'monuments, sites and natural spaces' is demanded, one which is relevant to local communities, this considering that such an intangible cultural heritage has to be "(…) practiced and learned within communities and between generations". In this sense what is important about such a heritage is not how it is manifested culturally but rather how the 'wealth of skills and knowledge is transmitted from one generation to another'; a process that creates space for it to mutate, evolve and adapt. (UNESCO 2009b:6)



2. Young boy whistling during a *Silbo* class with *Maestro* Lino (Matos 2007).

Here lies what will be the main thrust of this thesis: how might didactic materials be designed that will support the wealth of skills so that they can be transmitted from one generation to the other. Such interest is intimately tied to a close study of the Gomeran educational community, one that has shown a concern for expanding the *Silbo's* educational resources and learning methodologies[3]. However, taking into consideration that this form of language is a concern of distinct disciplines – spanning linguistics, bioacoustics, neurology and forms of local knowledge – it may be difficult to define a terrain that all parties will mutually agree. However, and considering that the learning of the *Silbo Gomero* has shifted from a form of apprenticeship characteristic of non-literate societies (Gardner 1993: 338-341) to being subject of contemporary educational paradigms, understanding the wealth of such skills becomes more pertinent than ever. Any attempt to design didactic materials has to be sensitive to this shift and take account of how indigenous practices might be situated within contemporary learning environments[4].

Before proceeding with this body of work, it is important to tackle this question: **what is a whistled form of language?** Professor Ramón Trujillo, one of the most prominent figures in the phonetic and phonological study of the *Silbo Gomero*, has presented this linguistic form not as

[3] For further information on this point consult the interview with *Maestro* Isidro in DVD 1, movie 1, in the attachment.

[4] Here, it is important to bear in mind that the *Silbo Gomero* is taught in schools that follow the Spanish national curriculum and where an understanding of literacy assumes the predominance of verbal and mathematical skills.

'natural language' – at least not in the orthodox sense – but rather as an independent phonological system[5]. One " (...) that contains a reduced number of phonic-schemes that are used to produce different sonorous substances (...)." And even though this linguistic form might resemble the local spoken Castilian Spanish 'it is not a direct imitation of this linguistic code' (Trujillo 2006:15). Here, it is important to understand that this complex system of telecommunication would not be possible without refiguring the body by means of a modification of the linguistic medium. Instead of relying on the lips, the whistled form relies on the interior oral cavity: the tongue must be elevated against the palate or teeth and supported with one or two fingers, or even not supported at all, according to the desired intensity (Trujillo 1978, Meyer 2005). The process clearly disturbs the local Castilian Spanish without disturbing its semantics – for this reason it is frequently called a surrogate of the language spoken in the island.

For example, when whistling the word *Octavio*, one is, in a certain sense, transcribing the same word as in the spoken and written language, but now the whistled forms of vowels and groups of consonants are used[6]. As will be discussed in chapter II, this 'translation' is not a direct 'imitation' of vowels and consonants as we verbally (and not to say visually) understand them, it represents a rather more fluid manipulation of the sonic 'range, contour, and steepness' (Busnel & Classe 1976:8) of the perceived utterance. Here, it is important to consider that this form of telecommunication has "(...) a rigorously articulated structure which clearly distinguishes it from standardized sign-systems and whose most notable attribute is that the meanings of its smallest constituent units cannot be analyzed" (Trujillo 2006:31). Despite this fact, and as explored throughout this thesis, even though the smallest constituent units of the system – its phonemes – cannot be clearly outlined; the study of the *Silbo Gomero* has been largely exploited from such a perspective, particularly when it has moved onto the terrain of phonology.

This position should not lead to any misunderstanding. The phonological approach has made a solid contribution, particularly, when arguing that this whistled form of language is an independent phonological system (Trujillo 1978, 2006). However, despite its influence amongst the *Silbo's* educational community (Brito et al. 2005), it is important to recognize (as will be discussed in chapter II) that this approach is tied to a specific methodology, one that is dependent upon a particular understanding of language, its study and documentation. That, in this particular case, is largely defined by spectrographic analyses of acoustic data. Despite the crucial

[5] A phonological system corresponds to the collection of phonemes used by a given language. Each phoneme corresponds to the smallest segmental unit of sound, a linguistic convention that attempts universally to represent, through a collection of graphical signs, the 'distinctive sounds' of each human language. As an example, in the English language one can identify phonemes such /c/ for '**c**ar' or /k/ for '**k**ettle'. (IPA 27)

[6] For more information consult DVD 1, track 1, in the attachment and Annex I.

contribution it has made while recognizing whistled languages as genuine immaterial 'objects' of study going beyond mere 'exoticism' or 'folklorization', this approach conceals an informational paradigm; one that assumes that communication is a highly formalized system[7]. Here, it is important to classify the unit of analyses which is composed of – precise – time-frequency rules that abide throughout the systems' code. As a consequence, the context in which learning takes place is relinquished to the background, particularly the relation that each whistler develops with the island's environment.

Before moving into an analysis of this ecological relation, it is important to understand that this methodology is, at times, inconsistent with the descriptions provided by local whistlers (Trujillo 1978, 2006)[8]. Also as documented by Annie Rialland (2003, 2005) and Julien Meyer (2005) this is particularly so when attempting to discern and describe the number of vowels that can be perceived and produced. However, what is lacking in such discussions is a more intricate understanding of the 'nature' of their scientific methodologies and subsequent techniques of spectrographic analyses. These techno-material contraptions cannot be regarded as neutral instruments that simply measure the reality of phenomena because they conceal their own ways of sensing the world[9] and they are not, by any means, pure 'external' phenomena.

In fact, understanding the 'technicity'[10] of such instruments will further mobilize an embodied and situated reading of human cognition. Here, it is important to understand that spectrographic analyses of sound largely used by phonological studies, through its own historicity, presents hearing as a formalized phenomena in which the ear is though it functions in a purely mechanical way and where auditory information is analyzed as a pure frequency shift, at times, 'distorting' a contextual and ecologically situated analyses of auditory experience. As explored in the following chapter, such an instrumental appropriation abstracts the flux of nature, treating it as an instantaneous moment of time. In this reduction, the object under observation is deprived – as Alfred North Whitehead (1961) would suggest – of all 'temporal expression'. As a

[7] For further information see the work of Claude Shannon (1948).

[8] I was able to confront the two approaches when attending the *Silbo* classes for adults in the *Centro de Profesorado de la Gomera* (The Centre for Teachers of La Gomera) of the village of San Sebastián (Island of La Gomera), particularly when attending the classes provided by Professor Trujillo and by local whistler *Maestro* Isidro; an experience that was further strengthened when attending the classes for children throughout the island's schools.

[9] Such reading of scientific apparatuses is based on the work of Donna Haraway (1991), Karen Barad (2007) and Bruno Latour (2004, 2007).

[10] This reading of 'technicity' draws upon the work of Gilbert Simondon. Further exploration of the term can be found in Adrian Mackenzie's work (2002) where: "technicity refers to a side of collectives which is not fully lived, represented or symbolized, yet which remains fundamental to their grounding, their situation and the constitution of their limits. Technicity interlaces geographic, ecological, energetic, economic and historical dimensions without being reducible to any of them (p.11). (…) For an isolated technical element, technicity refers to the degrees of concretization which the intersection of these diverse realities embodies (p.13)."

phonological approach to the study of whistled languages has become one of the central guiding lines in the elaboration of the educational programme (Brito et al. 2005), recognizing its inherent paradoxes and contradictions is fundamental, particularly, when attempting to localize the wealth of skills that are transmitted from one generation to the next.

2. A Working Hypothesis

Revealing the nature of phonological data and spectrographic modes of analyses – as they inform an understanding of hearing, perception and cognition – is a crucial ground for discussion. Particularly, when attempting to understand the sorts of skills and the embodied knowledge that inform the wealth of this linguistic form. Here, the concern shifts from safeguarding the *Silbo Gomero* as such to establishing a body of research to tackle the wealth of skills that inform local knowledge systems. This concern can be summarised by the following question: **what is really transmitted from one generation to the next? Is it simply a surrogate language** (Trujillo 1978, 2006) **or a complex and embodied auditory culture?** While acknowledging the *Silbo Gomero* as surrogate model of speech the researcher will clearly demarcate the code as it is rendered through a spectrographic measuring apparatus. While acknowledging this whistled form of language as situated and embodied phenomena that stretches the perceptual fabric beyond the delimitation of a verbal code, the researcher is drawn to its ecological significance. However, and in order to extend this phonological approach, one has to extend the unit of analyses and integrate an embodied account of this performative ecology, where whistler and environment cannot be easily detached from one another.

This approach is supported by recent contributions made by Julien Meyer (2005). Even though more inclined towards a quantitative frame of reference[11], this bioacoustic study has provided an insightful resource for the development of an ecological approach to the study of whistled languages and their surrounding environment. This move from an informational to an ecological stance, where both subject and environment become key elements, will ultimately reinforce the acknowledgement that the relation that whistlers establish with the surrounding environment is intrinsic to both performative and learning processes[12]. Such an ecological approach has been concurrently supported by work in the field of neuroscience, particularly when it has pursued the idea – largely based on fMRI brain scans of local whistlers – that the

[11] Most of Meyer's work (2005) is in line with more recent psychoacoustic ecological accounts (Neuhoff 2004) – even though he does not refer to them – however, the bulk of his methodological practice is indebted to more formal measuring techniques present in spectrographic analyses, the measurement of environmental noise and the psychological test of auditory (whistled) stimulus.

[12] This conclusion provided by Meyer's bioacoustic study is indebted to an earlier study of whistled forms of language proposed by André Classe and René-Guy Busnel (1976).

performance and intelligibility of this linguistic form involves recognition of complex pitch and melodic lines, where linguistic areas of the brain, largely conceived as speech dependent, show an incredible adaptability to non-verbal auditory signals (Carreiras et al. 2005). This reemphasizes Meyer's idea that: "At the level of the ear, the received whistle is only the visible part of a linguistic and acoustic iceberg of which the immersed part is the brain of the actors in the dialogue" (translated from the original thesis written in the French language, p.236).

However, and even though bioacoustic and neuroscientific approaches shift the research into the whistler's wealth of skills from the ear as a mechanical entity – as it is replicated by spectrographic analyses – to an ecological and neurological understanding of complex auditory phenomena, such body of work will also proceed by situating in the whistler's brain the locus of such embodied knowledge. In fact, by taking this organ as central to cognition, an ecological approach seems to lose sight of way the body relates to the mountainous and sonic environment. As will be argued in chapters II and III, ecology – that is, cognition as embodied and interactive phenomena[13] – cannot be easily localized in the brain or even in the simple adaptation to environmental constraints (Meyer 2005, Trujillo 1978, 2006), because it is performative. In this performance, spatial and temporally dynamic elements might escape such methodologies and apparatuses. In fact, my personal experience, when recording in the fields with both *Maestro*[14] Isidro Ortiz Mendonza and *Maestro* Lino Rodriguez, provided valuable information of the perceptual ambiguities that arise from the environment and the whistlers embodied performance within it. Here, it is important to account not only for the ways one reconfigures the verbal apparatus but also for the ways in which the sonic qualities of the surrounding environment play a role in performance while enriching the subject's auditory perceptual capacities. To take this further, while the *Silbo* might provide a surrogate means of communication to the verbal Castilian Spanish spoken in the island it also supersedes the logics of speech in unpredictable ways. Not identified by fMRI brain scans or techniques of spectrographic analyses, is the relation developed between whistlers and the Gomeran environment, one that provides an extension of the linguistic fabric into a distinct sonorous-instrumental domain.

While placing all presented contributions into play, a working hypothesis is brought to light, one that ecologically situates what phonological studies will identify as 'universal linguistic properties' (vowels and consonants) (Trujillo 2006:319). At this point it is important to proceed with care. This body of work does not neglect the fact that that the *Silbo Gomero* shares the same organizational principles with spoken language – that would be naïve. However, it is important

[13] Such an ecological or embodied reading of cognition is indebted to an 'enactive theory of perception' as proposed by Francisco Varela, Eleanor Rosch and Evan Thompson (1995) and the ecological and active reading of cognition as proposed by Alva Noë (2004) and James J. Gibson (1966).
[14] *Maestro* is the Spanish word for teacher.

to understand that the description of such 'universal properties' conceals a particular disciplinary methodology, one that separates what generative linguistics would qualify as the 'faculty of language in the narrow sense' – "(...) the abstract linguistic computational system alone, independent of other systems with which it interacts, and interfaces" (Hauser et al. 2002:1571) from the 'faculty of language-broad sense', where "(...) an internal computational system combined with at least two other organism-internal systems, which we call 'sensory-motor' and 'conceptual-intentional" (p.1570). Even though it seams rather difficult to imagine such a compartmentalized system, one might posit for a moment, in the particular case of whistled forms of language, a form of linguistic competence that interweaves both 'faculties'. In designing didactic materials for the *Silbo Gomero,* now conceived as an ecological practice, it is important to incorporate both systems. In this sense, whistled forms of language are as much forms of auditory cognitive apprenticeship as they are of purely generative linguistic competence.

3. The Quest for Methodology

Recognizing the safeguard of the *Silbo Gomero* as an educational challenge has opened a previously unforeseen interventional terrain, it further mobilizes the concern for indigenous knowledge systems and how they might be incorporated into a 'modern' project of literacy and 'schoolability'. This opens a space for design, particularly as it pertains to the development of didactic materials and how they might support, or even challenge, such an integrative process. This will provide a central thrust of this thesis. Before stepping into the most pertinent discussions that will arise throughout the project, and as briefly tackled in the previous sections, it is relevant to open space for a methodological discussion. Various approaches to the study of this whistled form of language will be considered – spanning phonology, bioacoustics, neurology and the whistler's personal experiential accounts – but the intersection of distinct accounts has instigated a 'slippery' ground of departure. With this is in mind, the first important question to tackle is the following: which analytical framework should be given special value throughout the process of design? Is it reasonable to open space for a phonological approach and provide children with a suitable and clear code to be learned? Is bioacoustic data sufficient and does it allow learners to exploit the code from a purely psychoacoustic auditory perspective? Or is it more relevant to consider the whistler's body of knowledge as the locus of investigation?

It seems that all paths are 'up for grabs' and orientating this body of works towards one path in detriment of another can appear problematic. It confirms what Paul Feyerabend (1975) would suggest – regarding scientific research – that it is 'essentially an anarchic enterprise' (p.9). This anarchism is not new for those who design the artefactual and techno-material fabrics of everyday life. And, as explored in this brief section, 'juggling' between all the information

provided will qualify design's methodologies as transgressors of disciplinary boundaries, pre-defined methodologies and theoretical frameworks or schools of thought. However, and prior to further discussion, it seems relevant to clarify what is meant by design?

By the early twentieth century, the idea of 'design'[15] was, on the one hand, concerned with the materialization of 'symbols and images' – an activity known today as graphic or communication design – and on the other hand, with the making of 'things', objects of industrial production – most commonly associated with industrial and product design. In more recent decades, this 'division' has suffered profound transformations, particularly, with the current development of computational based artefacts, systems and networks. (Buchanan 2001) Design, once shifting between the making of symbols and the making of objects, is now mostly concerned with orchestrating experiences and the making of the artificial fabrics of social and cultural life – what might be conceived as 'metadesign' (Wood 2007). The new emerging fields are largely informed by the proliferation of technologies[16] and by an expansion of a collective understanding of human experience in context, spanning not only the field of immaterial heritage, education or learning but also the fields of entertainment, politics, ecology and social innovation and fabrication. While 'systems thinking' – as a mechanical operation – has been at the heart of design in its early industrial production, the 'systems thinking' that today is most noticeable is concerned with how living entities function. In tune with the cybernetic organism[17], at this point most designers recognize that what is really important to grasp is the ways in which human beings experience artificially created systems[18], encompassing the techno-material as well as biological and socio-cultural configurations (Buchanan 2001:202).

Despite the incommensurable proliferation of design activities, most designers are able to communicate with one another, as testified by the various design conferences and publications. This communication is based on a very simple and flexible 'rule': design pertains "to the conception and planning of the artificial". (Buchanan 2001:14) However, and as design slips into academic discourse and verbal-discursive rhetoric – while working out the locus of reflection and

[15] This term is indebted to the work of Walter Gropius at the Bauhaus school and his idea of 'modern architectonic art' now directed towards industrial production (Buchanan 2001).
[16] Today, both graphic and product design are shifting towards the idea of 'interaction design', an umbrella concept that encompasses not only human computer interaction and service design but also the design of ubiquitous computing technologies and artefacts.
[17] This is in accordance with second-order cybernetics as proposed by Heinz von Foerster, particularly with the idea that any agent (or observer, in von Foerster's own terms) is inseparable from the system under observation (von Foerster 1984).
[18] As a consequence, many design schools have transformed their curriculum. For example, in schools such as the Design Academy Eindhoven (The Netherlands), design research is not divided into graphic, product or interactive design, rather into experimental fields dedicated to the study of 'man and communication', 'man and activity', 'man and identity', 'man and living', man and mobility', 'man and public space', 'man and well being' and 'man and leisure'. What John Wood (2007) has qualified as the shift of design as a profession that delivers objects or 'goods' to a phenomenological level" (p.167).

analyses of various academic disciplines such as history, anthropology and sociology, but also as it attempts to sustain design in university departments that were not initially dedicated to the workings of design – the quest for methodological accuracy or precision seems to present previously unforeseen challenges (Glanville 1999). This argument is not a new one. One can trace it back to the development of modern educational systems, particularly as they respond to the needs of a professionalizing society, one that has developed in response to the necessities of the industrial revolution that swept the XIXth and XXth centuries (Whitehead 1925:97). During this period, and while many sciences were able to progress along the lines of a rigorous Positivist epistemology, many spheres of knowledge dedicated to practice, craft and experiential know-how were confined to technical schools. And, with a subversive twist, they had to comply with the same axiomatic process, even more if they wanted to qualify as valuable – that is scientific – knowledge (Schön 1987).

This approach is crystallized by Donald Schön (1987) when analyzing the work of Thorstein Veblen in 'The Higher Learning in America':

> "The difference between the modern university and the lower and professional schools is broad and simple; not so much a difference of degree as of kind'. The universities have a higher mission to 'fit men for a life of science and scholarship'; and (they are) accordingly concerned with such discipline only as they will give efficiency in the pursuit of knowledge'; whereas the lower schools are occupied with 'instilling such knowledge and habits as will make their pupils fit citizens of the world in whatever position in the fabric of workday life they may fall.' The proper relation between the higher and lower schools is one of separation and exchange. Quite simply, the professions are to give their practical problems to the university while these unique sources of research are to give back to the professions new scientific knowledge worthy of material application" (pp. 35-36).

This model is not necessarily unproductive. In fact it has successfully influenced the development of most educational and professional paradigms. However, and as design shifts from being concerned with objects and symbols into the domain of situated experiences, such a division (between 'lower' and 'higher' sciences) seems to contradict the actual contributions made and does not take account of the methodological difficulties most designers face in the making of the artificial.

In fact, and as design gains more ground and brings into the debate its own particular epistemic contributions – contributions that are in line with Schön's (1987) 'reflection-in-action' (neither hard-nosed science nor pure relative or subjective indulgence) – previous linear and predictable endeavours have been destabilized by designers. The residues of a Positivist attitude can be read in the idea that designers need to 'clearly define the problem, analyze the data and provide the right solution'. In fact, when designers move into the study of complex, situated and

unpredictable phenomena they mostly find – particularly as the various spheres of design attempt to become proper (not to say scientific) disciplines (Glanville 1999), in line with their 'natural', 'social' and 'humanist' collaborators – challenging problems. Why is this? First, it should be recognized that design is able to enter into various alliances with distinct bodies of knowledge without necessarily having to 'mimic' their discourse or methodological practices (Positivist or otherwise), second, due to its situated and contextual nature, design rarely benefits from methodologies or theoretical framework that are given *a priori*. In the words of William Gaver (2006): "Designing and deploying speculative systems makes it clear that theory seldom drives design or guides evaluation, nor is it even the most appropriate or valuable outcome"(p.1). More precisely, design is highly contextual and it addresses particular circumstances. Also, in the 'resolution' of each circumstance various voices come into play, and various methodological frameworks are constructed in situ[19]. This is in consonance with John Wood's (n.d) reading of the ways designers use theoretical models – now largely conceived as 'think-through' mechanisms – while directing their research from practice to theory and then back to practice, as opposed to a logical progression from hypothesis to theory.

This does not mean that design cannot produce knowledge of its own. What is important to recognize is that such knowledge is not necessarily prone to verbal-discursive know-how; that it is not repeatable, generalizable or subject to appropriation by other contexts and disciplinary efforts. However, this was not always the case. In fact, the price design had to pay in order to become part of the 'modern university' (using the words of Veblen himself) was apparent in its new title – 'Design Science'. This implied more than a metaphorical contraption, in fact, it meant that previously design was flawed and could only be reshaped by 'proper scientific rules'. Unfortunately, the applied scientific rules were in themselves obsolete – at least for more daring scientists – based as it was on an idealized rather than practiced science. At the core of this obsolescence was the idea of a 'proper methodology'. (Glanville 1999) Transferring 'scientism' into design implied the resolution of problems, as proposed by distinct clients, in accordance with a linear model. Once dominant in some design circles, by the 1960's designers had started to criticize this methodological appropriation, one that distorted the workings and makings of design. In fact, most shared the intuition that a great many 'design problems' were ill informed, and where data appeared confusing and all the agents, ranging clients, decision makers and others that might be drawn into the design process seemed to have conflicting values (Buchanan 2001:15). In fact this shift – from a determinate methodological paradigm into one of

[19] This concept largely draws upon the work of cultural theorist Sarat Maharaj (2009), particularly when referring to the 'no-how' or 'non-knowledge' of artistic practices where attention is directed towards the 'unique, the qualitative, the particular, and the local' (p.50).

indeterminacy – is still celebrated in the words of Horst Rittel when he attempted to define design's actual problems or research hypothesis as 'wicked problems'[20] (Rittel & Webber 1973).

These 'wicked problems' were not only due to the temperament of the time and the complex nature of design interventions but also to the fact that design was never really attached to any particular discipline. The methodological challenge in this process of design is to 'discover' (and when necessary 'invent') a particular subject in a given circumstance. In this specific case – designing didactic materials for the *Silbo Gomero* language – designers have not only to 'provide solutions to a given problem' but, more fundamentally, to invent their own working hypothesis (Buchanan 2001:17-18). Methodologies have to be reinvented each time and their contribution to knowledge cannot be conceptualized outside of them. Within this, there is hidden a certain 'unschoolability' on the part of designers, what Schön (1987) defined as the 'reflection-in-action' as opposed to the more common methodology of 'reflective-abstraction'. Learning from 'reflection-in-action' implies that most knowledge is acquired from actual involvement with these 'wicked problems'. This same methodology reflects also the *Silbo Gomero's* own body of knowledge – a tacit and highly situated know-how. This is the point at which the ecologically situated 'language' of whistlers and that of design meet in interesting ways.

4. Rhetoric by Design

Lacking a stable and precise methodological and disciplinary frame has, most recently – particularly, as the makings of design mingle with other 'departments' of knowledge – come up against problems of communication (Buchanan 2001:14). How can design contribute to knowledge if designers lack 'proper methodologies' and well-defined theoretical frameworks? Where can we find design's thesis or argument? What is the audience for the design? Is it their academic, industrial and professional peers, or those for whom they design? Or, in the words of Buchanan (1985): "do design arguments accomplish the same things as rhetorical arguments in words? (p.18)" In fact, and considering both the whistler's own body of knowledge and the proposed body of work, particularly as it strives for an actual design proposal, this last question is of central importance and it resurrects an old quarrel, one that pertains to language, which has

[20] As proposed by Rittel, there are ten fundamental considerations when working with 'wicked problems'. They may be summarized as follows: 'design problems have no definitive formulation and no stopping rules; the solutions given can never be considered 'true' or 'false' as in other disciplines but rather as 'good' or 'bad'; when attempting to solve a wicked problem 'there is no exhaustive rule of admissible operations'; every wicked problem can be approached from various points of enquiry, largely depending on the 'intellectual perspective of the designer'; every wicked problem is part of another and at times more complex wicked problem; there is no definitive test for a wicked problem and most times there is not much space for trial and error; 'every wicked problem is unique' and finally, designers are fully responsible for their actions. (Buchanan 2001:16)

been mostly understood as verbal discursive description. In fact, the great pragmatic philosopher John Dewey was well aware of this same habit of thought. In opposition to this model, he suggests a connection between language and its 'operational forces' (Buchanan 2001:192). This same force conceals, as one might suspect, various material and techno-performative dimensions. Such an 'effect' further uncovers the true quality of design as a mode of 'reflection-in-action' (Schön 1987), in its practice-based and practice-led nature. As a practice-based knowledge, design is involved in the planning, making, testing and implementing particular (material or immaterial) artefacts or systems; as a form of practice-led knowledge, it is committed to an exploration of experience, action and the quality of tacit and embodied knowledge as such (CCS 2010).

A pragmatic understanding of language not only conceals the life of 'gesture, rites and ceremonies' (Buchanan 2001:192) but also the life of objects, of technology per se. Here it is important to understand that, for Dewey, technology is not simply a material but also a rhetorical articulation – it is experimental thinking (Buchanan 1992:18). Technology conceals 'technicity' (as described above through the words of Gilbert Simondon, p.13, n.9), it 'speaks' to users, and the interaction with these technologies has consequences beyond those of clear verbal-discursive argumentation since it has effects of its own. Here the Positivist motto that: 'everything that can be thought at all, can be thought of clearly', meaning verbally and logically enunciated (Langer 1942: 84-85), may not stand the test of design. As be proposed: "In approaching design from a rhetorical perspective, our hypothesis should be that all products – digital and analog, tangible and intangible – are vivid arguments about how we should lead our lives" (Buchanan 2001:194).

This might clarify Gaver's 'humble theory', one that also suggests that "we should be less demanding of our theories, and more demanding of our practice" (p.1). Here, it is important to understand that this same effect is not concealed in the artefact per se; it is rather distributed in a hazy intersection between geographical, economical, social and cultural networks, as they are used, appropriated, altered and remanipulated. This rhetorical effect of design has to be conceived beyond any form of technical rationality or hard-nosed technocentrism. To open the way for this mentality is, in the words of Bruno Latour (2007), to conceive of technology beyond its material existence. In fact, to solve this incommensurable Positivism, Latour calls for a 'thick description' of technology. This term should not lead to confusion. 'Thick description' does not necessarily entail verbal-discursive enumeration but an experimental effort to set up all those elements that bring a design, object, system and cultural immaterial artefact into existence in the first place.

Before stepping into exploration of the *Silbo Gomero* – its embodied qualities – it is important to define how this thesis will finally qualify its own 'language' while proposing a form of rhetoric by design. The first step is to understand design's rhetoric as being part of the 'design thinking' process; particularly in the various experiential and experimental ways that designers direct their efforts in gathering information, generating novel connections, new flexible hypothesis that might transverse various 'disciplines' while creating zones of 'reflection-in-action' that were previously unforeseen. This articulation was instigated by direct contact with the Gomeran community at an early stage of this project in 2007. Here, I participated in the *Silbo* classes for adults in the Language Institute in the main village of San Sebastián (in the island of La Gomera) and which were divided into practical and theoretical sessions. The practical sessions were conducted by *Maestro* Isidro, a teacher of the *Silbo* in various schools of the island and who learned the *Silbo Gomero* at a very young age when working in the fields or *barrancos*[21] of the island. The theoretical session was directed by Professor Ramón Trujillo (referred to above), from the University of La Laguna in the neighbouring island of Tenerife and who has studied the *Silbo Gomero* from a phonological perspective for more than thirty years. I also documented my participation in various classes throughout the island that are designed for young children and teenagers ranging from the ages of six to seventeen and are conducted by *Maestro* Isidro and *Maestro* Lino.

Another domain of rhetoric provided by this body of work – and a further implementation of Dewey's understanding of language as force – concerns the idea of action or intervention. While some scholastic domains of knowledge entail the construction of previously unforeseen reflexive zones – this is certainly not an invention of design – these zones do not necessarily entail action or intervention. For design this is imperative, to mobilize what can be sought as a purely verbal-discursive practice, 'theory', theoretical framework or scientific paradigm in order to address 'wicked' realms of situated practice within the life of concrete communities. This process has two important outcomes. First, design rarely follows a linear instantiation of ideas given *a priori,* and most of the time designers will use the information provided in a rather intuitive manner, shifting within the process of design. This particular 'methodology' has a precise outcome when measuring the 'academic' relevance of design's own body of knowledge, particularly when using the classical academic thesis as an element of evaluation. Such a theoretical element appears more in line with how Feyerabend (1975)

[21] The *barrancos* can be understood as ravines and they define the mountainous landscape of the island as it is 'cut' by deep gorges that radiate from its centre down to the sea. Until the 1950's these spaces were important platforms for agriculture and goat herding. Today, as tourism provides the island's main economic sustenance, many of the *barrancos* have become nearly deserted.

qualified the making of knowledge (or science) as an 'accidental encounter in opposition to a well-planned train of thought' (p.8).

This statement does not propose 'complexity' devoid of insight, but rather a non-disciplinary attitude. This is most visible in the general 'theoretical enquiry' provided by this thesis, where topics such as cognition, embodiment, interaction will be explored from a pluralistic territory as opposed to a more common approach where research revolves around the discussion and analysis of particular schools of thought, philosophers and scientific doctrines while setting them against each other[22]. Another effect of design's language or rhetoric should be uncovered through the actual process of intervention. Here, designers acquire rhetorical value when planning, making, testing and implementing their designs. This rhetorical value is, once again, distributed so that not only the designer's personal stance assumes an important role but also the ways in which various participants might contribute is taken into account. In this respect it is important to acknowledge the ways in which this project was distributed between myself, the *Silbo* teachers *Maestro's* Isidro and Lino and the children and staff at the school CEIP El Retamal. Collaboration with the computer engineer Theo Burt, who developed the mechanisms of the final application, was also of central importance.

Within this distribution, it is important to represent the appropriations of the proposed design (particularly the children at CEIP) made by the community. All of the actors figure in the design's 'contribution to knowledge', not as the 'what' of knowledge, but as the making of knowledge as such. Here it is important to recognize that a design's argument (or thesis) does not belong to the designers and their plans and blueprints but rather to the community of actors and practices. This also entails that those who are most frequently qualified as 'users' also evaluate the workings of the design alongside their academic, industrial or professional peers. Any evaluation of the design's 'contribution to knowledge' – as most often required when it partakes in the making of academic life – must be sensitive to this panoply of actors and to the proposed hypothesis, particularly as it evolves within the framework established. This is not to say that design does not provide contributions to knowledge; one must simply recognize that it does not necessarily present any generalizable point for future departures.

[22] Even though one should be cautious when qualifying the workings of design through particular theoretical currents or 'schools' of thought, one might find similarities between the adopted positions concerning cognition, embodiment, interaction within the frame of research provided by 'situated cognition'. This body of work spans distinct time-frames, personalities and 'disciplines, from the work of John Dewey, to the ecological psychology of James J. Gibson, the ecology of mind of Gregory Bateson, the tacit-knowledge of Michael Polanyi, the systems theory of Ludwig von Bertalanffy and the semiotic philosophy of Susan Langer, to name just a few (Clancey 2008).

5. Overview of the Text

In **chapter II**, the text will begin with a thorough presentation of three important approaches in the study of the *Silbo Gomero* – the phonological, bioacoustic and neurological. As briefly presented above, the phonological approach has been responsible for one of the most complete surveys of this whistled form of language, now regarded as an independent phonological system (Rialland 2003, 2005; Trujillo 1978, 2006). Despite the contributions made – particularly as they emphasize that such a form of telecommunication is not limited to a set of stereotyped messages (Rialland 2003, 2005) and that its underlying phonological system is not a simple and direct imitation of the Castilian Spanish spoken in the island (Trujillo 1978, 2006) – when contrasting the information obtained with my own experience among local whistlers some points of disagreement slowly emerged. One point that seemed to persist is that whistlers and linguists (Trujillo 1978, 2006) seem to disagree on the number of whistled vowels. While most approaches insist that these differences are optional (Rialland 2003, 2005) or dependent on external factors and therefore not accountable in the investigation of the subsumed formal code (Trujillo 1978, 2006), what they largely omit is the fact that both linguists and whistlers use distinct 'bodies' in the collection of 'data', a process that presupposes a distinct sensibility to this whistled form of language and its subsumed auditory perceptual ecology. With this is mind, and in the attempt to clarify this discussion, in chapter II the phonological approach will be complemented with information provided by recent bioacoustic (Meyer 2005) and neurological (Carreiras et al. 2005) accounts.

Once again, and despite these contributions – particularly as they further explore the language's auditory and ecologically situated qualities – a similar methodological paradox seems to persist. This is most visible, not only when they emphasize, and while using the field of psychoacoustics as main guiding line, a separation between innate auditory cognitive schemes and learned auditory schemas (Meyer 2005) but also when they locate the centre of investigation in the brain of whistlers (Meyer 2005, Carreiras et al. 2005). What is left in abeyance in this discussion is the situated and contextual 'nature' of the whistler's body of knowledge, here literally understood being immersed in an acoustically rich setting where degrees of improvisation are constantly required and from which 'scientific' techniques of bodily and spatial-temporal abstraction might not always provide a full experiential account. In the attempt to explore further the paradoxes this involves, while dwelling into an investigation of the body as the locus of knowledge, in **chapter III**, the text will proceed with an exploration of concepts of 'embodiment' and 'interaction' as they are conceptualized by the cognitive sciences. Taking a point of departure in the work of Jean Piaget (Piaget 1971, Inhelder & Piaget 1948, Rotman 1977) and the idea of

'cognitive schema' – which has been highly influential within the psychoacoustic community and the separation of innate and learned mental schemas – this chapter will analyse how these concepts are deployed by the field of artificial intelligence and robotics.

Taking this testing ground into consideration, this chapter will also refigure a discussion already advanced by Lucy Suchman (2007) in which the robot, making more than a theoretical contribution, stimulates a dominant and collective imagination that further conceptualizes higher modes of thought, language, perception and intelligence. Not always successful in their achievements, the challenges encountered by the field of artificial intelligence and robotics have nevertheless shed light on the impossibility of representing pure informational and abstracted approaches to the conceptualization of cognition while pushing formal-logical architectures – as proposed by the scientific approaches to the study of whistled languages – into contextual, situated and experiential states. To finalize chapter III, the text will proceed to a discussion of a new sensibility provided by the cognitive sciences and robotics, the concept of 'emergence'. This concept – much in line with work of Gilbert Simondon (2009) and his exploration of ontogenesis as a situated and temporal process of individuation – reinstigates the perceptual body – now a situated and dynamic trajectory – as the locus of a 'mental intellect'.

In **chapter IV**, and developing the main thrust of the thesis, the discussion will shift into the field of education and the development of computational based artefacts. Here, two important lines of investigation are pursued. First, and taking into account the impact of genetic epistemology (Piaget 1971) – now within the context of the learning sciences – I will consider ways in which such dynamic body will be explored. Once considered as a centralized and 'mental intellect' its status as a distributed locus is gaining strength within contemporary educational systems (excluding here certain culturally situated examples) (Gardner 1993) and their material fabrications (Clancey 2005). Second, I will consider how a separation between mind and body has enabled a certain emancipation of particular disciplines (Robinson 2006) but has also led to an understanding of knowledge as being devoid of any experiential locus (Dewey 1963) or necessary degrees of 'reflection-in-action' (Schön 1987). These two important lines of discussion will further instigate, throughout this chapter, a discussion of contemporary approaches to education based on situated forms of 'epistemological pluralism' (Papert & Turkle 1990) and how this pluralism might be further supported by design sensitivities, particularly as they focus on concepts of 'liveness, plasticity, incompleteness and emergence' (Cavallo 2000, Murtaugh 2008).

In **chapter V** this discussion will be further mobilized, while acknowledging the challenges that emerge when shifting the *Silbo Gomero* from the fields into the classroom. Taking into account that both spaces implicate distinct educational approaches – the first more in line

with a mode of learning characteristic of non-literate societies and the second indebted to the ordering of contemporary and secular educational systems – it is important to acknowledge what potentially risks being lost in this process, as well as the central challenges it raises and the potential contributions it can make. In this exchange, it is pertinent to emphasize the language's subsumed auditory culture as a mode of 'intelligence' (Gardner 1993) that not only is disappearing from contemporary educational systems but also as a bodily way of knowing that requires the design of distinct techno-material ecologies – a mode of knowing that will later be termed '*audile*' (Sterne 2003). More in line with what will be described as 'cognitive apprenticeship' (Brown et al. 1989, Gardner 1993), this mode of learning stands in close relation to design as a mode of 'reflection-in-action' (Schön 1987) a mode of learning that should not simply be subsumed to a formal linguistic model, largely informed by a phonological approach (Trujillo 1978, 2006) and devoid of ecological and perceptual significance. As argued in earlier chapters, this mode of bodily learning is not only essential for the preservation of the wealth of knowledge and cognitive skills provided by the *Silbo Gomero* but also for rethinking the role of digital computational artefacts within educational settings. This becomes even more relevant as one takes into account the initial presentation of the linguistic form of communication and its underlying perceptual qualities.

With this exploratory hypothesis in mind, the application *El Laberinto del Sonido* is presented. A computational based application that was designed and further developed in collaboration with computer engineer Theo Burt at the Music Research Center, University of York. The design and materialization of this platform had, as a fundamental underlying principle, the provision of an immersive auditory experience in which both the construction of utterances and, consequently, of small narratives, would intertwine with the exploration of subsumed auditory realms. Opening the application, which has a blank and grid like structure, the user is offered the possibility of recording distinct utterances. It allows one to explore the various sounds previously inserted in the computational medium while adding distinct reverberating effects and levels of interaction and proximity to the sound sources. Once narratives are created they can be exchanged amongst the students. Here, unknown narratives are explored and whistled utterances are deciphered while the *Silbo's* auditory and embodied qualities are further refined. In this sense, the application attempts to place this intangible cultural form in a rather complex experiential web where conceptual and perceptual approaches intertwine, constantly demanding from the body the reconfiguration of a sensuous dynamics. This didactic material takes into account not only the phonological, bioacoustic and neurological readings, but also, the ways in which one might take the whistlers' embodied knowledge as a locus of design.

In **chapter VI** a detailed presentation will be made of the appropriation of the designed application by the Gomeran educational community, a process developed in close collaboration with the school CEIP El Retamal in the small village of Valle Gran Rey. This investigative methodology is consonant with the recent appropriation of 'design-based research' in the learning sciences (Brown 1992, Cobb et al. 2003, TDBRC 2003). Taking this into account, the chapter will also discuss the ways in which this form of research is, at times, misidentified, particularly as it incorporates an understanding of design as 'science' (Brown 1992) or when attempting to use design-based research simply to refine detached theoretical principles (Cobb et al. 2003, DBRC 2003). Taking into consideration the 'wicked problems' (Rittel & Weber 1973) of design as presented in the previous section, an alternative reading of design-based methodologies within the educational realm will be further mobilized, particularly as they focus on the quality of interventions as opposed to the role of theoretical models (largely given *a priori*) in the development of culturally situated educational praxis. Opening a space for design-based research not only turns our attention away from the most common quantitative assessment of digital computational technologies in the classroom, it also yields potential for local intervention in real contexts while mobilizing the participation of various actors. In addition it allows for further exploration of the documentation and analyses of local situations and the social and cultural dynamic trajectories of the participants. This is most pertinent when attempting to locate the contribution provided by the designed application, particularly when further safeguarding the *Silbo Gomero* and the wealth of its subsumed auditory culture.

In **chapter VII** a detailed discussion of all the presented chapters and future directions the provided framework might develop will be thoroughly presented.

II

THE *SILBO GOMERO*.
AN ARCHAEOLOGY OF EMBODIED KNOWLEDGE

"Thus in a sense nature is independent of thought. By this statement no metaphysical pronouncement is intended. What I mean is that we can think about nature without thinking about thought. I shall say that then we are thinking 'homogeneously' about nature. (…) Of course it is possible to think of nature in conjunction with thought about the fact that nature is thought about. In such a case I shall say that we are thinking 'heterogeneously' about nature" (Whitehead 1920:3).

1. Brief Introduction

Taking into account a previous description given of the *Silbo Gomero* – particularly as it shifts from the fields into the space of the classroom – this chapter will proceed with the presentation and discussion of four lines of investigation that characterize distinct approaches to the study of this ancient form of telecommunication. Here, it is important to consider a 'phonological stage' as briefly discussed in the introductory chapter (Rialland 2003, 2005; Trujillo 1978, 2006), a bioacoustic (Meyer 2005) and neurological approach (Carreiras et al. 2005) and the whistler's own body of knowledge. This last approach is largely informed by *Maestro* Isidro and *Maestro* Lino. In fact, both men are part of an older generation of whistlers who learned this form of telecommunication at a very young age while working in the fields. They are also responsible for teaching a thirty-minute class every week throughout the various schools of the island. However, and before proceeding, it is also important to consider that the *Maestros* never had any form of institutionalized schooling and only *Maestro* Isidro learned how to write when he was nine years of age.

While exploring these distinct readings of the *Silbo Gomero,* my underlying concern is to tackle opposing methodologies, instruments and knowledge practices. I will examine how each body of knowledge – 'scientific' and 'indigenous' – is characterized by distinct epistemic realities, scientific ideas and, consequently, how distinct paradigms and educational points of departure are formed. Moving from a 'phonological stage' (Rialland 2005, Trujillo 1978, 2006) towards an

increasingly 'heterogeneous' point of analyses, where the development of the whistler's cognitive milieu – a complex verbal-auditory ecology – will challenge a common assumption that presents the *Silbo* as a surrogate of spoken Castilian Spanish. This movement between distinct methodologies and bodies of knowledge will shift the proposed project – designing a language support system for the *Silbo Gomero* – from a 'homogeneous' account, largely influenced by the idea of whistling languages as a verbal and discrete sound system, towards a 'heterogeneous' one, where the ecological refinement of auditory perception becomes the key element. While incorporating biacoustic (Meyer 2005) and neurological data (Carreiras et al. 2005) as well as drawing on the whistlers' own accounts – which will be proposed as a new ecological stage – the purpose of this analyses is to gain a situated and embodied understanding of this whistled form language, one that further intertwines verbal and auditory traits at the core of the whistler's body of knowledge. Later on, this depiction will open up space for a discussion of the *Silbo's* '*audile*' (Sterne 2003) culture.

In fact, and while contrasting a phonological approach and the whistlers own body of knowledge, this analysis will explore inherent points of disagreement such as the number of whistled vowels. This discussion will require the exploration of two complementary lines of inquiry. First, the analyses of whistled utterances will shift from a phonological reading to a bioacoustic one as proposed by Meyer (2005) while at the same time proposing a new ecological stage. However, while the bioacoustic reading will largely focus on the study of auditory perception and its underlying 'innate based schemas'[23] – the grouping of auditory information as informed by biological conditioning – the disagreement between whistlers and phoneticians will require further exploration of auditory perception as 'schema-based learning', one that is not solely dependent on 'natural' predisposition. Such analyses will take this body of work to explore the *Silbo's* auditory perceptual fabric as situated, ecologically interactive and embodied phenomena, one that is indebted to the whistler's experience of the island's mountainous environment. Such an experience cannot be easily located in the brain of the whistling subject – as proposed by the bioacoustic (Meyer 2005) and neurological accounts (Carreiras et al. 2005) – but rather in the continuous exploration of the sonic-orography of the island.

With this in mind, a new learning ecology is proposed, one that takes learning through the exploration of particular milieus, where the development of language, now a cognitive-ecological synergy, is seen to involve both body and environment as well. The introduction of the *Silbo Gomero* into the space of the classroom will be taken as the main thrust of this discussion. And, as will be explored in chapter IV, this space is largely characterized by a particular paradigm of

[23] Meyer's bioacoustic reading is largely based on the work of psychologist Albert S. Bregman in 'Auditory Scene Analysis: The Perceptual Organization of Sound' (1994) an important reference within the field of psychoacoustics.

'schoolability', one that is consonant with a phonological reading of the whistler's own body of knowledge (Brito et al. 2005, Trujillo et al. 2005). Recalling the contextual practice of design, as explored earlier on in relation to the challenges posed by its 'wicked problems' (Rittel & Webber 1973), to question the *Silbo's* constant surrogation is not only to question an understanding of this whistling form of language solely based on a phonological account; it is also to question a paradigm of 'schoolability' because both notions rely on a formal reading of linguistic bodies of knowledge. In this sense, and further exploring the embodied knowledge presented by whistlers themselves, the thesis will treat non-verbal and interactive ecological complexities as essential features. A phonological reading will not be overlooked but the intention will be to place all cards on the table while constructing a space for a 'heterogeneous' reading of what was previously delimited as a surrogate body of language. This is an idea largely embedded in phonology's proposed methodologies of research, particularly spectrographic analyses of auditory phenomena.

Before proceeding, it is important to recognize that none of the authors (Carreiras et al. 2005; Meyer 2005; Rialland 2005; Trujillo 1978, 2006) who have studied the subject (and here I include myself) are proficient in any of the whistling forms of language, particularly the *Silbo Gomero*. Despite having attended *Silbo* classes for adults at the *Centro de Profesorado de La Gomera* in the main village of San Sebastián of La Gomera during an initial visit in February/March of 2007, I could only develop rudimentary skills[24]. To compensate for this gap, the contact established with *Maestro* Isidro and *Maestro* Lino during February/March and November/December of 2007 was of the utmost importance, particularly for the development of the present chapter. During these periods of fieldwork, I was able to join *Silbo* classes for children in different schools of the island, an opportunity that greatly enhanced my skills, particularly in the refinement of listening, something that was most important in developing a closer 'reading' of the *Silbo's* performance[25]. It is important to take this information into account since the research would not be possible without continuous and active engagement with the Gomeran community.

[24] For further information consult DVD 1, movie 1, in attachment.
[25] When learning the *Silbo*, performance and intelligibility do not always work in unison. In fact, amongst the younger whistlers it is common to find a very good level of intelligibility combined with lower performative skills.

3. Young girl whistling during a *Silbo* class with *Maestro* Isidro (Matos 2007).

2. Studying the *Silbo Gomero* from a Phonological Perspective

In his latest book '*El Silbo Gomero, Nuevo Estudio Fonológico'* (2006), a revision of an initial study published in 1978, Professor Ramón Trujillo establishes a clear separation between three different phases of study that have largely characterized the *Silbo Gomero*: the 'impressionist' – or ethnographic – stage conducted by Juan Betthencourt Alfonso and Antonio Maria Manrique in the late XIXth century; the 'phonetic stage' of Max Quendefelt (1887), Joseph Lajard (1891) and André Classe (1957); and finally the 'phonological stage', where the work of Professor Trujillo and Annie Rialland (2005) may be located. It was only with the 'phonetic stage', particularly with the article '*Pfeifsprache auf der Insel Gomera'* by Quendefelt, that one finds the first truly linguistic understanding – a scientific study of the *Silbo Gomero* that went beyond speculation (Trujillo 2006). After many foreign and impressionistic accounts, Quendefelt recognized that the *Silbo Gomero* is not a language in its own right, since it imitates the spoken language of the island, the regional Castilian Spanish. He allowed us to understand that what is really whistled is the syllables of spoken Castilian words. This was the first time a foundation for further linguistic theorization had been established, one that considers how the *Silbo Gomero* manipulates consonantal and vocalic elements and therefore cannot be understood as anything but a surrogate of speech.

This phonetic stage has now largely been surpassed by the 'phonological stage' (Rialland 2005, Trujillo 1978, 2006). This stage presents the *Silbo Gomero* as an independent phonological

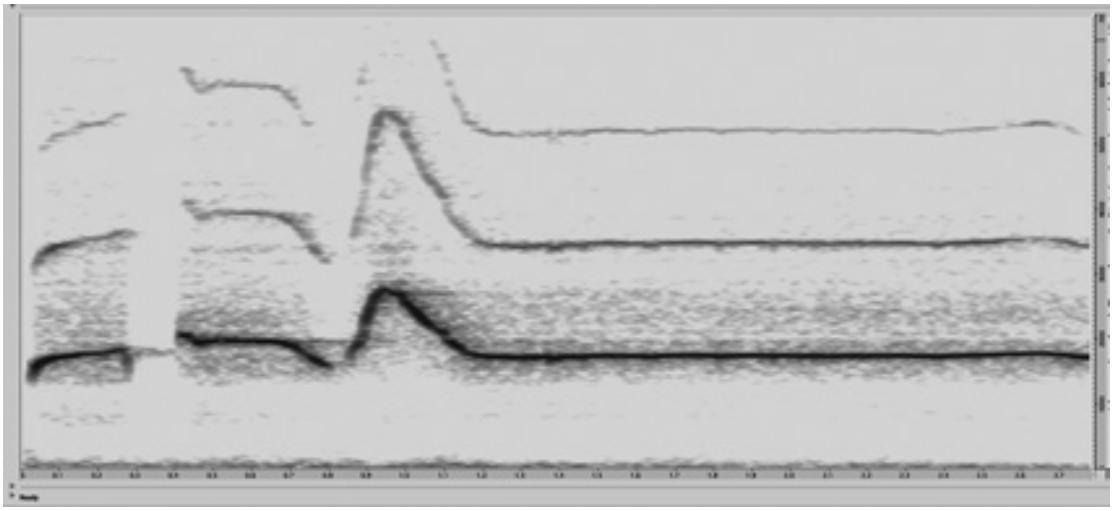
system: one "(...) that contains a reduced number of phonic schemes that are used to produce different sonorous substances (...)". The essence of this development is recognition that the *Silbo* has its own logic that cannot be simplified by direct representation. For example, the "grave vowel /A/ (...) is not a simplification of the Castilian Spanish grave vowels /o/, /u/ and /a/, but is a different vowel altogether because it belongs to an independent phonological system". In this sense, the *Silbo Gomero* has "(...) a rigorously articulated structure which clearly distinguishes it from standardized sign systems and whose most notable attribute is that the meanings of its smallest consistent units cannot be analyzed" (Trujillo 2006:11,31). According to this account, the formal simplicity of the whistled language – with its two groups of vowels and four groups of consonants – means that it can be used to communicate any given language, as long as it has been developed upon the similar organizational principles as a non-tonal language[26] such as the Castilian Spanish.

Trujillo (1978, 2006) and Rialland (2005) have both considered the possibility of a North African origin of this whistled form of language. This may have occurred through the Guanches, as discussed earlier. In fact, Trujillo suggests that the inhabitants of the island of La Gomera (and probably many other Canarian islands) might previously have whistled a three vowel Berber language (Trujillo 2006). This is debateable, reliant as it is on the scant remains of the linguistic culture of the Guanche, which makes it impossible to connect this ethnic group to a North African lineage. Nevertheless, as a result of the data collected during the 'phonological stage' (Trujillo 1978, 2006), one is able to attribute stable and precise values to each vocalic element. We can therefore say that the grave vowel corresponds to the /a, o, u/ vowels used in the spoken regional Castilian Spanish language. Their frequencies correspond respectively to: 1800, 1600 and 1600 Hz. The acute vowel corresponds to the /i, e/ vowels and correspond to the values: 3300 and 3000 Hz.

Spoken vowel	Whistled (frequency)
/a/	1800 Hz
/o/	1600 Hz
/u/	1600 Hz
/e/	3000 Hz
/i/	3300 Hz

[26] Non-tonal languages like English and Castilian Spanish use consonants, vowels and pitch to distinguish words, while tonal languages, such as languages from the Sinitic family (most commonly referred to as Chinese) only use pitch. (Yip 2002)

The limitation of the whistling apparatus is considered to be the main constraint, which explains why a whistler can only produce 'differences in tonal frequency' and this limits a vowel to being 'grave' or 'acute'. While the spoken vowel relies on a different set of physical resonators – allowing one to distinguish between acute/grave, open/closed, partial/intermittent and complete vowels – the whistled vowel is shaped by and depends upon one resonator, the mouth (Trujillo 1978, 2006). As will be considered later on, this phonological stage is embedded in a very particular and almost mechanical understanding of the body, which is in line with a cognitive paradigm[27], one that largely neglects the dynamic role of the body as a place of sonic articulation. Bioacoustic studies of communication in higher mammals offer a means of addressing this neglect, while presupposing that articulation is an emergent and highly distributed phenomena that cannot be precisely located[28].



4. Spectrographic representation of whistled utterances performed by *Maestro* Lino in the village of La Palmita and corresponding to the Castilian Spanish name 'Octavio'. For more information consult DVD 1, track 1, in attachment.

One of the authors to disagree with this separation between 'acute' and 'grave' vowels is Annie Rialland (2005). In fact, Professor Trujillo writes that, within the *Silbo Gomero* we can only find "(...) two 'whistled vowels' or groups of frequencies; two blocks that behave as they would in ordinary language (...) where functional confusion is impossible from a phonological

[27] This particular reading of cognitive theory is based on the informational or computational paradigm; one that further emphasizes formal representation over perceptual information. A fruitful discussion of this approach, particularly as it relates to the study of auditory perception and contrasts further with an ecological approach, can be found in the dissertation of William W. Gaver 'Everyday Listening and Auditory Icons' (1988).

[28] This idea is largely drawn from the work of composer Trevor Wishart in 'On Sonic Art' (1996), particularly when referring to the work of René-Guy Busnel (Wishart 1996:242), a bioacoustician who devoted his research to the study of bioacoustic systems of higher mammals, including human whistled languages (Busnel & Classe 1976), this last one, resulting in a body of work that has been extensively explored by Julien Meyer (2005).

perspective (…) properties that are always distinctive and those that are not consistently distinctive (depending on the context, the situation or what the whistler knows) cannot be considered (...). Obviously, these latter properties, which Annie Rialland sometimes calls 'optional' (...) do not form part of the structure of the whistled language because they depend on external factors" (Trujillo 2006:15). Here, a paradox seems to emerge. When attending *Silbo* classes or being in the fields recording with *Maestro* Isidro and *Maestro* Lino, I found that whistled languages are in fact highly 'dependent' on what a 'phonological stage' would call 'external factors'. In fact, and to take an ecological approach even further, it is important to understand that both *Maestro* Isidro and *Maestro* Lino are able to whistle and perceive at least two further groups of vowels within the grave/acute separation.

5. Young boy whistling during a *Silbo* classes with *Maestro* Lino (Matos 2007).

In considering the 'phonological stage', the 'acute' and 'grave' vowels should be completed by the addition of two other groups of consonants, the 'acute/grave continuant' and the 'acute/grave interrupted'. Here, the"(…) whistled consonants are nothing more than intonation curves, transitions or interruptions in the 'whistled line' of what we have called whistled vowels" (Trujillo 2006:201). The vocalic lines – between 1000 and 3000 Hz – are altered with the 'help' of the whistled consonants. In these terms, an acute consonant will always point the following vowel to a higher frequency; the opposite will happen when it is preceded by a grave consonant. All of the above 'consonantal intonations', whether continuant or interrupted, correspond to spoken Spanish, except for /s/ (that cannot easily be whistled) while "(...) a continuant is transposed into an interrupted (...)" (p.205).

The idea set forth by a phonological agenda sustains the intuition that whistled systems can be differentiated from spoken systems while exploiting their own embedded logic and subsequent rules. This also entails a reversal of the paradigm, because the *Silbo Gomero* cannot satisfactorily be studied through its constant surrogation to speech. In fact, when attending classes for children and teenagers (from six to eighteen years of age) in different schools of the island during February 2007, one thing that struck me was that *Maestro* Isidro and *Maestro* Lino did not teach how to whistle the isolated units that we conventionally associate with the vowels/consonant distinction. In their classes, one learns, at first hand, how to whistle words or melodic segments by grasping the contours of different syllables. One also learns that *Lalo* is whistled differently than *Lala*[29], contradicting the assumption that the *Silbo* only exploits two groups of vowels: one acute /e, i/ and one grave /a, o, u/. *Maestro* Isidro and *Maestro* Lino, even though not willing to discuss their disagreement with this notion, teach their students how to appreciate the possibility of whistling and perceiving two more sonorous segments within the presented acute/grave distinction. Also, in further discussion with *Maestro* Isidro, I learned that certain words are whistled in exactly the same way, as for example for *ballena* (whale) and *gallina* (chicken), an example also given by Professor Trujillo (2006).

However, this counter intuition – the exploration of extreme ambiguity provided by a whistled utterance – has also, at times, been highly formalized. This was most apparent in the assertion that the *Silbo* was only used "(…) to transmit very practical and highly contextualized information (…) and not poetic or expressive information." (Trujillo 2006:19) This idea was later challenged when *Maestro* Lino – while recording in the village of La Palmita where he lived for most of his life – exemplified a situation common in the 'old days'. At that time, when somebody from the village died, due to the rough terrain of this particular village, a message was whistled from house to house[30]. As the reader might follow, not only is the message rather long as the emotional or expressive quality is present in the initial 'call'. Here, it seems relevant to challenge further the idea that the *Silbo* was only used in the daily routines of agricultural life[31]. Even though my main concern has not been to explore semantic communicational qualities, this recorded sample challenges the idea that this whistled form of language was not used to convey expressive or emotional content. In fact, it challenges the phonological account and its reluctance to explore what is 'inconsistently distinctive' (Trujillo 2006:15).

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[29] For more information consult DVD1, movie 1, in attachment.

[30] For more information consult DVD 1, track 2, in attachment.

[31] In fact, this form of whistled language, and considering it was largely used by farmers and herders, has been largely mistaken for a set of stereotyped messages. In this respect, Annie Rialland (2005) noted: "(...) a system of whistled communication which allows fluent subjects to transmit and exchange potentially unlimited set of messages over long distances. In this respect, they are quite different from communication systems limited to a repertoire of stereotyped messages. For example, the whistled formulas used by certain herders or animal trainers do not constitute whistled languages as such" (p.1).

6. *Maestro* Lino and myself recording in the village of La Palmita (Hecker 2007).

7. Terrain of the village of La Palmita where one can still see the remains of two houses while demarcating the relative distance over neighbours would communicate (Matos 2007).

2.1 Phonology, Autonomy and the Quantification of Language

Comparing a phonological analyses with the body of knowledge of the whistlers themselves will open space for a presentation of the autonomous project of linguistics – where the sub-disciplines of phonetics and phonology are embedded – its disciplinary premises and subsequent scientific intuitive analyses of language as a self-contained entity. This will constitute an important thread throughout the thesis and will open space for a more 'heterogeneous' conceptualization of the linguistic event. One that will be further emphasized by an ecological understanding of representation and the development of perceptual and conceptual systems as complex situated and embodied phenomena. In fact and to situate this disciplinary premise within a Western tradition of scientific enquiry, one can trace the study of language to the ancient Greeks, particularly to their exploration of Homeric epics, a project that may be linked to contemporary philological or 'diachronic'[32] lines of enquiry. In the XVIIIth century, such an approach to the study of human language set much emphasis on the study of the classics, particularly ancient Greek, Roman Italic Latin and classical Sanskrit. Within the context of linguistic European enquiry, the interest in studying the classics, slowly cast light on the existence of similar structures within the Sanskrit language and languages of European tribes, such as the Gothic and the Celtic (Newmeyer 1988:17-18).

These similarities encouraged researchers to look for structural relations between what were apparently distinct languages. And in the XVIIIth and XIXth centuries this led to further consolidation of the 'comparative method'. At this point in history one can see the first attempts to develop a formal intuition, as – while using the comparative method – linguists attempted to find structural correspondences between sound and meaning among distinct languages. The ultimate quest was to trace all languages to a unique ancestral form common to human civilization (p.19). This was encapsulated by the project of 'Generative Grammar', where the morphology of syntax was slowly equated with the idea of an innate predisposition towards a universal language, a characteristic that all humans are endowed with (Chomsky 1976). Today, such 'naturalization' can be exemplified by the attempt to identify the human gene that is fundamental in the development of human linguistic competence (Trivedi 2001). To a certain extent, this approach reflects the power of an informational paradigm, one that has largely influenced contemporary life sciences, particularly genetic research. Where the very idea of life has been extensively equated with the linear execution of a binary code as recorded in the

[32] In structural linguistics it is possible to look at two defining elements in the study of language: synchrony ('the linguistic state', the study of language without reference to its historical context) and diachrony ('a phase of evolution', the study and description of the change or development in the structural systems of a language over a stated period of time) (Saussure 1966).

genome. It has been through this lens that the body of language has become a very particular body, the pre-programmed and syntactical body[33].

Most important to consider, is that such intuition would pick its investigative lines from a scientific project proposed in the XVIIth century – the European era of Enlightenment. It therefore drew heavily on the formal-logical achievements of Western mathematical thought as proposed by figures such as René Descartes and Gottfried Leibniz. In fact, the success of mathematical logic in the construction of complex mechanical devices – such as Leibniz's calculating machines – reinforced the idea that nature could also be de-codified by means of a similar 'mechanistic' explanation, one now largely based on the calculative potential of two reduced decimal numbers. (Scheutz 2002) In its turn, such intellectual movement drew heavily on the study of the classics, particularly Greek mathematical and philosophical thought, especially as proposed by Pythagorean mathematics and the idea of a 'Harmony of the Spheres' that speculated that the universe was ruled by mathematical principles.

In the words of Alfred North Whitehead, in Pythagorean cosmology:

"the logical Harmony involved in the unity of an occasion is both exclusive and inclusive. The occasion must exclude the inharmonious, and it must include the harmonious." Pythagoras "(…) insisted on the importance of the utmost generality in reasoning, and he divined the importance of number as an aid to the construction of any representation of the conditions involved in the order of nature. (…) Pythagoras is said to have taught that the mathematical entities, such as numbers and shapes, were the ultimate stuff out of which the real entities of our perceptual experience are constructed. (…) Number lies at the base of the real world (…)" (Whitehead 1925: 27-28).

A similar intuition is embedded in Leibniz's attempt to draw a '*Universal Characteristic'*, one that might be read in the following: "there is an old saying that God made everything in accordance with weight, measure and number. But there are things that cannot be weighed (...) there are also things that cannot be measured. But there is nothing that cannot be numbered. And so number is, as it were, metaphysical shape, and arithmetic is, in a certain sense, the statics of the Universe, that by which the powers of things are investigated" (Leibniz 1989:5). The further implications of such intuitions can be seen throughout the successive development of Western scientific thought (Whitehead 1925), a project that largely drew on the 'accuracy of reference' as opposed to the complexities of 'articulation' of observed phenomena (Latour 2004a). Finally it involves faith that the development of scientific thought provides objective, externally observed and factual knowledge devoid of controversy.

[33] Further discussion of the impact of a 'computational metaphor' on the project of genetics can be followed through the work of Evelyn Fox Keller in 'Refiguring Life. Metaphors of Twentieth-Century Biology' (1995).

With this in mind, it is with no surprise that the autonomous project found in the structural instantiation a distinction between *parole* and *langue*[34]. While in its most recent generative approach the mechanistic explanation finds language divided into two composing 'bandwidths'. First, and most important, one must consider the 'the faculty of language in a narrow sense' and secondly, the 'faculty of language in a broad sense' (Chomsky et al. 2002:1571), as presented in the introductory chapter of the thesis. Taking into account this separation between the two 'bandwidths' of language, one can sense a transposition of the method first deployed by Pythagoras in which the harmonious qualities or the 'narrow sense' (the innate grammatical configurations) are isolate from a conceptualization of language in the 'broader sense' (acquired linguistic practices). This method extracts the situated, contextual and messy (or 'inharmonious' qualities) while delineating the skeletal features of language – its phonological structuring. In fact, it further deploys the informational intuition, while confining an understanding of language to its 'code', one with a formal and stable existence prior to its execution.

However, and even though one might consider this particular historical lineage of the comparative method, its actual application did not always entail the construction of an autonomous and informational conception of language. Here it is important to consider that the comparative method was also developed during the Romantic period, a movement that influenced much of Western thought in the XIXth century and developed as a reaction to the rational project of the Enlightenment. Within the study and analyses of human language, this movement was marked by a contrasting approach, largely informed by an increasing interest in the customs, religions and folkloric practices of both Western and non-Western cultures and their relation to language. In fact, these newly discovered linguistic forms had lived on the margins of scholastic enquiry due to the fact that the classical study largely regarded such linguistic practices as 'barbaric' and not worthy of scientific investigation[35]. (Newmeyer 1988:19-20) In this sense, one of the most interesting concepts that emerged from Romantic intuition was the idea that language could not be studied as a self-contained entity. Language did not obey simple mechanical laws, but involved a complex organic-body[36]. Just as other bodies, such as

[34] Ferdinand de Saussure (1966) first proposed this distinction between *langue* (language) and *parole* (speech). While *langue* refers to the system of rules and conventions given a priori (genetically or culturally), *parole* refers to language as it is used in particular circumstances

[35] Here its is important to note that, in the old days, the *Silbo Gomero* provided a way of classifying the lower classes of the island – mainly peasants and goat herders. Information transmitted by *Maestro* Isidro in conversation.

[36] The idea of language as an organic-body is in consonance with the development of the biological sciences in the late XVIIIth century, particularly as scholars react to the "(…) scientific realism, based on mechanism (…) of higher animals as being composed of self-determining organisms" (Whitehead 1925:76), a reaction

those of plants and animals, language was seen as being inseparable from its context, of which its environment was the key factor (p.23).

Despite its methodological contributions, this intuition would soon be seen as insufficient. With the advent of Darwin's theory of evolution it was largely simplified within linguistic circles. While positioning language at the level of the organism, Darwin's theory would eventually lead to it being considered the result of a cumulative diachronic and linear process of evolution (p.24) one prone to mechanization, the principle that fully characterized the scientific thought of the XVIIIth and XIXth centuries (Whitehead 1925). Seeking methodological precision, a reading of Darwin's approach to the evolution of species was built on layers of functional adaptation excluding, to a certain extent, behavioral complications embedded in this ecological relation, now taken through a 'neat' and formal interpretation of adaptation[37]. The residues of such interpretation are still influential. In fact, within sociobiological discourses the prevailing idea is that 'in the beginning was simplicity' (Dawkins 2006:12). What this means is that all evolution, whether genetic or cultural (and here one must think of language), evolves from simplicity to complexity, rendering some languages more 'complicated' than others and justifying, to a certain extent, the belief that whistled forms of language are unsophisticated.

This discussion provides the means through which one might shift from what Bruno Latour (2007) identified as the 'teleportation scheme' into a 'continuous scheme'. While the 'teleportation scheme' presupposes a gap between subject and object (or environment), one that might be filled through objective understanding of both as they are contemplated a priori, the 'continuous scheme' assumes that this gap does not exist and therefore what is required is an understanding of 'chains of experience' as they are formed from within. This enables us to treat bodies as having greater functions than was previously thought, and that language exceeds, in unpredictable ways, the mechanization of pure phonetic code, of a script that is given a priori with little consideration for its contextual and performative generation. This approach is more than relevant, particularly when attempting to mobilize an ecological reading beyond any constraint as provided by the surrogate qualities of a whistled form of language. Even though one might consider whistled languages as adaptations to environmental constraints (Meyer 2005), in this case, to the mountain landscape of the island of La Gomera, it is also within this ecological

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that gave further strength to the separation between the biological and physical sciences, while considering that the latter could only deal with abstract entities.

[37] Here it is important to notice that a close inspection of Darwin's ideas on adaptation and evolution will bear paradoxical interpretations, where a simple organ such as the human eye evolved through the historical preservation of another organ with quite different behavioural function. In fact, for the naturalist, the preservation of some organs is considered to be fruit of 'maladaptation' or malfunction in opposition to any 'clever or good design' (Burian 1994:9). Darwin himself, when referring to the eye spoke of an "organ of extreme perfection and complication" (p.8).

relation that previous phonological rules will be pushed beyond their skeletal remains into embodied forms of knowledge and their underlying auditory configurations.

8. Image of the *mountainscape* of the island of La Gomera. Here, one can still see the rugged terrain supported by artificial terraces that creates stable land for agriculture (Matos 2007).

3. Enquiring into Nature, the Development of New Techno-Material Realities

To give continuity to this discussion and so set it in relation to a 'mechanistic' explanation of nature and the development of phonetics and phonology, a closer inspection of the development of the techno-scientific culture that has guided the development of this field of investigation seems pertinent. This seems relevant, particularly when one considers that the main conclusions drawn by the 'phonological stage' (Trujillo 1978, 2006) are solely based on:

"(...) phonic material (...) recorded on magnetic tape and then examined with an oscilloscope[38] and a spectrograph. The results from the oscilloscope were not very useful and their analyses did not lead to any interesting results, at least for our purpose. On the other hand, the spectrograph produced a very clear and evident 'visual' version of the whistled language phenomena" (Trujillo 2006:57).

It is important to note that in this study it appears, from the lack of 'visual evidence' or precision, that an analogue, rather than a digital, oscilloscope, is being considered. The following hypothesis might here be proposed: could such scientific instrumental interventions be the cause of the

[38] The oscilloscope (or scope) "is a powerful instrument used to display the voltage in a circuit as time passes. Scopes are available as analog scope and as a digital storage oscilloscope (DSO)" (Diffenderfer 2004:19).

disagreement between linguists and whistlers when referring to the number of whistled/perceived vowels? It is therefore relevant to investigate these instrumental appropriations and their embedded methodologies. In order to consider fully the information provided by the 'phonological stage', one always has to understand the role of scientific data – particularly recorded information – in relation to a given mode of instrumentation that, in this particular case, entails techno-scientific methodologies of sound visualization such as the spectrogram.

Before doing so, however, it is relevant to recall the historical relation between the formation of Western scientific thought and the development of technology. This relation conceals a long history of 'competition' with human performance, at times, rendering the degree to which scientific knowledge was coordinated as technological and institutional organization imperceptible[39]. In fact, one can trace this to Galileo Galilei, particularly in relation to his new creation, the telescope. In comparison to the 'old sense', this 'new sense' was more refined (Feyerabend 1975:81). Embedded in the new logic of instrumental manipulation and appropriation, it would count towards a long history of Western ratiocination, spanning the philosophical legacy of the era of Enlightenment. Here, science came to base its formulae and instrumental design on a mechanical principle upon the abstraction of both of time and space. Of course, this did not happen in a void, intellectuals of the time – such as Galileo and Newton – had at hand three powerful traditions. First, that of rational-mathematical thought handed down from the ancient Greeks (for instance, the work of Pythagoras); second, the abstract numerical-notational systems handed down from Arab cultures and thirdly, the faith in reason and order of nature that came from Christian religious thought (Whitehead 1925:1-18). These traditions all served to reinforce the 'mechanistic explanation' of nature.

The new cosmology became the dominant idea, supplying the imagination of society with a mechanized ideal of the natural order, one that subsumed an abstract harmony of forms and measurements of perceptual relations. It was through this process that Galileo was able to prove the 'heliocentric theory' of Copernicus, using a combination of abstract geometrical entities and detailed telescopic observation of the skies. This inaugurated a long tradition in which speculative thought supported by observed data would complete the construction of scientific and mathematical formulae. Through this embodied logic, the understanding of nature was slowly reduced from a holistic conception, as part of the flow or motion of space and time, into an

[39] A pertinent reading of the material conditions of scientific development and subsumed modes of thought can be found in the work of Bruno Latour (2007): "(…) why is it so difficult to have a history *of science*? Not a history of our representation but of the things known as well, of epistemic things? (…) Why is it so difficult to consider each of the successive interpretations as an *organism* for its own sake with its own capacious activity and reproductive risks? Why is it so difficult to take knowledge as a vector of transformation, and not as a shifting set aiming toward something that remains immobile and "has" no history?" (p.6)

abstract logic of quantification[40] (Whitehead 1925:19-37). Descartes would take this even further, particularly by identifying two sorts of nature, the external nature of primary and quantitative facts and the internal and secondary nature, where one would find the qualitative and subjective attributes (Descartes 1641). Time thus becomes an ordered succession of instants of time, and space becomes a fixed geometry, where points are organized in an ordered and stable continuum (Whitehead 1925). This particular organization of thought presupposes a methodological challenge – an embodied logics in its own right.

This method gradually imposed the idea that one could attain scientific veracity by moving from one generalizable fact to another. This inevitably led to the formation of many common fallacies and, despite the immense contributions of intellectuals of the time, it was common to treat concrete occurrences in terms of a set of abstract and general rules; this has been called the 'fallacy of misplaced concreteness' (Whitehead 1925:51). This approach was further extended through most of the XVIII^{th,} XIXth and XXth centuries and further supported through the construction and development of material artefacts, particularly scientific instruments of research and measurement.

One particular example showing how instrumentation and the formation of distinct bodies of knowledge are intertwined occurred during the tumultuous period of the French revolution (1789-1799) when the ideals of *liberté*, *equalité* et *fraternité* were the orders of the day. At this time science suffered one of its most radical transformations from qualitative mode of research to quantitative one. For example, within the field of chemistry, the new devised instruments would require from chemists an adaptation of the senses to the exigencies of the new methodological approach, entailing a different logic and process of embodiment. Previously, chemical compositions and processes were differentiated and controlled through a refinement of the senses as they were reconfigured through education and experience. The body underwent a complex learning process where the senses were mastered into new sensuous modalities. With the introduction of quantitative based instrumentation this bodily dynamic would gradually be altered into a distinct performative logic. In fact the body was also mastered, but now towards an ideology of precision (Roberts 2005).

With the introduction of an autonomous discipline of linguistics (Newmeyer 1988), this approach dominated the study and conceptualization of the *Silbo Gomero* (Trujillo 1978, 2006). This resulted in quantitative analyses, which distinguished and isolated the symbolic traits of

[40] A similar discussion can be found in the work of mathematician and cultural theorist Brian Rotman (1993), particularly his critique of Euclidian space and its exclusion of movement, one that draws on Pythagora's exclusion of the 'inharmonious'. This would have a profound impact on many methodologies devised by Western physical-scientific enquiry where movement was rendered imperceptible through numerical measurements of 'space, time, mass, energy, charge, gravitation, information' (p.11).

'language in the narrow sense' (Chomsky et al. 2002). As in the spectrographic analyses of aural phenomena – largely exploited by phonetic and phonological accounts – the experience of language no longer treated as flowing from auditory experience but in terms of the embodied-logics of numerical rigour. In fact, one can find the first developments of aural instrumentation in this logic of quantification, precision and further containment. Thomas Edison's invention of the phonograph, an instrument capable of playing recorded sound, in 1877, was especially important for the understanding of auditory experience.

As explained by Edison himself, in the 'North American Review' (of June, 1878):

"the phonograph (...) demonstrates the following *faits* accomplish: the captivity of all manner of sound waves heretofore designated as 'fugitive', and their permanent retention; their reproduction with all their original characteristics at will, without the presence or consent of the original source, and after the lapse of any period of time; the transmission of such captive sounds through ordinary channels of commercial intercourse and trade in material form, for purposes of communication or as merchantable goods; indefinite multiplication and preservation of such sounds, without regard for the existence or non-existence of the original source (...)" (quoted in Lastra 2000:19).

This idea of representation, confirmed through retention, would inaugurate the modern Western ideal of instrumentality largely based upon the materialist scientific project of precision and verifiability. Recursively, the ideal of retaining sound suggested that the process of hearing could be compared to the workings of the phonograph. This would bring a conceptual shift towards examining sound as what the ear hears, sacrificing the place of the body, action and the cultures of listening play in the way hearing develops in specific ecological milieus. The phonograph would thus come to play the role of technical archaeologist, and its ability to retain, would lead to the idea that human presence, was no longer necessary in the process of representation, since 'nature' could be copied more accurately than any artist ever could (Lastra 2000).

However, before Thomas Edison invented the phonograph he devoted most of his time to the study of the ear phonautograph invented by Édouard-Léon Scott de Martinville (Roads 1998, Sterne 2003). In close relation to contemporary spectrographic analyses, this instrument was able to demarcate sound vibrations on the surface of a cylinder, inaugurating one of the first attempts to visualize sound mechanically. To activate this device, the user would speak into a mouth like structure, one that would further channel the acoustic vibrations into another 'ear' that would act as a structural counterpart. The conversion of speech sound into a graphic representation took place through a wave like pattern, providing an ideal mechanical model of human auditory perception (Stern 2003:31-33) already conceived within the domain of music (as in Pythagorean

harmonics)[41]. What is most relevant to understand at this point, is that both phonograph and ear phonautograph would instigate new conceptualizations of sound in other domains of investigation, particularly in 'physics, acoustics, physiology and otology' (p.33). If earlier attempts at sonic mechanization would localize in the mouth or in the activity of musical instruments a way of understanding sound[42], the further transmutation of sound from the mouth to the ear provided a distinct degree of conceptual abstraction and detachment. Hearing could now be studied without taking account of source or context; emphasizing the idea that hearing occurs through a simple excitation of sound waves at the level of ear's cochlea (Sterne 2003:33). All forms of instrumentation, their own intrinsic methodologies, would further instigate the development of particular modes of conceptualizing human auditory perception.

Here the emancipation of the sense of sight as the sense of reason and abstraction will shift into the investigation of the ways in which the sonic landscapes of perceptual fabrication have been further mediated, instrumentalized, manipulated and abstracted. The core discussion, at least concerning this body of work, cannot be found in the simple act of contrasting the subjective indigenous ear with a technologized and scientific eye. In opposition, in my research I sought to conduct an investigation that dwells beyond this linear comparison while establishing pertinent correlations, further plunging into a thorough investigation of how distinct cultural fabrications have provided different ecologies, different logics of abstraction of embodied perceptual experience of sound[43]. The intention has been to avoid a simplistic account of objectivism versus subjectivism[44].

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[41] This approach, largely drawing from the field of theoretical physics, particularly within the XVIIth century discussions concerning the wave-particle duality within the field of optics, were later transported into the field of acoustics. To be read in the following: "The wave-particle debate in optics began in the early eighteenth century, when Isaac Newton, in the *Optiks* (published in 1704), described light as a stream of particles, partially because 'it travels in a straight line'. Through experiments with colour phenomena in glass plates he also recognized the necessity of ascribing certain wavelike properties to light beams. (…) A competing wave theory began to emerge shortly afterward with the experiments in reflection and refraction of Christian Huygens, who also performed experiments on the wave nature of acoustical signals. The early nineteenth century experiments of Thomas Young reinforced the wave view" (Roads 2001:49-50).

[42] In fact, before Bell engaged in the creation of the telephone he also developed a talking machine. This project was highly influenced by his father, a speech teacher, who had created "a remarkable system of symbols for depicting the actions of the vocal organs in uttering sounds (...) a universal alphabet (...)." (Lastra 2000 19:28)

[43] Pertinent discussion concerning this particular misidentification of sight as the sense of reason and sound as the sense subjectivity can be found in the work of Jonathan Sterne (2003). The opposite 'romanticization' of this idea can be found in the work of Jean-Jacques Rousseau (Gode et al. 1966), particularly in his idea that the first human languages were musical and that Western culture has denigrated such languages through acts of rhetoric and writing. Walter Ong (1982) also confronts the reader with a similar discourse.

[44] Here, it seems pertinent to introduce what Bruno Latour (2007) would identify as: "(…) a plain, healthy and innocent *relativism* — by which I mean neither the indifference to others' points of view nor an absolute privilege given to one's own point of view, but rather the honorable scientific, artistic, and moral activity of being able to *shift* one's point of view by establishing relations between frames of reference through the laying down of some instrumentation" (p.7).

3.1 The Spectrograph

Today, most phoneticians are acquainted with the use of the spectrographic analyses (Ladefoged 2003), which provides an optimal tool that treats sound as a discrete object prone to visualization and quantification (Gibson 1966:80). This mode of aural instrumentation has supported autonomous study, rendering sound-language in all its manifestations. To understand this better one has to account for a major contribution made within the history of Western physics and mathematical practice: the development of 'Fourier analysis' and the application of the 'Fourier series' in the study of body heat-flows. The first attempt can be found in the middle of the XIXth century, when Jean Baptiste Fourier devised a way of representing "(...) an arbitrary mathematical function by a sum (of possibly infinite) of simpler functions" (Wishart1996:48). Further, in 1843, George Ohm would apply the theories devised by Fourier, transferring them from analysis of body heat-flows to the domain of sound. Here, he would count using the 'Fourier transform', a mathematical function that translates one variable into another. Through this process of translation, it was possible to convert information on the variation of amplitude within time into information about the changes of amplitude within frequency (conventionally measured in Hz, cycles per second). It also became possible to conceive of an inverse 'Fourier transform', where information concerning frequency and amplitude was converted into information concerning amplitude and time.

Later, Hermann von Helmholtz developed Ohm's studies, and invented a 'method of harmonic analyses based on mechanical-acoustic resonators', a device that oscillates given specific frequencies. In a similar line of thought, later in the XIXth century, John Tyndall – influenced by Helmholtz's ideas concerning harmonic stable states (largely derived from Pythagorean mathematics) – would work towards the creation of new techniques of sound visualization. In fact, Tyndall would experiment with the idea of timbre as an added mingling of two or more tones to create imaginative experiments with the intent of actually visualizing sound. These achievements led to the idea that 'instrumental timbre' is largely determined by a steady state spectrum – thought of as the sustained part of an instrumental tone (Roads 1998:545-546). From these sorts of experiments various forms of mechanical 'visualization' of sound were developed, further emphasizing the reduction of qualitative timbre to the quantifiable measurements of frequency (Wishart 1996:31).

It was only in the 1940's that scientists working with the oscilloscope, an electronic instrument that visualizes signal voltages in two-dimensional wave graphs would actually apply the principles of 'Fourier analyses' to the visualization of sound, now conceptualized as a 'wave'. The procedure required photographing the image represented on the oscilloscope and then manually tracing it back into a mechanical Fourier analyzer. It wasn't until the development of

cybernetics, with Norbert Wiener's 'generalized harmonic analyses', that a shift occurred from the analysis of a harmonic spectrum to incorporate new continuous sounds, including 'noise'. In 1958 Blackman and Tukey, considering Wiener's accomplishment, saw the relevance of using Fourier analysis while manipulating diverse levels of sampled data. The method opened the way for the development of the 'fast Fourier transform', releasing the need for vast amounts of computer calculation. A new era of sound visualization appeared, still influenced by the Helmholtz paradigm of harmonic structures. (Roads 1998:546)

This interrelation had its basis in Pythagoras harmonic universals, where the vibrating quality of a string (the wave like structure) and the perceived quality are in strict numerical correlation, where the length of string and the quality of tone (now conceived as quantity) obey pre-established ratios. This is most visible in the further development of the Western musical tempered scale but also in that of particular instrumental appropriations of sound as in the Fourier transform. Here, sound was understood through a particular reading of pitch as that which is composed by various Fourier sine waves (that bore a harmonic ratio). By calculating their fundamental frequency one could locate the fundamental pitch, further relegating timbre to a secondary role (Wishart 1996:46-51). It is possible to identify an important movement that is fundamental to the further analysis of the *Silbo Gomero's* auditory ecology, in which perceived tones are translated through a particular (measured) reading of pitch/frequency. In strict correlation spectrographic analyses appears as a powerful research tool, particularly when one considers that it provides an elegant representation of transient auditory phenomena.

The use of the spectrogram in speech analyses became pertinent when considering – like the ear phonautograph – that it had a direct correlate to the organic functioning of the ear, simulating very accurately the way human beings actually hear sounds. Almost inevitably, both the ear and the 'Fourier transform' would be conceived as approximate perceptual-archetypal models (Roads 1998:563). Despite this, some researchers have acknowledged that frequency/periodicity or spectral information may not always represent how a sound might actually be heard (Bregman 1994:485, Gibson 1966:86), even more if one considers that 'we do not hear, we listen' (Gibson 1966:83). Moreover, using the Fourier transform to analyze sounds with frequencies around 4,000 Hz has proven unsuccessful, even if sounds emitted at this level are very important in our perception of timbre, and therefore the quality of a sound is difficult to quantify (Wishart 1996:53). At this point, it might seem redundant to compare the use of spectrographic analyses in the linguistic domain with its impact in the musical domain. However by taking the *Silbo Gomero* beyond its simple surrogate qualification, some paradigms might have points in common, particularly when one considers that the development of particular modes of

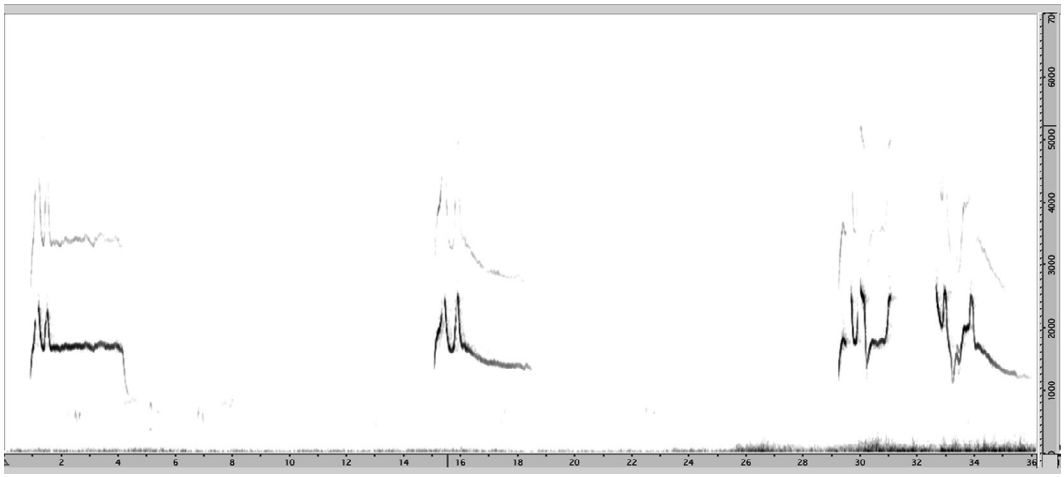
analyses of auditory experience stem from a similar instrumental history, one that finds a common root with Pythagoras, Helmholtz and Fourier.

It seems relevant here to interrupt this presentation and recall the ideas advanced by the 'phonological stage'. It is important to recall the one element that seemed to be contradictory, that is, the number of whistled vowels. While some whistlers are able to produce/perceive at least four vowels, a phonological account will only outline two groups of vowels (Trujillo 1978, 2006). At this point, it is important to account for the fact that this 'phonological stage' is determined by strict scientific data of recorded whistled utterances. Considering the presentation of Fourier analyses – the base of spectrographic analyses of sound – one might consider this point of disagreement to be inherently influenced by distinct modes of perception, largely determined by techno-scientific apparatus that are unable to render such subtleties or subdivisions within an acute/grave distinction.

In fact, some would present this limitation in two consistent ways: first, the inability of a Fourier transform to demarcate two different but very close frequencies; second, the emergence of errors within the spectral domain due to 'windowing'. It is important to understand this last concept: "in order for a digital Fourier transform to handle real-world signals, all of which are finite-length, these signals must be windowed – multiplied by a brief window function – to limit their duration. A window is a mathematical function that is non-zero only over a limited time range. To give an example, in terms of computer music, a window is nothing more than an envelope tailored to the demands of spectrum analyses". (Roads 1998:1099) This description points towards a methodological paradox, where the demands imposed by the technical apparatus condition the analyses of an embodied experience of sound. Above all, this parameter arises from a compromise when analyzing complex and situated phenomena and where observed-phenomena are further influenced by the techno-material exigencies of the measuring apparatus.

With a similar hypothesis in mind, physicist Neil Bohr was able to demonstrate in 'Atomic Physics and Human Knowledge' (1958) that an analogous paradox is apparent for sound (Roads 2001:49-50) as what is found within modern representations of the physical theory of light: such a phenomenon could be conceived either as a wave or as a particle – this is known as the wave-particle duality. Intrinsic to this wave-particle duality are opposing philosophical notions inherent to the designed experiments. Bohr's work was able to take this discussion further while providing the analyses of the light wave-particle through a '*gedanken'* (thought) experiment, one that established the idea that this distinction is solely dependent on the nature of the measuring apparatuses used (Barad 2007:97-131). Within the domain of physics, this breakthrough offered a new understanding of the makings of scientific knowledge, one that could no longer be conceived along the lines of a '*Characteristica Universalis*', as considered by Leibniz. Rather, the

making of knowledge was intrinsic to the nature of representations and measuring apparatuses. Following a reading of Pythagorean cosmology – as presented earlier in the words of Alfred North Whitehead (1925) – the nature of the measuring apparatus had to be considered as both inclusive and exclusive, where conceptions of the harmonious (the sound, the accurate, the cogent) and the inharmonious (the unsound, the ambiguous, the abnormal) can be understood within particular ecologies, composed by distinct resources and intuitions[45]. Here, taking the human-body as that which does not preclude the idea of an 'originary technicity'[46], apparatuses can no longer be conceived as mediating devices that provide simple contact with particular bodies of knowledge. They are, rather, intrinsic to the body of knowledge as such.



9. Spectrographic representation of a whistled utterance performed by *Maestro* Isidro out in Barranco de La Matanza. It corresponds to the Castilian Spanish sentence: '*a Sonia…cuando te vas…de La Gomera*' ('to Sonia…when are you leaving….La Gomera'). For more information consult DVD 1, movie 1, in attachment.

At this point, it is impossible to ignore the work of Dennis Gabor, founder of more recent accounts of microanalysis of sound. The Hungarian engineer took even further the separation of sound into constituent units, now at the level of micro-particles. This had revolutionary implications: "the orthodox method (of analysis) starts with the assumption that the signal is a function s (t) of time t. This is a very misleading start. If we take it literally, it means that we have a rule of constructing an exact value of s (t) to any instant of time t. Actually we are never in a

[45] The concept of 'ecology', particularly 'ecology of practice', draws on the work of Isabelle Stengers in '*Cosmopolitiques*'. This concept refers to the ways the 'practices' of each science relate to other 'practices' scientific or not.

[46] The concept of 'originary technicity', characteristic of current discourse within the field of philosophy of technology, can be understood through a close reading of Adrian Mackenzie (2002). Utilizing the work of Jacques Derrida and Bernard Stiegler, amongst others, MacKenzie further emphasizes the main thesis of Derrida: "The natural, originary body does not exist: technology has not simply added itself, from outside or after the fact, as a foreign body" (p.5), And further adds: "One tack we could take on this quasi-concept of originary technicity is to say that it concerns the status of the body as a body. It may not be possible to think of a body *as such* because bodies are already technical and therefore in some sense not self-identical or self-contained" (p.6).

position to do this (...)." (Roads 1998:57) Gabor's revolutionary experiments give further weight to the idea of 'uncertainty' in the process of analysis of time frequency relations: "time and frequency resolution are bound together; the more precisely we fix one magnitude, the more inexact is the determination of the other." (Roads 1998:58) This idea is line with Heisenberg's 'Uncertainty Principle', well known within the domain of physic and that states: "(...) that the position and momentum of a particle cannot both simultaneously be known exactly". (Wishart 1996:54) If one takes the sonic event as a complex spatial-temporal manifestation: "(...) how can we measure the frequency of the system at particular instant in time?" The answer is: we cannot. Frequency is a property of the system dependent on its actual evolution through time, "hence, the instantaneous energy of a system is not definable" (Wishart 1996:55).

The 'Uncertainty Principle' is mostly used in modern physics when attempting to account for interference caused by observational instruments (Barad 2007, Wishart 1996), when the technical apparatus may actually 'disturb' the object under observation, changing actual modes of perceiving its inherent modes of organization. Now shifting into the *Silbo Gomero*, this suggests that when studying human auditory perception, purely quantified modes of analyses will not allow one to go beyond a particular instrumentalized observation – a 'narrow' understanding of language (Chomsky et al. 2002) – and so relegating to the background what the apparatus will take for 'unsound', that is, noise, the ambiguous, the exception, the unusual. In the specific case of auditory perception, there have today, been more discoveries. To set a pertinent example and in face of a new uncovered dimension of sound, today, psychoacoustic researchers are able to recognize that the 'first half-second of the attack portion of a tone is actually more perceptually relevant than the so called steady-state portion' (Roads 1998:546), the measured frequency. This takes us to spectrographic analysis and its effects on our conception of what counts as sound – the figure – and what counts as 'unsound'[47]– the background – the yet inaudible.

Ideas devised by the field of microsound, as suggested above, revive a Romantic intuition, one that treated language as a complex organism. Recognizing this transition will call into action new situated and embodied accounts of language, where both cognition and environment cannot be easily drawn against phonological axiomatic lines. While spectrographic analyses seems to adequate for what it aims to achieve – that is, the delimitation and fixation of phonetic rules that characterize a given code or language – it is a rather poor tool for tackling temporally dynamic

[47] This reading is largely influenced by Steve Goodman's work (2009). Here, the concept gains two-dimensional perceptual relevance: on the one hand it refers to that which is unheard physiologically and, on the other hand, to what is unheard as techno-political aestheticization. In similar vein, cultural theorist Sarat Maharaj (2002) – in the development of his overall concept of '*xeno*-epistemics' – takes the 'unsound' as that which is unheard, not because it is a physiological impossibility but as the fruit of a certain sub-alternation of particular bodies of knowledge.

and situated auditory phenomena, particularly when we try to work out the complex ecologies that continually entangle subject and object (or environment).

4. Studying Whistled Languages from an Ecological Perspective

Recognizing some limitations in the methodologies proposed by a 'phonological stage' (Trujillo 1978, 2006), particularly in the delimitation of what counts as 'sound' – excluding to a certain extent the inharmonious, what is considered 'unsound' within the life of a whistled utterance, this text will move the proposed analyses into new relations. To this end, the information provided by a bioacoustic study (Meyer 2005) will be supported by extensive recent work done within the field of neurology (Carreiras et al. 2005). An intricate reading of the two bodies of work will establish a new agenda, pushing further the idea that the whistler's knowledge is a result of a complex and situated practice, which emerges from the peculiar mountainous environment of the island of La Gomera. This will make it impossible to consider the 'phonological stage' as a final stage of study (Trujillo 2006). The incorporation of relevant information in the following sections will instigate a new ecological or embodied stage, in which various 'disciplines' and bodies of knowledge enfold and cooperate.

My investigation of the mountainous environment of the island of La Gomera was intimately linked with the use of bioacoustic and neurological study. When recording in the fields with both *Maestro* Isidro and *Maestro* Lino I recognised the importance of understanding the *Silbo's* ecology. To give an example: at certain moments the intensity of the wind meant that one could not project a whistled utterance. This presents the whistler with new performative and perceptual challenges, requiring an auditory exploration of the mountainous terrain of the island. In fact, when recording with *Maestro* Lino in the village of La Palmita, where he lived for more than thirty years, I had the opportunity to learn about the (un)conventional practices associated with the given environment. In an attempt to understand the cognitive plasticity of this complex ecological milieu, *Maestro* Lino was able to reconstruct an aural mapping of the environment of La Palmita while taking into account the different 'tricks' each distinct spot required in order to project a whistled utterance most effectively. Such practice was highly personal and through a continuous mode of auditory-spatial exploration each member of the community developed an individualized approach.

And while taking into account the whistler's exploration of this geographical milieu, each echo and reverberation gained a new life and became intrinsic to the formation of this emergent body of knowledge, recursively feeding the whistler's learning process. In fact, demanding from the body a complex process of situated learning, one that is in opposition to the intuition provided by a phonological stage (Trujillo 1978, 2006). And to further extend the 'phonological

stage', while ecologically situating this ancient practice[48], it seems essential to consider these echoes and reverberations as what was previously neglected as being mere 'external factors' (Trujillo 2006:15). Here, the most curious subtleties became central piece, particularly when attempting to grasp what biacoustician Julien Meyer (2005) would present as the: 'acoustic tip of the iceberg' (p.236) presented earlier on.

During my research I made a documentary *'Aquí No Se Habla, Aquí Se Silba*' (Here We Don't Speak, Here We Whistle) (Matos 2007) in which I explored the echoes and reverberations recorded in La Gomera, more precisely in the Barranco de La Matanza[49]. This *barranco* was suggested by *Maestro* Isidro, because it was where he grew-up and worked the land for most of his life and was a place of agriculture and herding, but was also rich in topography, offering a complex topology of dense echoes and reverberating effects. Even though I used sophisticated equipment[50] they will not provide the reader with the 'actual' experience of the mountainous complexity of La Gomera. This further emphasized that our species *sensorium* is a highly entangled and mediated-phenomena, not to be confused with pure execution of coded information stored in the minds of whistlers and showed further how it is not a pure surrogate of speech. Here, *Maestro* Isidro's description seems indispensable: '**of course....you cannot separate them', referring to both the whistler and the environment** (Matos 2007).

In this sense, a close reading of bioacoustic and neurological data will make two important contributions: first – and beyond the problematic of phonetic morphology as presented by the 'phonological stage' (Rialland 2005, Trujillo 1978, 2006) – it will underline the importance of intelligibility (as opposed to the study of physical acoustic measurement). Second, and as a consequence of this shift, it will provide a greater amount of sonic information. In the process, the analyses of whistled utterances will be able to take into account the role of environmental

[48] This approach is in line with a transformation from cognitive (or informational approaches) to an ecological sensitivity in the study of auditory perception. One that is best described in the following passage: "The disagreements between cognitive and ecological theorists must be based on deeper issues than the adequacy of sensory information. I suggest that the dispute stems from the different perspectives these approaches take on the perceiving organism as a system. Traditional cognitive theories take what I call the observer perspective, noting and reifying correspondences between the perceptual system and the world in theories of symbolic mental representation. This leads to an emphasis on the perceptual system's separation from the world, and a view of perceptual information as fragmented stuff to be conveyed from the world to the mind. Ecological theories, in contrast, take what I will call the system perspective, from which correspondences between the perceptual system and the world are unavailable. They reject the reification of observed correspondences, and thus the notion of a symbolic mental representation. Instead, they view the organism as a subsystem within the larger perceptual system that includes events in the world as well as the energies by which they are perceived." (Gaver 1988:13).

[49] For more information consult DVD 1, movie 1, track 6 and 7, in attachment.

[50] Most sounds presented in the documentary '*Aquí No Se Habla. Aquí Se Silba*' (Matos 2007) were captured with the inbuilt microphone of the video recorder of a Sony handycam. However, the documentation of *Maestro* Isidro in Barranco de La Matanza and *Maestro* Lino in La Palmita was captured while using the Sound Devices 702 and DPA 406 omnidirectional microphone.

noise in the construction of intelligibility (Meyer 2005). If spectrographic analyses limits our understanding of hearing as it places all emphasis upon the verbal articulation and therefore stops at what the ear hears, a bioacoustic approach will take the problem of intelligibility into account while situating what is actually heard within specific environments. Once again the aim is to shift from an observer perspective – where all phenomena can be externally assessed – to an ecological and systemic one – where all phenomena will be studied from within (Gaver 1988:13).

Considering the bioacoustic nature of sampled data (Meyer 2005) it is important to explore further an inherent sensibility, one that relates to the biological understanding of 'environment'. In fact, within the context of the biological sciences (from which bioacoustics largely draws its line of enquiry), the environment has largely been obliterated as the emphasis has been on 'fitness' and 'adaptation'. Here again, it is important to recognize the difference between an environment that is external and one that is ecological (the study of living relations). For a classic biological approach – and to a certain extent, a phonological reading of whistled languages – the concept of environment demarcates what is internal or external to the organism. Following this nomenclature, measurement only applies to the external environment and any consideration for the organism is rendered obsolete. The problem is that this assumes that external factors determine (or not) the life of the organism. However, when the methodology is reversed, the organism will be taken as the unit of measurement in itself. The scientist then moves beyond the external environment into an ecological or relational environment (Brandon 1994:81).

When analyzing the data (Meyer 2005), the *Silbo Gomero* and the whistled language found in the village of Kuskoy (Turkey) show similar results[51]. This seems significant as both areas have a similarly mountainous terrain. If previously, within the 'phonological stage' (Trujillo 1978, 2006), noise or 'external factors' were rendered imperceptible the field of bioacoustics will qualify this 'noise' as all the streams of sound in flow of action at the moment communication. This shows that – on a bioacoustic level – information is emergent phenomena[52], one that counts with the intensity of a whistled utterance and the level of environmental noise. To discern what Gestalt psychology would describe the 'figure' and the 'foreground'[53] – whistled languages move with a refinement of the auditory system towards establishing their own embodied logic. This

[51] In this case, a whistled sentence located in a frequency band of 1500 to 3000Hz and immersed in a field of surrounding noise of approximately 20dB presented a good rate of intelligibility (Meyer 2005:54-56).
[52] Here, it is important to note that the term 'emergence' derives from a biological framework: it is to be understood as a complex system that might not necessarily be predicted from the analyses of lower level properties (Hendriks-Jansen 1996).
[53] This principle is taken from the work of Alfred Bregman and the field of psychoacoustics: "In the visual analogies, the grouping is predictable from the Gestalt psychologists proximity principle, which states roughly that the closer the visual elements in a set are to one another, the more strongly we tend to group them perceptually. (…). The word Gestalt means "pattern" and the theory described how the brain created mental patterns by forming connections between elements of sensory input" (Bregman 1994:18-19).

logic cannot be modelled by simply 'plotting power, intensity, amplitude or level to the function of frequency' as when analyzing spectrographic spectral information (Moore 2003:404); this process is situated, modelled on particular circumstances.

10. Image of the Barranco de La Matanza, one of the most precipitous mountainous terrains of La Gomera (Matos 2007).

11. *Maestro* Isidro Ortiz Mendonza and myself discussing the ecological significance of the *Silbo Gomero* while recording in Barranco de La Matanza (Hecker 2007).

4.1 Mobilizing a Psychoacoustic Reading of Sampled Data

When reading the data provided by a bioacoustic study (Meyer 2005), it is important to situate it within the field of psychoacoustics. It is particularly important – keeping in mind that 'listening is what the auditory system is for, hearing is purely incidental' (Gibson 1966) – to make sense of the auditory-informational world around us. For example: how does a whistler scan the auditory space while making sense of a sound that is in a continuum[54]? If during the 'phonological stage' (Rialland 2005; Trujillo 1978, 2006) the whistled utterances were analysed by demarcating the continuum and further quantifying the intensity, height and duration as correlates of frequency, bioacoustic data analyses (Meyer 2005) provides a broader contemplation of how auditory information – which is not uniquely filtered through verbal-phonetic lattice – triggers distinct perceptual mechanisms of identification. It is relevant to consider two unequally studied phenomena: that of the 'primitive' or 'innate' segregation of sound and that of the 'schema based organization' of sound or learned patterns of organization (Bregman 1994). The previous demarcation seems to 'ring a bell', since a similar distinction can be found within the autonomous project of linguistics when referring to language in the 'narrow sense' as having 'deep' and 'innate structures', and the 'faculty of language in the broad sense' (Chomsky et al. 2002).

Psychoacoustician Alfred Bregman (1994) further elucidates this comparison: it seems that

> "there is provocative similarity among the three examples: the syntactical, the visual, and the auditory. In all three cases, the perceivers are faced with complex shaping of the sensory input by the effects of various simple features, and they must recover those features from their effects. Transposing the linguistic vocabulary to the field of psychoacoustics, one might say that the task of the perceiver is to parse the sensory input while building a new and more complex structure. In some sense the perceiver has to build up a description of the regularities in the world that have shaped the evidence of our senses" (p.35).

As with a linguistics approach, a psychoacoustic approach – from which the bioacoustic analysis (Meyer 2005) is established – will propose, to a certain extent, a rather complicated premise: the idea that the subject mentally 'builds' a hierarchical gestalt of information, one that always departs from a given, isolated and innate syntax (Stanley 1995). Even though Bregman recognizes that both innate and learned schemas cooperate (p.402), he considers that they are rarely explored as emergent phenomena (not reducible to lower level properties) or even that they are

[54] Within the psychoacoustic community there are strong disagreements about which term best describes the human perception of sound. There is the idea of sound as 'stream' (Bregman 1994), as object or 'objecthood' (Kubovy & van Valkenburg 2004:124) and as 'event' (Blauert 1997).

paradoxical or contradictory phenomena, as explored within the field of contemporary psychoacoustics[55].

To further complicate this methodological departure point within this matrix of both innate and learned schemas, psychoacoustics also divides the perception of the flow of sound into 'horizontal' and 'vertical' processes of auditory segregation[56]. It is exactly within the horizontal group, that a bioacoustic analysis (Meyer 2005) will investigate auditory organization as thoroughly presented by a 'phonological stage', one that entails the analyses of aural sequential integration (frequency), connecting "(...) events that have arisen at different times from the same source (...)" and using "(...) changes in the spectrum[57] and the speeds of such changes as major clues to the correct grouping" (Bregman 1994:31). Just as in spectrographic analyses, horizontal grouping corresponds to the ordering of sonic elements that succeed each other as they are measured by spectrographic analyses (and followed by a particular 'windowing' of time). This implies a degree of formal abstraction of the same variable.

To test the efficiency of this approach, Meyer (2005) introduced subjects unacquainted with the practice of whistling languages to recorded whistled utterances. The subjects were submitted to perception tests of isolated whistled vowels. Interestingly enough the bioacoustician separated them into two classes of subjects: musicians and non-musicians. The group of musicians had better scores in the identification of whistled vowels, while non-musicians, using common verbal-linguistic practice, were not so successful. According to Meyer, musicians call upon a more complex body of knowledge, since they are 'trained' to associate perceived frequencies in an isolated manner. In fact, a close reading of Alfred Bregman's work (1994) will uncover a similar underlying intuition. Both 'vertical' and 'horizontal' processes of auditory perceptual organization are in fact closely related to the melodic organization found in Western classical music (based on the equal-tempered scale): "Musicians speak of a horizontal and vertical dimension in written music. By horizontal, they refer to the groupings across the pages that are

[55] Here, it is important to refer to the interesting psychoacoustic paradoxes discovered by Diana Deutsch (1991) such as the 'tritone paradox'. This was discovered when submitting distinct individuals to the auditory perceptual test of Shepard tones, "two tones that are related by a half-octave (or tritone) are presented in succession" (p.1) providing the illusion of audible movement. What is most interesting about the paradox is that this same movement will be rendered as ascending or descending in correlation to the listener's spoken language. In the case of Deutsch's experiment, North American Californian speakers would perceive an ascending tone while speakers from the South of the United Kingdom would perceive a descending tone.

[56] While horizontal processes correspond to the sequential organization of sound – "putting together events that follow one another in time" – vertical processes correspond to the spectral organization of sound – "the integration of components that occur at the same time in different parts of the spectrum" (Bregman 1994:30).

[57] In the field of psychoacoustics the 'spectrum' of a sound corresponds "to the distribution of frequency of the magnitudes (and sometimes the phases) of the components of the wave." One that is "represented by plotting power, intensity, amplitude or level as a function of frequency" (Moore 1977:404).

seen as melody. By vertical, they refer to the simultaneous events that form cords and harmony. These are the same two dimensions as the ones called sequential and simultaneous (p.31).

In this sense a psychoacoutic reading of bioacoustic data, where both 'background' noise and spectral organization (what a phonological stage would demarcate as the 'figure') provide a dynamic intra-relation of sonic streams. The experiments present pertinent results, emphasizing a broader understanding of auditory phenomenological experience in the formation of distinct bodies of linguistic knowledge. However, Meyer's (2005) tests leave one problem untouched. First, while using the *Silbo* 'in the wild' whistlers do not utter isolated vowels but rather complex streams of information. This hypothesis can be supported by recent neuro-imaging scans that show how within proficient whistlers, when hearing distinct whistled utterances, regions of the brain that were previously associated with speech signals are activated. What this test shows us is that these regions are highly plastic and exploit complex auditory signals in ways that were previously unforeseen. This neurological approach supports the claim by presenting the idea that whistlers exploit distinct levels of pitch and melodic line, which are quite perceptible in the formant glides (transitive consonants) (Carreiras et al. 2005). Most relevant to the discussion here presented is that this account runs close to the idea that whistlers exploit the ambiguities provided by the utterance/environment through a complex matrix whereby both verbal and auditory data are fundamental, further enhancing the relevance of 'learned schemas'[58]. Here, the process of learning should be understood through the lens of an active exploration of whistled utterances as ecological emergent phenomena, serving to refine further the psychoacoustic body of local whistlers. This data will run in contradiction to most recent discussions of language which treat it as being solely dependent on innate phenomena and therefore prone to localization within very particular modules of the brain, particularly the phonetic module[59].

Second, largely unreported by a bioacoustic analysis, this matrix of organization – horizontal and vertical – is highly influenced by what is called 'symbolic representation'. As referred to by Meyer (2005), through a reading of the work proposed by psychoacoustician Alfred Bregman (1994), this is a Western classical musical notation represented primarily by the tempered scale. In fact, this classical notation largely contradicts our actual experience of both pitch (perceived tone, to be distinguished from its measurement) and tempo (from the Latin

[58] 'Schema' or 'schemata' is a term frequently used within psychology and cognitive science to refer to a certain organized pattern of thought and behaviour. Within this tradition it gains both mental and motor coordinate value. This term was largely used by Jean Piaget when attempting to connect tactile-kinesthetic exploration – which most children explore through graphical drawing activities – with the formation of abstract schemas based on this same motor coordination (Piaget 1948:34).

[59] This approach runs in contradiction to the common cognitive psychological approach, one that proposes language as a cognitive separable module of the brain owing very little to other modules such as the module responsible for general auditory perception (psychoacoustician Alfred Bregman discussing the work of psychologist Alvin Liberman) (Bregman 1994:599).

tempi or time, referring to the pace or speed of a musical piece) (Wishart 1996:23). This particular notational system should not be confused with the flux of auditory perception. It is a symbolic representation of a particular harmonic and Pythagorean formal-logical ideal. A similar problematic may be found in the work of Brian Rotman (2008), particularly, when he discusses the difference between 'notational mediums', where events are transcribed into discrete symbols (what Rotman describes as 'algebraic frameworks') and contemporary 'capture media', where events are topologically modelled (p.42). Even though Rotman's distinction of 'capture media' is, at times, problematic[60], it is important to distinguish the possibility of distinct regimes of temporal inscription. Here, algebraic modes of representation differ from topological ones in the 'connectedness' or flux of temporal transformation, where horizontal psychoacoustic organization requires a new lattice. When referring to the study of whistled languages, particularly the *Silbo Gomero*, new degrees of situated spatial-temporal complication do not necessarily imply a lack of performative structural organization but rather the designation of a new one.

Here, the idea of structure along topological spatio-temporal organizational lines becomes pertinent, since this denies the almost 'naturalized' attempt to fragment all of our experience into serial delimited and measurable symbolic entities. The idea of topological object/space challenges exactly this point. In this sense, while a classical harmonic scale is based on serial structural organization of space – the Euclidean space defined by abstracted and formal-logical relations (as informed by Pythagorean mathematics) – topological space implies new spatio-temporal dimensions in which movement can no longer be rendered as imperceptible. Only through this situated spatial-temporal transformation might one understand a classic example borrowed from the field of topology: when considering a plastic medium such as a blob of rubber, it is important to consider that (with the same physical properties) it might at once be a sphere and a cube (Wishart 1996:83). There is a structural correlation between a blob of rubber and a cube, however there is more flexibility, specifically when compared with the Euclidean space/object (Rotman 1993, Whitehead 1961) and its matrix of organization and transformation.

Relocating the discussion between linguists and researchers into whistling concerning the number of perceived vowels, this seems to shed light on an important distinction in the approaches of the two bodies of knowledge, particularly in relation to their spatio-temporal experiences, informed as they are by distinct degrees of appropriation and embeddedness. This further emphasizes how much knowledge systems are intrinsic to the spaces and apparatuses one

[60] At this point, Rotman is referring to the phonogram and tape recorder as media that do not necessarily inscribe symbols in the process of capture and reproduction. This approach is at times rather confusing this considering that both capture and notation are set as two separate regimes, one corresponding to the analog and the later to the digital. Further analysis of the techno-material exigencies of such apparatuses might render this 'naturalization' of capture-media, one that as spatio-temporally attuned to real-time movement, as a rather complicated departure point.

inhabits. If the linguist explores the spatial-temporal qualities of sound through tools of measurement such as the spectrograph, this implies an analysis of vowels and consonants as energy peaks within spectral representation, while the space of the whistler is a topological space, one replete with 'micro-fluctuations'[61], which suggests a dynamic morphology through time. This is due not only to the whistler's aural orographic situatedness but also due to the fact that it is embedded in the subject's muscular performance, as the source of sonic articulation.

5. Challenging Algebraic Representation of Situated and Embodied Phenomena

Previously, this thesis explored certain limitations of a 'phonological stage' (Trujillo 1978, 2006), its methodologies and instrumental configurations, particularly spectrographic analyses. In fact, taking such instrumental configurations as intrinsic to the formation of distinct bodies of knowledge will allow this investigation to account further for differences that might exist amongst listeners. Here, any listener is highly influenced by the configurations of his own body, which is not only a body of instrumental locus but also a body with a history of interaction. In the case of the whistlers of La Gomera, this body transposes, within its linguistic fabric, a complex world of auditory perception that is not common to speakers of Castilian Spanish (Carreiras et al. 2005). Here the *Silbo's* sonic micro-deviations[62] further challenge the common surrogate explication (Trujillo 1978, 2006; Carreiras et al. 2005) and the formal conceptualization of language as that which is cognitively separate from other modes or modules of perceptual cognition. What is at stake is a profound paradoxical relation between distinct techno-scientific methodologies and their distinct ecological relations[63].

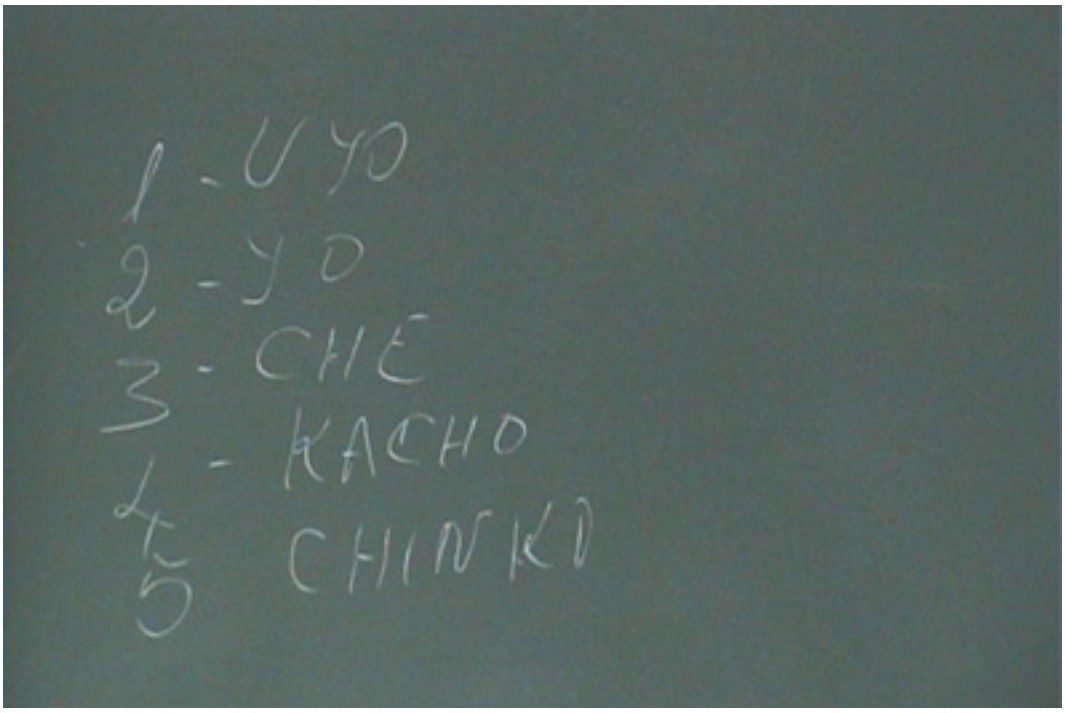
If the analysis has so far attempted to identify and further analyze these techno-scientific methodologies, it now seems relevant to bring into the locus of this discussion an important element that has been largely neglected within the phonological (Rialland 2005; Trujilllo 1978, 2006), bioacoustic (Meyer 2005) and neurological (Carreiras et al. 2005) literature; the fact that

[61] This concept is drawn from Trevor Wishart (1996), when he presented sound as a chaotic phenomenon, one that evolves through time. He also explores micro-fluctuations in our perception of such phenomena. An interesting example, closely related to this case study, is that of a wind instrument. Once we excite this instrument with breath we might perceive a fundamental pitch, however as we slowly increase the breath pressure we will suddenly perceive a second harmonic. (p.284) Looking at wind instruments as dynamic physical systems, will allow one to explore further the endless possibilities of auditory perception and sonic fabrication. More importantly for this research project it will allow one to understand the process of sonic-categorization as a dynamic organic system that evolves through time and space.

[62] Taking into account Dennis Gabor's analyses of sound through the lens of particle physics, Curtis Roads further proposes that " (...) training and culture condition and influence the perception of the time scales. To hear a flat pitch or a dragging beat, for example is to detect a temporal anomaly on a micro scale, that might not be noticed by other people."(Roads 1998:4)

[63] The term is borrowed from Isabelle Stengers (2003) when exploring the idea that distinct 'ecologies of practice' imply distinct makings of nature. In this sense, the 'what' of knowledge cannot be separated from the 'how'.

most whistlers did not have access to formal education. Fundamentally, whistlers were individuals who were not acquainted with the written alphabet – they did not posses a 'textual body' as such. To give an example, only *Maestro* Isidro – who briefly learned how to write in a later phase of his childhood – uses the Roman alphabet when teaching whistled utterances to young children. In fact, considering the generational gap between teacher and students, *Maestro* Isidro, through a manipulation of written alphabet, was able to design his own didactic material – the *Silfateo* (see figure number 12 bellow) – for the children to take home. According to this system, the consonants t, ch and s, used in spoken Castilian Spanish, are represented by 'CHE'. Therefore, when learning how to whistle *sientaté* (sit) the word is better understood if written as *chiénchache*. In this way, different whistles correspond to the group of consonants CHE (t, ch, s); YE (d,n,n, l,ll, y, r, rr); KE (p, k, f) and GE (b, m, g, j). *Maestro* Isidro uses the alphabet in an onomatopoeic fashion, as if presenting the notes of a 'foreign' musical instrument[64].



12. Transcription of numbers one to five using *Maestro* Isidro's *Silfateo*, snapshot taken for the documentary *'Aquí No Se Habla. Aquí Se Silba'* (Matos 2007).

This particular design is very useful and it also opens for the children a question about the definition of syllables, vowels and consonants and their intrinsic movements as collectively defined. Most of us will remember, from scholarly experience, that a clear definition is much

[64] Interesting similarities can be found between *Maestro* Isidro's *Silfateo* and the technique used by ornithologists when attempting to document the sounds of birdsongs, where for example the song of the hawfinch might be transcribed as: "deak…warsee-ree-ree Tchee….tchee…tur-wee-wee" (Wishart 1996:292). In both cases formant movements transcribe pitch movements.

more arduous than one would initially assume. Such a difficulty is tied to the problematic presented above concerning the possible number of whistled/perceived vowels.

With this in mind and concerning the definition of spoken vowels, David Abercrombie (1967) further elucidates. The problem, he argues, is that one has to break the melodic stream into a new set of units. Following this 'logic', "(...) writing has to be based on an analysis of speech, and the majority of the systems of writing which mankind has from time to time invented are syllabic systems (though the Roman alphabetic system is not) – that is to say, systems in which each written sign represents a single syllable. Within the literature provided by the field of linguistics, the syllable would appear to be an intuitively recognizable unit even for primitive peoples" (Abercrombie 1967:34). One thing that is certain – whether or not speaking of Abercrombie's 'primitive' people – is that in order to recognize the syllable one has to be able to recognize the unit. Now the question is how to represent this unit. What happens if one is to translate from different sensuous forms of representation, graphical or aural? If one is not acquainted with the process of graphic writing, according to the Roman alphabet, which decomposes the syllabic unit will the limits of that unit change?

As Abercrombie (1967) recognizes, linguists have not agreed on an exact definition of what a syllable is. In this sense, the most commonly deployed interpretation takes the syllable as an audible movement of the speech organs, a pure embodied phenomenon that is not reducible to abstracted linguistic rules and their modes of cultural appropriation and representation. Here language gains the locus of a complex articulation – language is 'mind' as much as it is 'body', the body of 'gesture', the 'kinematic body' (Rotman 2008). As "(...) the evolutionary neurologist Terrence Deacon would suggest: 'auditory processing of speech sounds do not appear to be based on extracting basic acoustic parameters of the signal, as a scientist might design a computer to do (...) speech analysis appears designed instead to predict which oral-vocal movements produced them (...)' (p.23). Relegating the previous account to this study of the *Silbo Gomero*, such articulation gains a complex interpretation and cannot be understood along the lines of a phonological stage, one that presupposes that the 'limitation of the whistling apparatus' is in strict correlation to the delimitation of two discrete – acute and grave – vowels (Trujillo 1978, 2006). Taking further the topological frame exposed above, horizontal segregation is intertwined with the movements of the body, the in-between sounds, "the dynamics of their preparatory phases, pauses, holds, accelerations, fallings away, and completions" (Rotman 2008: 23).

To instigate a more complex description of whistled languages and the exploitation of the physiological apparatus, the work of Julien Meyer (2005) provides relevant information. Here the whistled utterance is understood as a stream of air that is expelled from the lungs through the mouth, making it unnecessary to use the vocal chords. If for a moment such conceptualizing can

be considered a limitation, Meyer introduces an alternative articulation where whistled utterances exploit distinct mechanisms such as the speed of the expulsion of air (a feature that upgrades the acuteness of the sound), the work performed by the rib cage, the adjustment of the whole size performed by the mouth/lips and finally the insertion of the finger in the mouth, pushing the tongue backwards in order to control its movements. In this last instance, the mouth is stable and the lower jaw is used to produce slight movements, further outlining the articulation of words. Added to this feature, one has to account for the work performed by the tongue and the glottis that also help this process of sonic modulation. For particular spoken sounds, such as labial sounds (sounds that require distinct levels of the articulation of the lips), words cannot be directly 'translated' into whistled ones. In the case of glottal sounds (sounds that are produced through the glottis, in the larynx) words will be modulated by a ventriloquist technique, a process which also helps to control the frequency of the whistle (Meyer 2005:138); glottal stops and the manipulation of the tongue are also explored differently by distinct whistlers (Rialland 2005).

All of these aspects cooperate towards the expulsion of air[65], modulating different 'notes' that, later, spectrographic analyses will apprehend as the signals amplitude. These techniques cooperate towards complex modes of breath modulation (commonly known amongst flutists) (Meyer 2005). This gives further support to the description provided by *Maestro* Lino[66] when attempting to compare the process of learning a whistled language with that of a musical instrument, where intelligibility, body and environment are intertwined.

To conclude, the whistled utterance is 'audible movement', a 'gesture' (Rotman 2008), where vowel and consonant are identifiable points within this movement. However, these points "(...) are analyzed and described in terms of the processes which produce the sound, rather than the sound itself" (Abercrombie1967:39) or, in terms of the ways in which this sound is captured, translated and measured. In the linguistic and material-scientific tradition this forces phoneticians, at some given moment, to freeze that point in time, establishing a correspondence with a specific sonic frequency. Considering spoken and whistled forms of language to be 'streams' and not static 'objects' (Bregman 1994), this process will involve a degree of compromise like that in the 'windowing' of spectrographic analyses. Where exactly, does the 'stream' begin and end; at exactly what point do the different constituent elements influence each other? The situation is even more complex, particularly when comparing speech to whistling, a rather poorly studied phenomenon (Shadle 1983). Even if today it is possible to identify a complex interaction between the respiratory system (lungs, surrounding muscles, bronchial tubes and trachea), the phonatory system (larynx), the articulatory system (nose, lips and mouth) and

[65] This has been described as aerodynamic sounds, and that "(…) are caused by the direct introduction and modification of atmospheric pressure differences from the same source" (Gaver 1993:8).
[66] For more information consult DVD 1, movie 1, in attachment.

the auditory system (auditory nerve, cochlea, eardrum, auditory canal) (Abercrombie 1967), one is only referring to the basic anatomical and structural activity of a given system. The complete coordination with thought and representation is altogether another 'puzzle', one that is further complicated by the possibility of 'learned-schemas', that is, their distinct socio-cultural and techno-material realities[67].

5.1 Auditory Perception, Absolute Time Vs. Ecological Time

Moving from an algebraic to a topological approach is an important element of the quest for a situated and embodied conception of time and space. If language was previously presented as an emergent quality within the life of an organism, one that clearly denies the neat separation between innate perceptual capacities – the blueprint, the phonological organization (as it departs from a constant verbal surrogation of speech) – from acquired perceptual capacities. This separation has demarcated the phonological blueprint as self-sufficient, averaging-out the role of appropriation within the life of an organism, with its intrinsic techno-material realities now to be considered as 'external' (Trujillo 1978, 2006) or secondary phenomena. Within this particular linguistic approach, such a methodological endeavour has spoken of 'unsound' as representing a deviation from the isolated structure. To a certain extent, this particular methodology presupposes a very concrete structuralization of both time and space, further elucidating what Alfred North Whitehead (1961) would count as absolute representation of both phenomena as they are conceived without any ecological reference, independent of any event 'in' time and space. In fact, it has been the historical – scientific – separation of both elements that has instigated the ideal of formal clarity; a dismantling of our perceptual experience no longer considered as a unified and conglomerate phenomenon (p. 41-44).

This 'absolute' methodology has been largely deployed within various scientific readings of nature's complex endeavours. Here, further explored through an explication of the *Silbo* as verbal surrogate phenomena, where the nature of phonological measurement will render imperceptible the perceptual qualities of the flow of sound, relegating the sonic stream to a very particular

[67] From a bioacoustic perspective it is important to note that in higher mammals the locus of an utterance, its articulation, has to be conceived as an emergent phenomenon. In the words of René Guy Busnel, who has also made a brief study of whistled languages (Busnel & Classe 1976): "the higher we go in the animal kingdom, the more diffuse and heterogeneous become the motor zones, introducing a notion of the degrees of freedom. The production of complex signals depends upon numerous centres which interfere with each other, and thus no longer permit the 'all or none' responses of invertebrates or lower vertebrates. In mammals, zones corresponding to a specific signal are not found. Instead, generalized phonation zones can be described which are diversely activated by other centres concerned with different emotional behaviour patterns (Trevor Wishart referring to the René Guy Busnel) (Wishart 1996:242).

quantification or duration of time.[68] As a response to this homogenous account, the topological model (as it might provide an overall conceptual agenda of research – its degrees of plasticity and dynamic temporal change) foresees alternative exploratory models more in line with contemporary accounts of auditory perception as a dynamic system in its own right.

In fact, in 'Näive Time, Temporal Patterns, and Human Audition' (1995) Robert Port, Fred Cummins and J. Devin McAuley argue for the idea of language – here, intimately tied to auditory perception – as a dynamic system. They outline a common problem with most phonological approaches, particularly the fact that all possible phonemes can be pre-selected from a 'universal set'. What further instigates this process of universalization is the scientific appropriation of perceived time as measurable time. In fact, this approach has largely influenced the development of artificial systems for speech recognition, recursively feeding into the misplacement of ecological or perceived time with its correlative measured value. One of the first artificial systems to exploit this principle was Hearsay-II, a system that used the audio signal, as it is stored in a buffer, to recognize auditory cues, allophones (a variant of a phoneme), phonemes, words, sentences along a progressive structural order. Yet the very instantiation of a 'buffer' corresponds to the computational understanding of memory as space (in opposition to an understanding of memory as spatio-temporal phenomena) and the capacity of a computational system[69] – and as it is here conflated with a biological system – to 'hold', even if only temporarily, a set of collected data.

Within an engineering perspective (as it retrofits into a biological intuition), the idea of buffering is the consequence of an important methodological legacy where, in order to achieve clarity of representation, the technique of averaging-out (finding the middle tendency of a particular equation, its expected value) will appear as the most feasible temporal appropriation. This example provides not only an achievement in engineering but also an archetypal (or computational) perceptual theory of language, particularly spoken language. One of the problems

[68] Such account recalls Henri Bergson (1911), for whom the very idea of temporal duration was of utmost philosophical importance, and his exploration of the perceptual qualities of the sound of a bell. Here, a similar paradox seems to persist: "I do not count the sounds, I limit myself to gathering, so to speak, the qualitative impression produced by the whole series. Or else I intent explicitly to count them, and then I shall have to separate them, and this separation must take place within some homogeneous medium in which the sounds, stripped of their qualities, and in a manner emptied, leave traces of their presence which are absolutely alike" (p.87). It is this likeness – or lack of difference – that will further show that the algebraic idea of measurement is simply a conventional mode of representation, one that is mostly 'foreign to the intentions of nature' (p.239).

[69] The computational model that is here presented corresponds to a finite-sate machine: "a traditional mathematical system that recognizes and classifies sequences of events. (p.353) (…) Transitions between these sates are defined in a transition table (…). Transition is therefore dependent only on the state at the previous time step and the current input. The only memory that a finite state machine has for earlier inputs therefore resides in the state of the machine. (…) The only transitions that are labeled are the only ones that may appear if the machine is to recognize a sequence. All other possible combinations of input and state lead to an implicit 'reject' state (…)" (p.354).

presented by Hearsay-II in the correct identification of spoken (auditory) language, and considering its finite-state (see footnote 67) condition, is that the accuracy of identification can only have two states: it is either correct or incorrect. When patterns exhibit a wider range of sonic information, particularly when a phoneme extends the expected temporal region, the system tends to produce error as an output. When it is used to explain linguistic perceptual phenomena, the model seems to contradict our actual phenomenological experience and its wider range of perceptual capacities.

In the attempt to solve this lack of flexibility, the development of recurrent computational systems, most commonly known as artificial neural networks (a system that interconnects artificially programmed constructs that mimic the properties of biological neurons), has had advantages, particularly the idea that processes of speech recognition no longer require information to be encoded or prespecified by an external programmer because the system is able to 'learn' while exploiting a series of learning algorithms. Here it is important to avoid any confusion: artificial neural networks, just like finite-state machines, are created through an initial instantiation of symbols (or code), the difference being that neural networks do not require full instantiation of all their operations since they incorporate learning algorithms that recursively train the system in the recognition of correct or incorrect sequences. In this sense, the difference lies not in the programmed nature of the two machines but rather in the spatio-temporal appropriation. While a finite-machine cannot provide a robust relation with signals of dynamic and temporal evolving qualities – such as the signal of spoken or whistled utterances – the artificial neural network provides larger degrees of flexibility. Considering the nature of algorithms themselves, mostly informed by differential equations[70], signals are now rendered in a continuous space as opposed to a serial space. This particular temporal appropriation seems to be more in line with what might be presented as 'biological time', that is, an animal's capacity to detect aural patterns in time (p.344), and where physical buffers become obsolete mechanisms.

Here, Port, Cummins and McAuley propose a valuable concept in auditory perceptual cognition: the idea of dynamic memory (p.356). In order to understand this approach it is important to note that their methodological point of departure is embedded in the study of dynamic systems (systems that are sensitive to temporal patterns) particularly because they might provide an alternative to the computational metaphor in the study of auditory perception. The idea of dynamic memory therefore stems from an intuition that auditory cognition – here still understood as the ear-brain – might be best described as an oscillating mechanism. To grasp the significance of the proposed mechanism, this approach might be described in terms of the

[70] A differential equation is a mathematical equation "(…) that contains and independent variable, a dependent variable and derivatives of the dependent variable with respect to the independent variable" (Berry & Berry 1999:68).

harmonic oscillating principle in which a mass is attached to a spring: when the mass is activated the spring will oscillate and be given a certain degree of freedom. If another oscillator is added, the degree of freedom given will exhibit emergent qualities, where the coupling of the two oscillating springs will be rendered as one continuous oscillating phenomenon and each oscillator will influence and determine the movement of the other.

To understand aural memory – the ability to recognize a given pattern of sound – in terms of a similar dynamic principle will be to presuppose that the cognitive structures being referred to, their coupling effects, are best conceived as 'adaptive oscillators' (p.361). This will lead to the idea that auditory perception occurs in relative time[71] as opposed to absolute time or externally measured time. For a given perceptual system this means that the idea of duration is always relative, an environmentally synchronized duration. Assuming that environmental time cannot be fully explicated through the measurements proposed by absolute time will allow auditory memory to be understood as an ecologically situated phenomenon. It is also in this light that the artificial system proposed for the recognition of speech by Port, Cummins and McAuley (1995) is rather weak in its ability to recognize unfamiliar patterns (p.365). Even though this might be rendered as a failure – at least within an engineering perspective – for the purpose of understanding auditory perception, it further emphasises the importance of studying auditory perception in terms of a situated and embedded ecosystem that is susceptible to ecological differentiation and cannot be easily plotted by internal or external modes of representation, but can only be understood in terms of the interrelations taking place.

6. Final Remarks

This chapter has focused on the presentation and discussion of distinct 'disciplinary' approaches to the study of the *Silbo Gomero*. It has instigated a new challenge: to resituate each approach within specific techno-scientific intuitions. In fact, in considering one of the most prominent approaches – the phonological stage (Trujillo 1978, 2006) – the discussion has expanded into an analysis of the autonomous linguistic project, its historical and conceptual roots as they are embedded in the development of 'scientific materialism' (Whitehead 1961) – a natural philosophy that qualifies "nature as an aggregate of material that exists at each successive member

[71] A similar approach, now concerning the perception of spoken vowels is provided by Peter Ladefoged and Donald E. Broadbent (1956) where: "An experiment has been carried out which shows that the linguistic information conveyed by a vowel sound does not depend on the absolute values of its formant frequencies, but on the relationship between the formant frequencies for that value and the formant frequencies of other vowels pronounced by that speaker" (p.98). This approach is in line with earlier concept proposed by Roman Jakobson when delineating a conception of the phoneme not as an absolute entity, but as a cluster of articulatory contrasts established with other phonemes (James J. Gibson referring to the work of Jakobson) (Gibson 1966:93).

of a one dimensional series of extensionless instants of time" (p.87). This approach has drawn on specific techno-scientific methodologies such as the spectrogram. Within the logic of its own mechanical performativity – the Fourier transform – spectrographic analyses has been set the task of analyzing auditory signals in the attempt to locate sonic durations and peaks audio-visually, clearly demarcating a whistled utterance from the 'background' of environmental noise. Despite the accuracy of the results, the engagement with whistlers – in the schools where the *Silbo Gomero* is taught and when recording in the fields – soon made it clear that there were points of disagreement, particularly in relation to the number of whistled vowels. While some forms of phonological analyses (Trujillo 1978, 2006) divide whistled vowels into two groups, one grave vowel corresponding to the spoken vowels /a, o, u/ and the other corresponding to spoken vowels /e, i/. Yet both *Maestro* Isidro and *Maestro* Lino could produce and comprehend two other vowels within this distinction.

In an attempt to understand this point of disagreement it seemed pertinent to expand the 'phonological stage' – already recognized as the final stage within the study of the *Silbo Gomero* (Trujillo 2006) – while incorporating recent accounts provided by bioacoustic (Meyer 2005) and neurological accounts (Carreiras et al. 2005). Even though this point of disagreement is slightly touched upon (Meyer 2006), the data available does not engage in a wider debate. If bioacoustic data expands the quality of sampled data by incorporating and measuring levels of environmental noise, focusing its object of study on the role of intelligibility (Meyer 2005), neurological data (Carreiras et al. 2005) demonstrates that whistlers exercise regions of the brain in ways that are not exploited by non-whistlers. Both bodies of work bring into the spotlight an important hypothesis untouched upon by a phonological stage: the importance of the environment as integral to the whistler's auditory-body of knowledge, a complex emergent phenomenon that cannot be easily reduced to the analysis of lower level features such as phonological relations exploited by the spectrogram. This has also instigated a self-reflexive pattern, challenging the common assumption – as provided by a bioacoustic and neurological agenda – that the 'linguistic and acoustic iceberg' is not specifically hidden in the brain (Carreiras et al. 2005, Meyer 2005), but rather in the continual relation each whistler develops with the environment characteristic of the island.

Most relevant concerning this hypothesis is that the *Silbo Gomero* can no longer be regarded as a surrogate of speech (Trujillo 1978, 2006; Carreiras at al. 2005), reemphasizing the fact that this whistled form of language is not only an independent phonological system (Rialland 2005; Trujillo 1978, 2006), but is also a verbal-auditory body of knowledge in its own right. Such a transition will allow the study of whistled languages to be situated within a wider frame that is central to the philosophy of mind, one that attempts to avoid confusing 'raw sensation'

with ‘sense perception’. The first model implies a ‘passive’ model whereby our senses cannot be used to know the world, but that reality can only be known through reflective or ‘mental’ abstract thought. The second model implies ‘activity’ and ensures that the representation of the world can only occur trough situated and embedded action (Freeman 2000). This relocates the burden of storing information from the brain to emergent qualities, where bodies and environment establish a complex set of inter-relations. Moving from a ‘passive’ (external) to an ‘active’ (ecological) approach will finally strengthen the idea that the *Silbo Gomero* is intimately tied to a process of acquired skill and auditory-spatial environmental exploration. While acknowledging this relation, it seems relevant to relocate this study to a wider frame, one that is concerned with the development of language – and ‘higher’ modes of thought – as processes that are intimately situated within particular milieus that provide particular ways of sensing the world.

III

COGNITION, EMBODIMENT & INTERACTION

"Like the rest of us, scientists are language-speaking actors. The words they use play a crucial (and, more often than not, indispensable) role in motivating them to act, in directing their attention, in framing their questions, and in guiding their experimental efforts. By their words, their very landscapes of possibility are shaped" (Keller 1995:139).

1. Brief Introduction

Following the presentation of the *Silbo Gomero* – particularly as the unit of analyses shifts from an external conception of environment to an ecological one – this chapter will proceed with a more general discussion of cognition. Taking into account the previous entanglement of innate and learned auditory schemas (Bregman 1994), the investigation will be positioned within a understanding of cognitive development. With this in mind, the first section will engage with the work of Jean Piaget who largely influenced the way in which terms such as 'mental schema' (Bregman 1994:402) have been used within various investigative efforts. Piaget was responsible for an important constructivist agenda, one that has been developed by the learning sciences and the design of various material applications (Papert 1993) and that gives relevance to the capacity of individuals to construct the mind in the process of interacting with the world (Piaget 1971). Piaget also worked within the framework of logico-mathematical thought (Rotman 1977), which has been where most cognitive psychological approaches – while appropriating the idea of 'mental schema' – have drawn their conceptual approaches and developed their methodologies. As discussed, in such approaches, as in the case of the *Silbo Gomero*, auditory perception is divided into 'innate' and 'learned' (Meyer 2006, Bregman 1994) or language in the 'narrow-sense' and language in the 'broad-sense' (Chomsky et al. 2002).

This debate will take the proposed discussion to the third section of this chapter where, and in the attempt to figure the question of embodiment and interaction as proposed by the genetic epistemic program – particularly the idea that the mind is constructed as a direct process of interaction with the world – has provided a strong impact within the field of artificial intelligence (AI) (Boden 1981; Papert 1993:156-176). The novelty of such an approach – and considering that Piaget would introduce the idea that cognitive structures are built upon

interaction with the world and where 'operations' are not given a priori (Papert 1993:161) – was the fact that it was in stark opposition to the common representational account where internal structures operate upon the world. However, and despite the profound contributions, with the further development of artificial intelligence into the domain of robotics, the lessons provided by Piaget seemed to pose a stubborn obstacle, particularly when attempting to develop robots that could actually interact with unpredictable environments (Brooks 1991). Recalling a previous presentation of the *Silbo Gomero*, such environmental unpredictability becomes key, demanding a shift from a passive to an active approach to perception. In this sense, and with this section in mind, this chapter will figure a similar discussion, also proposed by Lucy Suchman (2007), and where the robot, more than a theoretical contribution, figures a pertinent debate of what it means to be human[72].

This will require a shift form a passive (environment as external) to an active (environment as ecology) approach. This shift will draw attention to the concept of emergence, the field of 'dynamical systems theory' and studies of chaos within the physical and biological sciences (Beer 2007). Briefly presented earlier on when referring to the work of Port, Cummins and McAuley (1995) it is also here that an investigation into a 'dynamic framework', its application in the study of neurobiology (Freeman 1990, 2000), will provide a shift from robotic to human agents. In the search for an ecological approach to cognition, section four will provide an alternative reading of emergence through the work of Gilbert Simondon and the concept of 'individuation' (Deleuze 1966, Simondon 2009). While emergence in robotics will consider the role of adaptation to complex environmental constraints – and therefore the term 'reactive architectures' (Brooks 1991) – the idea of individuation renders the ultimate plasticity and incompleteness of individuals as they become capable of effecting continuous individuations upon themselves.

This idea of individuation implies a reading of action, one that is not easily prefigured in a sequential and logical plan (Suchman 1987, 2007) or as a probabilistic adaptation to environmental constraints (Hendriks-Jansen 1996). Action always implies the possibility of change; of modifying an individual's own process of individuation as Gilles Deleuze said in reference to Gilbert Simondon (Deleuze 1966). This possibility qualifies our species 'natural kind' as already entangled in its own processes of fabrication. It is this 'fabrication' that opens up an ethical question, one that pertains to the incompleteness of knowledge and is relevant to their particular systems of representation. It is also with this possibility and consideration in mind that

[72] Here it is important to refer to the context of Suchman's investigation – the field of human-computer interaction (HCI). Even though this thesis does not place itself within this academic research context, Suchman's 'Human-Machine Reconfigurations: Plans and Situated Actions' provides a pertinent reflection when designing computational based artefacts that accompany discussions concerning cognition, particularly while emphasizing a situated or ecological approach.

this chapter will end with a reconceptualization of the idea of interaction not as mediation between subject and object but rather as intrinsic activity that constantly refigures both. This reconceptualization will shift the focus of analysis from the *Silbo's* 'sound objects' (vowels and consonants) towards a closer understanding of its sonic 'effects'. This is relevant point of departure, particularly when drawing upon the design of didactic materials beyond the distinction between 'primary' and 'secondary' qualities, 'innate' or 'learned schemas', and language in a 'narrow sense' from language in a 'broad sense'.

2. Thought and Environment, The Genetic Epistemic Legacy

Largely regarded as a 'child psychologist', Jean Piaget engaged in one of the most thorough studies of the development of human thought considered as a biological problem. Here, it is important to consider the researcher's concept of 'schema' one that has also played an important role in defining the field of psychoacoustics (Bregman 1994:402). For Piaget, 'schema' involves a structural and dynamic coupling with some regularity of our environment, most often described as a 'schema of action' (Inhelder & Piaget 1948:294). Influenced by Darwin's theory of evolution, particularly on the question of environmental adaptation, Piaget proposed the idea that human thought processes result from interaction with the environment. This is a biological process of self-regulation, where each individual can only know the world by acting in it – further accommodating and internalizing the discovered relations. In Piaget's understanding, adaptation is not a simple behavioral reaction to external constraints or even a simple execution of a pre-given plan or genetic blueprint. It is rather a process of organic and active 'assimilation' (Rotman 1977:37) and it has led, within the sciences (particularly in its design orientations (Papert 1993, Resnick 1996)), to the development of a very important 'constructivist' agenda (Papert 1993; Smith & Thelen 1994; von Glasersfeld 1995).

In order to understand fully this 'constructivist' intuition it is important to note that Piaget's early training was as a paleontologist who was influenced by the biological current of his time that was 'Haeckel's Law of Recapitulation'. Here, the idea of ontogeny (the development of the organism from egg to mature form) recapitulates phylogeny (the historical development of a particular species). In this sense, Piaget's interest in child development does not derive from observation of the child as such, but rather from his overall intuition that by analyzing child development (on the basis that there is insufficient information to analyze the development of thought in early hominids) it might be possible to gain a thorough understanding of the development of thought in the human species (Gould 1977:144). One of the most important contributions made by this epistemic genetic programme is in the study of ontogenesis, which is

now devised as following a line of progressive development in which each child constructs their mental structures by physically interacting with the surrounding environment. Organic assimilation therefore denies any separation between the learning process and what is being learned (Papert 1993:158). Piaget had one main interest: to show that what we learn collectively as a society is not separable from whom we are as a human species (Papert 1993:164).

Piaget would start by analyzing our relation – as a collective human species – with the surrounding environment. Amongst other cognitive capacities, such as the understanding of number, one element that intrigued Piaget was to understand the development of spatial perception in the child (Inhelder & Piaget 1948). In the first stage, known as the sensorimotor stage, the child learns how to organize the world of immediately perceived realities in order to develop what Piaget called a 'schema for permanent objects'. As he said: "The first two stages of development are marked by an absence of co-ordination between the various sensory spaces (…). Thus it is hardly surprising that at this level there exists as yet neither permanence of solid objects, nor perceptual constancy of shape and size " (p.6). Therefore, being able physically to coordinate visual and tactile sensory spaces constitutes the first topological abstraction achieved by the growing organism. It does so along the lines of a Gestalt sensory theory of coordination – which included auditory perception (Bregman 1994:18-29) – where proximity, separation, spatial succession and enclosure play a determinant role.

Yet, where Gestalt psychology sees in overall perceptual coordination the emergent manifestation of innate capacities (Bregman 1994:39), Piaget sees a succession of discovered (or learned) and abstracted kinaesthetic inter-relations (Inhelder & Piaget 1948:6-8). This process is cumulative and later 'schemas' will represent the evolutionary achievement of the previous ones, where structures always have a prior genesis, a process in line with the adaptive theory of evolution (Rotman 1977:47). If a prior visual tactile schema is formed along the lines of Gestalt principles, the second schema will further assimilate and internalize metric relations. This phase is characterized by the child's ability to recognize Euclidean shapes, which are later 'accommodated' when she attempts to draw these shapes (between ages four and six) (Inhelder & Piaget 1948:28). This progression, here recounted in a brief series of steps, will culminate in a final stage that corresponds to an operational or projective stage. This shift occurs around the age of seven and can be represented by the child's ability to react to the previous development of perceptual activity while reconstructing, with great precision, various dimensions of elementary geometrical shapes. In this sense the child moves from perceived shapes to mentally imagined ones (pp. 36-37).

The earlier process is further complicated when the child explores (usually through drawing) the inter-relations between different classes of geometrical objects, culminating in the

exploration of perceptual paradigms[73]. According to Piaget, this process reflects the assimilation and further internalization of what the mathematician Cantor, through logical analysis of forms, would propose as an 'infinite set' – a set that contains "the same number of elements as a proper subset of itself" (Rotman 1977:78). The culmination of this particular process of successive modes of schematic abstraction will take form around eleven years of age, when the child has fully internalized the actions mentioned above (p.41). This gradual structural emancipation implies a shift from what could be conceived as a mode of 'direct perception' (Gibson 1966) into a state of 'reflective-abstraction', characterized by 'concrete operations of thought' (Inhelder & Piaget 1948:125). Once these internal schemas start to form, the child will evolve two distinct 'cognitive acts': the 'figurative' and the 'operative'. While 'figurative' action takes on the role of 'perception, imitation and mental imagery' the operative will be responsible for 'transforming states into one another' (Rotman 1977:41) – a stage that characterizes adult thought processes.

2.1 Understanding Piaget's Methodology

This particular process of genetic epistemic development has given rise to an important scientific methodological legacy, one that is indebted to the development of formal-logical thought, which has followed from the field of mathematics and its influence upon related disciplines. By following the various stages of the child's development of spatial conceptions – from perceptual action to operational thought – Piaget uncovered the historical development of a particular mathematical practice. This can be read in the following: "first there is a contemplative stage where ignorance of the underlying processes of thought encourages the belief that what is thought of actually exists. The result is naïve realism which projects the end products of mathematical thinking onto the world, finds there numbers, classes and the like. Next there is the 'synthetic' stage where, having become aware of the operations behind his thought, the mathematician becomes conscious of its synthetic and operational nature. He is then able to create by reflective-abstraction more freely and deliberately. Finally, (...) there is the stage of 'intrinsic objectivity' which (…) represents the shedding of all subjective elements from mathematical structures" (Rotman 1977:137). Here, Piaget's underlying intuition reveals an intrinsic paradox, one that conflates the problems of ontogenic development with the development of logic as proposed by the historical development of mathematical thought.

This creates a problem for those attempting to use Piaget's constructivist approach (whether studying auditory, spatial or numerical categories), as it leads to a methodological incongruence. This is because it stubbornly excludes 'direct perception' from the development of

[73] This can be exemplified by the following question: how might a square and a rectangle become part of the same group of objects? (Inhelder & Piaget 1948:44-79)

thought as it inevitably progresses towards a form of 'reflective-abstraction'. For the cognizing subject – which paradoxically for Piaget is always an acting subject – evolution moves towards an increasing stable state, one that is in equilibrium with the ('real', here, understood as mathematized) environment (Rotman 1977). This raises the second methodological incongruence of the methodology devised by the genetic epistemic programme. If, for Darwin, the species has developed along a line of ever increasing progression, a model that was dependent on the complexities provided by the environment, Piaget would take this lesson and add a particular reading of the environment to this ever-increasing complexity, now along the lines of an 'absolute' spatial-temporal proposition (Whitehead 1961). In doing so, Piaget's methodology conflates two important conceptions of environment as they are rendered through distinct biological intuitions. These are the external as opposed to the ecological environment. As discussed earlier, the biological approach only measures the external environment, which is demarcated from what is internal and external to the organism. Within this logic, action appears as a mediator that reveals an inherent and universal structure. This leads to a common fallacy in which it is assumed that external factors fully determine the life of the organism (Burian 1994:8).

This is exactly where genetic epistemology reverses its interactive and constructive methodology and renders the organism as an ecological construction of a very peculiar measurement of the external (real) environment as it is found in a state of (absolute) equilibrium. This stems from Piaget's belief that the formal-logical or mathematical frame of thought, the ways in which it classifies 'numbers, points, shapes, patterns and functions', is a universal and fundamental principle that underlies nature's performative and structural organization (including the human organism) and therefore exists prior to any cultural appropriation (Rotman 1977:74). In fact, in Piaget's structural ontogenic evolution, as it moves from 'perception' to 'operationality' through various means of kinematic and mental abstraction, what is left in abeyance is exactly the 'means' through which this evolution might occur. This becomes obvious when we shift our attention from the conception of space or number and the child's ability to learn about space and number by manipulating objects and drawings – during the sessions of observation and experimentation conducted by Piaget himself (Rotman 1977).

In Piaget's experiments concerning how children learn to think about Euclidean space, the child was given miniaturized blocks, cones and prisms or copies of the same geometrical figures[74] (Inhelder & Piaget 1948). In this respect, the very notion of schematic abstraction –

[74] A similar remark is made by development psychologist Edith Ackerman (1996): "Stage theory emphasizes how the average child, or epistemic subject, becomes detached from the world of concrete objects and local contingencies, increasingly able to internalize action and to mentally manipulate symbolic objects within the realm of hypothetical worlds. While this is an important aspect of cognitive development, it does not account for the processes by which knowledge is formed and transformed within

here conceived as a formal-logical operation – can no longer render any absolute configuration of an external environment in a state of equilibrium rather the appropriation and assimilation of a very particular environment as it is designed, imagined, copied and further represented. These objects are intrinsic to the continuous development and reinscription of distinct modalities of 'perception, imitation and mental imagery' (Rotman 1977:41), where the further reinscription into the 'operational' logic can only be rendered as yet another logic of techno-material fabrication. Here we encounter Piaget's third methodological paradox: if the individual develops the dynamic of thought through action how can one remove from this action the place of culture, history, community and the life of objects (or the ecological environment)?

2.2 Genetic Epistemology and the Development of the Logico-Mathematical Sciences

To take the discussion further we need to understand the genesis of this paradigm. When referring to children's intellectual or mental development, Piaget focuses on the child's 'logic' as opposed to the child's 'logico-mathematical' thought, this last term is only used when referring to the adult 'organism'. The transition implies that logical thought can only evolve into logico-mathematical thought (Rotman 1977:76). In this sense, the use of logic within the mathematical domain represents the highest mode of thought, one towards which all experience and development evolves, a principle that should be applied to the development of all scientific methodology. What distinguishes mathematics from other scientific practices – Piaget has biology, psychology and physics in mind – is that it does not constantly refute previous lines of investigation. In contrast, other disciplines have not found the state of equilibrium that characterizes logico-mathematical thought. (p.95) Piaget makes the point:

> "It is perfectly true that when mathematicians describe intuition in terms of sensation and images, they generally do so with opposite intentions from those of the classical empiricists, since their aim is to condemn rather than to justify its demonstrative value. Intuition deceives us, they almost unanimously assert (…). Intuition, it is often said, is the instrument of invention, whereas demonstration or geometrical reasoning in the strict sense is a matter of logical analysis" (Inhelder & Piaget 1948:448).

The validation of logico-mathematical analyses, as opposed to intuition or grounded experience, derives from Piaget's axiomatic formalism, which does not allow him to question the role of proof in the formation of such a mathematical paradigm (Rotman 1977:142). As he said in relation to the child's development of a conceptual operational space: "projective and Euclidian space are related in another way which we have now to consider. (…) One of the features of this first type of relationship is that the axioms required to construct a co-ordinate

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specific contexts. Nor does it describes how knowledge is cultivated by individual minds, or shaped by the very media used to make it tangible (p.3).

systems are the same as those necessary to a projective geometry, a theorem first demonstrated by Hilbert" (Inhelder & Piaget 1948:301). Here the discovery of structural relations is conflated with historical proof as commonly deployed by the field of logic. In fact and taking Piaget's own reference into account, mathematician David Hilbert also proposed that all higher modes of thought culminate in mathematical thought and are constrained by logical axiomatic rules (Chaitin 2004:8). This thesis can be divided into two important aspects: "all mathematical truths can be translated into logical truths" and as consequence all "the theorems of mathematics are (…) subsets of the theorems of logic" (Irvine 1996). Following this development of logic within the field of mathematical thought, what is largely left abeyant in Piaget's thesis is the *Entscheidungsproblem* (the 'decision problem') already proposed by Hilbert:

"(…) when we are engaged in investigating the foundations of a science, we must set up a system of axioms which contains an exact and complete description of the relations subsisting between the elementary ideas of that science. The axioms so set up are at the same time the definitions of those elementary ideas; and no statement within the realm of the science whose foundation we are testing is held to be correct unless it can be derived from those axioms by means of a finite number of logical steps" (Hilbert 1900).

What Hilbert proposes is that, in order to be qualified, all mathematical thought would have to obey formal materialization of axiomatic rules. In this sense, Piaget's genetic epistemology is as much an attempt to explain the biological development of thought (here conflated with rational thought) as it is a thorough exploration of the evolutionary, social and material history of particular conceptual systems (Rotman 1977:175). This is visible in Hilbert's ideas concerning the true purpose and methodology of mathematical research: when "exploring the purely logical relations of dependence between statements, the familiar connotations of the primitive terms are to be ignored, and the sole 'meanings' that are to be associated with them are those assigned by the axioms in which they enter" (Hofstadter et al. 2008:9). Against such intuition was the work (which Piaget largely neglected) of mathematician Kurt Gödel, who, in 1931, published a paper in response to Hilbert's *Entscheidungsproblem*. Gödel showed that mathematical thought could not be formulated on the premise of logical axioms because it is incomplete (Hofstadter et al. 2008). This opened the way for a new epistemological agenda within the mathematical community in which the idea of incompleteness would prevail and brought into question Piaget's full circle – in which mathematics further informs psychology, physics and biology.

3. Learning from Robots, Redefining Environment and Representation

These ideas have inspired techno-metaphorical exchanges within the field of artificial intelligence (AI), where two concurrent agendas of research may be found. These are to engineer complex agential behavior and to initiate discussion about embodiment, agency and interaction while exploring distinct paradigms and empirical models (Boden 1981). The first approach to enter research into AI is that of classical cognitive psychological approach, in which ideas of cognition, action and the role of the external environment can be conceived as internalizations of prior categorical relations. In the 1960's and 70's the Artificial Intelligence Laboratory of Stanford Research Institute created a robot capable of reasoning about its mobility as it moved between distinct rooms and was able to push away objects found in its path. At the core of Shakey's reasoning was the programme Strips, which operated on the physical relations while abstracting the course of procedures to be followed. However, the interaction could only take place in fully controlled and 'mathematized' environments. If one were to situate Shakey in a complex ecology of other robots and unknown objects it would cease activity (Brooks 1991).

For some time, this robot represented the apogee of classical AI and information-processing approaches to the development of cognition and action where – and in line with a phonological approach – descriptions of the world could be fully rendered through a preexisting knowledge database containing information about the world (Cummins et al. 1995). When compared to the genetic epistemic project, the 'twist' lies in the fact that for Piaget these processes were not given a priori and rather given through exploration and assimilation of a formal and 'mathematized' ecology. Both conceptions of agency are in constant state of equilibrium with their surrounding environment in which interaction acquires a mediating effect. If for Shakey mediation is provided by the physical manipulation system, the Strips programme (reality in the head), for Piaget's child mediation is provided by proprioceptive action and its further abstraction into schemas or mental states (reality is external and must be coherently apprehended). If for Shakey structure is innate, for Piaget's child structure develops from (logically) abstracted schemas of action. Both proceed without taking into account any cultural and individual appropriation or ecological differentiation (Rotman 1977:165).

More recently and in the attempt to create mobile robots which could deal with unpredictable environments, the AI community has engaged in the development of reactive and mobile architectures – 'situated robotics'. In fact, and very much in line with Piaget's ideas, here thought and action are treated as not being innate but as only proceeding from interaction with the world. However, a 'twist' has been provided to this constructivist agenda while adding incompleteness or unpredictability to the subsumed informational architecture. This architecture depends less on information processing modules (such as the Strip language deployed by Shakey)

and more on 'task achieving behaviors' that are harboured in the complex interaction of distinct modules (all finite state machines). Another robot, Allen (Brooks 1991), deployed interaction between distinct modules through a complex layered architecture that exchanges information simultaneously. Even based upon a 'crude' and simplistic account of agential evolution (as Brooks recognizes), this architecture provided a decentralized artificial cognitive structure. Recursively the new robotic architecture can only evolve or learn while reacting to complex environments and by avoiding the repetition of a strictly preprogrammed command that would be fully structured by a central processor.

It should be noted that robots such as Allen are indebted to a shift within the field of AI. One that moves from a traditional information-processing approach – that has for a long time influenced the cognitive sciences (the attempt to naturalize and formalize representation of behavior) – to approaches drawn from the field of ethology. This is even more relevant as understanding behavior 'in the wild' (Hutchins 1995) gains importance as opposed to performance in controlled environments (Hendriks-Jansen 1996). In fact this concern for context and embeddedness of behavior has strong links with the enactive approach to cognition proposed by Humberto Maturana and Francisco Varela (1980). Through a cybernetic and constructive orientation, they treated living systems as mechanistic ones – made visible in the concept of '*autopoiesis'* (a self-organizing system). However this is not to be confused with a preprogrammed system. Rather it exploits a situated and contextual 'logic' of its own, one that should not be confused with the symbol processing machines that require prior implementation of a set of logical instructions. In fact, this lack of preprogrammed instruction allows organisms to exploit distinct models of the world with various degrees of unpredictable plasticity. Here representation cannot be conceived as a formal instruction to be harboured in the central nervous system. Instead it is to be found in the symbiotic relation each organism develops with the surrounding environment (Bishop & Nasuto 2005:1313).

The *Ophiocoma wendtii* can be presented as a good example of this. This brittle star is populated with smaller micro photosensitive units, much like the eyes of an insect. Such a physiognomy allows the brittle star to 'see' its predators from all possible angles. In fact, the brittle star can perform complex cognitive activities even though it has no nervous system. Thus this creature is able to 'categorize' or 'process information' – even in simplistic terms, such as 'here is a predator' – without the aid of the mediating powers of reason (Barad 2007:375-384). The brittle star has the ability to categorize without any sort of symbolic manipulation of representations as such. Its cognition therefore cannot be located in the specific anatomy of the creature, but rather in its continual existence as part of the aquatic medium. In this sense, the environment is not an external cognitive system but rather an ecological system in its own right.

It should be acknowledged that an *autopoietic* system differs from Piaget's construction of thought through action in the sense that it relies on a complex dynamic intra-relation as opposed to the assimilation of an external environment that is given a priori. In fact, once separated from the environment such cognitive system ceases to function, since the brittle star's 'being' lies in its ability to 'see' in a peculiar aquatic environment (p.375).

If one considers the brittle star as part of the aquatic environment – as a relation that provides its own cognitive means[75] – it seems reasonable to refigure the question of perception or representation of the auditory environment onto an ecological plain. This reconceptualization requires an understanding of embodiment (and its relation to the development of perception, action and thought in human beings) through the decomposition of a body by activity rather than by function. Also, the idea of cognitive agency (what robotics understands as autonomy) should be recovered not from the agent as such but rather from its subsumed and emergent ecology. With this in mind, the idea of interaction can no longer be conceived as a mediating relation between agent and object (or environment), but rather as a historical co-construction of emergent behavior. Without limiting the proposed ideas to problems of robotics or the biological study of aquatic organisms, it seems relevant now to ask: how would this figure in the development of human auditory perception? And particularly, how is it relevant for an understanding of whistled languages and the design of learning materials?

3.1 Evolving Language in a Community of Robots

Early work developed within the field of artificial intelligence was consonant with the structuralist programme in relation to the study of language as initially proposed by Ferdinand de Saussure (1966), particularly as he made an axiomatic division between divergent relations. For Saussure the first instance of language is syntax and this particular structural feature can be understood as being independent of practices of use and inscription, clearly demarcating physical/biological agency (language as an innate and phonological articulatory phenomenon) from complex forms of socio-material agency within the life of language. Against this background, *langue* represents a structural relation that is passively 'assimilated' by the individual (Goodwin 1997:114), a model that explicitly excludes agency, here understood as the situatedeness and learning of language as a form of cognitive apprenticeship.

[75] What James J. Gibson has qualified as 'affordances' "(…) as they are defined in terms of the relation between an event or object and perceiver." In this sense "Affordances are not merely properties of the environment, or even of design, but may vary between individuals as well as species. According to ecological theorists, affordances account for much of what we perceive, if only because they describe what we care about." (Gaver 1988:25-26)

A discussion of such axiomatic division was materialized in one of the first attempts to model the child's inherent capacity for language learning with the Zbie model. One that gives continuity to the presentation of the Hearsay-II model, presented earlier on. Developed initially by Saurent Siklóssy in 1968, the Zbie model was later taken up by the cognitive science community as an example that could fully account for the human capacity to learn a given language. Very simply, this artificial intelligent system learns a particular human-like language by juxtaposing sentences with images depicting particular scenes that refer to these sentences (Clancey 2005). In continual exchange, the system learns vocabulary and grammatical structures, later combining these elements in the creation of new utterances, following a clear path of assimilation and accommodation of symbolic interactions. Zbie intuitively learns a given language through continuous contact with such symbolic representations and their verbal descriptions. This methodology has been extensively deployed within the 'human' context of language learning, particularly with children who learn new languages 'through pictures'. This method avoids confusion while replacing the process of translation between a newly learned language and the child's mother language by a process of translation between a newly learned language with a system of reference of its own, in this case, pictures depicting some aspect of the world.

The success of this methodology has been widely questioned, however, the problem being that the Zbie model does not actually learn by exploring and exploiting the given pictures as classical cognitive science tends to assume. In fact, this artificial system is literally 'translating' from one given representation (a computational language used to describe the images in the system) into another human-like language or system of reference. This particular representational and symbolic mode of interactivity is embedded in the model, and therefore Zbie can only process a textual symbolic language (Clancey 2005). Even when considering 'learning language through pictures', the system would only truly replicate such a learning process if it could actively explore and exploit a given external artefact and learn from such a relation. Without translating from the language of pictures into the language of its depiction by a computing machine. Zbie would have to put to good use some sort of sensory-perceptual apparatus and a situated form of grounded communal interaction.

The belief that this system would model the actual methodology of 'learning language through pictures' would further disclose its true nature – the formalist approach to the conceptualization of cognition. Even though this model might be considered to be a constructive model, it actually presupposes a very particular kind of constructivism – one of that is tautological. This is because it responds to a controlled syntactical world that is given through symbolic manipulation of a particular reading (that is abstracted into formal axioms) of the

content of pictures as opposed to a dynamic interaction with the artefact as such, through its conversational, social use and embeddedness[76]. In fact, it seems that while the cognitive science community continues to insist on the use of models like Zbie it fails to note a methodological paradox (Clancey 2005). This might be formulated as follows: if construction is the motto of the day how might 'learning through pictures' be reduced to the syntactical manipulation of abstracted representations?

In fact, proposing Zbie as a paradigm of learning a language through pictures conceals a wider problem: the idea that all representation can be reduced to verbal-discursive or syntactical representation. This approach goes hand in hand with efforts to understand how children learn new words, where paradigmatic studies have shown that most vocabulary is learned outside the classroom in various situations of play where listening, conversation and the manipulation of alternative symbolic systems – at least in relation to the common dictionary – play a determinant role (Brown et. al. 1989). However, and in line with the previous discussion of perception – as it develops from an ecological or situated, contextual and embedded action – the making of artificial agencies can be seen to be slowly moving away from the syntactical internalization of representations of language learning to the active manipulation and making of representations as such.

More recently, and in the attempt to provide a response to models such as Zbie, Luc Steels (2003) has attempted to evolve a community of communicating robots. In the 'Talking Heads' experiment, two pan tilt cameras are featured facing a white board where various geometrical figures in different colours are displayed. Each 'talking head' takes on the role of listener and speaker and 'conversations' are built around the situation 'at hand', in this case the collection of geometrical figures. The 'language game' (as mentioned by Steels) will give rise to the development of situated lexical rules, based upon the mutual agreement of correctness or incorrectness as a direct consequence of each head's response to the previous 'question'. For example, when the game starts one of the heads will direct its sensing apparatus (the camera) to the whiteboard, leading the other 'head' – the listener – to focus on this area. The 'speaking agent' will then provide its own categorization of the perceived relations between distinct geometrical figures and will pass on this information. After learning a first category of words, the hearer will shift its attention to the correct area. In case the 'hearer' fails, the 'speaking' head will point out to the hearer the correct region of the white board (p.310).

[76] A similar discussion can be found in John Searle's (1997) 'Chinese Room Argument'. Here, the author defends that language learning cannot be reduced to a simple manipulation of syntactical relations. In the words of Searle: "(...) programs are entirely syntactical; minds have semantics, syntax is no the same as, nor by itself sufficient for semantics (...)" (p.14).

It is important to acknowledge that the lexicon is constructed from continuing and emergent interaction. The emergence is generative (the interaction of particular syntactical rules will give rise to other more complex ones) but it is still contextual. Its features will depend not only on the agents' cognitive capacities (here translated into particular learning algorithms) but also on the communicating medium itself, the environment where the interaction takes place and, of course, the quality of such interaction, which in the 'Talking Heads' experiment is largely based on the pan tilting quality of the moving heads (Steels 2003:310). One of the most important shifts provided by this example is the move away from a replication of human like language and towards evolving a collective dynamic organization of artificially created agents with a communicating language of their own. This paradigmatic shift represents, within the fields of artificial intelligence, a substantial transformation, considering that what is being learned is not a human-like language but rather a *machinic* form in its own right (Steels 2003). In fact, such models are largely based on particular accounts of 'grounded communication' (Brennan & Clark 1996) where the development of language will count upon the activity of co-existing agents with a shared background of knowledge but also with an inherent incompleteness, unpredictability and plasticity that allows these agents to 'update' the common ground at every moment (p.127).

This represents a valuable contribution provided by the field of robotics, particularly, as it mobilizes a discussion of cognition and action. Where the robot Shakey functioned in a controlled space of interaction where all representation of the environment was given a priori, the reactive architectures (Brooks 1991) explore the making of representations in the flow of interaction. Here, emergence is distributed between the complex surrounding environment and the agent's constructive ability (in a very Piagetian sense) and is therefore able to learn from its own embodied interactions 'in' the world. While the later preserves an individualized understanding of embodiment the 'Talking Heads' experiment shifted the space of interaction, to one in which both an enacted and grounded communication is intrinsic to the embodiment of *machinic* forms of language. The emergent coordination of distinct spaces of interaction generate not only distinct levels of embodiment, but above all subsequent agential complexities. This is not only relevant in emphasizing an already cliché idea of cognition as decentralized phenomena (Hutchins 1995), but also to emphasize how cognition might not always proceed through a general classification of the external environment or even by the classification of a generative rule as proposed by phonology. Rather, it is best understood as an emergent phenomenon that can only be rendered through a situated, contextual and ecological perspective.

4. From Emergence to Individuation, Understanding Information

The previous section instigated the discussion of the role of emergence. In fact, a similar conception was presented when thinking about the *Silbo's* ecology – one that entailed an ecological reading of the body, the effect of living in a mountainous environment and aural techniques of inscription. This suggests a relational agency, one that is in stark contrast to the idea of the immutable value of language as proposed by a phonological reading. Rather than a deceptive approximation between the cognitive metaphors used in robotics and a study of the *Silbo Gomero*, what is finally proposed is a methodological reconceptualization of 'agency', both natural and artificial, as what cannot be contained within the 'agent' or the external environment. It is also here that a third relational paradigm emerges. This attempts to displace the problem of agency from the idea that it is located 'within' the agent – even though here robotics still has much to uncover in this respect – to the idea that it is found in the various spaces of collision, which may be considered the place of the making of agencies as such[77].

A question seems to persist: does this really apply to human auditory perception and its relation to complex linguistic behavior? Can we really conceive of ourselves as decentred beings with no agential, perceptual or cognitive representational locus? To consider these questions it is important to move the focus of the discussion beyond the problem of emergence as 'natural' occurring phenomena materialized in artificial agents and aquatic organisms and think about the ways in which this concept has been deployed beyond the 'natural' or 'artificial' sciences. In this respect a close inspection of the work of Gilbert Simondon, particularly in the development of the concept of 'individuation' is valuable. Gilles Delueze in a (translated) review of Simondon's *L'individu et sa Genese Pphysico-biologique'* (1966) explores ways in which one might render an alternative reading of emergence: "Traditionally, the principle of individuation relates to an already made, fully constituted, individual. The only question regards what constitutes the individuality of such being, that is to say what characterizes an already individuated being" (p.43).

In contrast to this last description, emergence will always position the process of individuation as departing from an agent as a fully formed being. What is left in abeyance is the very idea that individuals, agents or beings already take part in their own transformative capacities. This renders the defining any being prior or after its own process of individuation impossible. It is also in this dynamic process that one might instigate a more complex reading of emergence, which cannot be easily located in the decomposition of activity and behaviour into

[77] The work of Lucy Suchman (2007) presents a similar reading of this metaphorical exchange (pp.226-40) even though the anthropologist is reluctant in using computational models in the conceptualization of human cognition.

co-participating modules of interaction as proposed by AI's reading of enactive perception. In fact, this impossibility is discussed in Simondon's critique of classical biological dogmas that tend to overemphasize an "already individuated living being as given". Largely situating the clichéd account of emergence within the biological sciences where (…)"The processes of development are set aside: it is a biology without ontogenesis. This notion of adaptation defines the problem of the individual in the terms of an opposition of forces: that is to say, of conflict between the forces that emanate from an individual that is oriented towards a goal, and the forces that emanate from the object (from the object for the living subject), that act as a kind of barrier (obstacle) between the subject and the object". (p.45) According to Simondon this renders the individual as entirely passive in the process of her own individuation.

Such an approach further informs the earlier discussion concerning the whistler's exploration of the mountainous environment of La Gomera. While both neurological and bioacoustic studies of whistled languages (Carreiras et al. 2005, Meyer 2005) present these linguistic forms as adaptations to – external – environmental constraints, an 'individuated' – or ecologically situated – reading will provide a distinct set of intuitions. In fact, and while further exploiting this process of adaptation, **whistlers are not only providing a solution to constraints, they are altering the very conditions of communication and informational exchange, as they co-elaborate a sonic milieu not fully represented in such a process of adaptation. This sonic milieu is nowhere to be found, it is neither in the environment nor in the brains of whistlers but rather in their continual exploration of complex performative actions**[78] **that can no longer be read against the constant surrogation to verbal-discursive performance.**

The passage from emergence to individuation is consonant with the shift from a passive to an active approach to perception, particularly as it draws from a philosophical problem already posed by Plato in the 'Allegory of the Cave'. This allegory presupposes that the real world contains forms (or ideas) that cannot be truly known through experience, but can only be grasped through their reflection. The only way to pass beyond reflection, in the attempt to access the real truth of these forms, is through the deployment of our instruments of reason. Transposing this allegory to contemporary discourse will imply, once again, a spatial metaphor, the idea that cognition is not a direct temporal process but rather a process that is executed in a 'central homunculus' (Searle 1997) or as direct response to environmental stimulus. Here, the brain – the organ of reason – is responsible for converting the information provided through sense

[78] Simondon further strengthens this idea: "It is not the abstract topological distribution of objects and subjects that is modified. It is, (…) the incompatibilities of *disparation* that are overcome and integrated thanks to the discovery of a new dimension. The world before action is not only a world in which there is a barrier between subject and the goal. Above all, it is a world that does not coincide with itself because it cannot be seen from a single point of view" (Deleuze 1966:45).

perception into coherent and stable representations. In a similar vein, throughout an individual's life, cognition will amount to a collection of representations that can be deployed whenever necessary, but they are static representations devoid of any process of individuation. Relegating the information presented to a reliable neurological account, this will amount to the idea that distinct patterns of neurons when triggered will average out noise, here represented by 'excessive' bits of information, so creating a clear interconnected pattern that 'matches' the 'correct version' of the required representation (Freeman 2000).

Such an interpretation has an intrinsic limitation. In real-time experience, the distinction between information (the figure) and noise (the background) is not clear-cut, particularly when considering that our experience is in constant temporal flux and not prone to dissection into discrete spatial-temporal instances or 'absolute' durations (Whitehead 1920, 1925). Let us recall the Gibson's assertion that 'we do not hear, we listen' (Gibson 1966: 83). This implies that, due to the complex process of individuation, we do not simply receive raw sense-information, but we are rather in a constant state of expectancy, seeking for informational cues within a given and already individuated milieu – as opposed to an external environment. In this respect, Plato's 'Allegory of the Cave' was not unchallenged as Aristotle's put forward his conception of 'action' as the necessary condition for distinguishing raw sensation from directed perception (Freeman 2000). For Simondon, action can never be conceptualized as a product of an agent's goal as it always gets redirected through distinct objects. In fact, action modifies these objects, that is to say that action is already the temporal individuation of what previously could be rendered as an external and stable object: "(…) action is the discovery of the meaning (…)" (Deleuze 1966:46). Here the environment is no longer external to the agent, and is best understood as a set of intra-relations. And if action continually changes this environment, it is reasonable to say that all possible viewpoints will be intrinsically systemic and relational and not necessarily 'subjective' as a phonological approach might consider (Trujillo 2006).

4.1 Rediscovering Noise and Chaotic Brains Structures

Following the idea of individuation, and in an attempt to provide a counter-argument to the idea of cognition as replete with representations that are manipulated through information processing mechanisms, new sorts of computations have recently been explored. A pertinent example can be found in Tim van Gelder's (1995) cybernetic reconceptualization of the mind as that which computes without using explicit representations or discrete symbols. Here James

Watt's centrifugal governor becomes the key[79]. Designed for steam engines in the late XVIIIth century, this rather simple device performed complex tasks – it could "measure the current steam pressure; calculate the desired alteration in steam pressure; calculate the necessary throttle valve adjustment; make the throttle valve adjustment, return to step 1" (p.348) – through a self-regulatory principle. Even though van Gelder will oppose this model to that of computation, it seems more accurate to say that it implied a computational model without explicit formal-logical representations or syntactical processes of calculation. This conception does not discard, the idea of computation but rather, as Simondon would suggest, it presupposes a reconceptualization of information as: "a transductive process which provisionally resolves some incompatibilities within an ensemble". Information is always 'in-formation', a process of individuation where distinct forces are constantly negotiated (Mackenzie 2002:50).

The interest in presenting the dynamic account provides two concurrent lines of investigation. On the one hand, it expands the notion of cognition beyond classic computationalism while mobilizing notions of embodiment and interaction and, on the other hand, that it suggests that 'agency' is already embedded in its own processes of individuation. If a genetic epistemic (or constructivist) paradigm of mind would previously have relied on a complex ecology of ideas where operations and axioms of first-order logic were the key element, a dynamic account proposes a new ecology of intuitions, with their own intrinsic instruments and methodological practices. In fact, further investigation of the ways in which the field of neurobiology has exploited dynamic systems will provide fruitful insights. One prominent contribution that threads together these orientations can be discovered in the work of neurobiologist Walter J. Freeman and his discovery of neural patterns of chaotic activity while recording[80] electrical activity of the mammalian brain – particularly, rabbits – during olfactory activity (Freeman 1990). Such chaos should not be understood as a direct representation of perceived sensory information but rather as the vehicle of ongoing perceptual qualities of distinct odorants as they relate to past experience, present stimulus and the chemical state of the brain.

In a way that resembles Simondon's process of individuation as already embedded in the formation of a metastable system, Freeman proposes that the mammalian brain with its collection of neurons "(…) is a dynamical system more like a hurricane than a digital computer" (Freeman 1997:32). Here, the digital computer should be understood as an artefact designed on the assumption of intelligence as a two-state logical decision maker (Freeman & Skarda 1987).

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[79] Anthropologist and cyberneticist Gregory Bateson (1972) was one of the first to use the watt-governor as a model in the further conceptualization of the mind, now to be understood as an emergent sense organ (p.462).

[80] Here the EEG (electroencephalography) is mostly used. A technique that combines a "(…) mixture of electrical potentials from several sources, not all of which are known" (Freeman 1990:5).

Freeman's thesis further refines the discussion between an active and a passive approach to perception. In the passive approach the 'object' is environmental and exists outside of the 'subject' and here the clear interconnected pattern found in the brain will correspond to a 'representation' of the external object. Taking an active approach to perception will render the chaotic metastable states found in the mammalian brain as the ongoing materialization of exploratory actions. Taking this neuronal pattern of organization (or metastability) as an active process of individuation what is 'represented' is no more than a tension, a process of differentiation between 'two disparate scales of reality' (Deleuze 1966:44).

Here the role of noise within the field of neurobiology, its deployment by techniques borrowed from dynamical systems theory, is of crucial importance because previously, an in spectrographic analysis of whistled utterances, the method of averaging-out inconsistent signals has also been commonly used within the neurological field. To quote Freeman (1990) again:

"(…) in the 1950's signal detection theory was, introduced into brain studies. Computer averaging of transient responses of brains to brief stimuli such as clicks and light-flashes became and remains the most common procedure for experimental testing of brain function in human cognition. Its aim is to retrieve a sensory induced "signal" from the brain noise in which it is embedded, thereby relegating the EEG to the status of noise, something to be eliminated by averaging"[81] (p.4).

Freeman substitutes this technique of averaging out inconsistent signals (or noise[82]) while rendering the provided information through a set of stochastic differential equations[83]. These equations differ from averaging techniques by taking the evolution of a signal 'in time'[84] as opposed to its displacement 'against time' (Freeman 1990:11), a process that is consonant with the dynamical systems theory – the study of a systems evolution through time (Kelso 1995, Smith & Thelen 1994, van Gelder 1995).

In this sense, the observed chaotic patterns can be conceived as the 'figuration' of a temporal process of individuation where distinct neurons compete for distinct relations of interaction. The result of this interaction is not 'error correction' as Freeman suggests, but rather

[81] Here, it is important to note that the "(…) chaotic motions have always existed. Experimentalists, however, were not trained to recognize them. Inspired by theoreticians, the engineer or scientist was taught to look for resonances and periodic vibrations in physical experiments and to label all other motions as 'noise'. Joe Keller, a mathematician at Stanford, has speculated on the reason for the apparent myopic vision of experimental scientists as regards chaotic phenomena in the last century. He notes that the completeness and beauty of linear differential equations led to its domination of the mathematical training of most scientists and engineers" (Moon 2004:91).

[82] "In experiments, noise usually denotes the small ransom background disturbance of either mechanical, thermal or electrical origin" (Moon 204:266).

[83] These equations are designed to handle stochastic processes, non-deterministic processes that take into account uncertainties and random noises (Sobczyk 2001:1).

[84] More recently, Gerold Baier and Thomas Herman (2004) have applied sonification techniques to EEG data. One of the qualities provided by this technique is the rich translation of rhythm, an important characteristic of the evolution of a dynamic system such as the one found in brain activity.

the chaotic activity (Freeman 1990:11). The development of this chaotic activity through time develops distinct 'attractor models' as the result of particular perceptual experiences. Here it is important to understand where the idea of 'attractor model' (as opposed to Piaget's schema) stems from. In the study of dynamic or chaotic systems, attractors correspond to preferred states of interaction between distinct subspaces. As in the harmonic oscillating principle presented earlier on (p.62), the working of a pendulum serves as a classic example:

"The circular orbit of a frictionless pendulum and the resting point of the pendulum with friction are the attractors of this system: a limit cycle attractor and a point attractor. When the pendulum is slightly perturbed, it returns, in time, to its periodic behaviour or resting point. Once the pendulum is given its squirt of energy, these time and space patterns capture all other possible trajectories on the state space (…)" (Smith & Thelen 1994:56).

Here, when referring to brain activity as a dynamic and chaotic system, periodic behaviour or resting points correspond to "deep anaesthesia, coma, or brain death" (Freeman 1990:2) – or to Piaget's environment in a state of equilibrium (Rotman 1977). All phenomena that we subjectively experience as remembering and recognition, is based on a dynamic process (p.3), shifting between distinct attractor spaces without ever reaching a point of total equilibrium or a formal and stable point of representation as it is externally recovered from detached observation.

5. The Dynamic Nature of Cognition, Perception and Memory

Now, if processes of categorization no longer appear as internal vs. external stable entities and so assuming the role of active perception as proposed by Freeman, where are the categories, as proposed by a phonological or psychoacoustic reading of whistled utterances, to be found? It is important to acknowledge that both representationalists (cognition as manipulation of logical rules) and dynamicists (cognition as a chaotic process that feeds on environmental 'noise') agree, to a certain extent, that when speaking of human cognition the existence of some sort of 'inner economy' (Clark 1997) must be considered. Both 'schools of thought' agree that to reject this richness is to comply with behaviorist logic and the idea of physical embodiment as a pure reaction, a simple response to direct stimuli. In fact, such an approach would imply a stagnant view of cognition, where flexibility would be seen as inexistent. Particularly to the extent that even though cognition is embedded in our actions in the world, these actions are no more than reactions (abstracted assimilations) of the surrounding environment. However, and as discussed throughout when presenting Simondon's concept of individuation, this approach to cognition – the idea that a pre-individual (a rich inner economy awaiting activation) might exist prior to or separable from its own process of individuation – will lead to a delicate point of departure: the

idea that some cognitive states (particularly higher mental states) can be characterized as 'off-line' states[85] (Clark 1997).

As clear as this may seem, when speculating on the nature of introspective thought, it seems to contain one intrinsic problem: the idea that cognition, and all subsequent modes of perceptual recognition, categorization and remembering have to be split between internal and external economies. The faith in the possibility of an 'off-line' state derives from two intrinsic ways of understanding 'inner states': on the one hand, the faith that internal mental states completely control immediate environmental interactions (the Kantian categories given a priori) and, on the other hand, the idea that inner states model the world in such a way as "to obviate the need for continual environmental interaction" (Piaget's discovered categories, the passage from 'figuration' to 'operationality') (p.464).

Both approaches are visible in the following example:

"Consider two ways to solve the problem of finding your way out of a radial maze. One way relies (initially) on trial and error, but the system stores good solutions and (over time) supports successful maze-running. (…) Thus, confronted by a new way into the maze, the agent can deploy a tactic of vicarious exploration to determine a viable route in advance of actual physical action. To support such functionality, the system uses distinct inner states as stand-ins for distinct features of the maze, and it is set up (by learning, evolution or hand-coding) so that the relations between these inner states mirror the actual relation (of distance, accessibility, etc.) between real-world maze features. Notice, then, that all that need ultimately distinguish such a case from any similarly articulated case of weak-substantive internal representation is the capacity to access such inner structures off-line and thus support planning and problem solving in the absence of rich on-going environmental exchange" (p.465).

Despite using this example as a way to breech both representational and dynamic approaches to cognition – in a way to salvage computational approaches[86] – it leaves two points to consider. First the idea that inner states would actually 'mirror' the distinct features of the maze and second that rich modes of 'off-line' cognition, the core of mental life, can be understood through a rehearsal of this mirroring process. Similar to Piaget's environmental abstraction, this reading of cognition will make an operational abstraction of complex modes of action. As Latour (1993) might say: we are here missing a 'middle kingdom' (p.78). Now let's imagine that our maze-runner encounters an unexpected obstacle while running through the

[85] As presented by Andy Clark (1997): 'off-line states correspond to cognitive states that exploit particular inner resources as to model the world and obviate the need to continually interact with the surrounding environment' (p.464). What the philosopher notes as 'vicarious exploration' (p.465) is activity that is indirect, and takes the place of direct environmental correlation, most visible in remembering, thinking, imagining, etc.

[86] For Andy Clark (1997) the radical non-representational approach to cognition as proposed by dynamicists needs to be handled with care this considering that what is at stake is not so much the need to disregard the role of mental life – a rich inner economy – but rather consider the distinct ways in which it 'computes' (p.472-473).

maze. Will it cease its 'off-line vicarious exploration' or will it proceed while further deploying a 'middle kingdom' of cognition, one that cannot be 'in' or 'out', 'on' or 'off'?

Here the work of Alfred North Whitehead (1961) might shed light on such paradox, particularly in relation to the intra-relations between time, space and matter:

"An object which (in some sense) is located in an event extending throughout a duration is not necessarily located in any slice of that event contained in a duration which is a part of the original duration. (…) We may call such objects "non-uniform" (p.67). (…) The theory of material is the theory of uniform objects, which endow the events in which they are located with a quantitative character. For example, an electron gives such a character to the occupied events, namely, the electric charge. Thus the concept of a quantity of material with a definite spatial configuration of time is a very complex abstraction, and is by no means a fundamental datum for science" (p.68).

This particular methodology can be conflated in the previous description of the maze-runner, particularly as it rehearses cognitive psychology's attempt to formalize mental schemas, operations and memory as static realities awaiting their formal processes of retrieval. This occurs either 'internally' or 'externally'.

This conceptualization of environment (internal or external) and time, challenges the idea of introspective thought (and its relation to memory) as 'off-line', as pure mental space. Instead it poses such space as an embodied situated and temporal occurrence that lives in a constant negotiation between body and its intricate performative qualities as they are revealed through time – a process of complex individuation. This takes the representational account of mental space, categorization, recollection or memory, from a mechanistic approach to an organic one. Memory, representations or processes of categorization are nowhere to be held and therefore will deny the slicing of time into past and present experience. Memory, thought, representation, categorization are always in transience; and they are simultaneous. Here what is termed as a 'rich inner economy' or 'off-line' situation is always informed by actual sense-experience. This renders the separation between 'interior' and 'exterior' economy as incongruent set of terms. Such a conjecture immediately imposes a form of 'bald interactionism' between both of them. Such a form of interactionism preserves a descriptive simplification of the very idea of cognition, embodiment and interaction.

5.1 Interacting with Sound's Effects

Interactionism, as presented by the mental appropriation of the maze by the maze runner, preserves a particular process of physical individuation, one that can only be 'prolonged to the limit of its body (its inner resources)'. This is in true opposition to complex process of individuation[87] where a "living being grows from both the inside and the outside" and where the "entire contents of its inner space are in 'topological' contact with the contents of exterior space" (Deleuze is here referring to the work of Gilbert Simondon in '*L'individu et sa genese physico-biologique*') (Deleuze 1966:47). In this sense, the idea of 'interaction' does not do full justice to a temporal and dynamic science, because it cannot give an account of the situated, 'noisy' and unpredictable aspects of life. Particularly, and even more relevant to the discussion, it cannot give an account of plasticity, novelty and change, which are necessary conditions in the continual development of rich 'inner' economies (Freeman 1990, 2000). It seems that 'internal' and 'external' environmental correlations are not consonant with whistled languages and their complex modes of categorization as highly distributed temporal synergies in which neuron, body, collectivities and environments are all involved in the process of communication.

While this has consequences for cognition and embodiment, there is another question to consider: what does this actually say for a reconceptualization of interaction? Here, it seems reasonable to proceed along the lines provided by Keller in the introductory quote of this chapter: what is needed is an alternative language, 'a new landscape of possibilities'. To rework this idea of interaction is not only a philosophical endeavour, it is permeated with an ethics, a pragmatics like that of design. This ethics will offer the necessary flexibility for any process of individuation to occur in the first place. It is here that the process of 'intra-action' proposed by Karen Barad (2007) might provide fruitful insights:

> "(…) agency is a matter of intra-acting (…). It cannot be designated as an attribute of subjects and objects (as they do not preexist as such). It is not an attribute whatsoever. Agency is 'doing' or 'being' in its intra-activity. It is the enactment of iterative changes to particular practices – iterative configurations of topological manifolds of space-time matter relations – through the dynamics of interactivity. Agency is about changing the possibilities of change entailed in reconfiguring material-discursive apparatuses of bodily production, including the boundary articulations and exclusions that are marked by those practices in the enactment of a causal structure. Particular possibilities for (intra-)acting exist at every moment, and these changing possibilities entail an ethical obligation to intra-act responsibly in the world's becoming, to contest and rework what matters and what is excluded from mattering" (p.178).

[87] It is important to acknowledge that Andy Clark in many ways contradicts this discussion concerning 'off line' modes of cognition. In fact, in 'Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence' (2003) he insists on conceptualizing cognition beyond the 'head and skull' (p.5) and developing an 'extended approach' to the same.

Moving closer to the agenda proposed by this thesis – the design of a language support system for the *Silbo Gomero* – Barad mobilizes the idea of representation (or reflection) of reality (the mirroring as suggested by Clark) into a 'logics' of diffraction. While mirroring entails a reflection of objects from the outside – the object that is held at a distance, the language's code prone to execution (interior milieu) or conversely to assimilation (exterior milieu) – diffraction entails an entangled state where differences emerge from within (p.89). In the case study such diffraction 'sustains' the disjunction between whistlers and linguists on the number of whistled vowels, because the auditory object and its sensory effects are already entangled in distinct processes of individuation.

In the attempt to move the concept of 'intra-action' towards the sonic realm, it is important to explore the idea of '**sensory effects**' as proposed by Augoyard and Torgue in 'Sonic Experience: a Guide to Everyday Sounds' (2005). In line with the research I propose in chapter II, the 'sonic effect' should be understood as 'interdisciplinary tool'[88]. In fact, this tool might instigate – and even legitimate – ways of understanding the 'sound object' (and let's keep in mind the phonological reading of whistled vowels) as a culturally situated and multidisciplinary entity. Instead of proceeding by separating the diverse spheres of knowledge and their interpretations of this 'object', one might proceed by taking into account the ways in which the whistler's ecological setting and performative actions are 'entangled'. Just as Augoyard and Torgue (2005), one might proceed by taking into account the way in which the 'sound object's' temporal and culturally situated qualities '*effect*' listeners in different ways. This shift in focus, from the 'sound object' as an identifiable entity to the study of its 'effects', might further clarify an ongoing discussion within the psychoacoustic community, one that was briefly tackled in the previous chapter.

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[88] The authors use this term in the attempt to situate the 'sound effect' within a particular history of investigation that is marked by the notion of 'sound object' or '*l'objet sonore*' (first proposed by Pierre Schaeffer) and the 'soundscape' (first proposed by R. Murray Schafer). These notions were introduced in the 1960s and 70s as a response to methodologies based on harmonic notions of musicality. Also, and just as the psychoacoustic readings of sound as 'event, stream or object of figure-ground segregation' (Kubovy & van Valkenburg 2004), these modes of investigation appeared as a response to the laboratorial and acoustic measurement of reduced sonic physical signals. Despite the similarities, it is important not to confuse these aesthetical readings of the 'sound object' with a psychoacoustic one (Kubovy & van Valkenburg 2004).
The notion of 'sound effect' also attempts to tackle the limitations of the '*objet sonore*' and 'soundscape'. While the first term describes all the perceived sounds of the environment it also attempts to formulate an elementary palette of possible sounds. This methodology was largely influenced by the work of physicist Abraham Moles and his application of Shannon's mathematical information theory as way to segment sound objects into small units (Roads 2001:63). Considering that this methodology proposes sound-by-sound analysis, when studying sounds in situ or even complex sounds that spread over time this methodology becomes rather fragile. The 'soundscape' was created as an aesthetic methodology, one that could be used while composing new sonic landscapes that would educate the listener. The downturn of this methodology is that it focuses essentially on 'hi-fi' sounds as opposed to sounds of everyday environments where unpredictable combinations might produce 'hazy' effects. (Augoyard & Torgue 2005:5-7)

This debate is not new and portrays different approaches to the study of human auditory perception that classify sound as 'event, stream or product of figure-ground segregation' (Kubovy & van Valkenburg 2004:113-147). The auditory perception of sound as 'event' takes further the elementary idea of auditory phenomena as the result of 'abrupt changes that occur in the environment' (p.118), a transformation that is marked by distinct 'events'. The auditory perception of sound as 'stream' takes into account how Gestalt perceptual principles organize our perception of the flow of sounds in the environment. Also presented in chapter II, this approach was used by Julian Meyer (2006) when studying whistled forms of language. The 'figure-ground segregation' approach focuses on the auditory perception of sound objects or 'units of attention' (p.122). Kubovy and van Valkenburg (2004) are inclined towards this last approach, considering it best supports the idea of sound as object[89]. This is visible in their understanding of the world as a collection of objects, not events[90] or processes (p.119).

Less explored by the psychoacoustic community is the fact that these three readings also imply distinct 'sensory effects', entangled as they are in our perceptual and customary habits. These three approaches also describe our interaction with sounds as we use them to classify events within particular environments, as we attend – consciously or unconsciously – to the temporal and streaming qualities of the flow of sound or as we focus on one particular sound in detriment of others. The 'vagueness' of the idea of sound as object, as the authors suggest (Kubovy & van Valkenburg 2004:123), is not only the consequence of various descriptive approaches as presented above, it is also in debt to the diverse ways one might interact and 'read' the sonic environment.

In opposition, Augoyard and Torgue (2005) propose a shift: from an understanding of the sound (or detached physical phenomena) as object – and the listener as subject – to an understanding of its 'effects'. Just as Barad (2007), the authors will draw on the field of physics and its attempt to understand the '*effects*' of the surrounding physical world as those 'facts whose appearance do not refer directly to their cause'. Effects are born with the field of relativity (Augoyard & Torgue 2005:10) that conceptualizes the physical world as 'phenomena' (Barad 2007:315). This approach stands in stark opposition to Kubovy's and van Valkenburg's psychoacoustic theory of 'objecthood', most important, it stands in opposition to the idea that the physical world is a 'collection of objects' (Kubovy & van Valkenburg 2004:119). As opposed to 'objects' these 'effects' are the product of a physical study of the acoustical source (the 'basic

[89] The authors admit that the idea of sound as a product of 'figure-ground segregation' might, at times, appear to be too narrow. Here, it is important to take into account that a listener might focus his or her attention on a 'figure' that is part of an array of alternatives that are not necessarily best represented as the 'foreground' since they are also 'auditory objects'. (Kubovy & van Valkenburg 2004:123)

[90] Here it is important to notice that the authors (Kubovy & van Valkenburg 2004) recognize that the difference between sound as object and sound as event is not clear-cut but rather 'interchangeable' (p.119).

effect' that is linked to distortion, filtering or variation of the propagating medium) or even the study of each sound's inhabited space (effects that are linked to concrete spaces, such as reverberation). These effects also conceal a world of culturally situated perceptions where sounds physical movements are perceived in unpredictable ways. (Augoyard & Torgue 2005:15)

Here it is equally important to mention ways in which the authors draw the idea of 'effect' from the social sciences. This field has emphasized the importance of understanding 'sounds inhabited spaces, the value of everyday sound perceptions and actions and the interaction between heard sounds and produced sounds' (p.8). In fact, and while using this psychosocial point of departure in the study of urban sonic environments, the authors have found that inhabitants often refer to effects such as echo and reverberation. This was also presented in chapter II when I emphasized *Maestro* Lino's performance in the small village of La Palmita and interviewed and recorded *Maestro* Isidro's utterances in Barranco de la Matanza. Once again, both examples draw on the idea of the environment as instrument – or '*instrumentarium'* as the authors propose – 'a reservoir of sound possibilities that shape the ways in which we relate to the same space' (p.8). A detailed account of these 'sound effects' will be given in chapter V, particularly when shifting the theoretical component of this thesis to the ways in which it might be used to inform the actual design of didactic materials for the Gomeran community.

Prior to this, it is important to finalize this chapter by recalling the idea of 'intra-action', 'diffraction' and finally the idea of 'effect' – or being 'effectuated' as Latour (2004a) might propose. These terms entail more than a simple enumeration of words; in fact, they raise an engrained methodological question. Such methodology is in strict opposition to a realist account (the physical measurement of acoustical signals) or even, to a certain extent, to the social constructivist account, in the sense that individuals are simply the fruit of social processes of enculturation. In both approaches all difference is marked as resulting from binary oppositions, where communication and information can only be considered 'in', 'out', 'on' or 'off', defined by the simple interaction between nature and nurture. When designing for the *Silbo Gomero*, this reverse of language implies a reverse of intuition. Instead of attempting to separate the differences between spoken and whistled forms of language while reducing the whistling to the level of a mere reflection or mirroring of spoken language, this pattern of 'diffraction' will draw attention to the 'effects' of such differences, as opposed to the formal, stable and representational qualities given to them a priori.

6. Final Remarks

Throughout this chapter the main locus of the discussion has engaged in a methodological quest through readings of cognition, embodiment and interaction as they move from prior concepts into situated, temporal and distributed synergies. Such an endeavour accompanies contemporary understanding of cognition as negotiated in the making of artificial agents (Beule & Steels 2006, Brooks 1991, Steels 2003) but also as it is refigured in the making of new investigative techniques explored when presenting dynamical approaches as provided by the field of neurobiology (Freeman 1990). Uncovering the history of both fields of investigation has mobilized an understanding of cognition beyond the formal and stable ideal of representation (or stable categorization) into an embodied, interactive and emergent (or individuated) account.

This has also moved the debate from a collective understanding of predefined methodologies to provisional instances that require a situated (or ethnographic) understanding from within. Particularly when attempting to mobilize a close reading of particular linguistic communities and their embedded practices these provisional instances accompany the situated and methodological challenges that contemporary investigations into the 'cognitive realm' constantly face[91], particularly when attempting to rework the classic brain-body-environment legacy, initially portrayed by a classic information-processing account of human cognition (Searle 1997).

If, previously, one could divide the *Silbo's* ecology into neurological, phonological and bioacoustic data, unleashing the entanglements of cognition, embodiment and interaction will require a new language or methodology; one that does not necessarily obey the conventional separation between a brain-science, a body-science and a culture-science[92]. In fact, mobilizing a 'grey-environ'[93] where readings of cognition, embodiment and interaction might dwell beyond

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[91] Within contemporary studies of cognition one can conceive as a move towards a more generalized need to contextualize the study of cognition. An orientation that can be read in the following: "we cannot locate meaning in the text, life in the cell, the person in the body, knowledge in the brain, a memory in a neuron. Rather these are all active dynamic processes, existing only in interactive behaviours of cultural, social, biological, and physical systems" (Clancey 2008:33).

[92] This sequence of 'sciences' is borrowed from Andy Clark (2001), particularly when referring to the methodological challenges one might face when attempting to study complex cognitive phenomena. As the author proposes: "One genuine methodological possibility, however, is to use alternate means of focusing and simplifying. Instead of simplifying by dividing the problem space (…) we should focus (where possible) on the interactions" (p.153).

[93] Here, I borrow the term 'grey-environ' from the work of cultural theorist Sarat Maharaj (2009); particularly as the author attempts to uncover the alternative knowledge provided by visual art practices as a form of non-disciplinary knowledge. "The query that crops up right away with the idea of "visual art as knowledge production" is: "what sort of knowledge?" Hard on its heels "What marks out its difference, its otherness?" Should we not rather speak of *non-knowledge* - activity that is neither hard-nosed know-how nor its ostensible opposite, ignorance? The question is especially pertinent in today's expanding knowledge economy that we should not only see as a "technological development" but as an emerging overall condition of living that I prefer to speak of as the "grey-matter" environs" (p.1).

rigidly permeated interfaces. To a certain extent, what is really implied in this methodological turning point is altogether a new understanding of the body. Particularly, as one recalls Simondon's concept of individuation and his belief in the impossibility of understanding 'being' as a static concept devoid of a dynamic trajectory of its own.

When analyzing the *Silbo Gomero* from this perspective both a phonological and a classic psychoacoustic approach (one that separates innate from learned schemas) will allow this incongruence of terms to be considered. Particularly as the methodological lines of investigation of both disciplines will help to define the whistler's body of knowledge as essentially innate or externally validated. While this methodology is relevant for those who attempt to uncover the rules of particular whistled languages, it seems inappropriate when attempting to understand not only the situated auditory 'effects' (Augoyard & Torgue 2005) of the language but also the ways in which the non-formal learning of this ancient practice might actually occur in a way devoid of a clearly delineated script. A methodology that largely omits all the pertinent experiential factors that reside 'outside' of the domain of language and, all too often, those details that are rendered in opposition to well established and preexisting 'matters of fact' (Latour 2004b).

Relocating this situated body will show the impossibility of opposing the objective body of science to the subjective body of indigenous systems of knowledge. As argued by Latour in 'How to Talk About the Body? The Normative Dimension of Science Studies' (2004)[94]: "acquiring a body is a progressive enterprise that produces at once a sensory medium and a sensitive world" (p.2). The current research is not confined to a materialist understanding of the body as such but rather to the ways in which various, natural and technical, bodies mobilize distinct experiential trajectories. If one reduces this trajectory to a 'secondary quality', one is committing the objectivist fallacy in which body, categories and subjects are simply intermediated without recurrent effects. It is a body, a category – as that of a simple vowel – and subject devoid of any learning and situated trajectory.

It is also here that one is tempted to ask: how accurate is the representation of whistler's? And without a suitable response, one is 'forced' to recognize that sounds are not equally registered by every ear. And, conversely, that the sensitivity to auditory rhythm, patterns and diffractions are not in strict correspondence to purified equations of both phonological and psychoacoustic data. Escaping this objectivation is nevertheless solvable, as long as one keeps in mind this dynamic definition of the body as explored throughout. Particularly, as it requires environments and techniques through which it can become 'affected' or 'effectuated' (Latour 2004a) mobilized and sensitive to auditory differences or articulations.

[94] Latour in reference to the work of Isabelle Stengers and Vinciane Despret.

IV

SITUATING COGNITION – EDUCATION, THEORY & DESIGN

"No gesture of the hand that holds the racket seeks a pose that the body would spontaneously strike, no English word issues from a form that the French mouth would easily outline, no ideas in geometry follow from wide open eyes, neither the wind or the birds teach us music…what remains is to seize the body, language, or the soul against the grain.
(Serres 1997:8).

1. Brief Introduction

As this body of research progresses towards the design of a language support system for the *Silbo Gomero,* this chapter will focus on the implications of situating cognition ecologically within the educational realm, moving from the position of an detached observer to that of adopting a systems approach and drawing consequences for the design of didactic materials. The sensitivity of the *Silbo's* educational community towards the development of materials that support the introduction of this indigenous form of language into the classroom (Brito et al. 2005) was especially important and raised challenges that would be encountered as education within the island incorporates computer based technologies and didactic materials[95].

With this in mind an overview will be given of discussions within the learning sciences, particularly as it has addressed how the cognitive unit of analysis has shifted from an information-processing paradigm of intelligence 'in the head' to one situated in material-historical and distributed approaches. This shift incorporates various semiotic domains – beyond the verbal-discursive and logico-mathematical – while broadening the panoply of 'intelligences' (Gardner 1993, Robinson 2006) – now understood as culturally situated phenomena (Gardner 1993, Solomon 1987). This approach is in line with early work developed by John Dewey (1929, 1963) that valorises rich qualitative experiences within the education, and the work of Donald Schön

[95] As Spanish territory and ultra-peripheral region of Europe, the island of La Gomera is part of a larger educational project towards 'modernization' of education (Balanskat et al. 2006). In the Canarian archipelago this is represented by '*Proyecto Medusa*' (Medusa Project). For more information consult: http://www.gobiernodecanarias.org/educacion/4/Medusa/GCMWEB/Code/Default.aspx

(1987) proposing that instead of an understanding of learning as a mode of 'reflective abstraction' it should be considered a mode of 'reflection-in-action'.

The discussion will then return to the exploration of the body as an ecologically bound and dynamic trajectory, where the senses, environments and techniques of inscription play a determinant role in the continuous formation of knowledge and the making of the 'intellect'. Such analyses involve a shift from previous formal-logical and verbal-discursive knowledge into situated frames of activity. This will slowly reveal a world of perceptions, techniques and manipulations, in a word – gestures. Within the field of mathematical thought this approach has been denoted as the 'feel for symbols' (Arcavi 1994, Rotman 2008); within the field of development psychology it is presented as the 'symbol systems approach' (Gardner 1993).

Approaching the domain of language, the text will take up the analysis proposed in the work of Lev Vygotsky (1962, 1978). Vygotsky considered that language in human beings is always geared, from an early age, towards a social and communicative role. This understanding is in opposition to the egocentric model proposed by Piaget. What is central to this distributed and dynamic cognitive approach, and is most relevant to the *Silbo Gomero*, is that this social and communicative role will take on board a vast panoply of semiotic domains, and not just those that are verbal-discursive. Vygotsky's understanding stems from his observation of early drawings of children, made prior to any period of alphabetization, and where the attempt to 'represent' language is already present in what the adult eye simply sees as a 'squiggle'. While formal agendas propose the learning of language through abstract and external reinforcement, Vygotsky's activity theory slowly uncovers the role of corporeality. It is also here, that 'abstraction' acquires a new meaning and does not necessarily entail a loss of the body but, rather, a new organization of distinct 'channels of symbolization' (Gardner 1993).

This analyses is valuable for those who design for learning and so the question of corporeality will take the discussion to an understanding of artefacts for learning as 'open models' (Wartofsky 1979). Conceiving of such a 'model' is not a simple task, particularly as this 'openness' is all too easily mistaken because of making a separation between 'art' and 'science' (or technology), 'creativity' versus 'rote learning'. This separation is disastrous not only for artistic practices but also for what has been termed the 'higher modes of thought'. Within this gap what is left in abeyance – in which is closely related to Simondon's work – is the role of individuation, the possibility of recreating one's own processes of change. This will lead, towards the end of this chapter, into analyses of three important approaches to design: the opportunistic model (Calmers et al. 2002), Michael Murtaugh's emphasis on 'liveness, plasticity and incompleteness' as necessary conditions for 'good' computational based design and finally David Cavallo's (2000,

2003) 'Emergent Design' within the field of educational design. In all three models, the balance between control and incompleteness is negotiated.

2. Education – Shifting the Cognitive Unit of Analyses

Moving the cognitive unit of analyses from a formal information-processing approach (cognition in the head) towards an embodied and culturally situated reading has shifted the study of cognition to distributed and ecological synergies (now studied 'in the wild' (Hutchins 1995). Most importantly, at least for the current study, it has also opened up a range of questions concerning intelligence, learning and the design of didactic materials. Whether one focuses on paradigms of 'situated learning' and its emphasis on the dynamic understanding of social communities of practice (Lave 1988, Lave & Wegner 1997), or on 'distributed cognition' (Salomon 1997) and its emphasis on the cultural-historical understanding of learning or 'constructionism' and its focus on the techno-material conditions necessary for the construction of complex intellectual processes (Papert 1993, Kafai & Resnick 1996), a common thread that links these bodies of research is a recognition that learning is an active, participative and constructive process. Most importantly, shifting the cognitive unit has further challenged the formal idea of education that stubbornly separates 'higher' modes of thought – mostly located in mathematical and verbal competence – from their situated and active practices within their cultural ecologies.

In fact, challenging the genetic epistemic model of child development as it moves from a 'sensorimotor stage' to a 'formal-operational stage' (Rotman 1977), leaving behind any necessity for grounding the process of learning in distinct 'semiotic fields' (Goodwin 2003:24) of gesture, social negotiation and embeddedness. This has not only privileged the emancipation of particular forms of intelligence, now localized in mathematical and verbal competence (Gardner 1993, Robinson 2006), it has also promoted the idea of intelligence as an individualized and localizable phenomena (Solomon 1987:xiv), so that some educational systems access and classify students through various forms of IQ and question-response testing (Wood 2007:68-87).

When attempting to 'transfer' this formal model of education – and consequently of intellect – to diverse socio-cultural settings, the impacts have provided many contributions to local development but also many misconceptions concerning which disciplines, texts, books, educational paradigms and applications should be valued to the detriment of others. For example, when incorporating multicultural curriculum within North American (U.S.A) education it has been noted that most Afro-American knowledge systems are taken by the arts and humanities but very rarely by the sciences and mathematics, largely omitting the intricate

mathematical knowledge of diverse African societies (Eglash 1999:225). The same thing could be said about the *Silbo's* half-hour class per week as well as the music and visual artistic classes that occupy a less prominent space in most of the schools of the island that were visited. Writing from another and yet very distinct island – and to give a wider glimpse of the variety of 'struggles' within specific projects of education – recent report (2009)[96] portraying the educational system in the United Kingdom presents the government's agenda for primary education. In short this approach can be rendered as: 'what children need is to learn the basics'. Against this Professor Robin Alexander (University of Cambridge) argues that this is inefficient because a process that is geared towards the three 'R's' of reading, writing and arithmetic 'squeezes-out' other forms of knowledge and also reduces the scope for experiment and creativity.

What is relevant to outline from this particular organizational hierarchy, is not so much the linear organization of disciplinary importance rather the underlying conception of how learning occurs. As explored throughout this thesis, this model was inherited from the consolidation of rational thought that emerged from the project of Enlightenment in the XVIIth century, a model that underwrote the golden age of industrialization and led into the XIXth century (Whitehead 1925). This was a century marked by great advances in technological development and by the materialization of the rational project proposed by Leibniz, Descartes and Spinoza, and was accompanied by the development of technological inventions, largely based on a formal understanding of logic and calculation.

Imbued in this logic, the process of industrialization characteristic of the XIXth and XXth centuries, put forward a new educational agenda. It was characterized on the one hand by the need to professionalize the 'working class' and on the other hand it was endorsed by the spirit of rational thought as it came to be conceptualised in the dogmas of Auguste Comte's Positivism. All knowledge that cannot be deduced from logical and observed premises (that is 'pseudo' or intuitive knowledge) was therefore removed from educational methodology (Schön 1987). This implied the negation of forms of knowledge that could no longer be expressed by the quantified and hypothetic-deductive axiomatic system as advanced by positivist agendas. It was a model that presupposed that in order for knowledge to qualify as proper – here meaning scientific – it had to be confirmed by observation and the construction of an hypothesis that could be abstracted into the formulation of particular theoretical endeavours.

All forms of knowledge that could not be geared towards the development of generalizable or rigorous knowledge were given a secondary status (Wood 2007:71), further disintegrating any potential uniqueness, locality and cultural situatedness in the making of 'other' intelligent

[96] For more information consult the 'The Cambridge Primary Review' concerning the future of primary education in England (http://www.primaryreview.org.uk/). This review was developed from 2006-10 by Esmée Fairbairn Foundation (University of Cambridge).

systems. Such as knowledge of specific bodily-manual crafts, became excluded from the domain of universities and now subscribed to the 'ghettos' of professional or industrial schools. This separation further consolidated a model that had already been proposed in Medieval Europe, one that separated the monastic and text based knowledge systems from craft-guild and task based approaches (Wood 2007:68). Decades ago, Donald Schön (1987) had already presented the turn-down of such narrow separation between these two modes of knowledge development, one that continuously figured in the separation between what universities would qualify as the higher intellectual achievements and, on the other hand, the practical professions of 'lower' intellect as described in the introductory chapter when the author refers to the words of Veblen (p.11).

2.1 From Reflective-Abstraction to Reflection-in-Action

A dramatic consequence of separating 'higher' and 'lower' modes of knowledge has been the narrow professionalization that characterizes the working (or non-workings) of our society. This has also influenced the construction of educational models where the execution of a given canonical programme is considered to be most fruitful (or safe)[97]. In the 1930's John Dewey in 'Experience and Education' suggested that this process has disconnected education from experience. Reemphasizing Schön's suggestion that while educating a 'reflective practitioner' one has to move from the idea of information transfer to the makings of such information in the first place. This shift has qualified conceptions of learning as self-discovery and appropriation of knowledge. In this sense 'design' is not only used as a metaphor for 'learning by doing' it is used as an actual methodology, one that is situated and cannot depart from a single blueprint. Schön's conception of knowledge as 'reflection-in-action', 'learning by doing' should not be confused with 'technical rationality'. Here design distinguishes itself from a formal relationship between learning and technology, where the appropriation of specific apparatus, largely defined as pure instrumental problem solving, is made rigorous through the application of specific pre-given axioms, theories and techniques.

This 'learning by doing', as framed by a design approach, has been further developed by the engineering and computational sciences, where the idea of computation as calculation is slowly shifting into tinkering with spaces of interaction (Stein 1999). Such a shift seems to suggest more than a crisis in computational science, it proposes a transformation in our ways of thinking about learning processes. As presented by Seymour Papert and Sherry Turkle (1990), it suggests a peculiar understanding of epistemology as that which conflates propositional

[97] Whitehead (1929) provides a good account of this situation: "the habit of unbiased thought, whereby the ideal variety of exemplification is discerned in its derivation from general principles cannot be acquired when there is the daily task of preserving a concrete organization. You must be free to think rightly and wrongly, and free to appreciate the variousness of the universe undisturbed by its perils" (p.93).

knowledge with a broader understanding of the making of knowledge as such. In fact, the authors were able to refute this through their detailed ethnographic account of how young programmers explore computations by using a tinkering style more in line with what would be expected from an artist. And if programmers have previously been taught that the making of computations as they are decomposed into logical sequences of steps (this also influenced the primary school curriculum, which has mimicked the same logic (Stein 1999)) this more creative way of working can open up space for ways of understanding how learning 'higher' modes of thought might be grounded in embodied experimentation.

This shift not only mobilizes a transformation within the mathematical field, it also sets up a challenge to the development of situated epistemological styles of learning. When it comes to literacy a new layer can be added to the three R's because, while the skills of reading, writing and arithmetic are essential, they may no longer progress along the simple 'transmission, internalization or even accumulation of pure syntaxes' (Salomon 1997). Recalling *Silbo Gomero* as the 'tip of the iceberg of more complex cognitive phenomena' (Meyer 2005), one can say that learning does not happen in a void of formal syntactic grids; it presupposes the construction of complex and interwoven dynamic structures in which, in the case of whistled forms of language, complex temporal-auditory and spatial exploration occur.

This brings to the fore the intrinsic and dynamic relationship between what behaviorists would define as 'explicit knowledge' (Johansson & Gärdenfors 2005: 4-7) and forms of knowledge that escape encapsulation, enumeration or quantification. This involves forms of knowledge that one might not be able to fully quantify or verbally describe, such as what polymath Michael Polanyi would describe as 'tacit knowledge', by which he means that "we know more than we can tell" (Polanyi 2003:92). This crucially indicates that learning the syntax of language – the grammar – does not equate to knowledge of a language as such (Searle 1997). 'Tacit knowledge' is therefore semantically embodied in our interaction with the world at large, the world of signs and their intrinsic sensuous modalities. Such knowledge finds, in its overall development – through performance a mode of 'reflection-in-action'. Largely challenging the approach that further pushes all unquantifiable knowledge systems and intelligences to the realm of the folkloric, artistic or even obscure.

3. The Feel for Symbols

What is particularly interesting in the 'epistemological pluralism' advocated by Seymour Papert and Sherry Turkle (1990) is that the computer – conceived as an abstract and formal machine – appears as the locus of refutation. In fact, such pluralism equates the tinkering style of young programmers with Claude Levi-Strauss' indigenous *bricoleur* who, devoid of an analytical methodology, develops complex bodies of knowledge while constantly manipulating, stretching and fabricating particular myths (here conflated with scientific theories) (p.136). The idea of the learner as *bricoleur* opens space for an alternative mode of analysis that uncovers children's preference for an intuitive method against the classical 'black-boxing' form of knowledge construction. In 'Knowing and the Known' (1949) John Dewey and Arthur Bentley analyzed the 'situated cognition' (my emphasis) of logicians, finding in their axiomatic universality a complex, situated and intricate pattern to the making of logical representations. These patterns are not singularly verbal-discursive but conceal a world of perceptions, techniques, manipulations and gestures. This helps to support the thesis proposed by Papert and Turkle in that it reinstigates the semiotic dimension.

Current studies of cognition as situated and techno-mediated phenomena also shed light on these issues. As an example, close examination of how young people learn linear equations has shown that while interacting with coordinate graphs, they soon lose sight of the initial question or problem to be solved and embark on a series of manipulations and conversations about the graph itself. When asked to predict how the line for Y= 5x + 1 will appear, the two students arrive at their answer by observing how the line, represented in the graph, changes its 'thickness' or 'straightness'. Such tinkering with the graphic representation goes on in every exercise. Although subtle, what is most interesting about this example is that the students arrived at their conclusion not by departing from logical premises known a priori but rather through a process of manipulation of the material qualities of the model. What is most pertinent about this example is that 'abstract and higher' modes of thought cannot be devoid of a situated coordination between perception and action. The students do not learn through procedural descriptions but rather through continual manipulation of relations that, in the case of linear equations, are expressed by coordinate graphs. (Clancey 2005:115) In fact within the field of mathematics and learning this mode of learning is said to encompass an underlying sensibility – a 'feel for symbols' (Arcavi 1994).

Within the learning sciences a major contribution to the situated approach to cognition, particularly as it frames the 'feel for symbols', is the work of Howard Gardner (1993)[98]. At its centre are the various phases in which individuals gain access and competence of particular bodies of knowledge through the appropriation of various symbolic domains. Here, aesthetics takes on a proprioceptive and sensorimotor value. This contradicts Piaget's view of the development of the child from a sensorimotor stage to an operational stage. It also contradicts Jerome Bruner's (1974) early theory of cognitive development where an initial enactive representation of the world (cognitive motor organization as a consequence of interaction with particular environments) would slowly give way to iconic representation (the development of perceptual gestalts) and symbolic representation (verbal discursive representation), erasing each previously accomplished step along the way[99]. Various 'intelligences' or symbolic domains, both mathematical and spatial, are at work when two students tinker with a coordinate graph (without further consideration of a communicative intelligence as the students exchange ideas through conversation). To a certain extent the mathematical intelligence is based on a visual spatial tinkering that is essentially perceptual and sensorimotor. Using the work of Rudolf Arnheim as a reference, Gardner would consider that this spatial (or visual) thinking emphasizes the role of non-verbal discursive cognition in processes of learning. While maintaining an embodied relation, therefore, various modes of intelligence open up a path for active exploration of diverse domains of knowledge, invention and construction.

Between the ages of two and five most individuals gain access to a vast repertoire of symbolic systems. Here, songs, plays, choreographies and various material designs gain a special value. An interesting recursive pattern of such process of development is made when the individual starts notating these symbolic systems. This is tied not only to alphabetization but also to musical notation systems, diagrams, codes, dance patterns, to name just a few (Gardner 1993:311). Gardner calls these symbolic mediums 'channels of symbolization'. These channels not only refer to notational systems such as developed through writing but they may acquire various material and processual characteristics[100], opening, within themselves, distinct semiotic possibilities.

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[98] This approach devised by Gardner (1993) – known as the 'multiple intelligence approach' or the 'symbols systems approach' – draws on the earlier phenomenology of knowledge of Ernst Cassirer, the semiotic philosophy of Susanne Langer and the work of Alfred North Whitehead. There is a connecting line amongst these authors, one that focuses on human symbolic faculty as a locus of analysis.

[99] It is important to note that in his later work Bruner (1996) reformulates this approach.

[100] An important reading of the various cultural appropriations of these channels of symbolization can be found in studies of ethnomathematics (Eglash 1999, Eglash & Tedre 2008). In fact when analyzing the development of fractal geometry one can sense ways in which algorithmic (or computational) concepts are, to a certain extent, 'universal'. Despite the fact, they will largely differ in their designs, meaning also, that alternative 'channels of symbolization' are opened through distinct processes of individuation.

The *Silbo Gomero* is an example of this process. Even though it is developed in consonance with spoken Castilian, its ecological milieu opens pathways to unusual symbolic combinations, where dynamic and situated spatial-temporal auditory phenomena become key. In fact, the *Silbo* appears to contradict a common assumption: the idea that as the individual grows older they will become reluctant to experiment with diverse symbolic systems. This relates to a theory of biological development that sees this reluctance as being in strict correlation with individual loss of an initial cognitive plasticity (Gardner 1993:314). In fact, and while further situating a reading of the *Silbo Gomero* within Gardner's own investigative efforts, when researching various linguistic, musical and spatial modalities the author sensed that many individuals or cultural groups are able to preserve a certain plasticity as they relate to the creation and ecological manipulation of distinct symbolic channels. In this sense, symbolic cognitive development is not the exclusive 'problem' of a cognitive (or brain) science. On this point Gardner argues that if the role of formal education is to furnish the individual with the symbolic channels most relevant to each culture, then a more intrinsic understanding of those systems as distributed phenomena becomes crucial.

With this in mind Gardner looks at European, North American and Japanese educational models, particularly as they draw on a history of notational, algebraic and alphabetical systems. It is also, and within these cultural spheres, that young learners are usually motivated to learn the proper ways in which to deploy these 'channels of symbolization'. In this process playful engagement with symbolic systems is often avoided and considered an undesired distraction from the learning process (p.312). However, while mastering a symbolic system should be the concern of any grounded and fruitful learning process, opening places of material experimentation only insures the possibility of using these channels in unpredictable ways that might actually lead to the creation of new symbolic domains (p.313). It is with this necessity in mind that Susanne Langer (1942) had previously argued that the formal qualities of objects – such as their triangularity, circularity, etc – might be learned not through the conventional enumeration of pure physical (primary) quantities, but through a 'sensuous conception' of the performative (secondary) qualities of objects and their construction as such (p.92). A passage that can be illustrated when one substitutes the phonetic measurement of sound by the perception of sound amongst Gomeran whistler's. In this sense, and taking the eye or ear as the locus of an ecologically situated perceptual activity, symbolic knowledge systems may not always be described through practices of quantification, opening way for a panoply of potential sensuous modes or exploratory models.

3.1 Language and Activity Theory

The question is raised: how will the 'feel for symbols' figure in the development of language? To answer it, one needs to recall the critique of cognitivism that took place within the learning sciences during the 1980's (Gärdenfors & Johansson 2005), a movement that was accompanied by the emancipation of previous cultural-historical approaches to learning (Salomon 1997). This shift would further challenge Piaget's constructivist learning-paradox, while arguing that thought or 'intelligence' is organized as an emergent phenomena (Salomon 1997:viv), where cultural and techno-material distributed organization becomes key. In fact, and even though the genetic epistemic agenda and its constructivist flavour conceived of cognition as activity, this same activity should now encompass a complex interrelation between historical and material processes of enculturation. Learning is no longer conceived as an assimilation of the external physical environment in a state of equilibrium as the project of genetic epistemology would propose. Here, a self-reflexive circle is open. This environment is ecological and conceals intrinsic modes of organization. To further support this intuitive and methodological challenge, the ideas set forth by Piaget would be largely contrasted, and at times complemented, with Soviet school of activity as originally proposed by Lev Vygotsky and others (Vygotsky 1962, 1978).

If Piaget conceptualized the development of speech as the child moves from 'egocentric-speech' to social-speech as the culmination (in the operational phase) of a formal-logical understanding and epistemic formation of thought, Vygotsky would take a distinct approach in which the development of speech encompasses a primordial social and communicative function that develops in consonance with other symbolic activities and their panoply of semiotic domains (Vygotsky 1978:23). Vygotsky was greatly influenced by the Soviet intellectual and post-revolutionary turmoil and so any consideration of this particular approach has to account for Marx's ideas concerning the phylogenic evolution of the human intellect, which was largely influenced by Darwin's theory of evolution, now to be conceived as a 'dialectical and historical materialist' phenomena (p.6). This implies that all phenomena has to be understood along its own lines of structural transformation through action, and that furthermore, largely neglected by genetic epistemology, these changes are rendered through various material transformations (for Marx, the role of labour and tools) (p.7).

Central to this discussion is the concept of categorization. For genetic epistemology categorization is conceived as a predictable consequence of nature's own regulatory processes, but for activity theory, particularly while taking on board dialectical materialism, nature is not regulatory but rather constitutive of historical transformations as they are deployed, transformed and manipulated by means of various tools. Any consideration for the enactive and symbolic

nature of thought has to account for this possibility of material transformation (p.6). Genetic epistemology and activity theory share the idea that the intellect is a construction, where they differ is in the place or unit they assign to this construction. For activity theory, construction will involve, within the field of education and learning, a methodological shift. Rather than focusing on the study of language and other complex bodies of knowledge (such as logico-mathematical thought as proposed by Piaget) as independent intellectual achievements, activity theory proposes that these achievements are in a constant dialectical process of construction not discernable from the society's cultural activity. If classical psychological behaviourism considered all behaviour (including language) to be a simple response to stimulus (here taken as social stimulus), Vygotsky (1978) would introduce the idea that 'individuals actively transform the stimulus situation as part of processes of response' (p.14).

This will cause Vygotsky to actively explore the role of methodology within the context of psychological enquiry. When studying language, particularly speech, the Soviet psychologist will attempt to study children in the most unexpected situations of play. Where verbal-discursive language and alternative semiotic dimensions (such as gesture or writing) co-participate with communal activities and the manipulation of artefacts. When analyzing writing as another symbolic channel the Soviet psychologist denotes that when learning how to write – one of the most precious technologies of the time – children are simply taught to trace out letters, so relegating 'living written language to the background' (p.105). Here, Vygotsky introduces the idea that notation conceals a life of gesture. In order to teach writing one has to understand the history of writing systems as they connect to the first drawings of children and the development of play through various games that they continuously reinvent. Vygotsky showed how many pre-school children use their (squiggled) drawings as linguistic notation systems and it follows that children might start learning reading and writing at a much younger age and that these gestures cannot be taught as rote motor skills considering they are intrinsic to complex communal and material activities.

This is where processes of individuation, as suggested by Simondon, gain strength and meaning. This also outlines the critical passage from drawing objects towards 'drawing the movements of speech' – when learning processes gain a dynamic and sustained embodied dimension. And while my research focus does not entail a design that safeguards mechanisms of particular visual notational-linguistic systems, this example opens the way for a more intricate understanding of how the life of gesture might be introduced into the learning of language. In fact Vygotsky's work challenges the way that alphabetization is conceived as an imposition of mind over body (Ong 1982, Rotman 2008). Adding a twist to this linear progression conceals a sensuous and material dimension of language, where both visual and auditory notation systems

(and here it is important to keep the *Silbo* in mind) imply the 'abstraction' of speech. However, such abstraction does not necessarily entail a loss of corporeality but rather a new organization of symbolic channels – the gestures of the hand, or of the ear.

4. Models as Cognitive Artefacts

In evaluating the role of contextualization, play and gesture within processes of learning there is again much of value in the work of John Dewey (1963), particularly as the philosopher emphasises the role of experience. But what is new is the ways in which computational mediums have 'afforded' (Gibson 1966) distinct ways of relating various semiotic dimensions within the development of 'higher or abstract' modes of thought (Salomon 1997:xiv). Taking the enactive approach to cognition explored in the previous chapter, the place of gesture has far-reaching consequences for perception, design and learning while carrying the life of language – or that of mathematical concepts – into all those processes assumed to be pre-rational or purely subjective. For those concerned with an educational design that promotes 'epistemological pluralism', material modes of perception gain a new value through various didactic models. However, by model no external reality is presupposed, it should rather be understood as 'cognitive artefact'. This term, presented by Marx Wartofsky (1979), follows a similar pragmatic and epistemological line as Dewey, where action and experience are necessary conditions in the construction of knowledge. Here, a model is devoid of any a priori content awaiting proper codification; on the contrary, the making of knowledge can only happen in its continuous act of appropriation and the model is not a model 'of' the world, a container of worlds, it is a 'mode of action' (p.xv).

Such conception opens the way for Wartofsky's discussion and concern about the separation between art and technology within the educational discourse and practice of his time. Here, the idea of bringing 'art' into the classroom generally represents material exploration as 'arty' practice, fruit of pure creativity. This must stand in opposition to procedural and analytical thought and can only be conceived as something 'subjective', 'free' and 'open' that 'you just have to do' (Wartofsky 1979b: 349). In fact much contemporary critique of constructionism, as initially proposed by educational technologist Seymour Papert, has fallen under this same conception (Papert 1996). Most seriously, at least for those who teach artistic practices, this poses an intrinsic burden where the role of the art class (as physical education and other non-analytical sciences) is now relinquished to a small time frame within the overall disciplinary overload, where its primary function is to allow children to 'release tension' (p.349). For Wartofsky, this model is a true representation of contemporary society and its notion of work and play as being incompatible. More dramatically, it perpetuates the idea that if a good educational reform wants

to introduce more 'freedom' and 'experience' into curriculum it will have to replicate this 'arty' conception of art while the old model can be neglected along with its professionalizing and technocratic vocabulary (p.350). Within the dualism, the role of technology falls into a trap, split between the 'arty' conception' of knowledge construction and a formal model of technocentrism.

It is also here that an earlier discussion of the 'feel for symbols' is linked with this 'epistemological pluralism'. The focus is not necessarily directed towards the subjects to be learned – even though there is rising concern for rethinking the notion of literacy itself (di Sessa 2001, Gardner 1993, Robinson 2006, UNESCO 2004) – but rather towards rethinking which processes should instigate more fruitful paths in the development of knowledge. In this sense, the idea of teaching mathematical or verbal competence through a 'feel for symbols' – for long associated with 'intuition', 'irrationality', 'emotion', the 'metaphysical' (Langer 1942) in one word, the uncountable – presents a challenge to the educational separation between 'art' and 'technology'.

In line with Schön's (1987) 'reflection-in-action' knowledge that is formed through practice cannot be reduced to 'academic' or 'bookish' (Whitehead 1929) forms of textual-discursive knowledge. 'Cognitive apprenticeship' cannot be separated from its contextual activities, a fact that can be seen when comparing how children learn vocabulary in school while using the dictionary with how children learn vocabulary in the playground during moments of social interaction. Here, what 'holds' the learning process is its context of use one that is replete with various semiotic dimensions. Mostly dismissed as 'noise', here, they represent the central concern for those who embrace a situated approach to learning. This challenges the common classroom task where the role of construction, models, symbols and the range of material panoplies are reduced to contextual backgrounds devoid of any central role. (Brown et al. 1989:7)

However, here, it is important to proceed with care. For today it seems tempting to relinquish such dimensions to contemporary computing power afforded by computer graphics, video games and other audiovisual simulations. The locus of semiotic dimensions does not reside in the artefact because the model is 'open' (Wartofsky 1979), relational and processual. In fact, as presented in the analysis of two students tinkering with a coordinate graph such process might be regarded as highly distributed and involving a material appropriation, fabrication and dialogue that cannot be fully contained in the material form of particular artefacts.

Once again, Simondon's (1958) work is significant here, now directed towards technological investigation since he does not reduce technology to a mere utilitarian function; rather, technology always implies 'technicity', an ensemble of various variables. This ensemble cannot be reduced to a grouping of machines because it continually delineates a relation between

machines and the human being who uses them, between human beings and their ecological milieus and the various materials provided by this environment. Here, technology cannot be confined to the computer or to any other particular element (the Internet or a new interactive screen) but rather to the ways in which technology continually reproduces the relation between people and their environments. Introducing the 'feel for symbols' within learning processes in techno-mediated milieus should further incorporate this relational account.

In this sense, the 'feel for symbols' should not be confused with the information-processing model and human-factors approach most commonly deployed by the field of human computer interaction (Card et al. 1983). Here, the model is an open model awaiting appropriation rather than a fixed departure point that sustains correct assimilation and codification. Such codification is based on the information-processing paradigm where interaction between user and computer can be fully designed upon the basis of discrete sequential steps of interaction, as in the early cognitive educational models made by Patrick Suppes[101]. This model has been a great success as an industrial and educational application but it falls short of any true sense of an 'open model', adaptable and improvised conversation[102], which are necessary conditions when developing a corporeal dynamics in the process of cognitive apprenticeship.

4.1 Challenges from a Constructionist Agenda

It was, in the 1960's, and with similar active participation in mind, that educational technologist Seymour Papert first developed the LOGO programming language to be used by children. Largely concerned with the failures of a formal instructional paradigm, particularly as it emphasized obsolete modes of rote learning, this programming language was developed with the

[101] In the 1970's Suppes developed the Computer Curriculum Corporation systems in the E.U.A. These applications presented the learner with an exercise, once solved, and depending on the 'correctness' of the answer, the system would take the learner to a 'higher' and more complex exercise. This system intended to be used in an individualized setting and for this same reason was highly valued, particularly when attempting to improve the grades of low-income students in arithmetic, reading and spelling skills. The success of the system consisted of two important features: it dealt with generalizable literacy skills and could be applied to individual learners, guaranteeing mass-educational success. However, under evaluation, Suppes's system proved simply to reinforce childrens' meta-cognitive skills within particular prescribed areas (Solomon 1986:8-9).

[102] Here, it is important to refer to the work of Gordon Pask when designing SAKI (Self Adaptive Keyboard Instructor) (Glanville 2008). In similar vein to Skinner's learning machine, SAKI added a particular twist to those attempting to learn typing. Here the output provided by the machine did not follow a linear formal path of reinforcement – correct or incorrect – rather it was adapted to the performance of the typist, providing unexpected exercises in the course of interaction. If a psychological theory of behaviour would conceive the machine as a teaching machine, Pask's system was more in line with what today might be described as 'computer aided learning' (p.62). At the basis of this transition, from teaching to learning, was Pask's 'Conversation Theory' (Scott 2008:19-34). It was greatly influenced by Heinz von Foerster's second-order cybernetics, a conversational model that attempted to explore the ways in which knowledge (or meaning) is co-constructed through ongoing interaction between distinct agents.

intent of radically changing the learning of mathematics while teaching children how to programme when creating their own graphical environments. Beyond the premise of learning as embedded activity, Papert attempted to reinstantiate Piaget's constructivist paradigm, particularly the belief that children have to actively to construct their own intellectual processes. Despite the Piagetian influence, Papert, under the rubric of 'constructionism', partially disagreed with some premises of genetic epistemology, particularly the idea that all 'higher' modes of thought can be fully explicated along a universal and already (logically) axiomatized paradigm.

Even though, at times, this constructionist agenda still holds faith in the idea of mathematical thought as a 'natural experience'[103], the project has mobilized new interesting ground within the educational domain. In fact, Papert has always privileged the belief that children should become appropriators of their own structures of knowledge, largely challenging previous instructional models. The initial challenge was to remove from mathematical educational culture all factors of alienation (Papert & Turkle 1990) and deliver their initial transgression, beauty and freedom, or rather new distributed-logics of control as the cybernetician Norbert Wiener might have proposed (Eglash 2000).

To the extent that this work is relevant for this thesis, Papert's constructionist agenda set a new flavour for educational research and the design of computational based artefacts and programmes. The new emphasis has stretched the use of the computer, now becoming an 'object-to-think-with' (Ackerman 1996). This is where the Logo programming language distinguishes itself from its contemporary attempts to reformulate the learning of mathematics[104]. Despite the many endeavours to situate the development of mathematical thought in children's grounded activities, most work has shared the common assumption that mathematics is inherently logical. Papert, while insisting on principles of flexibility and incompleteness (in the sense that all problems are constructed from a 'raw' given language) of the LOGO environment, proposes a new radical agenda for the learning of mathematics, where children are able to invent their own mathematical topics.

Papert's 'constructionism' emphasized a new 'epistemological pluralism' in the learning of mathematics (Papert & Turkle 1990) which was supported by his experiments with the Logo programming language, particularly when observing how children construct their own environments through a tinkering logic of 'debugging' and 'decomposability'. When 'debugging' children have to 'construct', 'test' and at times 'modify' what they initially constructed, which requires from the learner a certain organization of thought (of course, along the lines of Logo's

[103] This is not to say that mathematical knowledge is not 'universal' to human cultures. However, it is always co-created and the ways in which it is fabricated and applied will lead to distinct bodies of knowledge, as confirmed by the field of ethno-mathematics (Eglash 1999).
[104] See for example the work of Patrick Suppes and Robert Davis (Solomon 1987)

procedural language). Also, when the learner is writing a set of procedures that will move a computational object – such as the figure of a turtle – in circular forms, the child has to learn how to decompose this action into a particular hierarchical structure of steps that do not solely entail a few 'first-order' propositions (Solomon 1987:117). For a programme, defined specifically by formal-logical methods, this entails a specification of computational objects as a complex set of situated procedures. Papert's (1993, 1996) conception of the child as designer further emphasized cultural materials and ways of thinking about learning as opposed to the focus on teaching.

If Papert would see in functional programming the creation of new embedded computational artefacts and concepts, largely challenging the basis of the mathematical curriculum, more recently educator and technologist Mitchell Resnick has built upon his 'Logo Environment' the new 'StarLogo'. Based on principles of parallel computing, Resnick draws a major 'advantage' for learning about mathematics and decentralized systems. Resnick focuses the learner's attention on the minute interactions between distinct computational objects as opposed to an understanding of computation as departing from one single logical premise and arriving at pre-determined end-states, the term he uses is 'local interaction'. According to Resnick, the learner is not only exploring decentralized systems, she is building a decentralized mindset of her own and developing new ways of thinking about systems in general (Resnick 1996:258). It seems that the 'StarLogo' is a playground for the future development of the systems thinker[105]. Instead of 'mathematizing' the child (Solomon 1987:119) into a set of spatial descriptive geometries, as with Papert's model, the environment proposed by Resnick 'mathematizes' the child into new complex modes of systemic thinking[106]. For Resnick, such an exercise challenges the common assumption that a flock of birds must have a leader. By exploring this particular example the child is able to conceptualize new modes of dynamic organization not only in biology but spreading out to thought in general, opening new possibilities for the creation of computational based artefacts beyond the confinements of formal-logical systems.

This shows ways in which the constructionist paradigm proposed by Papert has been appropriated by distinct disciplinary enterprises and is by no means restricted to the learning of mathematics (Kafai & Resnick 1996). As a self-recursive turn, the constructionist motto of 'learning by manipulating the computer' or 'learning by doing' – which is also reminiscent of the educational work of John Dewey (1929, 1963) – has yielded its own intrinsic problems. Most important, and while focusing almost exclusively on the computer as the locus of design, the field

[105] The turtle was a representation used by Papert in the first Logo environment and derived from Grey Walter's cybernetic robot the tortoise. While using the Logo environment children could programme the turtle's action while developing complex geometrical notions (Solomon 1987:105).
[106] This is visible when attempting to incorporate fifteen turtles (described in the note above), assigning distinct distances between them, assigning their chosen 'buddies' and then setting them out to interact while displaying complex patterns as exhibited by bird flocks in the act of group flight (Resnick 1996:261).

has developed a stronger inclination towards the idea that multiple literacies might be supplanted by an encompassing 'computer literacy'. This is most visible in Resnick's appropriation of the LOGO environment as a means to develop systems thinking along various domains of knowledge. If a centralized approach would encompass all knowledge as logically progressive, the new decentralized approach will impose a reverse of intuition, which is un-malleable nonetheless. The locus of discussion remains more technocratic than it was ever intended to be and it takes the computer – as it is culturally conceived – as the locus of intellectual infrastructure[107]. Once again, it is important to return to Simondon's concept of 'technicity' (Mackenzie 2002:11) as the very idea of 'computation' interlaces specific geographic, social, economic and historical appropriations. In this sense the approach leaves a trace of technocentrism, where successive learning paradigms simply accompany the enabling power of computational technologies. Taking very literally Marshall McLuhan's (2001) 'the medium is the message'. When looking at the powers of computational medium it seems fair to ask: what computational power are we speaking of?

In fact, and with a similar concern in mind, Papert (1990) has further criticized the technocratic vision that sustains today's global determination of bringing technology into the classroom. Even if one considers this to be urgent and necessary it should not be bound to commonly accepted interpretations of the 'beneficial' effects of computation in modern societies. These same 'effects' might provide powerful computer graphics, faster Internet, complex simulations and interactive whiteboards in the classroom but they make very little contribution to the overall discussion of the role of technology in development and learning. In fact, there is one particular project that raises further contradictory positions, the OLPC (one-laptop-per-child) project. This inexpensive, simple and multilingual laptop, designed for children in 'developing countries' has been widely accepted in some nations. However, many other 'developing' nations still see this project as the fruit of a very particular – and largely 'Americanized' – approach not only to education but also to the overall concept of development (Eglash & Tedre 2008:98). This particular idea of technology as a necessary condition not only loses its universal pretence; it also loses the 'cheerful mood' in which technologies might be simply 'transferred' from one cultural context to another.

Even if one decides to focus on 'developed' countries the evaluation of the benefits of technology tend to generate antagonistic positions, particularly when debating the inherent problems of contemporary educational systems (Papert 1990). It is also here, in this profound division between the 'good' and the 'bad' aspects of technology, that one might drift between

[107] See for example Andrea diSessa's (2001) discussion concerning computational literacy as an infrastructural model for contemporary educational systems.

strict technocentrism and false 'humanist' conceptions of the technological as alienating. In this sense, if the constructionist agenda attempts to provide a wider impact in the lives of those who learn, at times it has been appropriated as providing justification for the necessity of computational based technologies. In fact, to a certain extent, the constructionist paradigm has fallen into trap of separating the technological from the cultural. Here, it seems relevant to come to terms with what Simondon (1958) proposed as the 'margins of indetermination of the machine'. The problem with both technocentrism and technophobia is that they support a view of the machine as already formulated (and therefore the learning subject simply cognitively mirrors its underlying architecture) as opposed to being what always pertains to complex processes of individuation. In this sense one loses sight of the contemporary machine as a model, an 'open machine' (Simondon, p.4), one that is part of a wider ensemble that also includes communities and their cultural praxis. In this sense it seems reasonable to finally lose sight of computational power as self-evolving and unstoppable external force that education simply needs to adopt.

5. From Blueprints to Emergent Design

This 'open machine' further mobilizes the dynamic approach to cognition as discussed earlier, particularly through the work of neurobiologist Walter J. Freeman. If a dynamic account would promote the development of an embodied and situated approach to human cognition, here it is similarly directed towards the design of educational computational technologies, a contribution that follows two important design models. The first model is 'opportunistic' design – not to be confused with selfish – as proposed by the Equator project[108], particularly as it integrates forms of both physical and digital interaction. One of the guidelines is that users best interact when they can literally appropriate the system. This creates diverse paths for construction and further exploration of models with distinct organizational qualities: 'the pessimistic, the optimistic, the cautious and the opportunistic'. 'The pessimistic only deals with information that is conceived as correct (what might be rendered as the *Silbo's* phonological account), the optimistic system shows everything and assumes all is correct, the cautious system explicitly presents uncertainty and finally, the opportunistic system exploits uncertainty to its fullest potential' (Calmers et al. 2002:2-3). Taking this lexicon as an interesting alternative to an almost dogmatic idea of 'user-friendliness' or even 'rote learning', will actually reinstantiate the idea that the development of language – whether natural or synthetic (Steels 2003) – is above all

[108] The 'Equator project' developed by various British institutions proposed to "address the technical, social and design issues in the development of new inter-relationships between the physical and digital". For more information go to: www.equator.ac.uk

opportunistic as it is embedded in situated and complex modes of organization of distinct social, cultural and material coalitions that simultaneously exploit various semiotic dimensions.

This celebrates what Michael Murtaugh (2008) presents as central themes when designing for interaction, as it emphasizes the place of "liveness, plasticity and incompleteness". 'Liveness' in the sense that not all possible paths of interaction can be pre-programmed and this opens up potential and unexpected paths for exploration. 'Plasticity' in the sense that the designed artefact, medium or system can be shaped to one's intent and 'incompleteness' as a degree of openness of the system when incorporating 'unpredictable input', what the information-theory approach to cognition would denote as 'noise'. The designer combines these ideas with a contribution provided by Peter Wegner in "The Paradigm Shift from Algorithms to Interaction" (1996). And proposed by Stein (1999), this resource frames a paradigm shift within the computer science community, one that is moving from 'mainframes to workstations and networks, from number crunching to embedded systems and graphical user interfaces' (p.1).

This marks the making of computation as pure syntax to the actual embeddedness of computations in real world environments, replete with semantical qualities that are not prone to algorithmic formalization given a priori. In this sense, real world embedded computations have to play with unpredictability and noise in unforeseen ways. Even though Wegner challenges the incompleteness of algorithms through the axiom of interaction, what is really implied is the making of new algorithms altogether. Here, the problem is not to consider interaction in opposition to algorithmic computation but rather to select algorithms – or blueprints – that are not exhaustible a priori.

Shifting from algorithms to interaction provides more than theoretical or metaphorical insight. If computational metaphors have for a long time occupied an important place in the conceptualization, modelling and testing of cognition, learning, mental schemas, behaviour and interaction (Boden 1981), it seems reasonable to reinscribe such computational metaphor. The challenges faced by new computational paradigms entail the impossibility of distinguishing rationality from pluralistic empirical enquiry (Chaitin 2004, Wegner 1996). For education this entails the design of pluralistic empirical models as they interweave the possibility of 'making' knowledge, interaction and representations as such. If Walter Ong (1982) would see in printing press technology a metaphor for spatial objective thinking, it seems pertinent to shift this same metaphor to new computational paradigms as they collide algorithms and unpredictability in interesting ways.

With this metaphorical turn in mind, distinct conceptions of experience, interaction, knowledge, space and time might appear. In this sense taking a computational metaphor does not entail a technocratic point of departure. On the contrary it engages the very essence of

contemporary processes of individuation as already embedded in this metaphorical and techno-material space of intervention. If the computer as calculating machine has been taken so seriously in the understanding of cognition, learning and the working of societies in general the remodelling of this same principle of calculation as one that accounts for uncertainty – as proposed by Godël (Hofstadter et al. 2008) – will certainly bring new interesting paradigmatic changes. While this is already under way as proposed by neurobiologist Walter J. Freeman there is more terrain to uncover when designing for situated learning environments.

Rendering these contributions – as provided by the 'opportunistic model' (Calmers et al. 2002) and Murtaugh's (2008) insistence on 'liveness, plasticity and incompleteness' – a new challenge is presented to those who design computational artefacts for learning. One that was already proposed by Edith Ackerman (1993) and that can be read in the following: 'How much should be built into the system and, on the other hand, how much should be left for the user to add, change and uncover?' This delicate balance should be kept in mind, particularly when one considers that simply defending the motto of 'learning by doing' does not necessarily lead to a rich learning experiences. In the words of Dewey:

"Any experience is mis-educative that has the effect of arresting or distorting the growth of further experience. An experience may be such as to engender callousness; it may produce lack of sensitivity and of responsiveness. Then the possibilities of having richer experiences in the future are restricted" (Dewey 1963:25).

With this passage in mind the philosopher attempted to figure out ways in which simply stating that education should involve 'creativity', 'art' or 'experience' might also entail mimicking, mechanical reproduction and rote learning.

5.1 Situating Design Praxis

One way to find a balance between what is 'built into the system and what is left for the user to add, change and uncover' is to shift the 'opportunistic, live, plastic and incomplete' guidelines beyond the design of an interactive architecture and further contextualizing its design amongst local knowledge systems. This considering that the design of 'open models' only gains value through their contextual appropriation. This approach further emphasizes Simondon's (1958) idea that we cannot find, or even delimit, the genesis of each technical object in its grand plan, this considering that the genesis of each technical object cannot be prioritized over its actual use (p.12). In fact, a preference for 'concrete technical objects', a true 'situated perspective', renders the impossibility of deploying some of the theoretical frameworks as proposed by the field of human computer interaction (HCI) and its contemporary influence on educational design.

Here the activity theory of Lev Vygotsky seems to have been continually appropriated with considerable unforeseen 'legislation'. A compromise that is expressed by Bonnie Nardi (1996) in the following:

"difficult though it may be to compare and generalize when the subject matter is people, it is nonetheless important if we are to do more than simply write one self-contained descriptive account after another. The more precise, careful, and sensitive comparisons and generalizations are, the better. This is true not only from the point of view of science but also of technology design" (p.92).

This approach, provided by the field of HCI, further clarifies a particular understanding of design but falls short when one considers the shift from blueprints to contextual and situated forms of design as local intervention[109].

Prioritizing the contextualization of educational design projects within specific local and cultural platforms will challenge such theoretical guidelines. Eve more if one considers ongoing shifts within the field of HCI itself, particularly as it embraces a new 'situated paradigm' (Harrison et al. 2007), one that cannot be fully accounted through generalizable rules given a priori. For those who attempt to design for learning within culturally situated contexts this shift renders what educational technologist David Cavallo (n.d) would defend as the incessant need to transform the design of educational reforms from a top-down approach to a paradigm of 'emergent design'. In fact, and while finding subtle, but nevertheless pertinent, similarities with an ecological and ethnographic study of the *Silbo Gomero* – particularly as this form of language shifts from the fields and into the classroom – this 'emergent design' model was developed by Cavallo when collaborating in the development of the 'Lighthouse project' in rural Thailand. This project was initially developed as a response to the Thai government and its attempt to modernize the countries' educational system while emancipating the use of computational based curriculum and forms of engaged learning by doing (Cavallo 2000:773).

However, one of the critical moments of this project was to conceive ways in which one might take such educational transformations into rural areas where teachers were mostly thought as incapable of embracing such transformations and where local knowledge systems were largely conceived as unscientific. This lead Cavallo to adopt an 'emergent model' where educational

[109] A similar critique is present in the work of Howard Gardner (1993): "It is always judicious to begin a review of the goals of a particular intervention or of a whole educational program. The more specifically these goals can be articulated, the more shorn of rhetoric or generalities, the better" (p.383). This situated approach finds an interesting articulation with ethnographic accounts provided by the field of human computer interaction (HCI) and largely explored by the 'situated action model' (Suchman 2007): "insofar as actions are always situated in particular social and material circumstances, the situation is crucial for the actions interpretation" (p.176). Human computer relations are then emergent and might not follow a pre-programmed and engineered path. Largely challenging an industrial lexicon that stubbornly insists on notions of the 'user-model' (p.179).

designs or technologies would have to adopt to existing local culture as opposed to forcing these rural and local communities to embrace pre-scripted – and so to say, 'modern' – technologies. In the midst of developing this project the designer sensed an ongoing 'combustion-engine design culture' (p.777) that was given little importance within the space of the classroom since it did not figure as valid scholastic knowledge. While introducing the use of the LEGO Logo[110] programming environment to local children, Cavallo would draw on the same 'engine design culture' and its informal body of expertise, further enhancing the development of ongoing local knowledge systems. In fact, systems that find similitude with what academically would be conceived as knowledge in the fields of 'engineering, control, mechanics and physics' (p.779).

Much in line with contemporary approaches to 'ethnocomputing'[111], Cavallo's 'emergent design' model reemphasizes the importance of outlining distinct socio-cultural intricacies of distinct groups as part of design practices. Here, it is important to move from a 'hierarchical' to a 'heterarchical' system[112], while shifting the 'computer' as the locus of design to the ways in which it is appropriated, further emphasizing local forms of 'intelligence' and their surrounding 'literacies'. This paradigm of 'emergent design' presents pertinent guidelines that can be read in the following:

Old Paradigm	Emerging Paradigm
Primarily Static System	Dynamic system
Certainty	Uncertainty
Standardization	Customization
Avoiding Change	Encouraging Positive Change
Average Case	Individual Case
Hierarchy	Heterarchy
Centralized Control	Decentralized Control
Mass Production	Customization for Small Groups
Eliminating Surprise	Taking Advantage of Serendipity

For more information consult Cavallo (n.d:91).

For design this implies a shift from the computer as the locus of educational transformation, the software as pre-specified instrumentality; from the problem of simply designing form and function, and step into the making of intra-actions as such. This takes on

[110] The LEGO Logo programming environment is a successor of Seymour Papert's Logo programming language, now directed towards the construction of robot Lego bricks. For more information on this topic consult: http://llk.media.mit.edu/papers/BCK.html

[111] 'Ethnocomputing' is a term devised by Ron Eglash and Matti Tedre (2008) and that encompasses three important approaches to the design of computational based technologies. First, how computation might be approached from specific and mostly indigenous knowledge systems; second, how technologies form part of complex socio-cultural networks and third, how, these technologies after being designed and fully formulated, might be appropriated by diverse cultural contexts (p.92).

[112] "Heterarchy may be defined as the relations of elements to one another when they are unranked or when they possess the potential for being ranked in a number of different ways" (Crumley 1995:3).

board not only the situated nature of the locus of design it also emphasizes the temporal character as a necessary condition for appropriation. Designing space and time appears as better frame of departure. Here, computational environments extend to the nature of activities and the intellectual or semiotic frames entailed by the same. At this point, learning is not framed in the minds of the one who learns; these processes stretch over into a network of co-participating actors each one with a relevant role in the process of decision-making and successful implementation of new didactic materials. Designs are not given a priori value and they entail more a plan for action, a plan for an actual course of actions as artefacts are used but also appropriated by the community for whom the design is intended.

Here, it is important to note that this same model is, for most schools, a problematic point of departure considering that most materials, textbooks, software and educational agendas obey hierarchical, governmental and centralized decision making policies. Even though this contribution does not entail a further investigation into such broader implications, 'emergent design' presupposes not only a way of looking at the design of specific learning environments and materials, it has profound implications – as demonstrated by Cavallo himself – within a broader infrastructural coordination, a true task for 'metadesign' (Wood 2007).

6. Final Remarks

Culturally situated and techno-material distributed frames of investigation and research within the educational field has opened space for 'epistemological pluralism' (Papert & Turkle 1990), a 'feel for symbols' (Arcavi 1994, Rotman 2008) and exploration of previously neglected 'channels of symbolization' (Gardner 1993). This has been accompanied not only by new theoretical contributions from the learning sciences (Gardner 1993, Lave & Wegner 1997, Salomon 1997) but also through techno-material fabrications within the field of computer design (di Sessa 2001, Papert 1993, Kafai & Resnick 1996). Both have engaged with concepts not necessarily driven by prior cognitive and behavioural or psychological models of learning (Gärdenfors & Johansson 2005, Salomon 1997).

A paradoxical situation emerges, considering that education today finds itself being questioned by the development of calculating machines. This has had profound implications not only for computational or mathematical educational projects (Stein 1999, Wegner 1996) but also affects most areas of knowledge production that have been rendered through such a formal and calculative bias. This brings new challenges to those who engage in the design of didactic materials, particularly as the community reviews conceptions of 'higher' and 'lower' forms of knowledge, black-boxing versus tinkering, rote learning versus creating and intervening. In face

of a new logic of contextualization, construction and embeddedness, it is recognized that intelligence does not amount to an old conception of a higher and abstracted academic intelligence (Schön 1987). On the contrary, intelligence is multi-various (Gardner 1993).

This means that formal models of knowledge encapsulation, conceived as purely mental and abstracted, has some valuable points of contact with the indigenous knowledge system proposed by this thesis. Moving from calculative and formal-logical understanding of intelligence towards sensuous forms mobilizes multiple ways of thinking through the visual, the kinaesthetic and the aural (Gardner 1993). This pushes design into culturally situated contexts, now to be understood through an incarnate, material and performative logic, where new ways of thinking, sensing and doing become enabled[113]. It lays down a challenge whereby the classic semiotic distinction between knowledge, knower and known, between subjects, objects and signs can be reformulated. This is further complicated by the possibilities of situated design models which offer 'liveness, plasticity and incompleteness' (Murtaugh 2008) or even 'emergence' (Cavallo n.d, 2000, 2003) as alternative approaches to formal cognitive models.

This revives the old constructivist dilemma that separates nature as genetic epistemology expressed by Piaget (1971) from nurture as cultural epistemology expressed by Vygotsky (1978). Further tackling both approaches, the 'hidden' potentialities of our sense perceptions are further mobilized as the 'other' of thought, that which is in opposition to 'higher' modes of intellectual development, relevant for the central discussion of linguistic forms of intelligence as presented throughout. For a cognitive psychological and educational agenda, through its two main constructivist paths, knowledge is to be conceived as a situated and embodied enterprise where the development of 'higher modes of thought' can no longer sustain the genetic epistemic separation between a 'sensorimotor stage' and a 'formal operational' one (Rotman 1977) or between language in the 'narrow sense' versus a 'broader' modality (Chomsky et al. 2002).

For education, especially the *Silbo Gomero* which is the focus of this thesis, this brings a challenge: to reconceptualize the place of didactic materials in education beyond 'higher modes of thought' that might confine language in its 'narrow-sense' (Chomsky et al. 2002). The three R's of literacy represent intellectual and mental achievements detached from the sensual and techno-material conditions. For education, it is through forms of interactive computation, treated as expanded sensory-data machines (Fuller 2009) that this body – its infinite emergent potentialities

[113] This particular approach to computational systems and artefacts was developed by Matthew Fuller (2009), particularly in relation to the intricate ways in which these artefacts and systems are entangled with multiple ways of "(…) reading, sensing, playing and acting upon. But the active life of data means one thing when it stays within the systems and events which originate it, something else when it moves on - and in contemporary digital cultures that is just what is happening. The afterlife of data couples events of all scales, from the intimate and personal, to the medical, ecological or institutional to new kinds of timescales."

– might find a place in indigenous knowledge systems. This challenge will be taken up in the next chapter.

V

EL LABERINTO DEL SONIDO

"We inherit our idea of the labyrinth from a tragic and pessimistic tradition, in which it signifies death, despair, madness. However, the maze is in fact the best model for allowing moving bodies to pass through while at the same time retracing their steps as much as possible; it gives the best odds to finite journeys with unstructured itineraries. Mazes maximize feedback…" (Serres 1985:2).

1. Brief Introduction

In 'The Five Senses, A Philosophy of Mingled Bodies' (1985), Michel Serres takes readers through a lush exploration of affective entanglements and their sensorial 'effects', considered as the core around which complex bodies of knowledge are formed (p.viii). Throughout this journey one is able to move from the idea of knowledge as a formal structure, set against a neutral backdrop – what is generally conceived as a form of knowledge devoid of any context – and plunge into a psychoactive topology. This particular approach is in line with Serres' continual search for a conceptualization of knowledge, the fruit of a pluralistic empirical enquiry. This empirical enquiry is not one of evidence and precision as once conceived through 'bifurcated' modes of ratiocination (Whitehead 1961) – one that sets primary against secondary qualities. Rather it returns 'empirical' to its etymological signification where it is conceived as a body of knowledge that emerges through experience and experimentation, performance and appropriation in the fullest sense. With this entanglement in mind, this chapter will continue with a presentation of the design process and materialization of a language support system for the *Silbo Gomero* – the application '*El Laberinto del Sonido*' [114].

In the following section and prior to a presentation of the language support system referred above it is important to give continuity to the discussion started in the previous chapter – the shift into an ecologically situated approach within the learning sciences and educational design – by developing further two topics that were less explored. First, the didactic materials

[114] '*El Laberinto del Sonido*', here in Castilian Spanish, can be understood as 'The Sound Labyrinth' in the English language.

under development by the *Silbo's* educational community (apart from what has already presented in relation to the work of *Maestro* Isidro and *Maestro* Lino). Second, the difference between bodies of knowledge learned in non-literate societies and those skills that are learned within the curriculum of modern secular schools. On the first point, the text will proceed with a presentation of didactic suggestions found in a small publication developed by the island's Bureau for Education, Culture and Sports (Brito et al. 2005). This publication represents a unique resource and in fact is the only one to act as a guide for the development of didactic materials for the *Silbo Gomero* in a school environment. Despite this contribution, little emphasis has been placed on the dynamic and complex auditory culture of the *Silbo's* ecological practice – a fact that might be due to the partial phonological orientation of this publication.

Recognizing this 'gap' I will draw this discussion towards the investigation of significant differences between auditory, bodily-kinesthetic and inter-personal literacy, mostly valued by non-literate societies, and the verbal-discursive and logico-mathematical skills of modern secular schools (Gardner 1993). The intention is not to set indigenous knowledge against modern (mostly termed as 'scientific') knowledge, or subjective against objective knowledge. The intention will be to draw upon what will be termed the *Silbo's* '*audile*' culture. This culture is made fragile when simply using the 'accuracy of reference' provided by a phonological account. As one might observe from the documentation that accompanies this thesis[115] learning this form of whistled communication opens the body to an active listening culture, where 'accuracy of reference' entails an auditory sensitivity to 'articulation' as opposed to 'exact reproduction' (Latour 2004a). This articulation conceals a performative and ecologically situated fabric. Taking this into account, the discussion will attempt to contribute towards the sustainability of the *Silbo Gomero* as an intangible cultural heritage, particularly as it shifts from the mountainous fields towards the space of the classroom.

Such recognition is necessary in order to safeguard this indigenous form of language beyond the motto of 'preservation for the sake of preservation'. This heritage is an important legacy to pass from one generation to the next (UNESCO 2009b). Therefore this chapter will present the *Silbo's* 'sonic effects' briefly mentioned in chapter III and detail the ways in which these 'effects' have influenced the design of the application *El Laberinto del Sonido* that was developed with the help of engineer Theo Burt at the Music Research Centre, University of York during the year of 2009/2010. The main features of this application, such as its electro-acoustic nature, auditory virtual qualities and the ground it provides for narrative construction, will then be considered in more detail.

[115] For further information consult DVD 1, movie 1, in attachment.

2. The *Silbo Gomero*, The Development of Didactic Materials

I will start by giving an overview of the continuing efforts by the *Silbo's* cultural and educational community to develop didactic materials. As discussed in chapter II, *Maestro* Isidro's *Silfateo* has been an important tool that fully utilizes the Roman alphabet to represent the temporal and auditory articulation of whistled vowels and consonants in an effective way while providing material for the students to take home. In a similar vein, *Maestro* Lino has based his teaching on deep conversational interaction between students. Based upon the idea of 'learning by doing', where a refinement of the senses becomes a key point, this idea is emphasized by the whistler [116]. To a certain extent, this approach is consonant with the 'opportunistic' design explored earlier on, in which uncertainty is exploited to its fullest potential. Even when the student does not know how to fully articulate a whistled utterance, *Maestro* Lino is the first to encourage experimentation with what is as yet unknown.

It is also important to account for the documentation of activities taking place in the scholarly context of the *Silbo Gomero* (Arbelo et al. 2000) and mostly designed by local teachers of other disciplines. This material, which I consulted at the Institute for Languages in the main village of San Sebastián, details the results of a small survey of short stories that present this whistled form of language to young children, particularly its history and main vocabulary. The material consulted in the local library of this village was very valuable, especially the recent publication '*El Silbo Gomero. Materiales Didácticos*' (The *Silbo Gomero*. Didactic Materials) developed by the Canarian Bureau for Education, Culture and Sports (Brito et al. 2005). Also advised by Professor Trujillo and *Maestro* Isidro, this publication presents several paths worth exploring when teaching the *Silbo*[117].

The first recommendation one encounters in this publication refers to the exploration of traditional situations of communication while taking into account the orographic terrain of the island. It argues that this is best explored while establishing a referential relation with topographic maps of the island, visually demarcating the places where the *Silbo* was most commonly used (p.82-81). The second recommendation entails an exploration of bodily configurations required for the performance of this peculiar linguistic form. This can be done while exploring the position of the tongue and the use of the fingers to modulate different tones and control the interruptions of the emitted utterance. To further strengthen this exploration, the text suggests that the learner should explore other instruments that give rise to similar auditory experiences,

[116] For more information consult DVD 1, movie 1, in attachment.
[117] This further strengthens the conversations I had with *Maestro* Isidro in La Gomera in February 2007, particularly, concerning the development of distinct methods when teaching and learning the *Silbo Gomero*. Here translated from the original documentation: 'the child should not have only one method' (Matos 2007). For more information consult DVD 1, movie 1, in attachment.

such as the local herder's flute (p.83-84). The third recommendation, and largely following the logic of a 'phonological stage' (Trujillo 1978, 2006) – although this approach was not encountered in the schools I visited – refers to the close inspection of the spectrographic representations of whistled words or, alternatively, to explore *Maestro* Isidro*'s Silfateo* (p.86).

This small publication also recommends further exploration of common communicative utterances used in the fields. To take one example: the many utterances used in salutation, when identifying oneself, when identifying and locating objects and people, when describing, narrating, expressing necessities, quantifying, etc. (p.87). Within this logic, further study of the main difficulties – such as strong wind, intense reverberations or extremely long distances – when decoding an uttered message is advised. These difficulties can be contoured by selecting an adequate and clear vocabulary, redundancy of discourse provided by a set of questions and answers (p.89); a method commonly used by both *Maestro*s as I was able to testify through visits to their classes (Matos 2007). The student should also be able to situate the *Silbo* within the vast panoply of whistled languages (p.91). And finally all of these recommendations should be explored with the intent of providing the student with an enrichment of linguistic capacities as an expression of both social and cultural value (p.90).

One aspect is left to be considered: the ecological and auditory relations that are central to the development of this form language, its spatial-temporal qualities and the environmental implications that one might extract from them, particularly when conceptualizing the cognitive realm as a situated and ecologically embodied niche – 'the tip of the iceberg' as suggested by Meyer (2005). This 'tip' is not necessarily located in the brain, but rather in the body, which now becomes the locus of an ecologically situated and embodied performance. And even though it was briefly touched upon in the first line of recommendations when the mountainous space of island was mentioned, the issue seems to have been relegated to a purely visual bias. In this sense, and to advance the fundamental ecological reading that is proposed throughout the current research, it is important to look at the designation of auditory, temporal and spatial representational topographies in a space that opens educational design up towards the construction of auditory computational artefacts.

It might be asked: why computational? Why not proceed with the local instruments – the herder's flute, the spectrogram or visual topographic maps – or engage with on-site training? The problem is that the local herder's flute does not sustain the same corporeal relation that characterizes the embodied configurations, particularly the position of the fingers and tongue, which are essential when learning how to whistle. The local flute might 'tune the ear' to similar temporally dynamic melodic lines. However, this instrument does not offer the possibility of a more thorough exploration of the auditory and ecological relations to be explored, particularly

the characteristic echoes and reverberations that modulate the auditory experience when performing the *Silbo* in the *barrancos* of the island. And while on-site training is provided once a year at the annual gathering of all schools in an exterior environment[118], actual access to most remote areas of the island, particularly the *barranco*s where the *Silbo* was extensively used, is usually out of question for most schools. While this does not necessarily mean that digital computational artefacts are necessary when designing for the transmission of whistling techniques, it is important to recognize that the required auditory, temporal and spatial qualities open space for the incorporation of digital technologies that more readily facilitate their exploration.

The core contribution to this suggestion was provided by design's rhetoric and ways of knowing (Buchanan 1985, 2001; Schön 1987; Wood 2007). An approach already discussed in the introductory chapter and that, at this point, can be read along the following lines: "Here it is important to distinguish between the self-perception of designers (…) and other professionals. One major difference is the fact that designers are trained to see facts as opportunities for innovation, rather than as a 'reality' that requires suitable response" (Wood 2007:171). This sensibility is paired with the attempt to find ways in which the safeguarding of immaterial culture entails the transmission of the wealth of cognitive skills as opposed to 'frozen' cultural objects (UNESCO 2009a). Paring these concerns not only opens up space for 'innovation'; it also demands, particularly from those who design it, a delicate balance between the wealth of knowledge that is transmitted by this ancient form of communication and the new opportunities this presents to young Gomerans when learning and further embodying the indigenous perceptual fabric.

At this point it seems reasonable to ask: **What is really at stake when one transposes the *Silbo Gomero* from the fields – as it was once used by the peasant islanders – into the space of the classroom? What does this really imply for the wealth of cognitive skills that are transmitted from one generation to the next?**

2.1 The *Silbo Gomero* as a Form of Cognitive Apprenticeship

Any proposed design should be sensitive to differences and mutual enhancements of both 'educational' systems while recognizing the situated, embodied and ecologically distributed value of the cognitive skills to be transmitted. This is particularly important when one attempts to situate the phonological (Rialland 2003, 2005; Trujillo 1978, 2006), bioacoustic (Meyer 2005), neurological (Carreiras et al. 2005) data and the embodied auditory culture as it shifts

[118] Information provided in conversation by *Maestro* Isidro in February 2007.

into a contemporary educational setting. As the United Nations Educational, Scientific and Cultural Organization has stated: "The importance of intangible cultural heritage is not the cultural manifestation itself but rather the wealth of knowledge and skills that is transmitted through it from one generation to the next" (UNESCO 2009b:4). It is also here that the *Silbo's* rich auditory ecology – which is certainly a mode of embodied knowledge – might be of crucial value. And that should be added to the educational and didactic approaches presented above when referring to the documentation consulted in the language centre and library of the village of San Sebastián in the island of La Gomera (Arbelo et al. 2000, Brito et al. 2005). In an attempt to understand this body of knowledge, I will first take into account the historical implications of teaching the *Silbo* in the midst of what was once a non-alphabetized society, as has already been briefly explored in Chapter II, when looking at the whistler's body of knowledge devoid of processes of alphabetization and subsequent textualization.

In 'Frames of Mind' (1993) Howard Gardner analyses both modes of 'schooling' through a study of the 'skills learned in non-literate societies' and those learned in the 'scientific curriculum of modern secular schools' (p.339). According to the author, while the first implies that knowledge is transmitted through direct observation (mostly unmediated) and where linguistic, spatial, bodily-kinesthetic and interpersonal forms of 'intelligence' are most valued, in the latter the learning of skills is usually assimilated through mediation (books, diagrams, computers, films, etc.). Here, mathematical and linguistic skills are the basis of a broad disciplinary project and its methodologies are similar to what was discussed earlier on when tracing the heritage of educational approaches developed throughout the XVIIth and XIXth centuries (Schön 1987, Whitehead 1925, Wood 2007). In this sense, Gardner's description of both modes of learning further emphasizes the need to shift from an understanding of learning as a mode of 'reflective-abstraction' (Piaget 1971, Rotman 1977) into one of 'reflection-in-action' (Schön 1987).

Even though I would disagree that non-literate societies engage in forms of learning that are unmediated (it would seem more accurate to speak of distinct forms of material and immaterial mediation), the author's study reveals the ways in which modes of intelligence characteristic of non-literate societies might play a role within a contemporary educational curriculum. While not intending harsh criticism of contemporary educational systems Gardner recognizes that contemporary educational systems, with their over-emphasis on logico-mathematical and grammatical verbal skills, have largely replaced the value of 'other' bodily intelligences (p.352). It is also here, and further incorporating Gardner's sensibility, that one might propose to the Gomeran educational community to open the possibility to further shift the preservation of culture for the sake of preservation, further exploring the value of already

ingrained knowledge systems and their subsumed practices. This is, to recognize that the *Silbo Gomero* conceals its own degree of abstraction and formalization. The difference lies in the places of articulation and 'channels of symbolization' that are deployed, and not in any naïve attempt to oppose objective, 'scientific' and contemporary educational curriculum to subjective indigenous forms of learning.

Care should nevertheless be taken, and one should keep in mind the discussion in the previous chapter about the two students tinkering with a coordinate graph or Vygotsky's analyses of childrens' passage from drawing to writing, when various forms of 'intelligence' (to use Gardner's terminology) were identified. In this sense, it is important to rephrase: various modes of intelligence are at play in contemporary schooling systems; however, most spatial, bodily (not to say auditory) modes are usually consigned to the background (the only exception being musical and artistic schools (Gardner 1993)) and rarely figure in the conscious development of didactic materials beyond the kindergarten years. Here, the role of perception is largely neglected and is rarely used in the development of 'higher' or 'abstract' modes of thought (Clancey 2005).

Here it is important to identify the bodies of knowledge and skills that characterize whistling languages as part of a perceptual and communicational heritage. Besides its rich linguistic (verbal-discursive) heritage or 'intelligence', the *Silbo Gomero* entails two ecologically situated forms of heritage that pertain to the auditory and spatial. While the linguistic trait is largely articulated in phonological studies, the two later modes are worthy of further exploration. It became clear during the discussion in chapter II that whistlers exploit a rather complex auditory fabric, a quality that is correlated to the situated and embedded character of the *Silbo's* ecological milieu. And while looking into the phonological stage and its intrinsic methodology (spectrographic analyses), it became clear that whistlers, mostly analphabet, did not use any visual notation system in the deployment of linguistic capacities. Such recognition is also indebted to the psychoacoustic (Meyer 2005) and neurological data (Carreiras et al. 2005) and the view that whistlers exploit an auditory 'intelligence' that is not common to speakers of Castilian Spanish. Not only do perceived melodic lines (as opposed to measured frequency) play a fundamental role but also the perception of auditory form is ecologically experienced in time and space. It is also here that the two forms of literacy appear in an interesting co-relation, particularly if we take into account the explanation given by *Maestro* Lino of the ways in which whistlers exploit the acoustic qualities of the mountainous environment, not only by directing the body towards a whistled utterance but also when projecting a message.

2.2 The *Silbo Gomero* and 'Active Listening'

This ecology mobilizes an understanding of 'active listening'. And while hearing might be conceived as a reactive sensitivity to 'physical vibration within certain ranges of frequencies and intensities' (Truax 2001:15), the primary and quantitative qualities (as physically and acoustically measured), as Whitehead (1961) would denote, listening is ecological (Gibson 1966). Recalling the dynamic account provided by Freeman (1987, 2000) in chapter III, perception can never be conceived as passive. In this respect the words of Barry Truax in 'Acoustic Communication' (2001) provide a fruitful insight: "listening implies an active role involving differing levels of attention – 'listening for', not just 'listening to'. The level of attention may be causal and distracted, or in state of readiness, and its scope may be global (a general 'scan' of the entire environment) or focused on a particular source to the exclusion of other sounds. However in each case listening can be consciously controlled. It can also produce categories of perceptual immediacy such as 'background' and 'foreground' (…) (p.18). A general characteristic of cognitive processing that seems to lie at the basis of listening is the detection of difference, what Bateson calls 'the difference that makes a difference' (…)" (p.19)[119].

Once again, and taking a glance at contemporary educational systems, this form of auditory literacy is uncommon and is usually consigned to music classes (mostly classical in conception). While verbal and mathematical illiteracy seems unacceptable in our current society, the same cannot be said for auditory illiteracy (Gardner 1993:109), taking of course certain cultural agendas as exceptions[120]. In this sense, the didactic approaches presented in the publication '*El Silbo Gomero. Materiales Didácticos* ' (Brito et al. 2005) also omits, to a certain degree, the core contribution provided by the *Silbo Gomero* as a form of cognitive apprenticeship in the contemporary classroom environment. Here it is important to recognize a rich auditory culture not easily reduced to a surrogate code. As discussed in chapter II, whistling languages conceal a world of auditory abstraction, yet this abstraction is not based on formal-logical axioms, as are some phonological and psychoacoustic modes of analysis. Sound is not analyzed against time but rather as being in time, and information can be conceived as serial sequencing of quantifiable units. If one is to consider any process of quantification it has to be conceived as a situated and ecological practice, devoid of any metric and external ruler (Cummins et al. 1995).

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[119] This reference to cybernetician Gregory Bateson emphasizes his systemic and ecological approach to cognition, important in rethinking the role of cognitive apprenticeship in contemporary educational environments.

[120] Considering this, Gardner (1993) presents the Suzuki school in Japan, largely focusing on European classical music; the Anang society of Nigeria; the Hungarian school system; the Ewe society is Ghana. In these particular examples auditory literacy, generally deployed through local musical instruments, is highly valued (p.109-11).

More than teaching or learning a code, therefore, young *silbadores* should engage in a voyage where the body learns to be 'effectuated'; the question now becomes, as posed by Latour (2004): "under what conditions can we mobilize the body?" (p.1).

In exploring the body as a situated and distributed synergy, one that is intrinsic to the development of complex forms of knowledge, Latour presents an interesting form of intelligence, which he calls the 'perfumer' or the '*nez*' (a 'nose'). In this notion, while the '*nez*' goes with a '*Mallette à odeurs'* (the perfumer's kit of odours) in the refinement of the senses, the chemical engineer working for the perfume industry counts upon a body of formulas and chemical measuring apparatuses, something which establishes a close parallel with the analysis of the linguist and the whistler's body of knowledge and their deeply entangled, distinctly performative and techno-material realities. Latour argues that these two professional bodies deal with distinct levels of articulation (or difference), levels that are intrinsic to their methodological and technical apparatuses and to the community of co-participating subjects. And with this example in mind, it seems reasonable to present the *silbador* as an '*audile*'[121], a term that is used by Jonathan Sterne in "The Audible Past' (2003) and that refers to:

> "a person in whom auditory knowing is privileged (…) the term is useful because it refers to the physiological process-based sense of hearing (…) and because it references conditions under which hearing is the privileged sense for knowing or experiencing" (p.96).

While the '*nez*' deploys an embodied form of odorant articulation, not necessarily expressed in precise verbal-discursive forms, the chemical engineer will most likely deploy what Latour denotes as an 'accuracy of reference'. While accuracy is mostly focused upon exact validation, 'articulation' does not necessarily entail exact precision of results (Latour 2004:5), a fact that is also visible in the discussion of vowels between linguists and whistlers. Taking this discussion as an effect of two distinct ecologies of knowledge conceals more than a trivial disagreement, it also conceals the true value of 'epistemological pluralism' (Papert & Turkle 1990) as previously discussed. While the feel for 'accuracy of reference' is more concerned with the replication of the original, the feel for 'articulation' is mostly sensitive to registering differences while opening the body to the making of representations as such, their performative and ecological value. I believe this is the true contribution of the *Silbo Gomero* as intangible cultural heritage within contemporary school environments.

[121] Here it is important to mention that *Maestro* Isidro is not only a *Silbo* teacher but also a constructor of local musical instruments such as the Gomeran *chácaras* (similar to castanets, but of bigger size) and the *Tambor Gomero* (a local drum made with goat skin and local varieties of wood). He is also an active participant in the local '*Bailes de Tambor*' (Drum Dances). This information was provided in conversation by *Maestro* Isidro in September 2010 when visiting his house in the village of Chipude.

3. Initial Design Development

A continuing engagement with the *Silbo's* auditory epistemic ecology has become the key underlying component in the design of didactic materials, thus taking the potential to reenact this linguistic form beyond the preservation of a surrogate code while recreating the ancient body of knowledge. This instigated the development of a methodological intuition in the design of the application '*El Laberinto del Sonido*'. Developed, as noted above, in collaboration with computer engineer Theo Burt[122], at the Music Research Centre, University of York. The initial design stage was developed by myself and through a close reading of the theoretical component presented in the previous chapters. Here, two important elements appeared as key-points. First, the underlying interactive and performative rational behind the *Silbo's* acoustic ecology. Second, the use of cartographic maps in the development of didactic materials as presented above.

Regarding the first point, it is important to take into account the ethnographic and investigative work presented in chapter II. This part of the text presented different approaches to the study of this whistled form of language, slowly incorporating distinct readings of the environment. While the phonological and neurological approaches will consider an external and detached environment, the bioacoustic approach will consider that the environment conditions the whistler's performance but is externally measurable nonetheless. Finally, an ethnographic account of the whistler's acoustic body will enhance a performative reading of what has been understood as a secondary, external, internal and measurable environment. This shift will take the reader to chapter III where, in the final section, the idea of 'sonic effects' and the environment as '*instrumentarium*' (Augoyard & Torgue 2005) appear as key concepts.

As proposed in 'Sonic Experience: a Guide to Everyday Sounds' (2005) – also discussed in chapter III – five groups of 'effects' were considered:

- The '**elementary effects** that concern the sound material itself' (p. 17). In the case of the *Silbo Gomero's* auditory ecology this category is associated with the **reverberation** and **echo** that one can sense when performing in the *barrancos* of the island. Reverberation refers to the "effect in which a sound continues after the cessation of its emission", this phenomena is enhanced by the "reflections of the sound on surfaces in the surrounding space". "(…) The longer these reflections conserve their energy, the greater the reverberation time". (Augoyrad & Torgue 2005:111) Socially, this effect is "perceived as an indication of monumentality" of the environment (p.116). An extension of this effect is echo, "the simple or multiple repetition of a sound emission, linked to a reflection in the space of diffusion" (p.47).

[122] For more information on Theo Burt's work go to: http://www.theoburt.com/

- The '**composition effect** concerns complex sound arrangements' (p.17). This effect refers to sounds that might occur at the same time or sounds that have a complex temporal development. This phenomena is visible when performing the *Silbo* out in the fields where various sounds may be heard simultaneously: such as the sounds of other animals (e.g.: birds, goats, spoken human sounds), sounds of the environment (e.g.: effect of wind on leaves or water) or even sounds that mark the urban development of the island (e.g.: sounds of cars and the small aircrafts that use the local aerodrome). Within the psychoacoustic literature, this effect is understood as '**masking**', "where the threshold of audibility for one sound is raised by the presence of another" (Moore 2003:402).

- The '**mnemo-perceptive effects**' 'concern the way listeners memorize sounds, a feature that also influences the ways in which a listener searches for sounds in the environment and the sounds that are culturally valorized over others' (Augoyard & Torgue 2005:17). Here it is important to consider the '**anamnesis effect**' in "which a past situation or atmosphere is brought back to the listener's consciousness" (p.21). This effect is visible throughout the initial ethnographic work that was developed with *Maestro* Isidro and *Maestro* Lino. One might also find such effect in the classrooms, particularly when both *Maestro's* recall the common utterances used in the 'old days'. One might also witness this effect when recording out in the field, particularly in the village of La Palmita, where *Maestro* Lino shows how the *Silbo* was performed from house to house or how it was used to express emotional content. These examples are also associated with the '**synecdoche effect**' and the '**metamorphosis effect**'. The first effect can be understood as the 'ability to valorize one specific element of the sound environment through the development of selective forms of listening' (p.123). The '**metamorphosis effect**'[123] appears as a product of 'unstable and complex sound environments where sounds might be well localized but constantly evolving through time' (p.74).

- The '**psychomotor effects**' concern 'the actions or schemes developed by listeners when interacting with particular sounds' (Augoyard & Torgue 2005:17). The phenomenon qualifies the ways in which the receiver of a whistled message directs the body towards the source of the whistled utterance. This example is associated with the '**attraction effect**', where "an emerging sound phenomenon attracts and polarizes attention" (Augoyard & Torgue 2005:27).

[123] As Shafer presents in the foreword to Augoyard and Torgue's book, this effect is best described through the words of Mearlau Ponty: "the perceptual something is always in the middle of something else" (p.xiv). A quote that complexifies the psychoacoustic reading of the 'sound object' as 'a product of figure-ground segregation' (Kubovy & van Valkenburg 2004:118) presented in chapter III and the 'inherent tendency of acoustic researchers to think of the soundscape as static data' (Schafer in Augoyard & Torgue 2005:xiv).

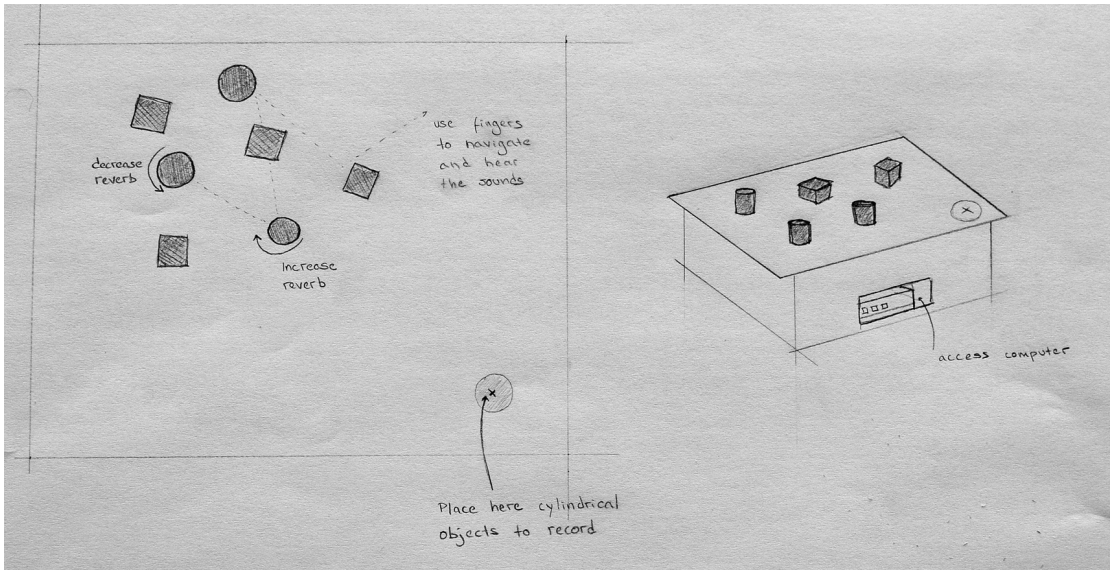
- The '**semantic effects**' are 'associated with the ways in which sounds might differ in context'. In this case, examples of decontextualization are important. This effect refers to the occurrence of certain sounds in determined circumstances that might cause humor or even shock'. (p.17) This effect was visible in an initial phase of research, particularly when visiting the *Silbo* classes for children that were documented throughout the island, where an incorrect whistled form (or better, a whistle without form) would easily lead to a giggle amongst younger students.

At this stage of design development, it was important to take into account the fact that these 'effects' are central to the ecological development of the whistler's body of knowledge as presented in chapter II and III. In this stage it was also pertinent to understand these 'effects' as entangled phenomena that provide distinct schemes of interaction and therefore cannot be reenacted in isolation. This feature reemphasized the potential afforded by computational mediums, one that would shift the cartographic map – as suggested in the small didactic publication (Brito et al. 2005) – to a medium with vaster interactive and sonic potentials. While taking into account computational mediums, I also drew inspiration from key interactive design concepts explored in chapter IV. Here it is important to refer to: Wartofsky's 'open models' (1979), Murtaugh's (2008) insistence on 'liveness, plasticity and incompleteness' in the design of 'good' interaction and finally Cavallo's (n.d, 2000) 'emergent design' where users best understand a system when they can actually appropriate and incorporate it into ongoing activities.

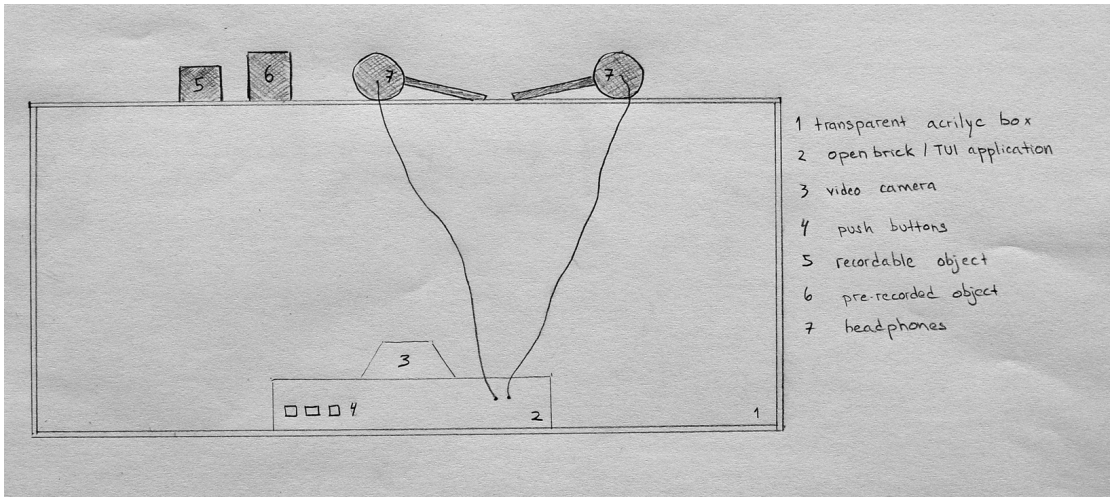
The 'openness' that is implied in all three approaches suggest that a final didactic material would not necessarily 'force' students to use the whistled form of language while correcting them but rather explore what they have already learned while emphasizing the whistler's auditory body and its entanglement within a complex sonic environment. In this sense, and when interacting with the idea of a sonic cartographic map, the proposed 'openness' should not be confused with a principle of 'whatever works' as expressed through the words of Wartofsky earlier on in chapter IV. In fact, as suggested by recent work developed within the field of interactive design and human computer interaction design (HCI), this 'openness' should incite an understanding of 'an open system within a constrained space of possibility' (Blythe et al. 2010). Taking into account the research I have proposed so far, such constraint would enable the exploration of the 'effects' described above while strengthening the acoustic ecology that is inseparable from whistled forms of language and subsumed learning processes.

This approach shifts an understanding of the cartographic map into what Brian Rotman (2008), using contemporary Geographic Information Systems (GIS) as example, has presented as a multilayered and multiperspectival navigational ecology (p.98). Here, a linear configuration, one that presupposed a view of the world from above – the difference between the observer

(subject/object) and a systems approach – was replaced by a view from within, one that is readily afforded while interacting with sonic environments. This 'view from within' radically challenges the visual and photographic/cartographic view while providing new sonic spatial-temporal configuration. This is what the author would denote as modalities of 'multi-seeing' (p.98) or, as one might suggest, and more in line with the designed application, new modalities of 'multi-sensing'. Here it is important to redefine the idea of space as lived spatial-temporal dimension.



13. Sketch of the interactive table. View from above (left-hand side). Perspective-drawing (right-hand side).



14. Sketch of the interactive table. Drawing of longitudinal cut.

The first design solution explored the idea of cartographic map. In this initial design, I conceptualized a simple system where, on a flat surface, distinct objects could be manipulated and arranged. Here, two important features were considered: first, the possibility of using these objects to record sounds (e.g.: whistled utterances), second, the possibility of pre-ascribing sounds to particular objects (e.g.: sounds that would be used as environmental triggers, such as wind,

animals, etc.). Two other features were added to the previous ones: first, the possibility of adding, within distinct areas of the map, 'elementary effects' (e.g.: reverberation or echo), second, the possibility of navigating within this sonic cartographic composition. The 'composition effects' would be enhanced by the proximity or distance of sound/objects within the map and the ways one could navigate the map once it was created. The 'perceptual organization effects' and the 'semantic effects' would be enhanced by the activities developed with the students when recording or using pre-ascribed sounds.

On a technical level, the first design solution was largely influenced by the development of new interactive technologies such as the free and open-source interactive tables. After a period of research, the Reactable[124] system, developed at the Pompeu Fabra University in Barcelona, proved to be the most robust. This system, initially developed as the 'reacTIVision', was developed as an 'open source, cross-platform computer vision framework for tracking markers that are attached onto physical objects, as well as for multi-touch finger tracking'[125]. While taking this flexibility into account, the system provided the most feasible option. As presented in the sketch above, certain objects defined by form (cylindrical and square), would only record and once placed on the table they could 'capture' whistled utterances. The other objects would be given pre-ascribed sounds that could be recognized once placed on the table. Effects such as reverb and echo could be added by rotating the object clockwise (to increase) and counter-clockwise (to reduce). The navigation between objects could be done while using the finger tracking option.

Prior to the actual construction of the proposed system, a few obstacles started to emerge. First, and considering that the setup and programming would be done in the U.K., it was important to take into account the flexibility of transporting the interactive table to the island. Second, and considering that most schools can only provide a small audiovisual room or a computer room where the setup is largely defined by desktop computers, consideration was given to the ways in which schools would display and maintain this table. The third obstacle was related to the construction cost. Here, it was important to keep in mind that this final cost would amount to a table with an acrylic semi-opaque screen[126], a small computer[127], a video camera[128] that tracks the markers that are glued to the bottom of the objects, a sound card, at least two

[124] For more information go to: http://www.reactable.com/
[125] For more information go to: http://reactivision.sourceforge.net/
[126] In this case, and during an initial phase of experimentation, a cardboard structure would be used to support the acrylic screen. This solution would not only reduce the final cost but also facilitate the transport to the island of La Gomera.
[127] In this case, the final solution would incorporate an open unit that could be custom built with motherboard, memory, power supply and hard disk while reducing the final cost.
[128] In this case, the final solution would incorporate a firewire board camera to reduce the final cost.

headphones or speakers and the objects[129] that are placed on the table. In case the application would succeed, later on, the schools of the island would support this production cost.

3.1 Designing the Application '*El Laberinto del Sonido'*

While taking the previous considerations into account, a shift to a screen based system was prioritized. The final design solution – an interactive platform to be used on a laptop or desktop environment – was designed for children ranging seven to nine years of age (the primary school years) who attend different schools on La Gomera. Initial experimental sessions with this application took place in April of 2009, in the school CEIP El Retamal, a school in the village of Valle Gran Rey – an institution that has kindly given the space, time and effort to experiment with the material. This initial experiment instigated some final changes and adjustments of the application, informed mostly by the children as they interacted with the material given to them. Details of the system's architecture can be found in Annex II and movie 7 in DVD 3. The installation folder can also be found in DVD 3 in the 'English' folder, 'LaberintoV1.4' sub-folder. Prior to any process of installation please read the file 'readme_install_V1.4.pdf', this file is also contained in this last folder.

Largely drawing from the previous design solution, the final language support system essentially consists of a software application that allows children to develop auditory-spatial virtual worlds while providing a frame for non-linear narrative creation and exploration as the basis of intuitive auditory exploration. The application was designed with the intention of further strengthening the embodied skills of the children who learn the *Silbo Gomero,* on the assumption that verbal-auditory and non-verbal-auditory are entangled. '*El Laberinto del Sonido'* presents a first-person experience in which the creation and exploration of an immersive, auditory and 'virtual space'[130].

In order to explore linguistic and '*audile*' spaces, the application is divided into distinct nodes that are visually accessible to those of the user/s in a grid-like shape (see images in the

[129] These objects would be made with natural wood. In case they would get lost during the activities with the children, other objects could be used. Here, the only essential consideration to keep in mind is that the corresponding marker – that is printed on a sheet of paper – has to be safely attached to each object.
[130] In fact, such 'virtuality' is in line with Rotman's (2008) exploration of the term, particularly as it transverses different media and their distinctive experiential ecologies. And while the 'I', or agential experience, of printed media gave rise to the idea of a spirit (God, the word) separable from the body, the 'virtuality' of digital media opens a space for embodied forms of exploration while deploying more complex proprioceptive qualities and therefore providing distinct virtual effects. And as the mathematician and cultural theorist states in reference to the words of philosopher of mind Andy Clark: "it is harder and harder to say where the world stops and the person begins"(p.8). It is exactly this 'effect' that the application exploits.

following section 3.1). Within this grid, the user/s are able to create record sounds or to move and reconfigurate existing ones. Each is accessible for direct sound recording or to import sounds created elsewhere in the computational medium (harboured in the 'common_files' folder of the main application folder[131]).

To this feature, and as part of the developed design proposal, engineer Theo Burt added a binaural sound generator or algorithm that allows the development of a binaural sound field (Roads 1998:469). One that is described within the context of psychophysical theories of spatial hearing while acknowledging that the position of our ears in the head and our constant mobility are the base of a peculiar psychoacoustic phenomena where hearing in both ears occurs with a small time delay – most commonly known as 'interaural time differences'. This delay is one of the most important features in the configuration of our sense of acoustic-spatiality. (Blauert 1997:13, 51) This feature is further enhanced by the possibility of directly manipulating distinct reverb presets while 'painting' each preselected reverb onto the grid of the narrative space.

Here, I would like to open space for the work of Barry Blesser and Linda-Ruth Salter (2006), particularly their critique of simulation or replica of the 'real' physical/auditory structures and their inherent experiential qualities:

> "Aural architecture of virtual spaces becomes the design of a spatial experience for each individual listener, not the aural architecture of the composite space. Space is individualized, with listeners having the same individual control over their listening environments that audio engineers have over their spatial synthesizers. Space becomes an individual experience, rather than a common environment with relatively uniform properties" (p.186-87).

Two assumptions are at play here and are worth deconstructing before proceeding. First, the idea that while deploying a binaural algorithm one is necessarily entailing a 'copy' of a 'real' and 'external' environment; second, that a 'real' environment is necessarily 'external' – as opposed to an internal and 'subjective' environment – and prone to general and accurate reference. This demands further clarification about the application. First, it does not entail a copy of the *barrancos* of the island. Instead, the application focuses on the 'effects' of particular '*audile*' cultures and their ecological environments as opposed to any attempt to replicate culture as primordial form (rather as an entangled relation). And second – as will be explored in the next chapter when analyzing the appropriation of the material by the children themselves – virtual architectures do not necessarily entail individualized spaces of 'intra-action'.

To further continue, the application offers the possibility of switching between a dual visual/auditory and an isolated auditory mode. This feature opens up a potential for user/s to

[131] For more information consult DVD 3, 'English' folder, in attachment.

exploit distinct perceptual channels when creating narratives that are later explored by other user/s. This was a feature that would be explored by the children at the school CEIP El Retamal (island of La Gomera), as will be discussed in the next chapter. In this sense, *aesthesis* (to perceive) and *poiesis* (to create) are combined. The possibility of 'hiding' the visual interface allows children to focus on the recorded and inserted 'sounds objects'[132] while relegating their representation on the screen – the 'visual objects' – to the background. Finally, this process demands a shift from an understanding of sound as object to an understating of its 'effects' (Augoyard & Torgue 2005) as described earlier on in chapter II as well as in section 3 of this chapter. While accessing the application through sonic means, moving through the space and engaging in different schemes of interaction, the listener is experiencing the '*effects*' of sound. Once clear and identifiable 'objects', they are now spatially and temporally entangled and no longer appear as easily discernable and identifiable units, at least without demanding larger degrees of active or 'selective forms of listening' (Truax 2001:18). This feature will become clearer in the following chapter, particularly when describing the activities with the children or when listening to their created narratives.

Also, and returning to the 'sound objects' presented above, these elements are divided into three categories that are readily identified through distinct colours. The first, represented by the colour orange, corresponds to ambient like sounds that are in constant loop; the second, corresponding to the colour blue, also corresponds to ambient like sounds, however with a smaller duration and therefore triggered by proximity. The third, corresponding to the yellow colour, was created with the intention of harbouring recorded whistled utterances, a node that is also triggered by proximity during the navigational experience. Of course, this logic was programmed with a certain flexibility in mind and each node may be rearranged at any time while deleting the outside circle of both blue and yellow nodes. The yellow coloured sources may be used to record other sounds in case the user does not want to use sounds that are previously harboured in the computational medium.

An initial and important feature of the application was the inclusion, within its auditory space, of the users' navigational position. This feature can be understood as the 'avatars' own sound while moving, standing in place or rotating. Later on, and prior to the actual experimental sessions with the children, this feature was removed because it provided a perceptually conflicting experience with the created auditory landscapes. In fact, the avatars sound largely conflicted with the already improved binaural field.

[132] Here it is important not to confuse the 'sound object' with its corresponding sound file that is harbored in the computational medium. When using the word 'object' I am referring to the realm of perception. In fact, for each sound file – represented on the screen by the yellow, blue and orange circles – one might perceive various 'sound objects'.

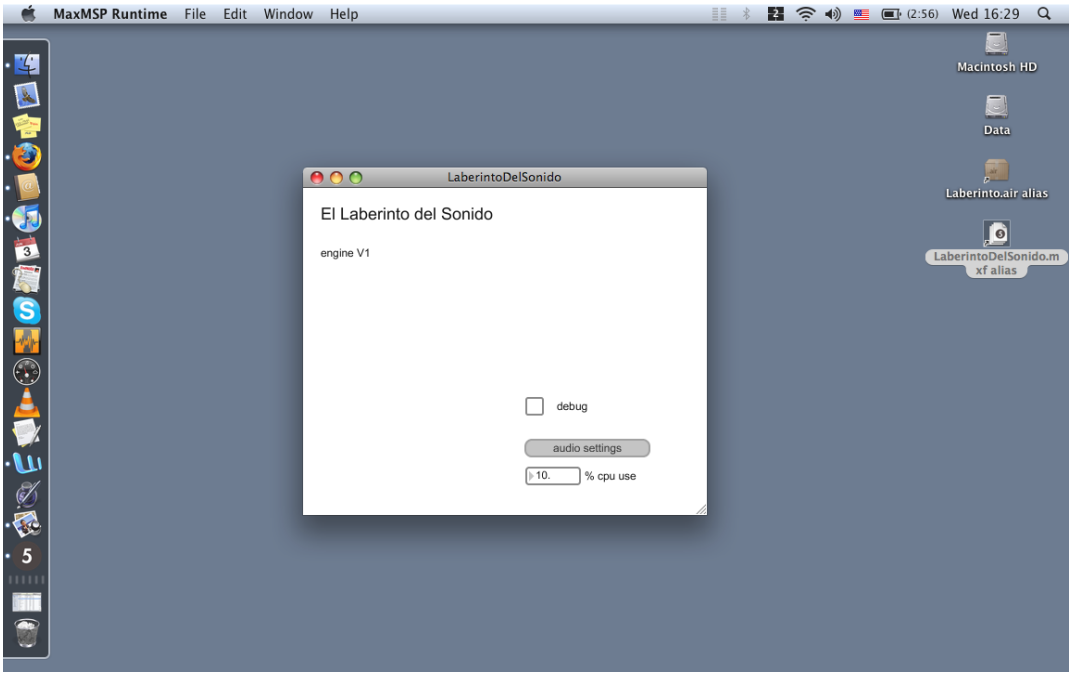
By these means, different scenarios are layered while exploring the potential auditory and interactive space. This space acquires an auditory mode as the user is driven to explore the intricate relations between 'sound objects', while trying to decipher different whistled utterances within the cacophony of a sonic narrative. Here it is important to consider the different layers of complexity that are instigated through this process, where each user manipulates these characteristics while achieving distinct levels of complexity within the spatial auditory environments. This platform can be used by more than one user at a time, depending of course on the number of available headphones. However only one user will be able to manipulate the navigation while using a graphics tablet because the pressure of the pen can only trigger the input device once at a given time. In the future, and to overcome this limitation, it would be interesting to develop the application for a multi-touch screen[133]. Unfortunately the Gomeran schools visited do not have the infrastructure that would be needed for it and the application was designed for desktop navigation while using a drawing pad or even a mouse.

3.2 Using the Application

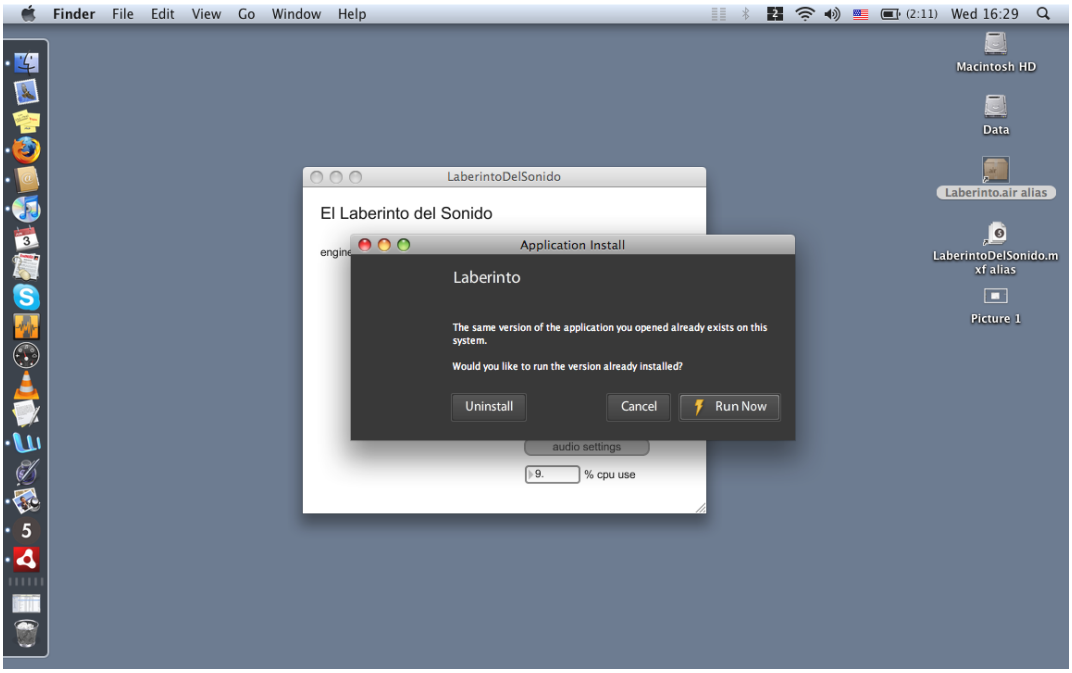
This section will begin with a visual presentation of the application, reproduced through a series of 'screen-shots'. It is also possible to access this presentation by consulting the audio-visual guide in the annex[134]. Or, alternatively, while consulting the installation package and guide in the Spanish language[135]. Here the reader will also find the information necessary to install and run the application on both Mac OSX and Microsoft Windows system[136].

[133] Wacom already provides a graphic tablet ('Bamboo Touch') that is triggered by the user's hand rather than a pen, however, the work area is still quite small, limiting once again the number of participants, reason for requiring a multi-touch screen within the context of the referred application.
[134] For more information consult DVD 3, movie 7, in attachment.
[135] For more information consult DVD 3, 'Espanol' folder, 'guia_usuario.pdf' file, in attachment.
[136] For more information consult DVD 3, 'English' folder.

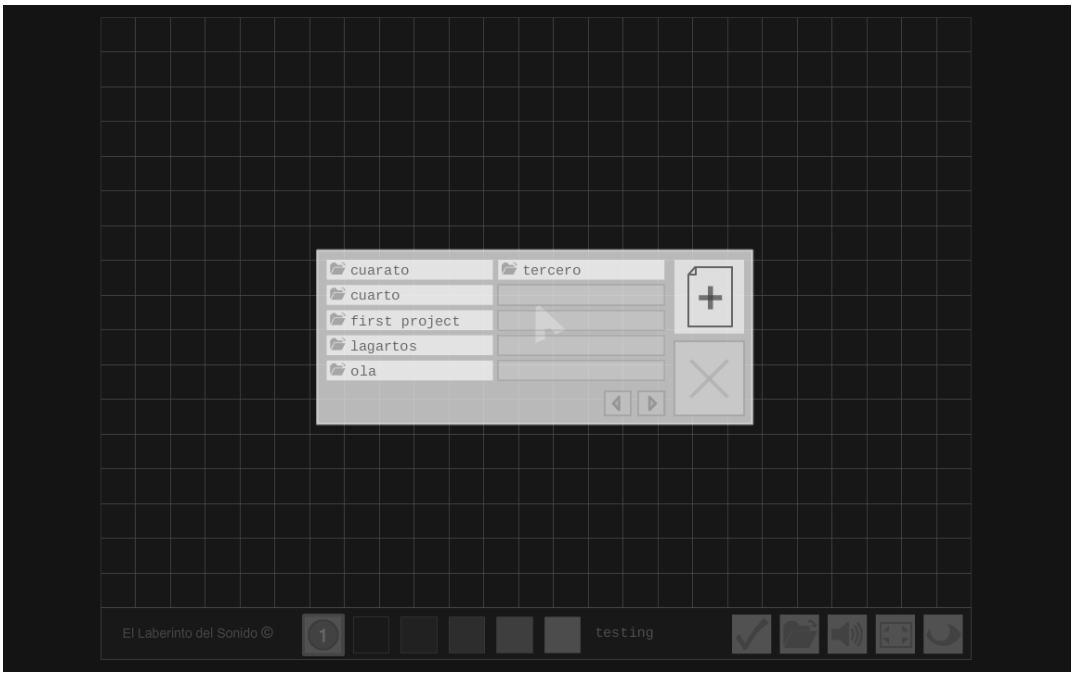
15. In order to open the application *El Laberinto del Sonido*, first you have to click on the icon 'LaberintoDelSonido.mfx' alias.



16. Once this window appears, click on the icon 'LaberintoDelSonido.air' alias

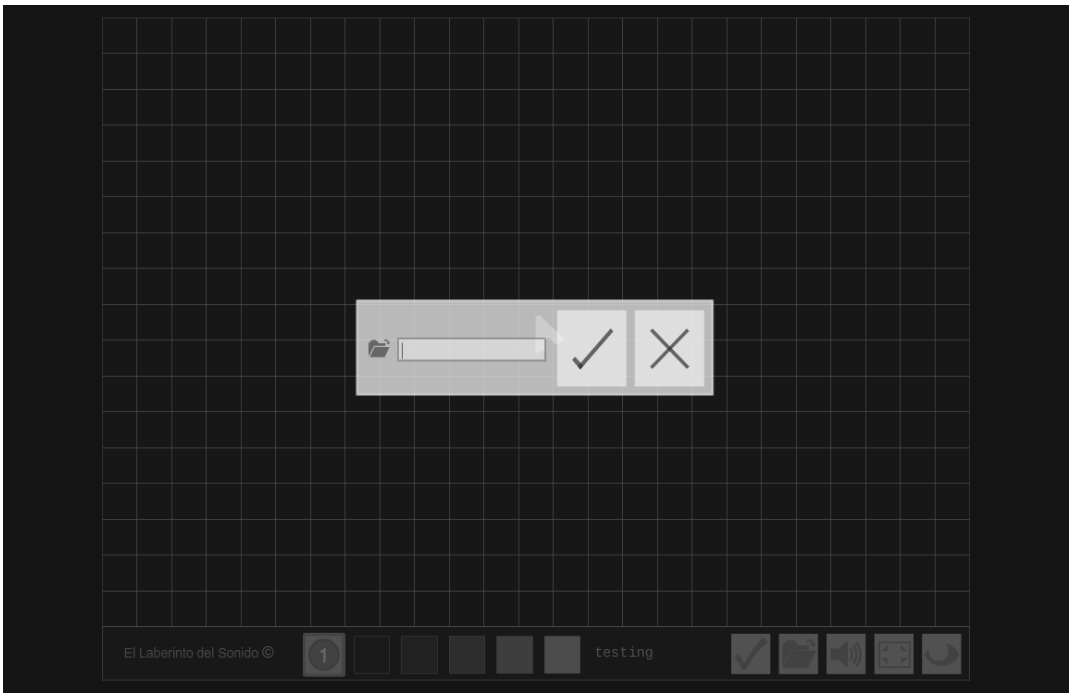


17. The following window will appear. To run the application, simply press the icon 'Run Now'[137].

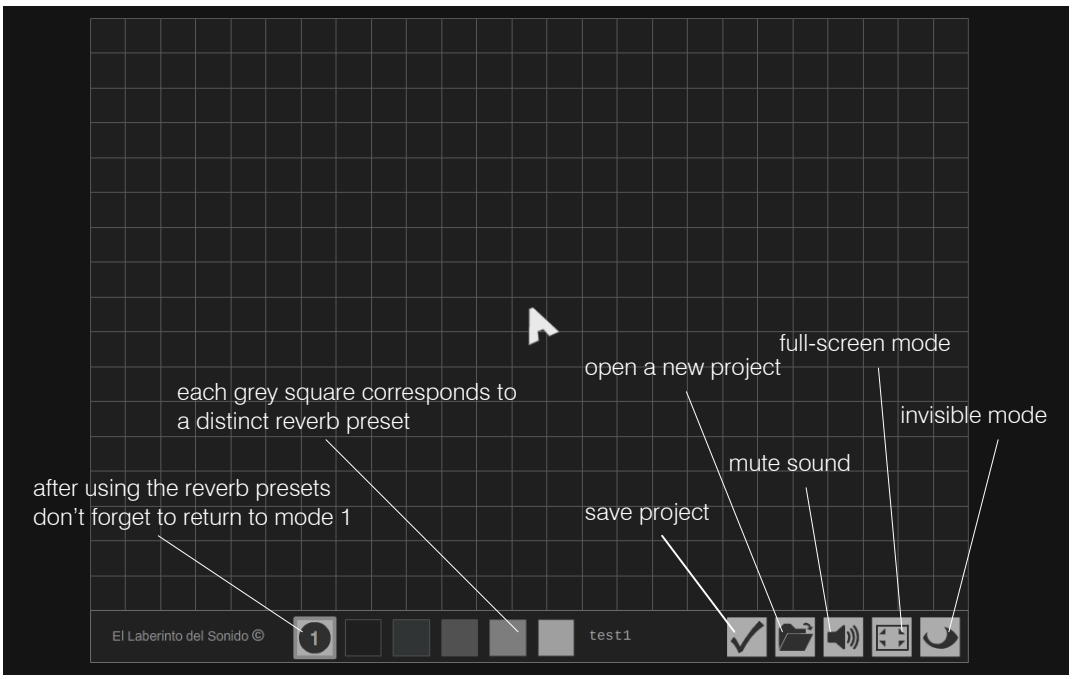


18. When you open the application, a small window will appear. Here, one can retrieve an existing project or, create a new one. To create a new project, simply press the 'plus' icon.

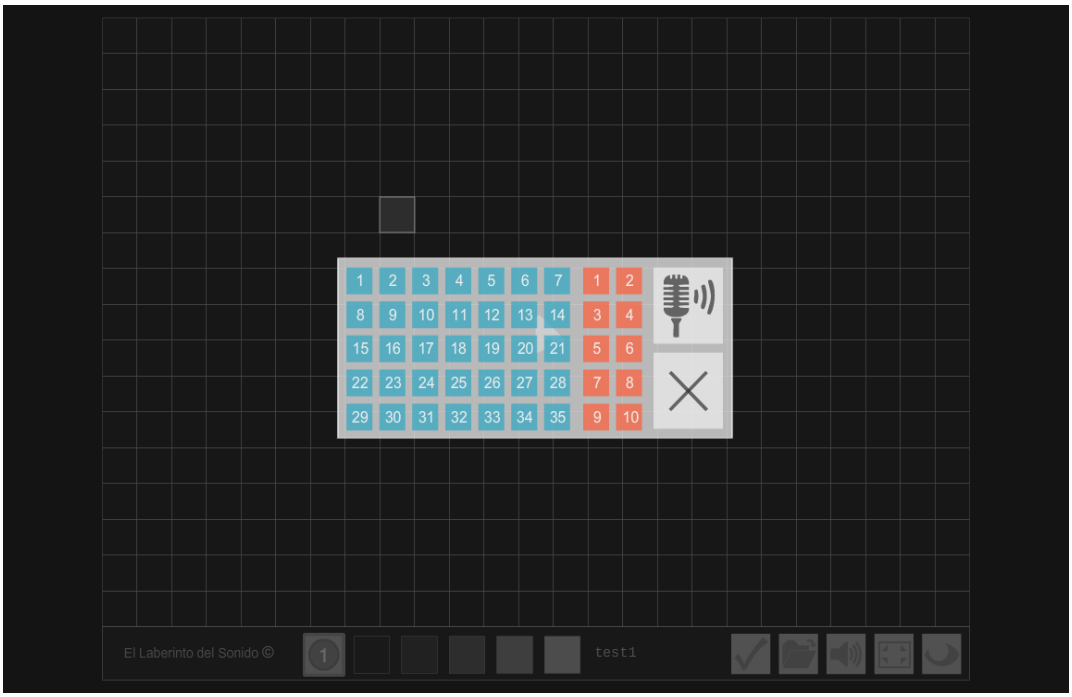
[137] As the reader will notice, this instruction was kept in the English language, this considering that the children learn this language from early as 6 years of age and that the older children (ages 8 and 9) immediately understood the message 'run now'. However, and as will be discussed in chapter VI, if the application further incorporates the '*Proyecto Medusa*' (Project Medusa) portal it seems reasonable to change these small initial features to the Spanish language.



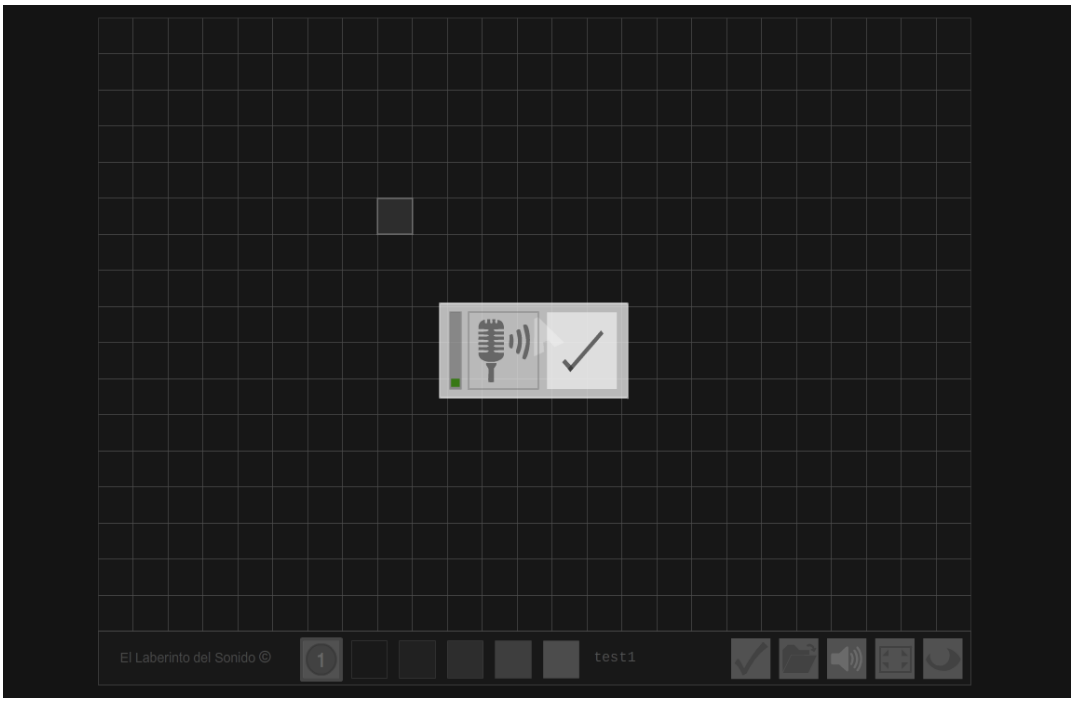
19. If the user decided to create a new project, this small window will appear. Here, the title of a new project should be typed and confirmed with the 'check' icon.



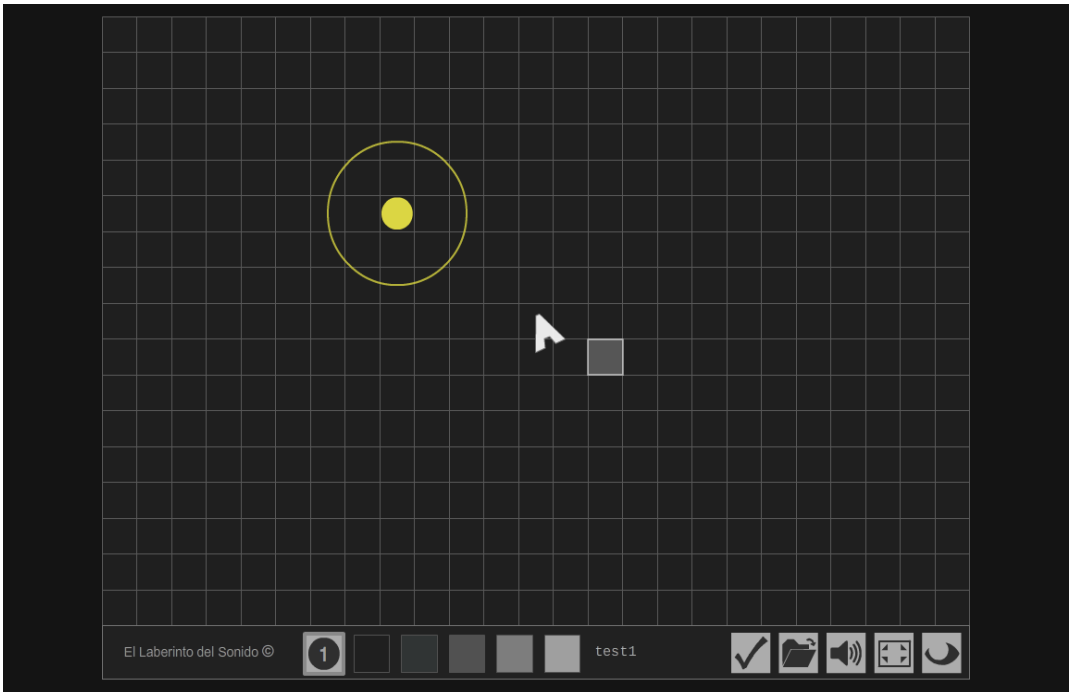
20. After this is done, a grid like area will appear. This is the editing space.



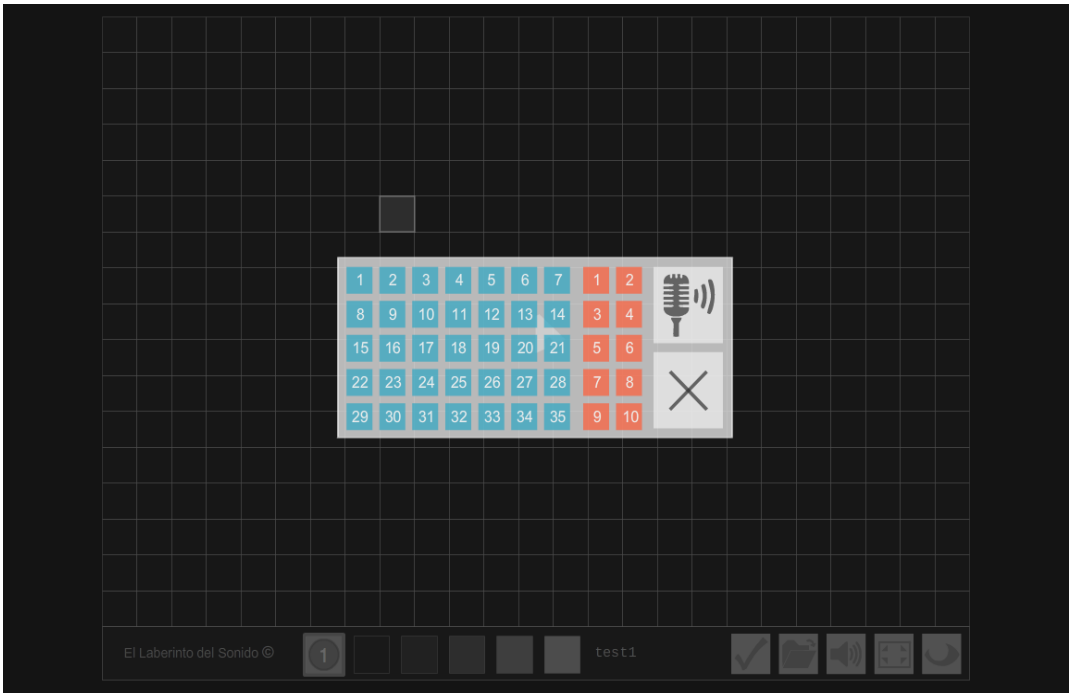
21. To insert a new sound in the editing space, simply select and press one square of the grid surface. Here, a new window will appear. To hear pre-existing sounds slowly rollover each coloured square. To record a new sound, select the 'microphone' icon.



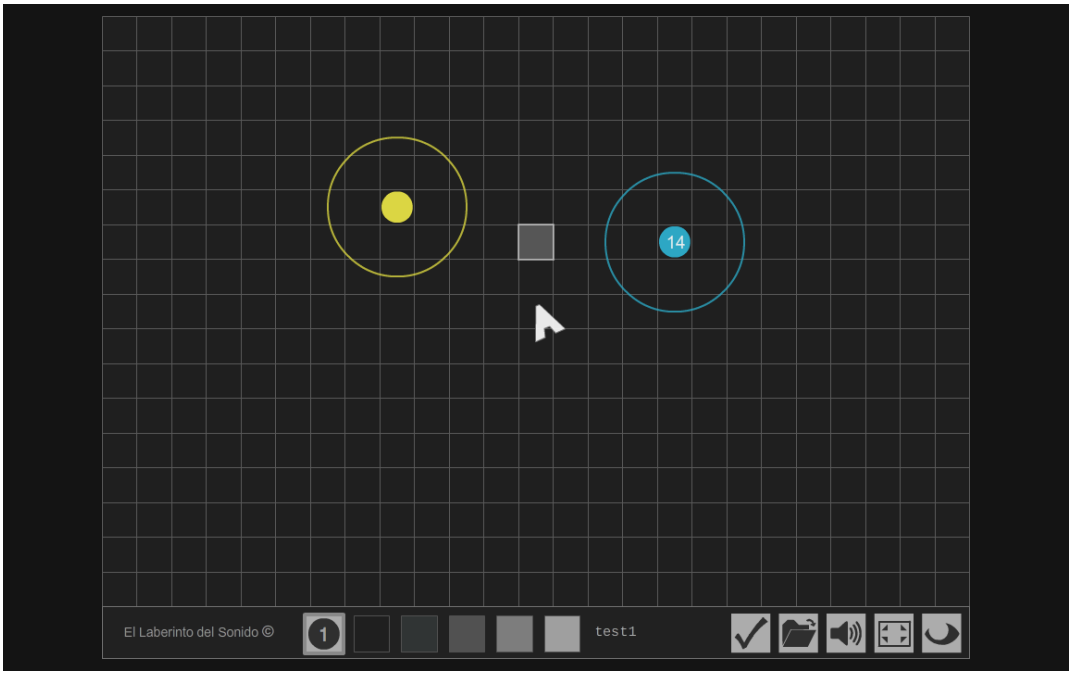
22. If you decide to use the record function, this window will appear. Record the intended message. Pay attention to the coloured bar on the left side of the microphone, in order to obtain a successful recording, this will have to change from the colour green to red. Make sure you are loud enough!



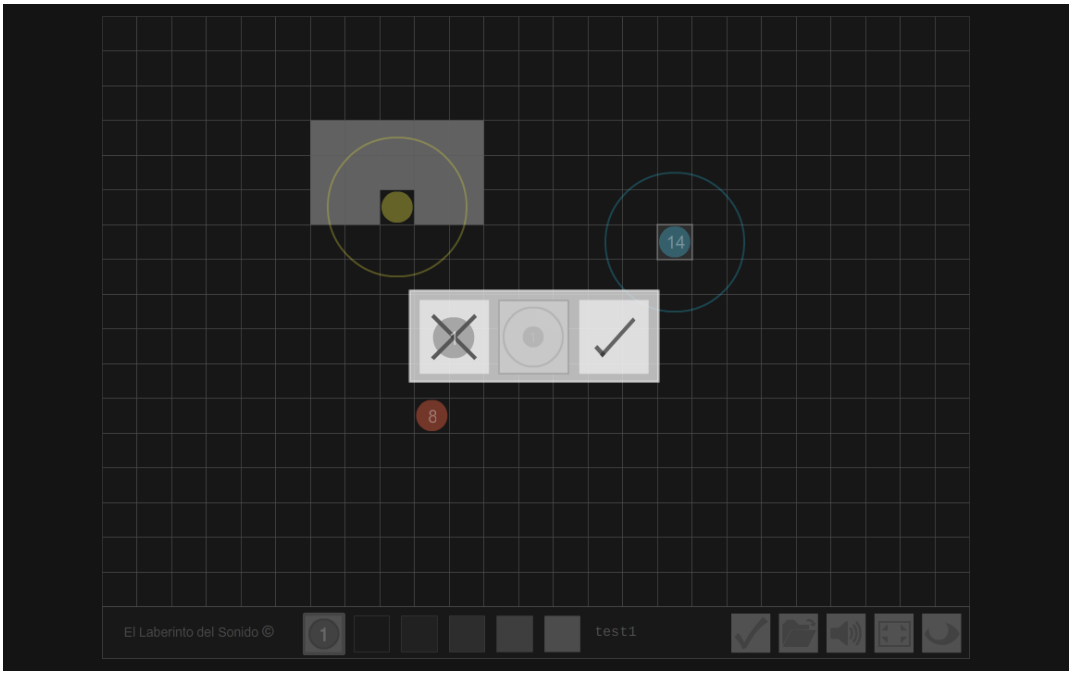
23. Here you have your first recorded sound source. In order to hear it use your space bar on the keyboard to activate the binaural feature. You can confirm this by looking at the two existing mouse cursors, black and white. Once the space bar is pressed they should be together.



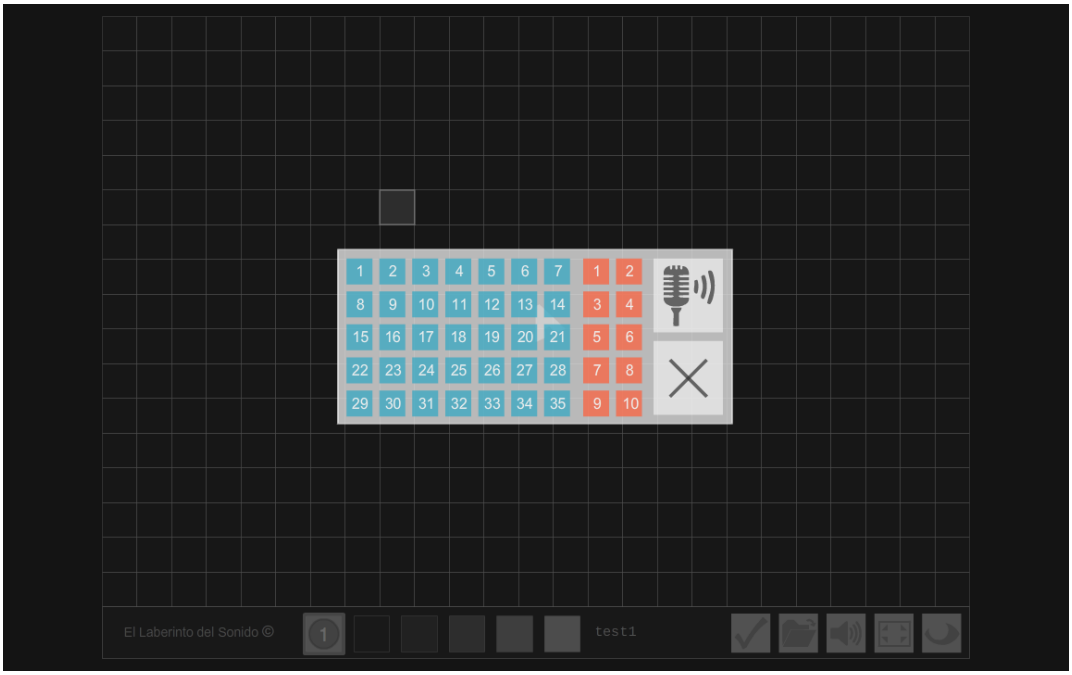
24. To exit this binaural mode and return to an editing mode, just press the space bar again. If you want to insert a new sound just press any square with the black cursor. The same window will appear once again. Here you can choose from a selection of previously recorded sounds, represented by the blue and orange squares.



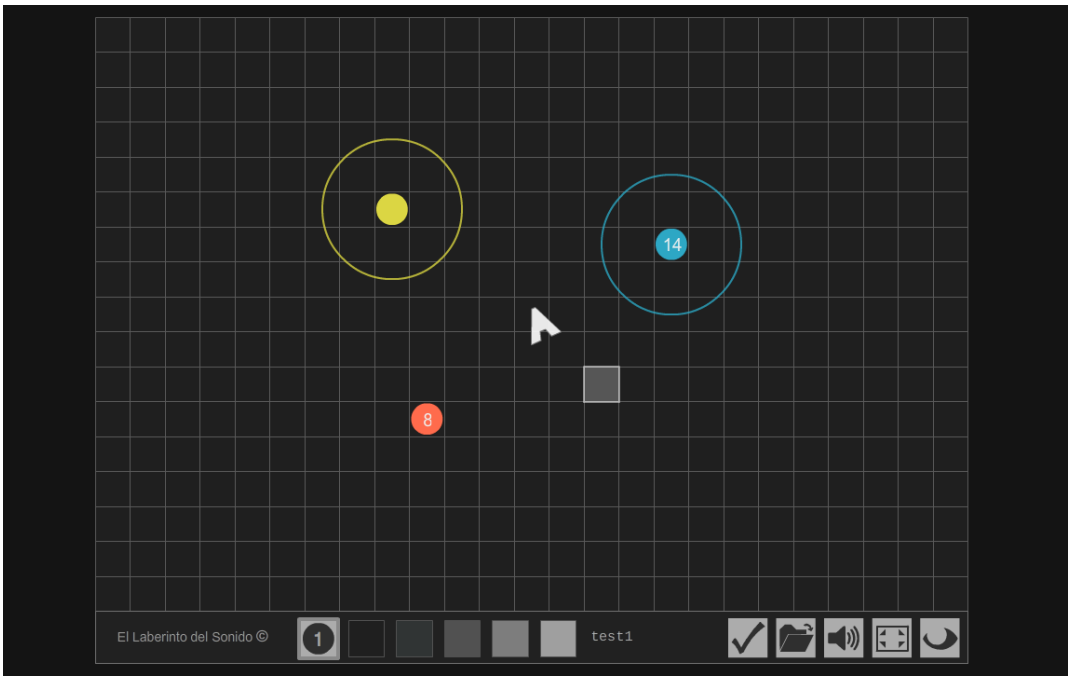
25. Now you have another sound source. The blue coloured sound sources, just like the yellow ones, are only audible when the 'avatar' is positioned inside the first thinner circle.



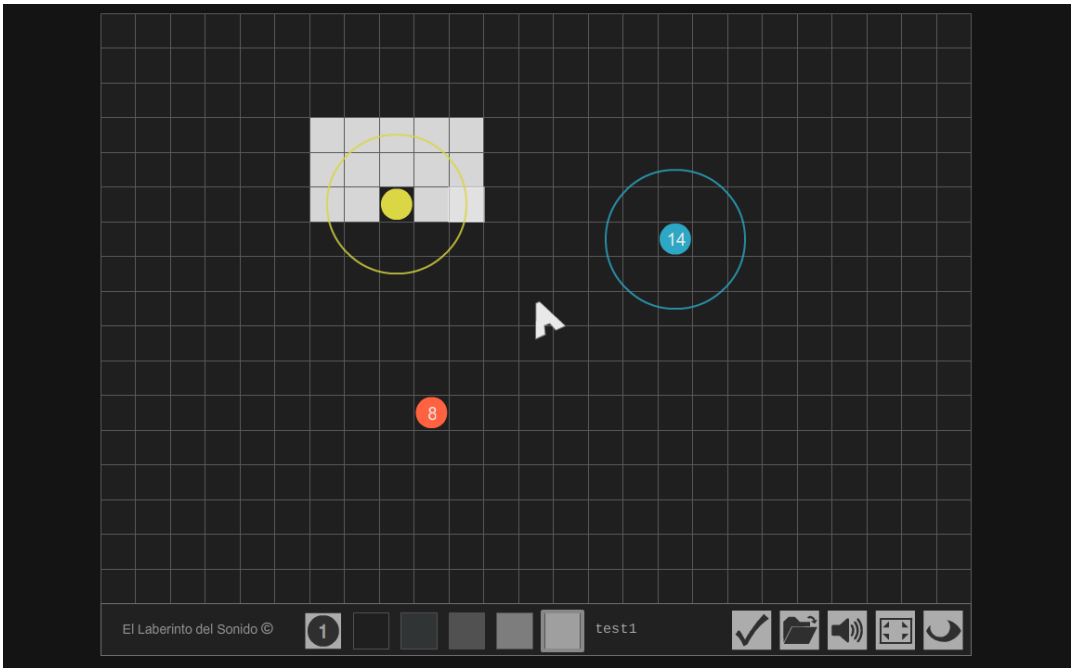
26. You can change this feature by selecting one of the yellow sound sources. This window will appear, just select the left hand icon and confirm with the right hand one. You can also use this window to delete any sound source.



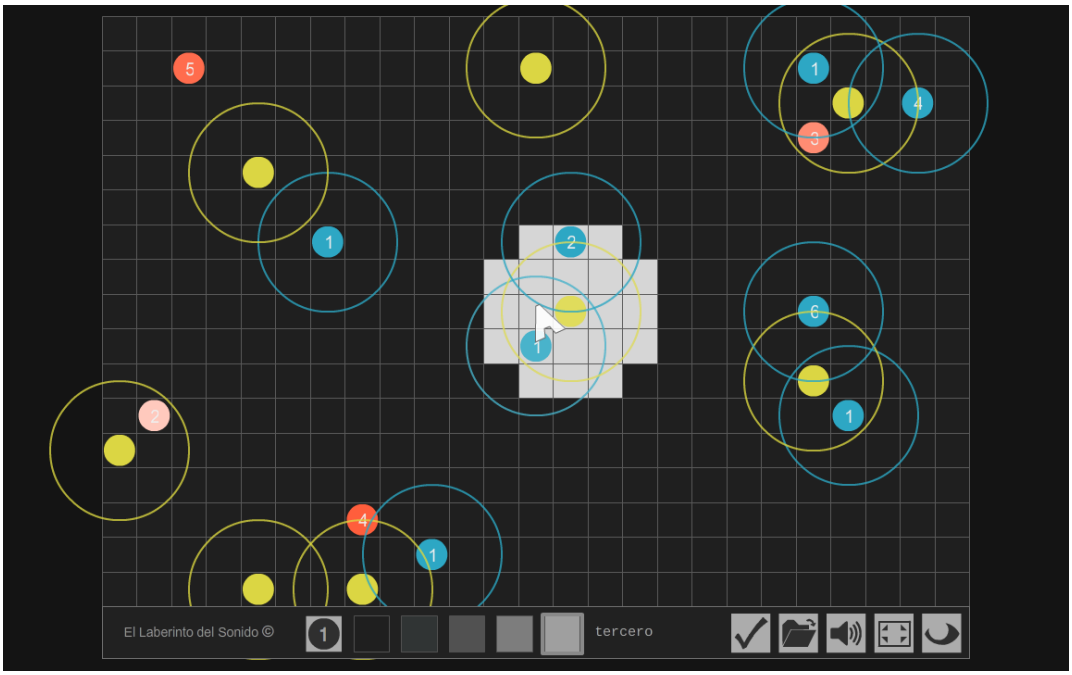
27. Repeat the procedure for any sound source you would like to insert.



28. Here you have an orange sound source. These are audible through out the grid space, according to the positioned distance between the 'avatar' and the sound source.



29. You can change the reverb quality of distinct areas of the grid by selecting any of the grey squares – according to the intended intensity, that increases from left to reight – and after painting each square grid.



30. Repeat the operation up to twenty sound-sources. This feature can be changed in the application setup properties, file 'config.txt'. However, it will increase the use of the system's power.

31. Finally you can use the 'eye' icon and switch to 'invisible' mode. Allowing others to interact with your created piece. In order to provide a richer aural experience, don't forget to press your keyboard space bar to activate the binaural mode.

4. Auditory Virtual Environments, Timeline and the Manipulation of Sound

The application 'El *Laberinto del Sonido*' takes into account the *Silbo's* auditory-linguistic heritage while drawing upon the development of electro-acoustic tools. In this sense it stands in stark opposition to other linguistic heritage applications, such as the 'Little Linguist'[138], developed in an attempt to safeguard and revitalize indigenous language scripts (Eglash & Tedre 2008). Because the *Silbo's* wealth of skills pertains to a distinct body of knowledge, it seemed most necessary to gain insight from the invention of virtual acoustic spaces as opposed to the most common safeguard of endangered languages, which is through the preservation of their alphabetic scripts. Here it is important to take into account the development of electro-acoustic tools as they have been popularized in the mid-twentieth century[139] and that instigated the development of acoustic spaces beyond the constraints of rhythm, melody, timbre, and tempo that were once afforded by classical musical instruments (Blesser & Salter 2006:164). Besides the obvious impact in the development of 'avant-garde, postmodern and experimental music' (p.366), such tools instigated the design of complex 'aural architectures' existing beyond physical constraints, while expanding the auditory and collective imagination. Space is then no longer

[138] Developed by filmmaker Don Thorton in collaboration with the Cherokee Nation tribal council and the Neurosmith Corporation.

[139] One of the first instruments can be traced to the 1920's when Russian inventor León Theremin created an instrument that consisted of a radio antenna that reacts to the movement of the hands of a conductor while generating voltages that are translated into amplitude and pitch (Roads 1998: 629).

purely physical or defined by the acoustics of 'real' environments and so virtual auditory spaces gained material dimensions that were previously unforeseen.

While some describe this passage as a leap from an external aural space towards increasingly subjective aural spaces (Blesser & Salter 2006:166), it is pertinent to add that such a degree of objectivity (or subjectivity) is not necessarily tied to a preference for particular techno-material conditions but rather to cultural and social process of individuation, the locus of auditory classification as explored throughout this thesis. Both experiences are grounded in particular techno-material fabrications and one does not necessarily have to consider the physical or geographical environment to be more 'real' than an electronically construed one. To assume this distinction is to pose an already refuted idea that the mind construes (or reflects) an objective and external world as opposed to the idea that the mind is already embedded in particular realms of ecological fabrication. In fact, cultural geographers have been contesting for a long time the idea of space (here understood as auditory space) as a pure physical constraint – a backdrop against which events unfold (Barad 2007:224).

This spatial approach still challenges recurrent acoustical (largely musical) educational software such as 'Hyperscore'[140] (Farbood & Pasztor 2006) and 'TamTam'[141] developed for OLPC (One Lap Top per Child). Even though these applications pertain to a vaster terrain of auditory orchestration, they are more realistically inclined towards the exploration of the auditory realm as defined by harmonic Pythagorean principles. It will take projects such as the 'Touch the Sound Project' (Breinbjerg et al. 2009) based on the idea of '*objet sonore'* developed by Pierre Schaeffer and the '*Musique Concrete'* movement to take the idea of composition into the realm of everyday sounds. The project developed at the Sound Lab, University of Aarhus (Denmark) allows children to explore the sonic environment through a series of created 'instruments' that can be enacted through touch. Within a similar logic – now exploring sound as a support for graphic expression – is the 'Jabberstamp Project' (Ishii et al. 2007). In this application, young children can add recorded sound to their own drawings, using a Java application that maps recordings to a drawing pad. I will also mention projects such as the 'Caress project' (Canagarajah et al. 2000) that resulted in the creation of 'Soundbeam', a device that uses sensors to translate body movement into digitized sound and image. In contrast to '*El Laberinto del Sonido',* these platforms were designed with a general educational purpose in mind.

Nevertheless, when analyzing the designed application, it seems pertinent to recognize new added values less explored in the described applications. This description will serve as a means to further elaborate one particular theme less explored in most auditory compositional

[140] For more information consult: http://www.hyperscore.com/

[141] For more information consult: http://wiki.laptop.org/go/TamTam

applications or even audiovisual editing tools: the issue of time and space and their intrinsic inter-relation, also central the whistler's body of knowledge. Most sound editing media is based on peculiar approaches to the stratification of time, dividing the timeline window into hours, minutes, seconds or milliseconds. This linear approach is imbued with a particular scientific logic that cuts time into a series of discrete frames (Goodman 2008:256), as discussed in chapter II. It is also embedded in graphic representational traditions such as writing, where sequences develop in an orderly fashion from left to write. Here information is arranged and experienced in a linear and time based manner, ignoring one of the most important aspects of sound, its spatial-temporal qualities.

Addressing this was one of the underlying concerns when developing '*El Laberinto del Sonido'*, where an absolute-time based rendering was converted into a plastic spatial-temporal medium, a quality visible in the application's layout: the possibility to insert sound sources according to a spatial orientation[142], to 'paint' reverberant qualities directly and to explore the composed narrative through a spatial orientation while using a drawing pad or even a more conventional mouse. One of the main driving forces behind this design paradigm has been, on the one hand, to explore fully the whistler's cosmology in the construction of cognitive niches (at the same time exploring complex auditory topographical maps) and, on the other hand, to instigate narrative construction and interaction in unforeseen ways – at least unforeseen within the logic of commercial applications currently available for children. Also, while creating narratives through the disposition of distinct sound sources, the application will also enable users to interact with each personalized story in unscripted ways. This opens the way for an implementation of Murtaugh's (2008) demand for 'liveness, plasticity and incompleteness' and design's 'opportunistic' model (Calmers et al. 2002).

4.1 Grounding Language. Narrative as Cognitive Process

One of the potential ways to explore the application '*El Laberinto del Sonido'* is through narrative construction. Here it is important to understand narrative under a wider frame, a constructive process where a subject organizes distinct materials (visual, tactile, sonic, etc.) in a personalized and meaningful way. In this sense, narrative appears less as traditional storytelling – where words, phrases and sentences are interwoven into a plot – than as a space where various auditory 'semiotic dimensions' (Gardner 1993) – here taken by the auditory realm – are able to merge. In fact, and concerning the proposed domain of auditory-spatial enquiry, narrative will appear as a meta-cognitive tool. In this sense, one way to look at narrative construction, is by

[142] Here, it is important to note that 'Jabberstamp Project' (Ishii et al. 2007) offers similar flexibility.

drawing attention to the ways in which users create their own narratives – inserting distinct sound sources, recording their own whistled utterances, and adding distinct reverb presets. Another way is by motivating them to explore – when the screen is shut-off by clicking on the 'eye button' – previously created narratives. In both situations, it is possible to uncover layers of embodied skill, where whistled communication and the auditory environment are entangled. Taking as ultimate goal the development of an '*audile*' culture, in both compositional and exploratory modes, 'active listening' becomes central.

While thinking through the idea of narrative construction and the sort of exploration that is afforded by the auditory-spatial medium, the idea of a 'cognitive map' comes to mind. In the opening lines of 'The Origin of Perspective', Hubert Damisch takes the reader through the realms of spatial representation and its ability to 'model thought' (Damisch 1995:xiii). This is particularly visible in the recurrent reorganization of geophysical maps as 'faithful representations of the real', and as suggested by the small publication on the *Silbo Gomero* and the development of didactic materials (Brito et al. 2005) when using visual cartographic maps to represent the locations where the whistled form of language was most often used. In a similar vein, Susanne Langer (1942) recounts how a child looking at the Mercator projected map (the representation of the globe on a flat surface) easily reaches the conclusion that Greenland is larger than the Australian continent. Here it is important to understand that this mode of representation requires knowledge of a peculiar mathematical language, one that challenges the idea of 'realistic' representation.

In fact, and in order to grasp the actual dimensions of the continents represented on a map one has to learn how to 'see-through' its subsumed mathematical rules (Langer 1942:80). This is called our 'virtualizing' capacity. This is valid for both formal-mathematical geophysical maps and the animist maps of Australian aboriginal cultures. These latter maps, commonly known as the 'songlines' are song-paths recorded both aurally and visually and that cross the entire continent, displaying a form of geographic knowledge while informing ways of navigating through space (Chatwin 1988). Both ways of mapping the geophysical environment contain complex cognitive milieus. While the Mercator map displays a bird's-eye view, the 'songlines' constantly reenact a view from within, a dynamic view.

Even though when considering computational based 'virtual' spaces some might distinguish between 'inhabited interaction' and 'disconnected control', where, in the case of virtual environments, 'users are disconnected observers of a reality they do not inhabit', (Dourish 2004:36-38). It is also reasonable to assume that this same boundary is rather more complex, particularly when considering interaction with spatial-auditory environments. As explored earlier on, in our critique of cognition as an 'off-line' modality (Clark 2001), it is difficult to imagine in

which sense are we ever disconnected, no matter what techno-material reality one might consider. Here one is able to draw an interesting point. What might enhance this sense of disconnection is our 'lack of skills' when interacting with a particular environment – whether it be 'real' or 'virtual'. In this sense, designed environments should allow the user to reason with the space, where body and space co-develop, as opposed to spaces that force the user to reason about the space that is embodied and that ultimately separates both (Dourish 2004:150).

To the extent that different ways of representing provide distinct embodied cognitive niches, the Mercator map can be understood through the logic of 'reflection' as opposed to one of 'diffraction', which is more in line with the Australian aboriginal song-lines. Both 'reflection' and diffraction' are central concepts used by Karen Barad (2007) when discussing ways of understanding the entangled nature of our techno-material realities and the formation of bodies of knowledge, as explored earlier on. While 'reflection' implies a logic of representation as that which demarcates the boundary between subject and object, reflection as a copy of what is to be gazed from a distance. 'Diffraction' (a term taken from the realm of Physics, when conceptualizing how a wave of energy, such as sound, travels through a particular medium) implies a demarcation of differences from within, meaning that subject and object are contained in the same synergy, through an entangled performance (p.89).

Taking on board, Barad's rich terminology, the idea of a cognitive map gains both *poietic* and aesthetic relevance. In fact, when attempting to preserve the idea of knowledge construction as 'reflection', a similar approach can be found in the first didactic recommendation within the *Silbo's* educational project (Brito et al. 2005), when simply locating, within a visual representational medium, the ancient places where the *Silbo* was once used. It is also here that the proposed application '*El Laberinto del Sonido'* attempts to create a situated and embodied '*audile*' culture from within as opposed to a mode of learning as purely representational, externally mediated and detached. This provides a way of understanding a cognitive map as a meta-cognitive tool, one that mobilizes the creation of '*audile*' bodies, reinstantiating a previous approach to dynamics and cognition in which all subjects are endowed with the highly plastic capacity of continuously restructuring their bodies of knowledge as such.

To give pertinent example, this is particularly important when designing interactive and audio-based games for blind children – a therapy that is used in the development of spatial and auditory skills. The effects of such applications are usually successful, particularly, when taking the realm of sound, within the interactive game culture, from pure 'emotional' backdrop to new 'affective' levels, in which sensory information provides a rich spatial-temporal reference in the construction of cognitive niches. This shift emphasizes a particular situation within contemporary computational and educational environments where the majority of sighted children do not use

sound as a means of learning. In fact, and when exposed to the same audio-based interactive games, sighted children rely less on auditory information. (Lumbreras & Sánchez 2000) Challenging this point implies a more complex understanding of performance, representation and knowledge as a continuous entanglement. This needs to be taken into account when exploring the ways in which the application '*El Laberinto del Sonido*' – as an auditory constructive and navigational environment – might instigate the creation of a complex '*audile*' culture. This point of investigation will be taken up in the next chapter when testing the application in a concrete educational environment in the island of La Gomera.

5. Final Remarks

This chapter drew its first lines while recognizing that in order to safeguard the *Silbo Gomero*, as both educational literacy and indigenous cultural heritage, a new and previously unforeseen interventional gap has opened up. This gap emphasizes the concern for indigenous knowledge systems and how they might be incorporated into a 'modern' project where both notions of literacy and 'schoolability' are concurrently challenged. While this form of whistling language was largely conceived within the educational logic of non-literate societies, the environment that this body of intangible heritage encounters is largely built on a distinct set of techno-scientific and intellectual values.

Taking such point as a pertinent line of investigation has mobilized an exploration of the *Silbo's* modes of cognitive apprenticeship while exploring both auditory and spatial skills. What bioacoustician Julien Meyer (2005) has said is the 'tip of the iceberg' opens up a pertinent discussion. Not only does this 'tip' characterize the value and skills that are transmitted from one generation to another, it also relates to an overall concern with the general disappearance of such skills within the workings of contemporary and secular educational environments (Gardner 1993). This is in line with the research provided by David Turnbull – here reviewed through the work of cybernetician and educational designer Ron Eglash (2003) – particularly the idea that contemporary indigenous bodies of knowledge and their wealth of skills are erroneously classified as pre-modern forms of literacy, carrying little value beyond folkloric preservation.

The design of the application '*El Laberinto del Sonido'* has further developed this point, which does not focus on the idea of preservation for the sake of preservation, but rather attempts to uncover the '*audile*' potentialities of this cultural body and its 'sonic effects' as they await further exploration. In section three, this chapter has proceeded with an overall presentation of the designed application and a brief overview of how it can be used; while proposing a broader understanding of the developed application as it is embedded in a long history of virtual acoustic environments. It is also here that, contemporarily, one might find various applications that are

mostly designed for a general educational audience, where the fabric of musical intelligence is largely taken as main guiding point. In this sense, the proposed application largely differs from the same, particularly while taking what is generally conceived as the 'timeline' into a distributed spatial-temporal logic.

This same logic is mobilized when recording sounds sources and allocating their position within distinct spaces provided by the applications interface and when exploring previously created narratives. With this in mind, both spatial and rich temporal and auditory considerations become key points and inherent qualities of the *Silbo's* investigated skills. This same feature was further enhanced by aural-spatial binaural algorithm and different reverb presets. The main concern when designing the presented features was to facilitate a process of perceptual exploration where the whistlers '*audile*' body can be further recreated through practice.

VI

RESEARCHING EXPERIENCES, DESIGNING METHODOLOGIES

"'For myself, I want to be alive and thus I want more words, more controversies, more artificial settings, more instruments, so as to become sensitive to even more differences. My kingdom for a more embodied body!" (Latour 2004a).

1. Brief Introduction

Before proceeding with the discussion of how the application '*El Laberinto del Sonido*' was received by the Gomeran educational community, it is important to provide a brief methodological discussion. Accordingly, it seems relevant to start the discussion by indicating how 'design' has been incorporated as guiding methodology in the development of research by the learning sciences (Bell 2004, Brown 1992, Cobb et al. 2003, DBRC 2003). Despite the provided contributions – particularly, as the field engages with localized settings in the devise of interventions and qualitative modes of evaluation – 'design thinking' has also been used by various educational theoretical strains – the psychological, social, cognitive and anthropological. To further sustain necessary interventions but also the theoretical frames that support such work. While the proposed ecological reading of the *Silbo Gomero* is not devoid of its own ethnography and theoretical discussion, it is important to keep in mind that each disciplinary approach will draw particular conceptual inclinations, language and academic goals. And while some are in line with an initial reading of design, other approaches slightly contradict a conception of this activity as a form of 'reflection-in-action' (Schön 1987) – one that largely deals with 'wicked problems' (Rittel & Webber 1973) that can only be conceptualized in situ. Considering this body of research, it is important to clarify which methodological orientations were chosen prior to the experimentation of the designed application.

Understanding the value of researching learning in situ will further complete section three of this chapter while outlining major points under consideration. Particularly when attempting to experiment with the designed application within the Gomeran educational context. Here, all factors will be described, particularly as they were taken into consideration. Further mobilizing attention to details such as time, available resources, number of people involved in this process and how all the above factors have instigated a course of development. As discussed in the

introductory chapter, this process has expanded an understanding of design as activity, mostly concerned with the planning and materialization of artefacts, to a larger frame of intervention that counts with experience and contribution of various actors. Taking this into account, this section will proceed with the presentation of the actual appropriation of the application by the children in the small school CEIP El Retamal in the Gomeran village of Valle Gran Rey. Keeping in mind the main working hypothesis – the ecological approach to the *Silbo Gomero* – in section four the text will provide a description of the activities developed in this school. This section will conclude with a presentation of the project's dissemination, stage that took place in a final visit to the island of La Gomera in September 2010.

2. 'Design' a New Emerging Research Paradigm

The idea of design as an interventional space has slowly gained ground throughout this thesis. Here it is important to keep in mind the idea of 'rhetoric by design' as suggested by Buchanan (1985, 2001), which was introduced in the first chapter. This form of rhetoric focuses less on the nature of theoretical argumentation – what some have presented as design's 'humble theory' (Gaver 2006) – than on the situated study of objects and technologies as they are appropriated and evaluated by distinct communities. However, design is not confined to the world of designers and it is therefore necessary to account for the 'design-based research' approach within the learning sciences (Bell 2004, Brown 1992, DBRC 2003). This approach has shifted the assessment of educational interventions from detached forms of quantitative evaluation to the design and exploration of material and organizational innovations within particular educational settings (DBRC 2003:4-5).

However, and as design becomes the province of various academic endeavours, it will also draw upon its own growing body of research other intellectual commitments. And while some approaches recognize that a design methodology primarily deals with 'wicked problems' (Rittel & Weber 1973), where unpredictability and diversity abide, a particular conflation between a design methodology and its necessary 'theoretical validity' (DBRC 2003) – as proposed by particular strains of the learning sciences – will provide a distinct conception of design. And before proceeding with a design-research approach to the experimentation of the proposed application it is important to clarify where this thesis stands. Three approaches utilised by this method will be considered: the 'developmental psychology design-based research', the 'cognitive science' approach, and the 'cultural psychology' approach which is also sometimes associated with a 'cultural or cognitive anthropology design based research' (Bell 2004).

All three stances are committed to interventional experimentation within educational settings while proposing long-term and sustainable interventions (Brown 1992). Where they differ, is in the theoretical breadth that guides their investigative and explanatory efforts. While the developmental psychologist will use a designed intervention to understand the ways in which 'participant-empowered learning' might be informed from a 'socio-cognitive approach' (Bell 2004:11). The cognitive scientist will use interventional design to study how 'perception, schematic reasoning, meta-cognition and problem solving' might be best understood in localized settings (p.14). Finally, the cultural psychologist and anthropologist will exploit design in the attempt to understand the ways in which development and learning is sustained by communities of individuals within particular 'micro-cultures' (p.16). In contrast, the cultural approach is less inclined towards theoretical validation and generalization of findings – an approach that is still largely deployed by the cognitive and developmental psychology approaches – and is concerned with 'customization', 'localization' and design of 'sustainable interventions' within situated and culturally grounded environments (p.17). This approach goes hand-in-hand with the 'emergent design' model (Cavallo 2003) presented earlier on.

Drawing from Rittel and Weber's (1973) description of design's 'wicked problems', the 'cultural' approach (as identified by the learning sciences) shares much in common with a vaster community of practicing designers. In fact, a clarification of this discussion might benefit the learning sciences and its community of practice. While acknowledging that before design became 'design-based research' it already provided a diverse, even though at times chaotic (Buchanan 1992), body of investigative work, one that in fact challenges the idea that design might be paired with 'theoretical validity'. This is a model that at times sustains the separation between the design of designers and the design of learning theorists (DBRC 2003). They are, so to say, very different. This is due not to the "theoretical claims about teaching and learning (…)" or reflections "on a commitment between theory, designed artefacts, and practice" as opposed to "merely designing and testing particular interventions" as designers are assumed to do (p.6). In fact, they are, as Latour (2005a) would add, politically different – so "as to study is always to do politics" (p.257). Here, by politics the sociologist is thinking of a *dingpolitik* (Latour 2005a), a politics that intervenes on a semantical level while altering the notion of design and its commitment to the material orchestration of objects, technologies, activities, educational curriculum, etc. While the cognitive or developmental psychologist will use design as a means through which one might gain access to richer descriptions of various psycho or socio-cognitive phenomena, the designer (and other culturally inclined psychologists and anthropologists) will use design as a means of cultural orchestration in and of itself.

Here two conceptions are at play. On the one hand, the idea of 'object' (or design) consonant with the description of technical artefacts as neutral backdrops against which one might schematize the psychic or social development of children – these 'objects' have been granted little degree of agency. On the other hand, there are objects that look more like 'things' (Latour 2005a), assemblies (or ecologies) of 'subjects' and 'objects' as they are continually being reenacted, one through the other. Now, if one were to take the 'interventions' provided by 'design-based research', as it separates its subjects from the objects of study, in the attempt to extrapolate 'usable knowledge' (DBRC 2003:5) – meaning those that are generalizable and applicable with certain degree of predictability across various educational settings – one is omitting, to a certain degree, the essence of design as mode of 'reflection-in-action' (Schön 1987), a process that is committed to a localization of its working hypothesis. In fact, and to sustain this argument further, Rittel and Weber (1973) make two important observations which were briefly discussed in the introductory chapter. First, against the idea that the learning sciences – while using 'design-based research'– are in close relation to engineering (Brown 1992), is the idea that educational designers are dealing with complex 'social problems' that are 'wicked' and not 'solvable'. "At best they are only re-solved – over and over again" (Rittel & Webber 1973:160). This makes them distinct from an engineering approach as material industrial orchestration.

With this statement Rittel and Weber were not attempting to destroy any effort to intervene within the complex fabric of communal life or even to deny the possibility of extracting from this intervention knowledge of some sort. Rather, they were attempting to produce a shift within design professions and methodologies – largely drawing from work in urban planning and other forms of cultural, educational and social policy making – as they 'redefine their problems and priorities towards goal-directed actions as opposed to a constant reorientation of professions into themselves' (p.157). This is not to say that the cognitive and psychological approaches to 'design-based research' are erroneous, that would be naïve and largely incorrect. However, it is important to acknowledge – here following positions within the learning sciences (Bell 2004:19) – that these approaches largely serve an already recognized academic or professional community of practice. And so it seems fair to ask at any given step of a 'design-based research' project: 'in whose interest is the designer operating (p.19)?' In fact, the descriptions of 'psyche' or 'social force' might have no relevance for those who receive the supposed design.

2.1 *El Laberinto del Sonido* – Moving from Plan to Practice

Such a diversity of approaches to learning leaves us with the task of designing the 'design-based research'. And if the cognitive scientist approaches design as a way, or means, to formulate richer descriptions of 'memory', 'mental schemas' amongst other things, what will the 'design-based research' of an educational design approach entail? Returning to the work of Buchanan (1985), it seems relevant to ask: "what do design arguments accomplish" (p.18). While recognizing that these designs, objects or interventions are best sought as ecologies – '*ding*' – that sustain particular contexts, agency should be delegated to the 'opinions, interests, attitudes, and values of users' (p.19) – a form of rhetoric in its own right. Such an approach is not devoid of recognition within the learning sciences. And as proposed by Perkins and Salomon (1996), learning cannot be solely based on the computer, network or software in and by itself (and here one could add, the learning theory) rather in the kind of intellectual and social activities the learner is able to engage in while deploying these mediums. This approach can be drawn from Perkins' and Salomon's attempt to understand educational media as part of a larger ecology not necessarily situated in the material qualities of media itself but rather in the ways each media is used and incorporated into processes of communal knowledge production.

In fact, and as a response to an approach where local orchestration is given a priori value, Perkins and Salomon (1996) direct the learning sciences towards a grounded understanding of both cognition and knowledge, not as something one might possess or abstract from any given context but rather as giving access to a particular ecology of environments, ideas, people and practices (p.16-18). What does this mean for this project? The designed application and its experimentation within the context provided by this thesis, particularly as it attempts to relocate the *Silbo Gomero* as an ecological practice valued by its own educational community? At this point it is important to recall how the whistler's body of knowledge represents an ecologically grounded '*audile*' synergy, and that this synergy might enrich the contemporary secular learning systems that characterizes the educational space of the island. While experimenting and acknowledging the successes and failures of the application, it is important to keep in mind the sensible orchestration of a generational transformation. It was with such factors in mind that the following guidelines were put forward when designing, guiding and documenting the experimental sessions.

As developed above, the users interpretations of the designed technology as well as my own interpretation were taken into account. Here, it is important to understand 'users' in a broader context. Initially, this term corresponded to three groups of children with ages 7 to 9, that attend the schools of the island and for whom the technology was initially designed. Another group of 'users' were the teachers of *Silbo Gomero* who would provide an interpretation of the application,

this considering that it supports an ongoing process of language learning. During this initial planning phase, it was important to consider the interpretations provided by the island's educational bureau. In case the application would succeed, this organization, lead by Ms. Jeannette Plasencia Moreno, could provide support for further dissemination. As the project takes an unexpected turn, another 'user' will be taken into account. Here, I am referring to elementary school teacher Ms. Marisa Blanco Perés who showed interest in the application and would incorporate this into ongoing class activities.

As presented by Gaver and Sengers in 'Staying Open to Interpretation: Engaging Multiple Meanings in Design Evaluation' (2006), besides the panoply of 'users', it was important to organize and prioritize distinct levels of interpretation. According to the authors, the designer might encounter three distinct levels: on a lower level the designer might find issues concerning the usability of a designed application while on a middle level one might encounter issues concerning the ways in which the designed application will relate to the everyday lives of users. In this last level, it is important to take into account questions such as: 'what is the application for or what activities is it appropriate for' (p.2). Finally, on a higher level of interpretation the designer might find issues concerning the conceptual understanding of a designed system. In this last case, the user might value ways in which the designed application is meaningful on a personal, social or even cultural level. The higher the level of interpretation the more personalized will be the users understanding of a designed system. As presented in this chapter, and defended by the authors mentioned above, this relationship is not straightforward.

Taking this frame of work into account and the specificity of the research project developed in the island of La Gomera, the following scheme of interpretation was developed:

- Lower Level of Interpretation.

This level of interpretation is mainly directed to the children, primary users of the application. Here it is important to consider the following questions:

1. Do the children understand the application and its intended use?
2. Do they use the application to experiment with the *Silbo Gomero* language?
3. How does their capacity to manipulate the application evolve throughout?
4. Do they use the non-linear architecture provided by the interface to contextualize their created dialogues and narratives or, contrarily, do they follow a linear progression?

- Middle Level of Interpretation:

This level of interpretation is mainly directed to the children, teachers of the *Silbo Gomero* as well as other teachers that are involved in the preservation this local form of heritage. Here it is important to take into account the following questions:

1. How can the application be integrated within ongoing school and learning activities?
2. Does the application support an ongoing language learning process?

- Higher Level of Interpretation:

This level of interpretation will consider my own interpretation of the activities, particularly the ways in which it draws on the theoretical concerns expressed in chapters II, III and IV and that are essential to the ethnographic reading of the whistlers auditory body. This level also takes into account the activities with different users as well as the teachers and the bureaus interpretation of the overall project. This level of interpretation takes into consideration the following questions:

1. Does the use of the application enhance principles of **learning through design**, or learning by doing as developed in chapter IV (Dewey 1929, 1963; Schön 1987)?
2. Does the use of the application enhance principles of **learning through grounded processes of communication** as developed in chapter III and IV (Steels 2003; Vygotsky 1962, 1978; Brown et al. 1989)?
3. Does the use of the application enhance principles of interacting and **learning through exploration** of **'sound effects'** as explored in chapter IV (Calmers et al. 2002, Murtaugh 2008, Wartofsky 1979) and chapter V (Augoyard & Torgue 2005).
4. Does the overall use of the application indicate potential for the development of a rich '*audile*' (Sterne 2003) culture as proposed by an ecological reading of the *Silbo Gomero* in chapter II?
5. Is the application conceptually and culturally meaningful to the community as explored in chapter IV through the concept of 'emergent design' (Cavallo n.d, 2000)?

First, and in order to put this plan into practice, a number of 'wicked' (and logistic) design-research questions had to be considered. In fact, and as recognized by other educational and technological design projects (Connelly et al. 2007), one of the major difficulties when studying designs 'out in the wild' is not only its cost but also deciding how long an evaluation process should last. Is one day sufficient, perhaps one week, one month or even a complete year will be needed? Another challenge was to decide which tools should be used in the documentation of the experimental process. Taking this last question into account, and considering that an early involvement with the Gomeran community, particularly when participating in the various *Silbo* classes for both children and adults, was mobilized by direct

participation, interviews and audio-visual documentation, it seemed relevant to keep the same approach throughout. Initially, and upon my suggestion, the computer engineer Theo Burt created a log-file[143] which would be used to document interaction with the software. However, and as the data obtained did not yield any relevant description of the children's interaction with the software, this tool was consigned to the background.

This was a methodological decision that was made in the first experimental sessions, but the issue concerning how long this process should last and how many schools should be incorporated were still to be taken into consideration. Here two important factors had to be considered, first the fact that the software would support existing activities – learning the *Silbo Gomero* – but also that some new features were to be further emphasized such as the ability of the children to understand the application, their ability to use it in the development of narratives while using the *Silbo Gomero* and the overall exploration of an auditory learning environment. Considering this, a minimum of sessions with the same group of children was considered to be a priority. A second consideration was to decide which children and teachers should be involved. Should the evaluation process be restricted to the *Silbo* teachers and their half-hour class per week? Or should the evaluation process focus on the possibility of children using the application on their own? Or while accompanied by their full-time teachers, within the language module? One important consideration when choosing a school to participate in the experimental sessions was not only conditioned by early participation in the *Silbo* classes, but also by the support different schools were able to offer. For this same reason, and considering the time spent in the small school CEIP[144] El Retamal during previous research periods conducted in 2007 and the interest shown then by the staff and students, this school was chosen as the main locus for experiment and a two-week period in which to conduct it was negotiated.

3. CEIP El Retamal

This small school, set on the backdrop of the island's green valley, teaches first to sixth grade students, raging from the age of six to an average of eleven/twelve. The nature of the application meant that experimental efforts were orientated towards the ages seven to nine, consisting of second, third and fourth grade students. This choice was influenced by two factors: fluency with the *Silbo Gomero* and understanding of the nature of the proposed activity – the

[143] A 'log file' is an application that quantitatively records the actions of users as they take place in real time. In the particular case of the application *El Laberinto del Sonido*, this file is still in use and records the movement of the mouse, the number of inserted sound sources, the number of recorded sound sources, the amount of painted reverb presets and the number of interactions with visual display turned off.
[144] CEIP stands for '*Colegio de Educación Infantil y Primaria*'; translated into the English as: 'school for infant and primary education'.

creation of narratives using both whistled language and other forms of sound exploration. Even though it would have been interesting to evaluate the application within the context of the *Silbo's* classes, the thirty minutes allowed per week did not provide a feasible context for experimentation. This constraint meant that the application was implemented within the second grade classroom, largely supported by teacher Mrs. Marisa Blanco Perés. Even though not teaching the *Silbo Gomero*, this teacher is a committed facilitator and very much engaged in the safeguard of this form of language. In fact, early on, Mrs. Perés demonstrated an overall sensitivity to the underlying educational implications of this project. This support, in this setting, meant that all students, more or less fluent in the *Silbo Gomero*, were able to participate.

When it came to the third and fourth graders, the activities were divided among six sessions of one hour each, in the afternoons after normal school time, and for one hour on a Wednesday, a period that was kindly given by the sports teacher, Ms. Vicky. Considering that most students were not in school during the afternoons and also that the only two computers were provided by myself because the initial version of the application was developed for a Macintosh system which the school did not have – the activities were developed with the students chosen by *Maestro* Isidro the *Silbo* teacher in this school.

Three factors were taken into consideration when deciding which students to include. First, there was fluency in the language; second, the child's personal interest in the project; and third, permission of their parents and legal tutors. One of the students initially chosen was only able to participate on the first day, because he could not be in school during the following afternoons. Two other students were chosen although they were not so fluent in the language because they spent most afternoons in school and had an interest in the project. One of the students had great difficulty in school in most subjects, and to my disappointment, even though showing an initial interest in the project, after the first day, decided no longer to participate. Despite my attempts to convince the student that there was much she could do and learn with this project, this student was reluctant to participate. The other student, despite not being initially selected for her fluency in the *Silbo Gomero*, proved to be extremely keen to participate, showing particular interest in learning how to manipulate the overall application.

As part of the Canarian archipelago, the small school CEIP El Retamal follows Spanish educational national guidelines. Consonant with most European Union state members, Spain had also, early on, showed interest in the 'modernization' of the school system, particularly through the implementation of computers in the classroom. In the Canary Islands, particularly in La Gomera, the development of digital cultures within educational settings has most recently

been implemented in *Proyecto Medusa* (The Medusa Project)[145]. This project has brought to CEIP El Retamal twelve PC computers set up in one of the schoolrooms where the children engage with information and communication technologies (ICT's) for one hour per-week. According to Mrs. Perés, not all teachers have incorporated this project within their own methodology. In fact, she is quite suspicious about forcing computers into education, considering that what might work for particular subject areas does not necessarily work for all. In fact, this seems to be a common opinion amongst teachers. 'It all depends on how one incorporates these tools, the same could be said for a pen and pencil', was how Mrs. Perés herself put it.[146] The school, in spite of having a basic computerized infrastructure, still lacks ways of fitting this into everyday activities.

Despite this, the children who participated in the evaluation of the application showed great fluency with the computer medium, a fact that might have been aided by *Proyecto Medusa*. Mrs. Perés said that most children already have computers at home and they learn to use them almost by themselves and are more likely to teach the teachers how to use them. However, amongst the children, some only have the possibility to access a computer in school (for various, mostly economic reasons) in the ICT class provided by *Proyecto Medusa*. Despite the presence of this project one does not find a distributed computational culture within the school context, this considering, that such infrastructure is largely used outside of the classroom, confined to a few hours a week, particular subject areas and didactic materials that are more instructional in nature[147]. Even though my project did not aim at a deep evaluation of this situation, by its own nature, a situated approach requires a careful attention to its contextual setting.

Because the ICT and the *Silbo* class are relegated to a short weekly timeframe, there seemed to be no alternative besides developing the activities in an extra curricular way. This was the working plan developed for both third grade and fourth grade students. With the second grade students I was able to develop, in collaboration with Mrs. Perés, the project within normal class hours and incorporating a narrative theme that the teacher and the students had already started. In this sense, the use of the application '*El Laberinto del Sonido'* was further incorporated in the daily school activities dedicated to the language module, which in fact is divided between Spanish and the *Silbo Gomero*, this last one occupying less time within the proposed curriculum. Overall, I found positive results in both situations, however, this latter setting offered more

[145] More information concerning this project can be found at:
http://www.gobiernodecanarias.org/educacion/4/Medusa/GCMWEB/Code/Default.aspx
[146] For more information consult DVD 2, movie 5, in attachment.
[147] More information concerning these applications can be found under '*Recursos Educativos*' (Educational Resources) at:
http://www.gobiernodecanarias.org/educacion/4/Medusa/GCMWEB/Code/Recursos/DetalleRecurso.aspx?IdNodo=1514

possibilities to find exchanges with other environments, a feature that had not previously been foreseen.

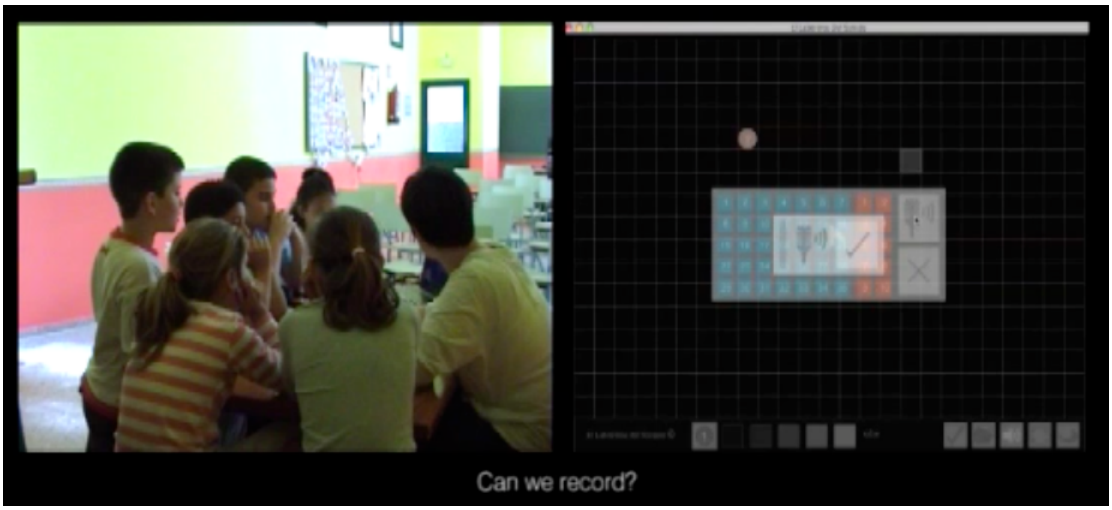
On the other hand, with the third and fourth graders, and considering that I was working in two small groups of four/five older students, there was more time to exchange ideas about the project. In these two groups, most students were interested in having a copy of the application to install on their own personal computers and also made recommendations about changing some design features (to be explored in the following section). The children's overall interest in the application seemed to be positive. Finally, each setting brought its own distinct contribution, one concerning the implementation of the application in the school context outside of the ICT or even the *Silbo Gomero* class; the other concerning the potential for the application to be used outside of the school context, taking a situated approach to knowledge construction beyond conventional learning environments. In fact, the children's requirement concerning the acquisition of a personal copy to install in their own computers further supports an already increasing awareness that many digital technologies, particularly the new ubiquitous, distributed and mobile technologies, are changing learning settings from the school into new distributed networks and environments (Rogers & Price 2009).

3.1 *El Laberinto del Sonido*, Sessions I

The following section should be read in conjunction with DVD 2 contained in the attachment of this thesis, in which one can find audiovisual documentation of the activities of second, third and fourth grade students at CEIP El Retamal. The experimental sessions with third and fourth grade students extended over a period of six days, one-hour session each day. Students were divided into two groups of four to five. *Maestro* Isidro chose the children based on their proficiency in the language, overall performance and intelligibility and the initial session was followed by a thorough presentation of the designed application *El Laberinto del Sonido*. The two groups consisted of five students (Andrea de la Noé, Andrea Correa, Inés, Carla and Daniela) aged eight and nine, and four students (Melani, Maday, Gustavo and Sergio) who were aged nine. These children all attend together the same class throughout the year and were therefore acquainted with each other.

In the first session, and for the first thirty minutes, I adopted the role of a transmitter but quickly passed to being a facilitator when the children showed interest in trying out the application and clarifying their own doubts. This was most visible amongst the older group of children who soon asked if they could record and playback Sergio's whistle (see image bellow). In both groups the children showed a particular interest at the facilitating stage, where they could closely engage with the application. The transmission phase was purely informational and so the

children did not engage with such eloquence, confirming, once again, Dewey's (1963) motto of 'learning through discovery'. This introduction provides information concerning a middle level of interpretation, particularly when thinking of the ways in which the application might integrate ongoing school activities instead of being formally explained in isolation. For this reason, in future experimental studies, it might be more productive to take an alternative approach by which the children can start from scratch, with hands-on materials. Considering that the children very quickly took charge of the overall activity, from this point, I mainly worked as a facilitator, helping when judging it necessary or as required by the children.



32. First session with the older group of students (age 9) (snapshot from movie 2, DVD 2).

The second session was devoted to the development of a narrative while exploring previously discussed concepts such as the auditory, temporal and spatial qualities of the *Silbo Gomero* and how the non-linear 'editing' space of the application could be explored to enhance narrative construction. Regarding point 4 of the first level of interpretation presented earlier on: 'do they use the non-linear architecture provided by the interface to contextualize their created dialogues and narratives or, contrarily, do they follow a linear progression?' The first group, particularly Andrea de la Noé, was able to explore the flexibility of this non-linear approach further (see quote and image bellow). This group's narrative was based on the idea of the labyrinth[148], where the listener approaches distinct doors that lead into distinct scenarios. For each scenario, they created a set of sentences – which they were able to perform while using the *Silbo Gomero* – and a set of sounds I provided later on, in the third session while manipulating the sound palette[149].

[148] For more information consult Annex III.
[149] For more information consult DVD 2, movie 2, in attachment.

33. Second session with the first group (age 8 and 9). In this session Andrea de la Noé (on the left window) explains her idea for the narrative (snapshot from movie 2, DVD 2).

Andrea de la Noé: **'So there is a boy wandering and he finds many doors. Every time he opens one he goes to a different place where he listens to different sounds.'**

On a first level of interpretation, particularly concerning the question of usability, the second group decided to use the 'editing' space to create particular and non-related scenarios[150]. For this reason, they did not exploit the non-linear dynamic nature of the application as did the first group[151]. Overall, this session proved to be highly creative where all children engaged by means of their own contribution. Some, who were more proficient in the language, gave suggestions for possible utterances. This is visible during the session with the second group where Melani asks Sergio – a more proficient whistler – if it is possible to whistle: 'the chickens cluck'. This passage provides useful information regarding a higher level of interpretation where aspects of language **learning through grounded processes of communication** (Brown et al. 1989, Vygotsky 1962, 1978), as explored in chapter IV, become key. Similar information can be found during the session with the first group where Carla – also a more proficient whistler – explains the other group members how to whistle the phrase *'buenos dias*' (good morning).

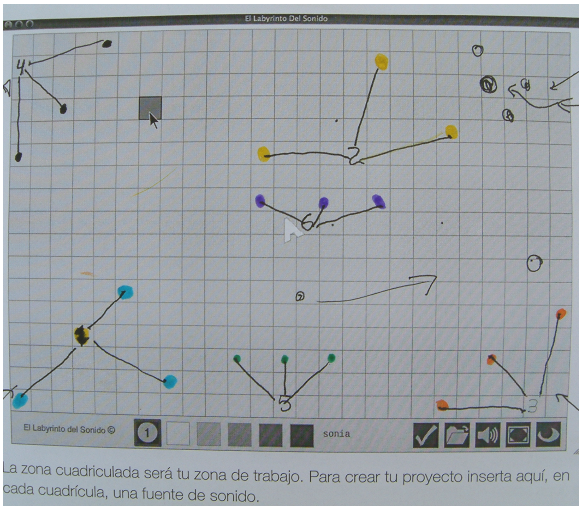
In both groups, some children were focused on the **correctness of the whistled utterances**[152] while others, more prone to **narrative exploration**, provided structural cues. This was the case for Andrea de la Noé, in the first group, and Gustavo, in the second. This **collaborative approach**, where children bring different areas and levels of proficiency provides useful information regarding point 1 of a middle level of interpretation. Here, one can imagine ways in which the application might support ongoing activities and classroom dynamics. This process has potential

[150] For more information consult Annex III.
[151] For more information consult DVD 2, movie 2, in attachment.
[152] Here it is important to note that even thought the system was not designed with the purpose of correcting whistled utterances, interaction amongst the children while using the application enhanced this feature.

to open previously unforeseen possibilities for each child. This was the case with Gustavo who initially wasn't very fond of computers and only wanted to participate because the *Silbo Gomero* was involved. However, after some sessions and while following the activities with his classmates, soon, he was 'hands on' the computer. This was also the case with Melani, who was invited to participate considering her interest in interacting with the application while using a computer. Considering this student's question enunciated above, the participation in the project also enhanced **curiosity**, particularly regarding the correctness of whistled utterances.

To complement this session, each group was a given a squared sheet of paper, resembling the notation space of the application. The children used this sheet as a mnemonic device while noting down the place of each recorded and preloaded sound. This proved to be useful, particularly since we only had one computer per group. Also, with this notation they could, more easily, circulate ideas amongst themselves or keep what they had done from one session to the other. In the future it is important to provide this element when interacting with the application. This auxiliary element also informs point 4 of a lower level of interpretation, particularly as it emphasizes the non-linear architecture of the interface, a structure that contextualizes their created dialogues and narratives.


34 & 35. Maday, Melani, Sergio and Gustavo using the notation paper to create their narrative while exploring both the *Silbo* and other sounds (left). Sergio training the *Silbo* (right).



36 & 37. The final sketch of second group narrative (left). Carla training the *Silbo* (right).

The third session was devoted to recording whistled utterances directly, while using the application. For this reason, the groups were divided between those who performed whistled utterances and those who showed more interest in working with the computer. This division was not strict and, children throughout exchanged roles while engaging with distinct phases of the proposed activity. However, and regarding points two and three of a lower level of interpretation: "Do the children understand the application and its intended use? How does their capacity to manipulate the application evolve throughout?" It may be that not all children understood the application with the same efficacy, a reason that could be contoured when working with larger devices – such as interactive whiteboards – or a larger number of computers per person. In the first group, Andrea Correa and Carla were the most dynamic, engaging both in the *Silbo* performance while using the application.

It was also during this session that pertinent discussions regarding the correctness of a whistled utterance were further discussed. In fact, within the first group, the word '*parad*' originated a lengthy debate, one that would reappear in the final session.

38. First group discussing the correctness of the whistled word '*parad*' (left) (snapshot from movie 2, DVD 2).

Daniela, Andrea Correa, Andrea de la Noé, Carla and Inés: **'*Parad*. Did you understand?'**
Carla: '**No! It does not sound like '*parad*'.**
Andrea Correa: **'*Parad*' is more like this….'**(Andrea Correa whistles).
Andrea de la Noé: **'So let's change it'.**
(Andre Correa gives a try but finally Inés repeats the whistle successfully).
Andrea Correa: **O.k. Now we got it!**

As presented later on, *Maestro* Isidro made an interesting comment while observing this part of the video:

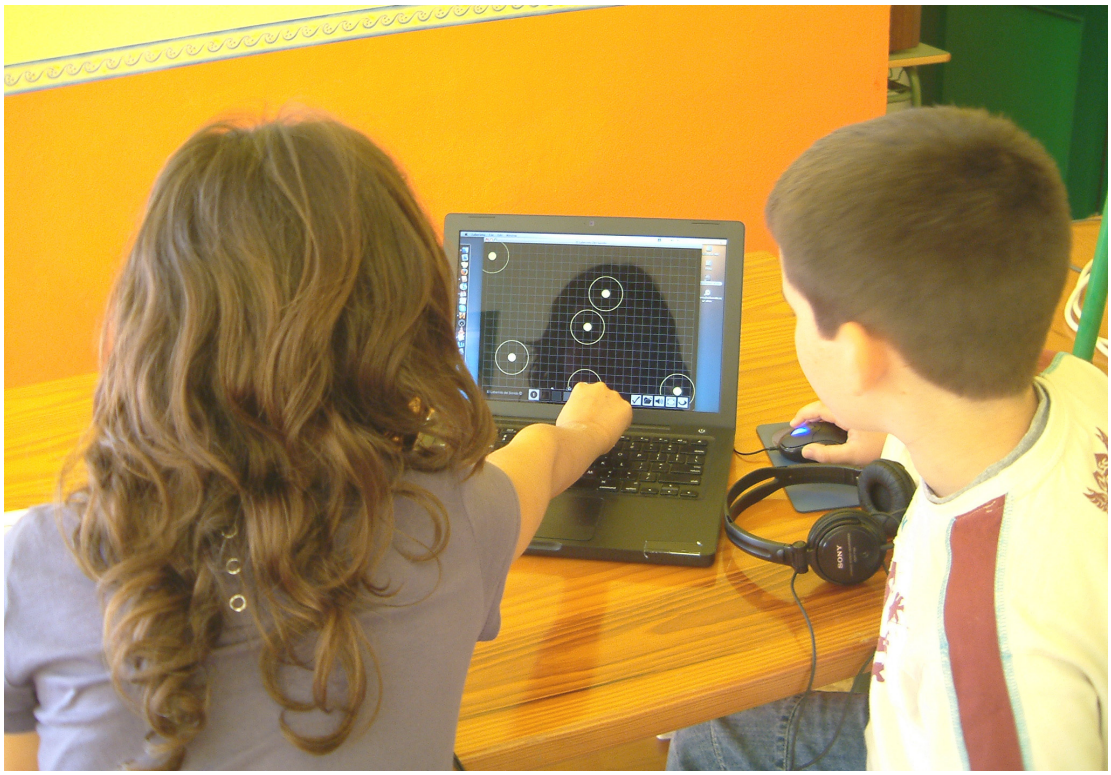
'They still do not know how to vocalize'
'but they are searching for the sounds'
'the sound that the word carries'
'Not the expression but the sound'

Both passages are important when assessing a middle level of interpretation and a higher level of interpretation. Regarding a middle level and higher level of interpretation, this passage further strengthens the idea that the application supports ongoing language learning processes through '**grounded communication'** as explored in chapter IV (Vygotsky 1962, 1978; Brown et al. 1989). Regarding a higher level of interpretation, this passage further strengthens the idea that the application supports the development of a rich 'audile' (Sterne 2003) culture. This last point is made possible through a '**learning process based on exploration**' (Wartofsky 1979) of '**sound effects**' (Augoyard & Torgue 2005). When the children are 'searching for sounds' (as explained by *Maestro* Isidro) they are exploring 'sound effects' that are linked to 'memory and perceptive

organization' (p.17). Here it is important to account for effects such as 'synecdoche' explored earlier on, one that affects ways in which listeners search, mentally organize and memorize sounds. This interaction also enhances the shift from forms of passive listening (a form of simply 'listening to') to forms of 'active listening' (a form of 'listening for') (Truax 2001:18) or 'selective listening' as explored in chapter V.

In the second group two students were unable to attend this session due to illness and were not able to participate. Gustavo and Maday were in charge of initiating the project, dividing their tasks between computer and performance. As presented earlier on, this change of plan proved to be quite fruitful particularly for Gustavo, who disliked computers and only wanted to participate in the project due to a particular interest in the *Silbo Gomero*. After a couple of sessions, however, he was using the computer while recording Maday's utterances and engaging with the application in a fruitful way. This particular session demanded collaboration and teamwork from the students. Students had to record whistled messages and periods of silence had to be agreed and respected. Also, and when they were not happy with one particular utterance, they motivated each other to repeat the process. Regarding point 3 of a lower level of interpretation: "How does their capacity to manipulate the application evolve throughout?" The interaction around the application demonstrated a good degree of integration within each group dynamic.

39 & 40. Part of the first group discussing if the utterances are whistled correctly (left). Andrea de la Noé recording Andrea Correa's whistled utterances (right).



41. Gustavo and Maday discussing the structure of the narrative.

The fourth and fifth sessions were devoted to the completion of the narrative while inserting new sounds and adding reverb presets. These sounds were mostly provided by myself[153] and based on the suggestions of the students. If the application is integrated into the school environment, this support can be given by teachers. However, and for those who wish to take this a step further, it would be fruitful to allow students to record their own sounds in the court-yard or even at home, an activity that was not pursued because of lack of sufficient digital sound recorders. The sound files have to be in a *wav* format and so children will need final assistance when converting them, using a sound editing software[154]. However, in this particular session, Andrea de la Noé, Andrea Correa and Carla in the first group were more engaged throughout, a fact that was partially constrained by the setup, composed of one small laptop.

During this session the first group took further the recording function and used it to capture sounds other than whistled utterances. This was useful as the first group wanted to integrate the sounds of a jungle with African music, sound that they composed while using the working table as a drum. This moment of improvisation directs this assessment towards point 3 of a higher level of interpretation and where **'learning through exploration'** of **'sound effects'** is emphasized. This refers to the use of 'psychomotor sound effects' (Augoyard & Torgue 2005:17)

[153] Royalty free sounds from the BBC sound effects library or recorded by myself during time spent in the island of La Gomera.
[154] See the free audio editing software Audacity at: http://audacity.sourceforge.net/

mentioned earlier on when presenting the *Silbo's* 'effects'. Here I am thinking about the '**synchronization effect**' (p.123), as the children coordinate sound and motor activity while 'drumming' and the '**imitation effect**' as the children 'consciously produce a sound according to a style of reference' (p.59). Both effects appear as a result of interacting with the application, they are not fruit of an early ethnographic reading of the whistler's auditory body. This interaction also exemplifies ways in which the children explore '**composition effects**' (Augoyard & Torgue 2005:17), particularly as they use the recorded drumming to 'mask' (p.66) whistled utterances within the cacophony of sounds.

It was also during this session that the children explored the blue and orange 'sound objects' that I had previously added to the computational medium. Considering the abstract character of most of these sounds, children had to memorize which sounds they wanted and which number they corresponded to. Considering that the children had to memorize distinct sounds, this feature also emphasized point 3 of a higher level of interpretation – 'does the use of the application enhance principles of interacting and **learning through exploration** of **'sound effects'**. This example is visible in one of Andrea Correa's remarks:

'It's number six'. (When referring to an environmental sound that Andrea de la Noé was looking for and which Andrea Correa had memorized while interacting with the application the day before).

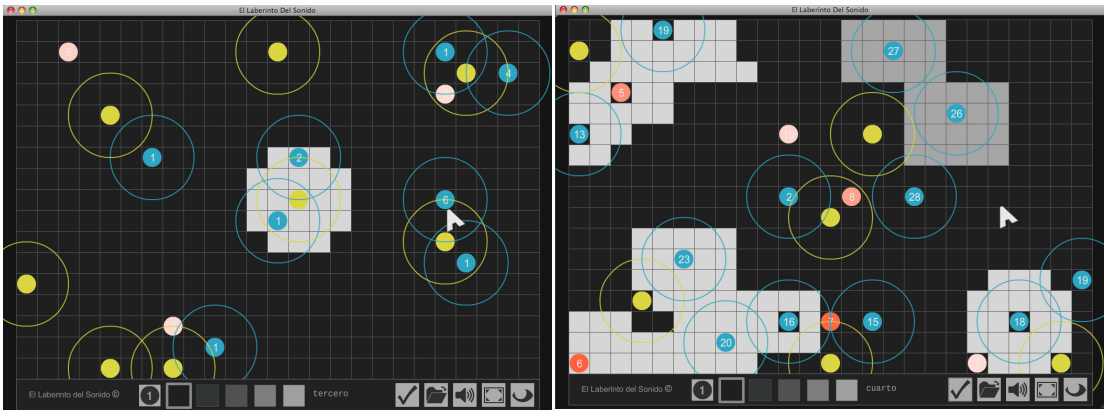
This quote also enhances the 'perceptual and organizational sound effect' (Augoyard & Torgue 2005:17), particularly forms of active listening as explored above (Truax 2001:18) and in chapter V when researching the wealth of skills that are transmitted from one generation of whistlers to the other.

Regarding point 3 of a lower level of interpretation: 'how does their capacity to manipulate the application evolve throughout?' It is important to consider that the final activities were done with greater ease because the children were by now comfortable with the application. However and when considering the first group composed by five elements it seemed that Daniela and Inés did not always engage so systematically with the application. Taking this observation into account, activities using the application '*El Laberinto del Sonido'* might become more easily appropriated by a vaster number of students when applied to a larger setup – as with an interactive whiteboard. Despite the fact, this proposal seems unfeasible, at least for the moment, this considering the material infrastructure of CEIP El Retamal and other visited schools of the island. However, and concerning the intent of designing for concrete educational settings, it seems reasonable to include in such account available technical resources while taking the benefit of existing conditions. This feature was emphasized in chapter IV when presenting the 'emergent'

design model. Particularly, when drawing attention to the importance of 'individualization' and 'customization for small groups' in the development of interventional educational design projects (Cavallo 2000:91). These aspects also inform a middle level of interpretation, particularly as I attempted to figure ways in which the application could be integrated within ongoing school activities while supporting the language learning process.

In the second group, due to the illness of the other classmates, Gustavo and Maday completed the previously designed narrative. The children had to keep in mind the number of possible sound-sources, which for the moment is set at twenty. Although it is possible to change it, this is not recommended since it tends to overload the application and cause unexpected crashes. This occurred with the second group as they exceeded the number of possible sound sources. However, considering how many recorded utterances (six for each group) and aural details they wanted to explore, compromises had to be made. This informs point 1 of a higher level of interpretation while emphasizing ways in which the application was used to **learn through design**. This last process not only strengthens the children's use of computer applications but also shifts ways of learning the *Silbo Gomero* from a passive to an active form as they design and reflect on the successes and failures of their creations. Regarding point 4 of a higher level of interpretation: "Does the overall use of the application lead to the development of a rich '*audile*' culture as proposed by an ecological reading of the *Silbo Gomero*?" This constraint proved to be quite productive, particularly when engaging children in a debate about the selection of sounds that would be part of the final composition.

At the end of this session both groups decided to add the reverb presets to distinct areas of the narrative. We decided to extend this session further on into the next session, where the final touches were added. It is interesting to note that initially the children avoided using the stronger reverb presets because of the greater distortion of whistled utterances. In fact, in the final documentary produced by the children (consult movie 3, DVD 2), Gustavo refers to the application as being rather 'noisy'. This remark can be understood from two distinct perspectives. First, it might indicate that Gustavo does not, on a personal level, relate to the application. This remark also provides information regarding point 5 of a higher level of interpretation: 'is the application conceptually and culturally meaningful to the community'. On the other hand, it indicates the possibility of opening new realms of sound exploration for the children. In fact, regarding this last point, most children used this 'noisy' aspect while adding degrees of playfulness, curiosity and exploration to their narratives. This was emphasized by the fact that their classmates would, in the final session, interpret their narrative/design.



42 & 43. The first group's narrative and first reverb application (left). The second group's final narrative (right).

However, only with time did they become interested in experimenting with the reverbs. Here it is also important to note that the children would name this effect as 'echo'. Even though I would attempt to call it a 'reverb' this term seemed confusing for them and so I proceeded with the name 'echo'. However it is important to emend this in future sessions, this considering that 'reverb' and 'echo' refer to distinct auditory-spatial qualities[155]. This passage also provides information regarding point 3 of a higher level of interpretation. Here, I am thinking of the ways in which this slow progression indicates a development of the children's curiosity regarding the 'composition' and 'elementary' sound effects (Augoyard & Torgue 2005). They explored these effects by **tinkering** with the ways in which sounds could be heard simultaneously – the 'masking effect' (p.66) – and while altering the temporal quality of a sound object while using the 'reverb effect' (p.111).

On the last day the two groups joined together in an organized session and exchanged narratives. The setup was comprised of two laptop computers, one for each narrative, and a set of two headphones for each laptop. During this session the interface was dimmed while using the 'eye icon', this meant that the children could only interact with the interface and narrative through sonic means. In one computer this interaction was established through a graphic tablet while in the other computer we used a mouse. As the reader might witness in movie 2 in the attached DVD 2, this progression from a visual to a purely sonic interface enhanced the interaction with the 'sound effects' (Augoyard et al. 2008) explored earlier on, while blurring the ease at which one would identify 'sound objects' through their visual counterparts.

All of the children engaged with each project in groups of two. Once this was complete, each group explained the narrative to the other classmates. To better understand the impact of

[155] While reverberation refers to the "temporal extension of acoustical events in a space generated by multiple sound reflections" (Everest & Streicher 2006:G.9), echo refers to relative delay (50 or more milliseconds) of this same propagation (p.G.4).

interacting with the 'sound effects' mentioned above, it is important to notice the following comments that are presented in movie 2 (DVD 2):

Maday: **'Andrea. Do you use the echo.'**

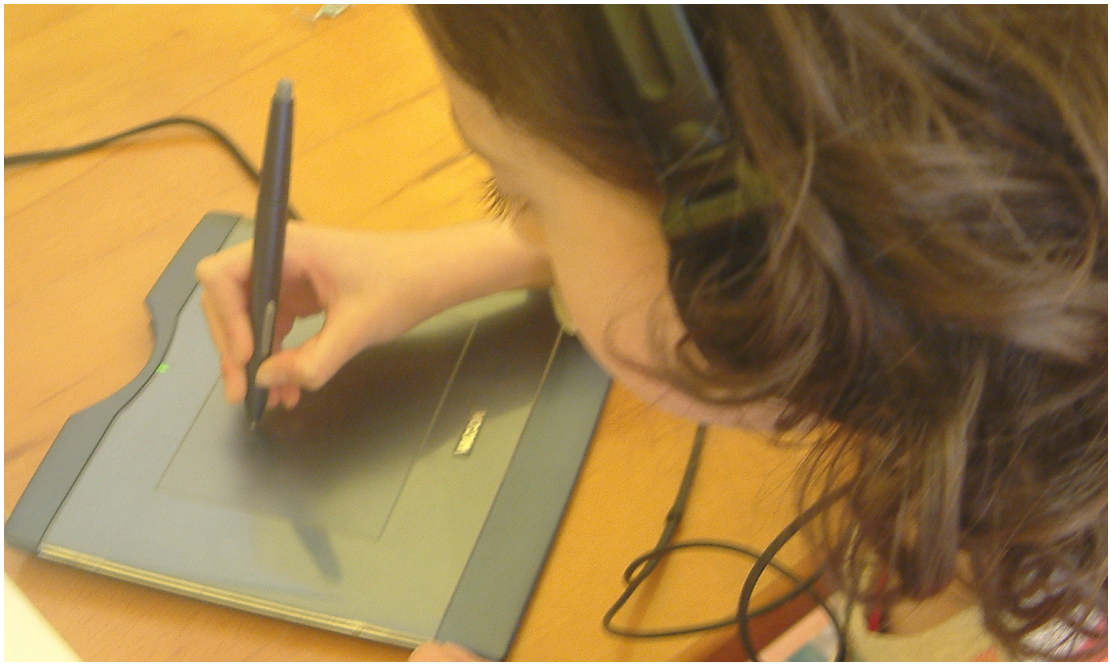
Gustavo: **'there it seems like aiai'.**
Sergio: **'*Parad*'…this one?**

Maday's comment indicates concern for the 'elementary' and 'composition effect' where the sound material is manipulated in a way that alters its complex temporal development (Augoyard & Torgue 2005:17). Gustavo's and Sergio's discussion concerning the whistled word '*parad*' (stop) informs ways in which the interaction with the application might enhance the development of a 'perceptual organization of sounds' (p.17), extremely important when strengthening the whistles auditory body of knowledge as explored in chapter II. This passage also shows us how the children had difficulty when deciphering their classmates' whistled messages. This testifies the complexity involved when learning the *Silbo Gomero*, in which performance and intelligibility are unequally intertwined. While this difficulty hindered their potential to push the learning process further[156] it also instigated a fruitful discussion concerning the overall sonic structure of each whistled utterance.


44 & 45. Carla and Andrea Correa discussing their classmate's narrative while uncovering each whistled utterance (left). Andrea de la Noé interacting with her classmate's narrative while Andrea Correa writes down the discovered whistled utterances.

[156] This idea, today, commonly deployed in the learning sciences, was first proposed by Lev Vygotsky when suggesting that learning was best promoted while establishing 'zones of proximal development'; briefly, this concept promotes the idea that activities should engage in complex forms of learning (at least more complex than what is supposed for the child's age) while opening the child into unforeseen terrains. (Vygotsky 1978)

46. Maday and Melani trying to decipher their classmate's narrative.



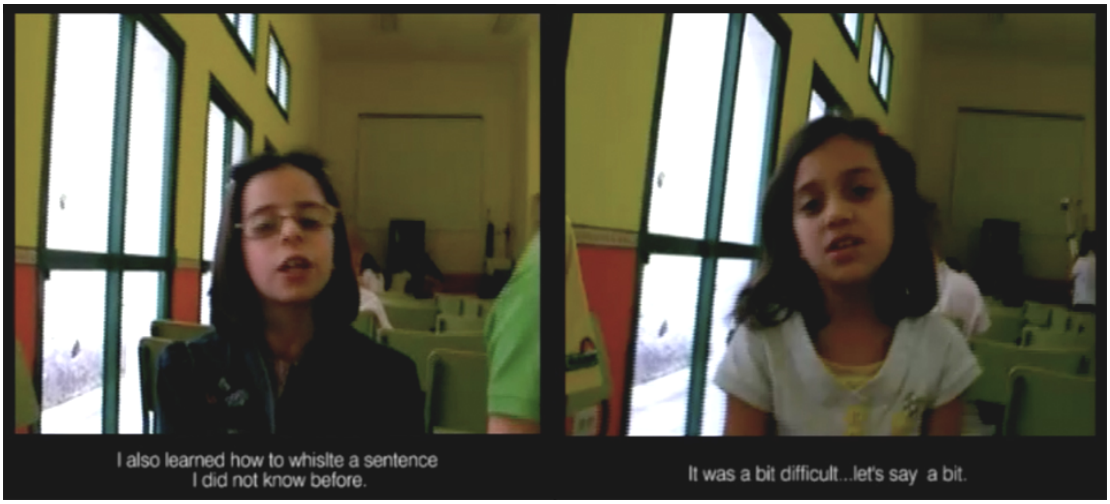
47. Andrea de la Noé interacting with her classmate's narrative.

Later, at the end of the session, when all activities were done, Andrea Correa and Daniela went back, in an attempt to decipher the missing utterances. Extremely focused, they each engaged in an interesting play[157]. The girls were curious about the 'masking' (Moore 2003:402) 'composition sound effect' (Augoyard & Torgue 2005:17) that was used by other classmates in order to conceal whistled utterances. The use of this 'effect' added layers of **curiosity**, **play** and **exploration** to the final activity, particularly when using the dimmed screen. This observation regards point 4 of a higher level of interpretation: "Does the overall use of the application lead to the development of a rich '*audile*' culture as proposed by an ecological reading of the *Silbo Gomero*?"

48. Andrea Correa interacting with her classmates' narrative (left). Daniela interacting with her classmates' narrative (right).

It is also important to note that during this last session a small video camera with space for one-hour's worth of documentation was provided to the children that were waiting for their turn to interact with their colleagues designed narrative. Initially this was not part of my plan, however it later became a valuable resource, particularly, when noticing, at the end of the day, that the children had worked on a small documentary concerning their experience of the project. This material collected by the children became a valuable asset for this thesis, this considering that, here, the children had the opportunity to reflect on the usability, comprehension and utility of the application[158].

[157] For more information consult DVD 2, movie 2, in attachment.
[158] For more information consult DVD 2, movie 3, in attachment.



49 & 50. Andrea Correa's interview (left). Daniela's interview (right).

From this series of interviews I would like to outline the following comments:

Melani: **'we learned how to use it in order to build a narrative'.**

Andrea Correa: **'Yes because it is very interesting and we learn more things'** (referring to the application)**. 'One of the sentences is *'buenos dias'*.' You say it like this….' (whistle). 'I also learned how to whistle a sentence I did not know before.'**

Daniela: **'It was bit difficult…. let's say a bit'** (referring to the application)**.**

Andrea de la Noé: **'we got to work with a computer and use the *Silbo*'.**

In these four reflective moments one can sense ways in which the application enhanced a language learning process by introducing a novel and playful didactic material. This is more pertinent in Melani's and Andrea de la Noé's comment. One can also sense ways in which the application enhanced an ongoing learning process already initiated during *Maestro* Isidro's classes. This is particularly visible in Andrea Correa's comment: 'I also learned how to whistle a sentence I did not know before'. This comment also sustains an understanding of the application as a system that supports **exploration** of the yet unheard. Taking a closer look at Andrea Correa's comment and the attempt to whistle the utterances used in previous activities, one can also sense ways in which the application emphasizes effects linked to the 'perceptual organization' of complex sounds (Augoyard & Torgue 2005). This information provides relevant information concerning a higher level of interpretation of the application as presented above.

Throughout these sessions, the main goal was to investigate the application's ability to support narrative creation within the context of the *Silbo Gomero* educational project and while mobilizing the development of its intrinsic '*audile*' (Sterne 2003) culture. Based on the data collected, one can see ways in which it may be successfully implemented. On a **lower level of interpretation**, the children understood how to manipulate the application in most of its detail[159]; they learned how to record sound, introduce existing sounds, change reverb presets and delete sound sources. The first group went a bit further and showed greater aptitude when understanding the intrinsic dynamics of the application and in exploiting the non-linear structure to its fullest potential, particularly while taking advantage of the 'masking effect'. On a **middle level of interpretation**, this suggests that the application might be more easily embraced by younger children, particularly in relation to narrative creation this considering that group one demonstrated more playfulness with such activity. In order to further strengthen this claim it would be important to conduct a larger number of sessions with younger children in distinct groups throughout the various schools of the island. On a **higher level of interpretation** and in terms of group dynamics and potential for the development of an '*audile*' culture, there was a fruitful exchange of suggestions, particularly when learning how to use the application, improving their whistled utterances and in moments of discussion. In fact, when explaining the overall project, both groups engaged in discussion, particularly concerning the whistled utterances and their auditory qualities. One can also sense ways in which the application sustains the exploration of distinct 'sound effects' (Augoyard & Torgue 2005) as explored earlier on – effects that are intrinsic to the development of the young whistler's auditory body.

3.2 *El Laberinto del Sonido*, Sessions II

Another phase of experimentation was conducted with the collaboration of Mrs. Perés and the second grade class, and where the students are about seven years of age. The involvement of this teacher in the *Silbo Gomero* educational project meant we were able to experiment with the application as a transversal activity that cuts through diverse levels of the language module, one that integrates Castilian Spanish and this whistled form of language. In fact, and prior to my arrival in Gomera, Mrs. Perés was developing a narrative project combining both. This involvement provides useful information regarding point 1 and 2 of a middle level of interpretation: 'how can the application be integrated within ongoing school and learning activities?' and 'does the application support an ongoing language learning process?'

[159] Here it is important to mention that the children did not change the orange and blue sounds that are given in advance and did not record their own sound besides the whistled utterances and the African drums by group 1 (for further information consult DVD 2, movie 2, in attachment). This would require the use of audio editing software by students or teachers supporting their work while using the application.

At the age of seven children are taking their first steps in this whistled form of language and so suitable utterances were chosen by the teacher in conversation with the three students able to perform the whistled language most fluently (Belém, Fátima and Sara). This narrative consisted of distinct dialogues which were nevertheless developed by all fifteen of the students in the class. Taking into account our limited material resources and what we initially thought would be the degree of difficulty presented by the application to children of seven years of age, we first of all decided to record their narrative dialogues while using a digital audio recorder. Later on, Mrs. Perés, with my guidance and while using this material, designed an interactive aural piece for the children[160]. These activities were spread throughout four sessions of one hour each. Two sessions for recording, one to work with Mrs.Perés and a final session to work with the children and the material they had created.

This experiment was important in assessing not only the partial interaction of the children with the application, while exploring strategies for its introduction within the community and, most importantly, in instigating the possibility of use by students and teachers when developing new learning material. Mrs. Perés was very interested in the application and was quick to grasp its value. Our collaboration ended with a conversation about the core issues that had arisen when during the session.[161] Mrs. Perés considered that the main barrier to the implementation of computational based technologies in the classroom is tied not only to deficiency in the material infrastructure (and here Gomeran schools have benefited from the introduction of the Medusa Project), but also to the fact that most teachers lack preparation and the openness to experiment with new material, particularly when the medium might involve profound methodological challenges[162].

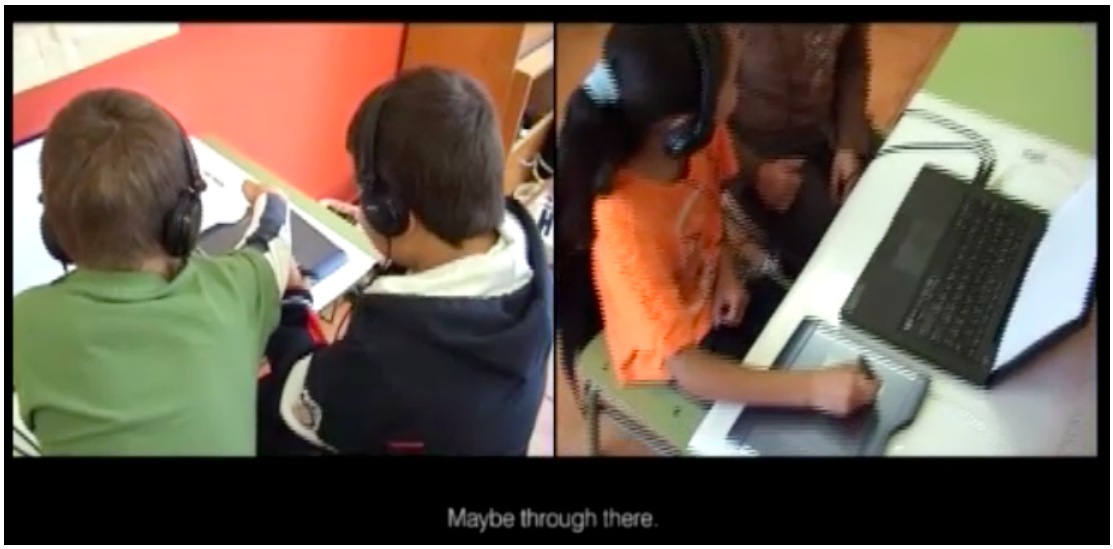
[160] For more information consult DVD 2, movie 4, in attachment. If you have installed the application you can run this project that is saved in DVD 3, subfolder 'English', 'Laberinto V1.4', in the folder 'lagartos'.
[161] For more information consult DVD 2, movie 5, in attachment.
[162] Mrs. Perés opinion is line with studies that suggest that this lack of motivation and confidence of teachers when using ICT is more or less widespread within the context of European educational systems (Balanskat et al. 2006), and particularly stronger in southern European countries (OSEP 2007). It seems that such reluctance is not only connected to a generational gap between students and teachers, but also to a lack of appropriate teacher training in ICT's and more freedom and incentives to experiment with new pedagogical practices (Balanskat et al. 2006:50).

51. Recording the children while performing their narrative '*Los Lagartos*' (The Lizards).

In order to provide the second-graders with a rich auditory experience, we thought of experimenting with a simple interactive collage of distinct aural elements that had been explored in the making of their proposed narrative, now composed of four whistled utterances, the names of characters – Arturo, Manolo and Carpa – and a more difficult sentence – '*fuera bichos'* ('go away creatures'). Surrounding each of these utterances were a collection of sounds that appear in the underlying lines of the narrative, sounds of water, frogs, '*pardelas'* (*Calonectris diomedea borealis*) a peculiar Atlantic bird common in the island and which emits a very strong and loud call.

After this was done, we took one hour within the normal activities of the children, such as the Maths class, and made a small setup of one laptop and two simultaneously connected headphones. Here, it is important to mention that during this session a white sheet of paper was used to cover the screen, this considering the numerous crashes that the first version of the software encountered once the 'eye icon' or 'invisible mode' was activated. Despite this unexpected change of setup, all fifteen students, in groups of two, interacted with the piece that was created and were invited to decipher the uttered sentences. In most cases this was achieved after some thorough interaction, however, some groups showed more difficulty[163]. Particularly interesting was one group of two students (see image bellow), that developed a complex dialogue around this activity, showing us the beneficial qualities of **exploration**, **collaboration** and **communicational** activities in the development of an embodied '*audile*' culture.

[163] For more information consult DVD 2, movie 4, in attachment.



52 & 53. Two boys interacting with the sound piece created by Mrs. Perés. Here they are trying to find all the whistled utterances that are hidden in a cacophony of other sounds while deciphering each one. (See the two left hand images) (snapshot from movie 4, DVD 2).

From this interaction with the application I would like to emphasize the following parts of the boys dialogue:

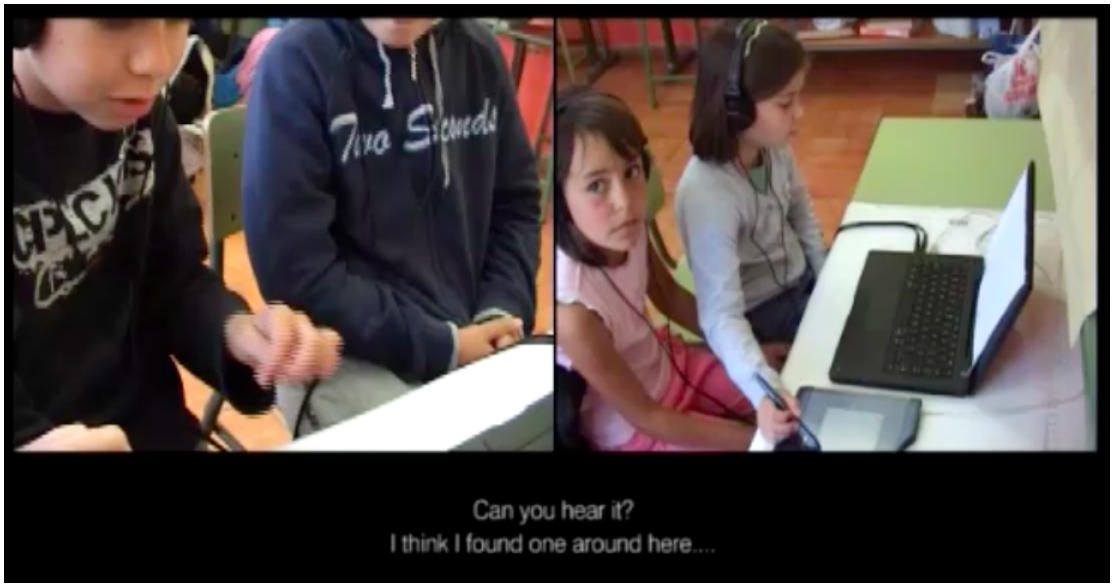
'What was that?'
'Continue moving.'
'Maybe through there.'
'Now that was a really big wave.'
'Another *silbo*.'
'I am almost sure they are saying: *ven pa'ca'* (come here).
'Did you listen to that?'
'Hear the words.'
'Yes, it's (the word) ***Carpa* because it's shorter.'**
'Think….' (referring to their previously recorded story that was written by the second grader's).
The boys – particularly the one on the right-hand side (left image) – fully concentrate on a particular whistled utterance.
'Fuera bichos (go away creatures)**' 'Yes, super'** (the boys finally deciphered all four utterances)

54. The boys, particularly the one on the right-hand side (left image), fully concentrate on a particular whistled utterance (snapshot from movie 4, DVD 2).

This dialogue between the two boys informs point 2 and 3 of a higher level of interpretation: 'does the use of the application enhance principles of **learning through grounded processes of communication** as developed in chapter III and IV (Steels 2003; Vygotsky 1962, 1978; Brown et al. 1989) and 'does the use of the application enhance principles of interacting and **learning through exploration** of **'sound effects'** as explored in chapter IV (Calmers et al. 2002, Murtaugh 2008, Wartofsky 1979) and chapter V (Augoyard & Torgue 2005). Concerning a learning process grounded on processes of communication, it is important to emphasize ways in which the boys exchange a set of opinions regarding the meaning of each whistled utterance. Regarding a learning process through the exploration of 'sound effects', it is important to emphasize the ways in which the boys activate effects linked to 'composition, perceptual organization, psychomotor and semantics' (Augoyard & Torgue 2005:17). The children **explore** the 'composition effect' as they search for whistled utterances that are 'masked' by particular environmental sounds (such as the sounds of birds and waves). They strengthen the 'perceptual and organizational effect' as they attempt to decipher the whistled utterances. The 'psychomotor effect' is activated while interacting with sounds through the drawing pad. The 'semantic effect' is activated through a playful exploration of environmental sounds that cause surprise and laughter, such as the 'big wave'.

This rich interaction also indicates a shift in interpretation. Considering that the children did not use the application to create the narrative, it seemed relevant to shift lower levels of interpretation – particularly the questions concerning usability – while focusing on the ability of the boys to use the drawing pad in order to successfully interact with the narrative. Here, some limitations were found, particularly when the boys couldn't find any sounds unless they moved

the pen to the outer edges of the tablet. This constraint was influenced by teacher Marisa's design that only placed sounds on these same spots. In the future, it seems pertinent to provide a richer composition with sounds throughout. On the other hand, this rich interaction also expands the notion of usability while incorporating values that might normally be part of a higher level of interpretation, such as notions of 'curiosity, play, exploration and reflection' (Gaver & Sengers 2006). This interaction with the application demonstrated ways in which these elements are essential for a first level of interpretation.



55. Two other boys interacting with the sound piece created by Mrs. Perés. Here they are trying to find all the whistled utterances that are hidden in a cacophony of other sounds while deciphering each one. (See left hand image) (snapshot from movie 4, DVD 2).

Just as the previous group, the interaction between two other boys and the application also provided pertinent information regarding point 2 and 3 of a higher level of interpretation. Prior any explanation it is important to regard the following dialogue between both:

'Do you find a *silbo* there?'
'Can you hear it? I think I found one around here….'
'Very good! Carpa'
'It's difficult isn't it?' (referring to the hidden and 'masked' utterances).

Concerning a learning process grounded on processes of communication, it is important to emphasize ways in which this group of boys did not instigate such a rich exchange, particularly when regarding the meaning of each whistled utterance. This might be due to the fact that one of the boys (the one on the right-hand side of the left screen presented above) was much more proficient in *Silbo Gomero*. As there were only two children to exchange opinions concerning the whistled utterances, this created a certain unbalance. Amongst the third and fourth grade

students, presented earlier on, this dynamics was very distinct. This may be due to the fact that the number of participants in each activity was considerably higher, fact that kept in balance the number of proficient and less proficient whistlers, the number of children who were better in perceiving the complex whistled utterances and the number of children who demonstrated more or less proficiency when interacting with the application/computer.

Like the other two boys described above, the children explore the 'composition effect' as they search for whistled utterances that are 'masked' by particular environmental sounds. The 'perceptual and organizational effect' was less developed, this considering the unbalance discussed above. While one boy was still concentrated on the whistled utterance the other one had already provided the answer. The 'psychomotor effect' was activated while interacting with sounds through the drawing pad. Also, here, this group of boys was less proficient. In fact, at times, I had to intervene and help conduct the interaction, particularly when they seemed confused with the drawing pad and what they were supposed to do with this element. As expressed above, this might be related to the fact that the composition was very empty in the middle area of the drawing pad. This provided a sense of disorientation, particularly when they passed through areas where they could not hear any sound. This was also the case with two girls – Fátima and Belém – that also attended this session (see image bellow). However, here, one of the girls was more at ease and helped the other one use the pen from the drawing-pad to find whistled utterances. In this sense this group was better balanced.

56. Two girls, Belém and Fátima, interacting with the sound piece created by Mrs. Perés. Here they are trying to find all the whistled utterances that are hidden in a cacophony of other sounds while deciphering each one. (See right-hand image) (snapshot from movie 4, DVD 2).

57. Fátima and Belém interacting with the sound piece created by Mrs. Perés. Here they are trying to find all the whistled utterances (some performed by themselves) that are hidden in a cacophony of other sounds.

Concerning this last group, it is important to mention that these two girls, that integrated the group of whistlers that were recorded during the initial session, were not able to decipher their own whistled utterances. One main reason for this event is linked to the fact that the girls were so intrigued by this aural application that most of the times they only explored its composition and semantic 'sound effects'. Considering the 'compositional effect', they seemed to have more difficulty in finding the 'masked' whistles. This was enhanced by a 'semantic effect', this considering that the cacophony of sounds mostly enhanced their playfulness as opposed to a more curious, explorative and reflective attitude as demonstrated by their classmates presented above.

On a middle level of interpretation, this information seems to direct attention towards points 1 and 2: 'how can the application be integrated within ongoing school and learning activities' and 'does the application support an ongoing language learning process?' Concerning point 1, it is important to take into account that even though this activity was integrated within ongoing school activities, my presence amongst the children caused certain 'shyness' on their behalf. I believe this element influenced Fátima's and Belém's interaction with the application. In other sessions, this could be avoided by audio-visually documenting the activities while avoiding

the researcher's presence. Concerning point 2, once again, this attitude might be diminished when developing the activities with larger groups of children, fact that seems to balance the group dynamics.

Overall, and on higher level of interpretation, the activities developed with the second-grader's provided a positive outcome, further instigating the appropriation of the designed application by distinct groups in the overall development of classroom projects in the domain of language, now including both spoken and whistled performances. These experimental sessions were largely directed towards point 4 of the level mentioned above: 'does the overall use of the application lead to the development of a rich '*audile*' culture as proposed by an ecological reading of the *Silbo Gomero*', mainly because the appropriation and use of the *Silbo Gomero* was instigated by the teacher's project. In this sense, the nature of the created piece emphasized the most difficult trait of the *Silbo Gomero*, that is, its 'mnemo-perceptive effects' (Augoyard & Torgue 2005:17), its intelligibility or sensitivity to complex auditory realms. Most groups engaged for as long as they could with the created piece, dwelling, with acute attention, on the overall task. Despite larger degrees of difficulty, the mysterious and compelling activity of 'treasure hunting' for sounds made this experience quite engaging for the majority of children. This interaction also enhances the '**ubiquity effect**' that is "linked to spatial-temporal conditions that express the difficulty of locating a sound source" (Augoyard & Torgue 2005:130).

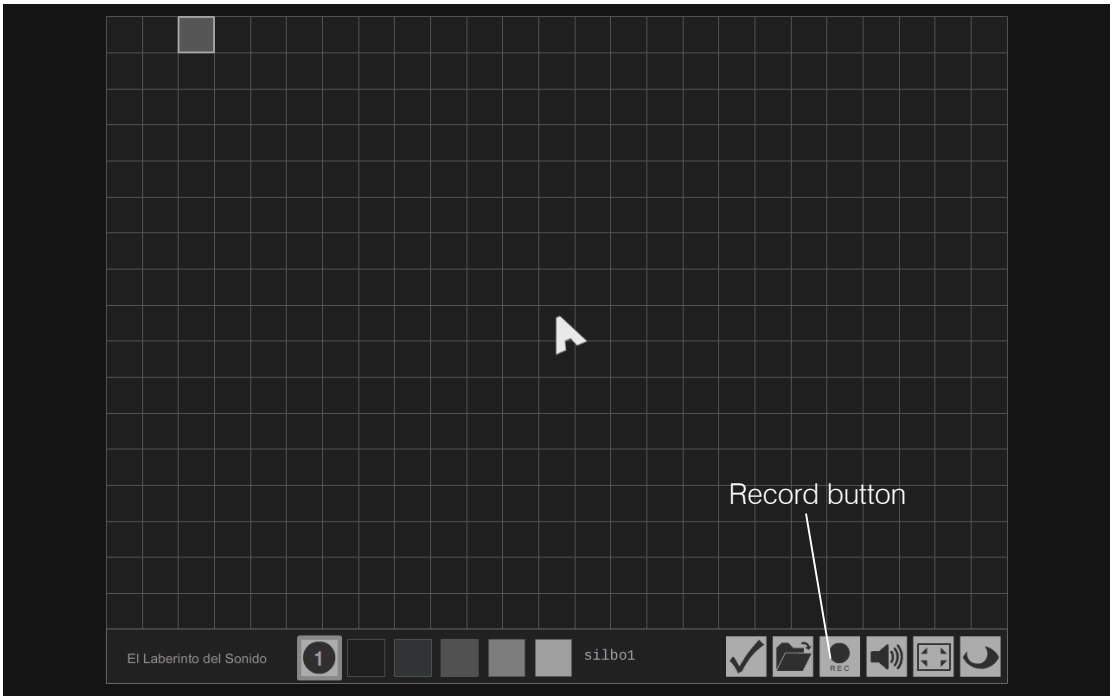
This seems an appropriate moment to refer to the intersection of the application with the *Silbo Gomero* class. The contingencies encountered, firstly due to the small timeframe allowed by this class and also due to the fact that *Maestro* Isidro could not be present during this period of experimentation, have certainly provided more than a constraint. And while employing an intuitive approach to design as 'reflection-in-action', on a middle level of interpretation, such constraints have provided new opportunities while the application acquired a life of its own. Here it is important to understand this impact beyond the thirty minutes of weekly *Silbo* class. Not only has the language learning process shown potential to be incorporated into the domain of extra-curricular activities – particularly as it became an educational instrument to use at home (as required by the older children) – or as one that transverses distinct bodies of knowledge as proposed by Mrs. Perés when using this application in her language class.

It is also here that reinstigating the role of local knowledge within concrete educational agendas gains strength. Despite this fact, it also seems reasonable to point towards a better integration of this application within a classroom environment when it is furnished with computational infrastructures, while providing larger number of computers per student. In the case of Mrs. Perés's class at CEIP El Retamal, it would be pertinent to suggest the further exploration of this application in the classroom provided by *Proyecto Medusa*. This would also

open space – and sufficient time – for younger children to learn how to further explore the application while creating their own narratives as the older children described above.

4. Technical Challenges

Regarding a lower level of interpretation, throughout the sessions, particularly those with third and fourth graders, I asked children if there was any element of the application that should be changed, eliminated or add to. The older children showed interest in playing back their narrative on digital portable device. This suggestion also shows ways in which a lower level of interpretation might enhance a middle level, particularly while demonstrating that alternative uses of the application might also support a language learning process. Also, my own observation of the children's activities made me realize that, most often, it was impossible to move the sound sources within the compositional area – erasing and reinserting when necessary – which created at times a frustrating situation. Both elements were later added in collaboration with computer engineer Theo Burt.[164]



58. Screen snapshot of application *El Laberinto del Sonido* with latest updates.

The record function was based on the possibility of recording any particular navigational path. To activate this function the user simply presses the new record button and then uses the two superimposed arrows (by clicking on the space bar) to navigate through the desired path. Once this exploration is over and in order to stop recording, the user simply presses the same

[164] For more information consult DVD 3, movie 8, in attachment.

button again. The file will be saved in the 'projects folder' of the application. Some children had difficulty in accessing this folder, particularly when changing the preexisting sound files. However, with time, most children learned the path intuitively while observing my actions. The same thing can be said for the sound sources that also need to be incorporated into the 'programs folder' under 'common files/ presets'. Now returning to the compositional area and in order to move the sound-sources the user simply has to drag each sound source from one square to another. In fact, and to facilitate the children's initial coordination with this process, a small line, indicating the chosen path, was added. This line only appears during the interactive process of moving one sound source from one square to another[165].

4.1 General Discussion of Proposed Activities

To conclude this discussion and consider suggestions for further modification and implementation that will be explored in the final chapter, I will return to the working hypothesis – here best represented by point 4 of a higher level of interpretation: "Does the overall use of the application lead to the development of a rich '*audile*' culture as proposed by an ecological reading of the *Silbo Gomero*?" Here, it is important to recognize the ways in which the children engaged in the **design** of narratives while recording their whistled utterances, **exploring 'sound effects'**, particularly the reverb presets and the interrelation between sound sources, and **discussing** the correctness of these utterances as the activities unfold but also while presenting their projects to each other.

This last point is particularly important. First, it should be noted that while exploring created narratives – here using the screen's invisible mode – the children are **engaged in active explorative tasks**, searching for whistled utterances within the sonic cacophony of the overall narrative. This emphasis also shifts the children's attention from forms of interaction with visual objects – supported by the graphical user interface – to more complex spatial and temporal forms of interaction with 'sound objects' and their 'effects' – supported by the audio engine. This shift, from a visual to a sonic interface, also enhanced the 'ubiquity effect'. This effect belongs to the mnemo-perceptive category and is associated with the 'difficulty of locating a sound source' (Augoyard & Torgue 2005:130). Second, the children engaged in interesting discussions when attempting to uncover the ways in which whistled utterances should be performed. These moments provided the first cues concerning the potential use of the application in the transmission and exploration of the complex auditory culture that characterizes the richness of the *Silbo Gomero* as immaterial cultural heritage.

[165] For more information consult DVD 3, movie 8, in attachment.

It is important to consider the ways in which the application was used to instigate degrees of playfulness with local heritage amongst a younger generation of *silbadores*. Enhancing the rich auditory (temporally dynamic) 'intelligence' encountered by this '*audile*' culture as it shifts from the fields – where it was once used by peasant islanders – and into the classroom. While the application supports the transmission of the wealth of skills from an older body of knowledge to a contemporary setting, it also supports a reversal of potential exchanges, where heritage finds new challenges instigated by the performance of this younger generation. Here it is important to account for other 'sound effects' – such as 'synchronization', 'imitation' and 'ubiquity' – that were instigated by the application and that weren't explored by older whistlers in a traditionally setting.

With this is mind, it is important to end with a brief comment on how computational design, here understood through Murtaugh's (2008) 'liveness, plasticity and incompleteness' – also intrinsic to the indigenous cognitive milieu – might support this form of embodied knowledge while devising a viable language support system. This considering that the application is to be used by a younger generation – sensitively between 7 and 10 years of age – that already have some basic knowledge of the *Silbo Gomero*. In this sense, the application does not overshadow the role of the *Silbo's* class where children learn how to perform and interpret this linguistic form but rather involves the enhancement of learned skills.

One can conclude with three contributing lines that have been emphasized throughout and that show potential to be explored by a possible dissemination of the application amongst the *Silbo's* educational community inside and outside the classroom:

- **Learning through design**: participants use the proposed application to construct dynamic and richly textured narratives, opening the possibility of enhancing linguistic, auditory and tinkering practices and subsumed modes of 'intelligence'.

- **Learning through communication:** elaborating the activities of narrative construction while using the *Silbo Gomero*, opens potential space for children to improve their overall phonological awareness, decoding, fluency, comprehension and vocabulary through a process of grounded communication.

- **Learning through exploration**: while interacting with the designed narratives (particularly while using the invisible mode), the application opens space for the potential development of an intrinsic correlation between auditory and spatial 'intelligence' while the children engage in a rich imaginative journey of 'treasure hunting'.

- Strengthening the educational and local '*audile*' culture: the use of this application, as presented throughout, might further strengthen the development of a 'feel for auditory symbols' while enhancing a certain playfulness with the local culture. A process that attempts to enhance the rich educational experience already provided by *Maestro* Isidro and *Maestro* Lino during their classes, and through which the above points became relevant in the first place.

As a consequence, one can conclude this chapter with an overall positive judgment of the potential dissemination of the application amongst the Gomeran educational community. However, there are points that need future consideration. First, the sessions need to be provided with richer computational platforms, whether interactive whiteboards or, and according to what is feasible for the moment, more computers per student or group, something which could be developed within the context of the '*Proyecto Medusa*'. Second, and considering a less engaged performance in the creation of narratives by the older group of students (age 9), it might be feasible to shift the age group to younger children. In fact, incorporating longer sessions with the younger students (age 7) where they could actually create their narratives directly while manipulating the application. These steps require longer phases of experimentation – possibly, a complete school year to be effective.

Here, I would also like take to take into account the possibility of incorporating other 'sound effects' such as 'echo'. While the 'reverberating effect' was explored by the children, it rarely lead into interesting 'echo effects' as experienced in the *barrancos* of the island. It would also be interesting to extend the reverberation effect in the opposite direction while creating situations of extreme 'dullness' or 'total absence of reflected sound signals' (Augoyard & Torgue 2005:46). In the final chapter I will provide examples of how these 'effects' could be used and displayed. Provided this conclusion, the next stage was developed in collaboration with computer engineer Theo Burt, and marked the final preparation of the application for use in a Windows environment because most of the children and schools throughout the island use this system.

4.2 Presentation of the Application to the Community

The consolidation of this final stage took place during a visit to the island of La Gomera during the month of September 2010[166]. During this same visit the audiovisual documentation provided throughout this thesis as well as the application '*El Laberinto del Sonido*' were demonstrated to *Maestro* Isidro. Considering that the school year had not yet started, this meeting took place in his home in the village of Chipude.

[166] For more information consult DVD 2, movie 6, in attachment.

59. Demonstration of the application to *Maestro* Isidro (left-hand side) (snapshot from movie 6, DVD 2).

Here, it is important to present *Maestro* Isidro's impression of the application:

'this is an incredible sensitivity' (referring to the emphasis I made on the *Silbo's* auditory body of knowledge and relation to the surrounding sonic environment)

'How much this could support the children'
'This should be in all the schools'

'They still do not know how to vocalize'
'but they are searching for the sounds'
'the sound that the word carries'
'Not the expression but the sound'

'this is a tool that supports'
'so that they can progress within this field'

On a middle level of interpretation, *Maestro* Isidro marked his own conclusion to this thesis and its proposed project, particularly while presenting the application as an imperative acquisition for all the schools of Gomera[167]. This remark also informs point 5 of a higher level of interpretation: 'is the application conceptually and culturally meaningful to the community as explored?' His observation also indicates that the application has potential to support the development of 'mnemo-perceptive sound effects' (Augoyard & Torgue 2005:17), particularly the 'metamorphosis effect' – 'the capacity to perceive complex sound structures in time' (p.74) – a process that is enhanced by the development of active and selective forms of 'listening to' (Truax 2001:18). This is particularly relevant when taking into account the *Maestro's* following comment: 'they still do not know how to vocalize, but they are searching for the sounds, the

[167] For more information consult DVD 2, movie 6, in attachment.

sound that the word carries, not the expression but the sound'. This also enhances the **exploratory quality** that integrates this higher level of interpretation.

Following this meeting CD's with translated instructions of the overall use and installation process (see image bellow)[168] were given to the first two groups who participated in the initial experimental sessions and one to the director Ms. Pilar Mesa Fuentes at CEIP Retamal.

60. Image of final CD containing the installation files and user guide concerning the application *El Laberinto del Sonido*.

After this was done a meeting with Ms. Jeannette Plasencia Moreno, Insular Director for Education, Culture and Sports of Gomera, was scheduled.

61. Demonstration of the application to Ms. Jeannette Plasencia Moreno (left-hand side) (snapshot from movie 6, DVD 2).

[168] For more information consult DVD 3, folder 'Espanol', in attachment.

From this meeting it is important to outline the director's following comments:

'and this is contextualized'
'they are working not only the *Silbo*, the stories, comprehension, communicational competence that is now so much valued'

'it has an application'

'We are now introducing new technologies as part of new educational laws'
'It is important to work communicational competences. Even more the *Silbo* as a canarian context.'

'It seemed to me that the children like to learn in this context'.

This passage provides information regarding point 2 of a middle level of interpretation: 'does the application support an ongoing language learning process? It also informs point 5 of higher level of interpretation: 'is the application conceptually and culturally meaningful to the community'. Regarding point 2, it is important to keep in mind the comment: 'they are working not only the *Silbo*, the stories, comprehension, communicational competence that is now so much valued'. Regarding point 5, it is important to keep in mind the comment: 'it is important to work communicational competences…even more the *Silbo* as a canarian context.'

This meeting had a positive outcome as the director mobilized all efforts to incorporate the application in the regional Internet portal dedicated to the '*Proyecto* Medusa' and where the *Silbo Gomero* does not yet figure. Considering the directors recommendations, a selection of the documentation provided by this thesis, namely a booklet concerning the use of application, audiovisual documentation of the children interacting with the application and an installation CD, were evaluated by Ms. Maria Victoria González Ares the General Director for Organization and Educational Innovation of the Canarian Regional Government and her team. This process marks the final and necessary approval for the application to figure in the Internet portal of the Canarian Educational Bureau[169], making it more widely available for all the children of the island and elsewhere.

[169] For further information consult the webpage '*Proyecto Abriendo la Escuela. Creando una Videoteca Educativa Canaria*' (Opening the School Project. Creating a Canarian Educational Video Library) by following the link: http://www.evagdcanarias.org/videoteca2/
Here you can access audiovisual documentation concerning the application 'El Laberinto del Sonido', you can also download the application for a Windows system and the user guide in the Spanish language.

5. Final Remarks

This chapter has presented the documentation and discussion of experimental sessions conducted in the school CEIP El Retamal in La Gomera during April 2009, sessions that involved two major groups of children aged 7 to 9. This chapter has also provided guidelines to support the potential dissemination of the application, further developed in September 2010 as the project was presented to *Maestro* Isidro and Ms. Jeannette Plasencia Moreno. It was also hoped to mobilize a more integral view of the *Silbo's* potential within a contemporary and secular educational setting and so further to safeguard this linguistic form and its situated auditory culture as a mode of cognitive apprenticeship. The experimental sessions hopefully led to relevant insights upon this point. Insights that should be supported with further experimentation once the application is more widely distributed amongst all schools of the island. In this sense, it is hoped that the application has pointed towards future directions to help mobilize the *Silbo's* auditory body of knowledge, and to support *Maestro* Isidro's and *Maestro* Lino's already engrained methodologies.

Most unexpectedly, the appropriation of this application seems to suggest an expansion of the life of the *Silbo Gomero* beyond a thirty minute class per week, not only into the space of the general classroom, as proposed by Mrs. Perés, but also, by the children, particularly, when they requested copies of the application to take home. This was largely based on an understanding of the role of contextual and design-based approaches when tackling issues of local heritage and its integration in educational programs. Even more relevant when we consider that the Gomeran educational system is now taking its first steps to mobilize its own educational/computational culture – essentially through the '*Proyecto Medusa*' as described above, which transverses all subject areas within the educational context of the island (excluding, at the moment, the *Silbo Gomero*). In this sense, the implementation of the application did not ignore a broader scope of issues concerning digital computational technologies and their role within contemporary educational contexts. This was particularly relevant when refiguring learning through tinkering and the shift from a predominantly verbal-discursive and logico-mathematical 'intelligence' to a broader scope where local heritage has the potential to yield powerful contributions.

VII

GENERAL DISCUSSION, IMPLICATIONS & FUTURE DIRECTIONS

1. Brief Introduction

In this final chapter, I will summarize the findings, drawing attention to its main claims and the implications it raises. The first section will concentrate on a discussion of chapters II, III and IV. Here, the initial mobilization of an ecological reading will traverse the ethnographic work conducted in the island of La Gomera. The reflection on the last two chapters, more theoretical in nature, will be more concerned on how such ecological reading traverses studies in cognition and learning. This follows the development of the thesis as it moved from practice-led ethnography, passed through a theoretical component and culminated in the practice-based interventional design.

The text will then proceed with presentation of the implications of such an ecological mobilization. Making a closer inspection of the analysis in chapters V and VI, it will focus on the design of the application *El Laberinto del Sonido* and its experimental use in a Gomeran educational context at CEIP El Retamal. Even though, traditionally, the discussion of concrete problems would be found in earlier chapters, the last section will be concerned with presenting the difficulties encountered and that marked the development of the research project and will end with suggestions for future technical and educational platforms. The structure of this discussion is based on the attempt to link the conceptual concerns with the practical exigencies of the project. A challenge that was presented in the introductory chapter when discussing a form of 'rhetoric by design', a form that encompasses grounded research but also design interventions within the Gomeran educational community.

2. Discussion of Main Claims I

The main point of entry into the presentation of the *Silbo Gomero* was marked by a thorough study of the research conducted into this whistled form of language known as the phonological account. A clear conceptualization was given of this linguistic form, now widely conceived as an independent phonological system. Even though it is intimately tied to the local Castilian Spanish spoken in the island – something that also commonly leads to its surrogacy – the *Silbo* is characterized by an independent sonic articulation of discernable contrasting units,

most commonly represented as vowels and consonants (Trujillo 2006:15). While Professor Trujillo's study presents a comprehensive and locally established body of work it also recognizes that local whistlers will, at times disagree on the number of whistled vowels.

The phonological account identified two contrasting grave and acute vowels, but the whistlers themselves – particularly, *Maestro* Isidro and *Maestro* Lino, and who were the informants for the initial ethnographic investigation – were able to discern at least two more contrasts within the sonic units. This has been recognized by other phonological (Rialland 2005) and bioacoustic (Meyer 2005) accounts. This leads to the idea that such differences could be considered optional features, although this is contested by others who consider such 'optional' features as largely subjective and dependent on external factors and therefore as 'unscientific' (Trujillo 2006:15). This has instigated a disinterested investigation of exceptions which is indebted to the nature of particular scientific and methodological forms of inquiry, that look for coherent patterns while working within precise discernable rules.

Since the presented research project relates to design and addresses 'wicked problems' (Rittel & Webber 1973) and their influence on situated forms of local knowledge and intervention – here drawn by the community's call for the materialization of didactic materials. Such contrasting approaches between linguists and whistlers could not pass without drawing relevant attention. In fact, one of the 'wicked problems' is the idea that most design problems are ill informed, a fact that is in debt to the collected data and the various agents that are drawn into the design process – each presenting a conflicting value (Buchanan 2001:15). Such conflicts can be seen in the phonological approach to the educational transmission of the *Silbo* and, by contrast, the approaches of the whistlers themselves. The phonological approach proposed clear transmission of the 'rigorous articulation' of its six sonic forms (composed by two vowels and four consonantal variations) and the various ways this system 'represents the practical reality of speech' (Trujillo 2006:17). The whistlers approach is largely drawn on the possibility of whistling two more groups of vowels but also learning how to produce and perceive a temporal and interlinked sonorous substance. This is visible in *Maestro* Isidro's *Silfateo* that converts consonants into representations that have more in common with musical notation or notations used by ornithologists than with alphabetic and linguistic representations of vowels. *Maestro* Lino's approach to grounded communication was similar, where students practice the *Silbo* while grasping the contours of a melodic line and while 'fine tuning' the ear as one would do when learning to play a musical instrument.

In both accounts, and even though learning the *Silbo* is always tied to the locally spoken Castilian Spanish, what is visible is that different ecological sensibilities are at play – sensibilities that are geographically, technologically and culturally grounded. While a phonological approach

counts upon a particular scientific understanding, and excludes, to a certain extent, the grounded approach to language learning used by local whistlers because it is deemed 'unscientific'. As a result, and what the phonological reading largely omits, is that its view-point, is, in itself, conditioned by its own material appropriations. While the *Silbo* was developed and further transmitted, at least to date, by an analphabetic society working in the *barrancos* that cut the rugged terrain of island. The phonological approach is not only based on assumptions of alphabetization but also on forms of instrumental research that are drawn from a particular history and a subsequent development of knowledge. These ecological differences mobilized a study of phonology's instrument in the research of language – spectrographic analysis.

An investigation into spectrographic analysis is tied to this thesis' 'practice-led' and 'practice-based' approach. The first one is committed to an exploration of the experience, action and the quality of tacit and embodied knowledge and the 'mechanisms' that sustain this approach (CCS 2010). In this sense, the investigation into spectrographic analyses leads to the historical and material investigation of subsumed conceptualizations of hearing, now largely conceived as physical acoustic phenomena. This tradition, already recognized by others (Gibson 1966; Roads 1998, 2001; Wishart 1996), not only draws upon particular philosophical conceptions of sound, hearing and underlying representations of time and space, it also conceals technical difficulties when attempting to demarcate sonic transitions or articulations, now conceived as the base of the *Silbo's* inherent embodied account – a refinement of an auditory perceptual fabric.

This has taken this thesis' investigative efforts to more recent study of the *Silbo Gomero* as drawn upon the field of bioacoustics (Meyer 2005) and neurology (Carreiras et al. 2005). These are approaches that do not figure in the local publication (Brito et al. 2005) that provides guidelines in the development of didactic practices. While the first approach entails a study of whistled languages as they are practiced in particular auditory environments and from which an understanding of intelligibility as situated phenomena becomes key, the second approach entails a presentation of the whistler's cognitive milieu as essentially distinct from the milieu of speakers of the Castilian Spanish language. However, while bioacoustics draws mainly on a psychoacoustic approach that hinders any underlying concern for the separation of auditory perception into innate or learned mental phenomena, the neurological approach will sustain the idea that the whistler's cognitive milieu is situated in the 'head'. In this separation what is left in abeyance is a more situated reading of such mental or cognitive milieus as ecological phenomena, one that is neither situated 'in' or 'out' of the head, that does not assume that it is 'innate' or 'learned' (that one is given through 'nature'; the other through 'nurture') but rather in the continuous interaction with the performative and experiential conditions of the mountainous environment of La Gomera – seen as inseparable from the whistler's body of knowledge.

This approach is in line with the fields of ecological psychoacoustics (Neuhoff 2004), second-order cybernetics (Bishop & Nasuto 2005, Clancey 2008) and also involves a dynamic systems approach to cognition (Smith & Thelen 1994), as well as, more particularly, with what has been identified as the difference between an external 'observer perspective' and a 'systems perspective' in the study of cognitive phenomena or auditory perception (Gaver 1988:50). This cross-references with a relative and 'ecologically situated experience of time' (Cummins et al. 1995) as opposed to a conception based on a detached and observer dependent upon 'absolute time' (Whitehead 1961). This takes illustrative examples from the field of artificial intelligence (AI) as it attempts to challenge the design of conventional speech recognition systems, and was made visible in the construction of Hearsay-II (Cummins et al. 1995). This has little margin of flexibility, considering that it can only count upon the recognition of an exact reproduction of representations of speech sounds that have been stored in a buffer or memory; a conceptual approach that is in line with a phonological reading of the *Silbo Gomero* (Trujillo 1978, 2006).

As a response, an alternative model is proposed. Largely based on a dynamic systems approach to cognition, some have attempted to shift the agent's relation to time while using learning algorithms rather than working to a pre-subscribed script. While the first technique is able to handle a continuous flow of time (ecologically synchronized time) and therefore co-construct what has been conceived as a 'dynamical memory', the later can only deal with serialized and abstracted notions of time, stored in a pre-given buffer with little degree of flexibility and potential for change. From an engineering point of view the dynamical systems approach is subsumed to a series of technical limitations because the acoustic patterns have to be learned through situated interaction. From a cognitive and conceptual perspective such a dynamic model provides an interesting departure point when attempting to refigure the discussion of 'innate' and 'learned schemas', which it supplants by an ecologically bound development.

2.1 Discussion of Main Claims II

In Chapter III, a reading of 'technicity'[170] is visible in the psychoacoustic presentation of 'mental schema' (Bregman 1994), a term that was first suggested by the genetic epistemic program of Piaget (1971). Here an absolute and ecological conception of time was further discussed, particularly in relation to Piaget's conception of 'schema', now conceived as an accommodation to Nature's environments. This environment is always rendered in a state of

[170] 'Technicity' referred to a movement that gives continuity to the presentation of spectrographic analyses as it interlaces geographic and historical dimensions, shifting a conceptualization of sound into physical acoustic phenomena and, by consequence, influencing the scientific reading of the ways in which human hearing occurs.

equilibrium (or what a phonological reading would propose as consistent phenomena). And even though the genetic epistemic program would recognize that learning processes occur as the fruit of an interaction with the world, this world – or environment – is the fruit of a formalized reading. This approach was largely influenced by the development of mathematical thought, particularly the field of logic.

In this sense, Piaget's reading of the environment – and by consequence of mental schema – is as much an attempt to explain the biological development of cognition as it is a thorough 'mathematization' of the environment (Rotman 1977:175). And even though the researcher could be conceived as an ecological psychologist – in the sense that he asserts that the 'child constructs the mind while further interacting with the world' (Smith & Thelen 1994) – this ecology is not entirely understood from an organismic perspective, but rather from an external and mathematical appropriation of the organisms environment. This strikes the separation between a psychoacoustic reading of the whistler immersed in a world of sound through which one might measure the levels of environmental noise, or test the intelligibility of isolated vowels (Meyer 2005) with an ethnographic and situated reading of the whistlers relation with this same environment, when exploring its reverberant qualities, using a cliff to project a whistled utterance or building an auditory topographic model of the potentialities of this same environment as suggested by *Maestro* Lino and documented in Chapter II. While psychoacoustics implies a characterization of the qualities of the environment at each given moment, the ethnographic approach will take the idea of environment as action, as co-construction.

In Chapter III, and through this idea of cognition as ecological co-construction, Piaget's 'environment in state of equilibrium' is, once again, put to test, now by the field of artificial intelligence, particularly by challenging the design of existing artificial intelligent systems that can only interact with predictable environments (Brooks 1991). As an alternative, robots inspired by the field of ethology, ideas of enactive cognition (Rosch et al. 1995) and co-construction of symbiotic environments have become prevalent (Barad 2007). What this approach emphasizes is the idea of 'emergence', where an understanding of complex behaviour is not reducible to an isolated study of lower level features (Hendriks-Jansen 1996). Like the ecological approach to time and its role in the development of auditory perception (Cummins et. al. 1995), this idea draws upon a dynamic systems approach to the study of cognition and the idea that the brain is best conceived as a dynamic and self-regulating 'machine', one that feeds on environmental noise – the unpredictable and messy (Freeman 1987, van Gelder 1995).

Once again the idea of 'technicity' supports this discussion. And one of the major consequences of this approach is that perceptual development is best conceived as an active endeavour in which ecological relations are never in state of equilibrium, because an organic

system is constantly evolving through time. For my own research this entailed a reversal of intuition, one that presupposes a more flexible relation between whistlers and the surrounding environment characteristic of this island. This relation does not entail a simple adaptation to environmental constrains (Meyer 2005), but the communal fabrication of a perceptual fabric that previously did not exist and that cannot be reduced to an understanding of environment and whistler taken in isolation. Simondon's (2009) conception of 'individuation' (Deleuze 1966) (as a reformulation of the biological conception of emergence) provides a pertinent guideline here, particularly as it reinforces the idea of cognitive phenomena as ecologically situated – and therefore intrinsically embodied – and intra-actively co-constructed as opposed to simply being reflected or assimilated.

Towards the end of chapter III, the notion of 'intra-action' (Barad 2007) also shifts the identification of whistled utterances – clearly identifiable units or 'sound objects' – into an understanding of their performative and ecological '*effects*' (Augoyard & Torgue 2005). While this section finds similitude with a reallocation of the 'observer' (subject/object) to a 'system' (ecological) approach in the study of cognitive phenomena it also has analogies within development psychology (Smith & Thelen 1994), neurobiology (Freeman 1987) and cognitive science/philosophy of mind (van Gelder 1995). In Chapter IV, the task was to uncover ways in which the educational field has used these approaches more broadly. And following the ecological approach to cognition as an embodied and intra-active phenomenon, it was important here to find the implications for the role of design within this particular sphere of action. This led to the early development of a secular educational project and a separation between 'higher modes of thought' and 'lower or craft based approaches to the construction of knowledge'. What Donald Schön (1987) had qualified as the separation between modes of 'reflective-abstraction' (observer perspective) and modes of 'reflection-in-action' (system perspective), which are characteristic of the design professions as they engage with the study of situated and 'wicked problems'. Such a separation is intrinsic to the development of genetic epistemology, and where cognition progresses from a sensorimotor stage into a formal operative one. The sensorimotor stage no longer grounded on perceptual exploration of the environment, this considering that it has been already assimilated, abstracted and set to the foreground (Rotman 1977).

In order to refigure this perceptual dimension – taking its central role in the systemic or ecological development of the *Silbo Gomero* as such – this thesis then looked at the 'symbol systems approach' (Gardner 1993) as related to education. This has been characterized by a social and material expansion of the 'cognitive unit' of analyses from a psychological and informational approach to one that is situated and material-historical (Lave 1988, Salomon 1997) within the learning sciences. It is also here that perceptual channels are recovered from the situated and

cultural contexts and their co-participation in the development of various learning processes (Gardner 1993). Directing specific attention to language learning, the 'activity theory' as suggested by Vygotsky in the early XXth century sheds light on the role of perceptual channels in the development of linguistic competence through writing. This offers some common ground with the ecological reading of the *Silbo Gomero*. It also goes beyond the problem of assimilating a given language through distinct channels of symbolization – that of the graphical eye or that of the ear – while bringing to light the role of 'gesture' as intrinsic to such a process. The development of this 'gesture' can only find further strength in the interchange between semiotic playfulness, material infrastructure and communal and grounded processes of communication – in a word, activity.

The development of computational based technologies for the classroom has helped to provide a grounded approach to education (Papert 1993, Resnick 1996) and in supporting new educational styles based on 'epistemological pluralism' (Papert & Turkle 1990) where children are motivated not only to 'tinker' but also to deploy distinct channels of symbolization in the process of intellectual construction. Taking the potential of computers to support the shift of the *Silbo Gomero* from the fields into the classroom – while sustaining an ecological reading – such tinkering might, at times, produce deceptive approaches, particularly as one takes an all – encompassing 'computer literacy' (di Sessa 2001) as a substitute for other forms of literacy. This has hindered a more thorough discussion of computational platforms and their role in the development of learning as being culturally situated. Here the very idea of a 'model as a cognitive artefact', 'one that does not model the world' but rather instigates a 'mode of action' has provided a more sensible approach (Wartofsky 1979). For design, this entails less focus on computational/didactic material and more on the modes of interaction (or activity) that surround its appropriation as well as less on the computer power afforded by contemporary technologies and more in the ways local communities appropriate them.

This process is consonant with more recent approaches to interactive design as presented by the 'opportunistic approach', which asserts that users best interact when they can literally appropriate a given system (Calmers et al. 2002). A 'live, incomplete and unpredictable approach' (Murtaugh 2008) where not all possible paths of interaction are pre-programmed and where – and just as in the opportunistic approach – the system can be shaped to the users' intent, creating a degree of openness within the system when incorporating 'unpredictable input'. These two approaches, even though directly intended for the design of concrete applications, find interesting points of contact with the 'emergent approach' proposed by the field of educational design (Cavallo 2003). Here, the dynamic plasticity explored in previous design paradigms entails ways in which the architecture of applications, particularly their degrees of freedom, are best informed

by ongoing local knowledge practices. This contributes towards the elaboration of practices in which the customization and appropriation of educational technology by smaller groups becomes prioritized. Drawing an integrative circle around these three chapters emphasizes the importance of shifting from an 'observer' to a 'systems' approach while mobilizing a reading of the *Silbo Gomero* but also a broader discussion that pertains to the cognitive and educational realms.

3. Discussion of Main Results I

Against this background an investigation of the didactic recommendations provided by a local Gomeran publication (Brito et al. 2005) was made. This involved analyzing topographic maps of the island while visually locating the places where the *Silbo Gomero* was once used, using the local herder's flute to 'tune' the ear, *Maestro* Isidro's *Silfateo* or spectrograms of depicted whistled utterances. However, here, one main point seems to be largely relinquished – the auditory and spatial-temporal qualities of the *Silbo's* subsumed ecology, its 'sensory effects'. The herder's flute helps to mobilize this sensibility, but due to its own inherent configuration, it has limitations particularly because the body is articulated on a distinct synergetic level when compared to whistled forms of language, in which tongue, glottis and fingers intimately cooperate. At this point, the mobilization of computational based artefacts seemed to open an unforeseen potential when exploring the subsumed auditory qualities. Here, a delicate balance had to be maintained, to prevent the computational medium from simply simulating the Gomeran *barrancos*. The limitations of this approach, visible in the impossibility of actually simulating this complex sonic and geographical setting (Blesser & Salter 2006) – at least without requiring computer power that is not readily available in local schools – or even the rather uninteresting design strategy represented by a simple copy of these *barrancos*, meant that further investigation of the whistler's body of knowledge was necessary.

In order to enhance the ecological reading, an investigative effort was directed towards a more comprehensive understanding of the 'wealth of skills' (UNESCO 2009b) that are passed from one generation to the next. This recommendation was emphasized by UNESCO when dealing with the safeguarding of intangible heritage – a category for which the *Silbo* has recently qualified (UNESCO 2009a). In fact, the transmission of such a 'wealth of skills' attempts to mobilize an understanding of heritage and safeguard projects as ecological and dynamic systems in their own right that evolve and change with each generational appropriation so that such body of knowledge might, contemporarily, find pertinent modes of valorisation. Here, a deeper and more intricate understanding was proposed that utilizes knowledge drawn from the fields – where it was used by peasant and mostly analphabetic individuals – into modern and secular educational systems.

As presented by others (Gardner 1993), and now confirmed by ethnographic research both in the fields with *Maestro* Isidro and *Maestro* Lino or when attending *Silbo* classes in the schools of the island, different modes of 'intelligence' are at play. 'Intelligences' that are in line with modes most valued by non-literate societies – even though this should not be taken as a generalizable norm – forms of 'intelligence' more directly concerned with bodily craft and interpersonal skills. These modes of intelligence are largely learned in situ from an older generation, and are largely unmediated (at least unmediated by 'common' educational means such as books, audio-visual material, Internet, computer software, etc.). To contrast, in modern secular systems, the curriculum rarely takes local needs into account but rather is developed from national schemes where more centralized forms of assessment and design are valorised. While this does not necessarily entail a simplistic and harsh critique of such processes, it is important to understand how the indigenous form of learning is a form of 'reflection-in-action' (Schön 1987), or what some would qualify as a form of 'learning through grounded experience' (Dewey 1963). As *Maestro* Lino develops in his classes, it can generally be described as a mode of 'active listening' – where one develops a sensibility towards a mode of 'listening for' as opposed to simply 'listening to' (Truax 2001:18). The focus is on the qualities of an '*audile*' (Sterne 2003) culture and its subsumed body of knowledge.

This is tied to the idea that the *Silbo Gomero* integrates an '*audile*' culture that is 'effectuated' (Latour 2004a) by distinct psychological, environmental and cultural 'sound effects' (Augoyard & Torgue 2005). These 'effects' further articulate the theoretical research and the practical outcome provided by this thesis and accompanying project. In fact, the idea of the 'sound effect' accompanies the ongoing shift from an environment that is composed by objects that are external, detached and given a priori to one that is ecological and performative. This is visible in chapter II when contrasting the phonological, bioacoustic and neurological readings with an ethnographic approach to the whistler's own body of knowledge. It also accompanies chapter III, particularly as it shifts from Piaget's constructivism where the environment is externally validated a priori to contemporary accounts of situated and embodied cognition as emergent and dynamic phenomena. In chapter IV this movement follows an understanding of learning as it is embedded within distinct performative and cultural logics' and from which the didactic artifact – computational or not – cannot be detached. In a later stage of design development, these theoretical explorations and major articulatory points have constrained a design space within which decisions were made in detriment of others. Shifting from a system that proposes the *Silbo* as a surrogate of speech – reinforcing the correctness of whistled utterances – to one that reenacts the *Silbo's* auditory and performative body as part of the sonic environment.

It was with these points in mind that the application *El Laberinto del Sonido* was designed by myself and built by computer engineer Theo Burt. The application attempts to materialize an ecological framework and create a compositional space where children can record whistled utterances, insert other sounds as well as add and manipulate 'sound effects' (Augoyard & Torgue 2005), such as reverb and masking. To this a binaural algorithm was added, further instigating these immersive effects, visible in the construction of auditory narratives by the children. Through the 'eye icon' that triggers visible and invisible modes, these features can be explored from an auditory perspective, opening intriguing possibilities for the potential development of 'active listening'. This was explored when the children at CEIP El Retamal exchanged created narratives and attempted to decipher the whistled utterances they had created. The application also shifted the focus from a 'bird-eye view' – the external observer approach towards a 'perspective from within' (Rotman 2008: 98) – that is, a systems approach. This was largely inspired by *Maestro* Lino's interaction with the sonic environment in the village of La Palmita as described in Chapter II. It is hoped that the creation of narratives might instigate a certain playfulness with the local culture that will move beyond the strict reproducibility of sonic substances (vowels and consonants) and its surrogation to speech as presented by the phonological account and its didactic recommendations (Trujillo 2006:17).

3.1 Discussion of Main Results II

One of the underlying potentials of 'thinking-through' the 'opportunistic, alive, plastic, unpredictable and emergent models' described above was mobilized not only when designing the application – its potential uses and perceptual contours – but also when thinking of the possible ways in which the Gomeran educational community might appropriate the application *El Laberinto del Sonido*. If, and until the present moment, the proposed project would follow a design model where one progresses from practice to theory and back to practice (Wood n.d), now it was time to push this practice even further, particularly while testing the designed application amongst the island's educational community. At this point it became relevant to return to 'design's rhetoric' (Buchanan 1985, 2001) as explored in the introductory chapter, a progression that outlines the importance of situating the community of users in the process of investigation, appropriation and 'evaluation'. Here, design is understood as professional practice that deals with 'wicked problems' in situ and where 'results are largely directed outwards' as opposed to a strict correlation with design's disciplinary quarrels (Rittel & Weber 1973).

This makes a difference in terms of the experiment with the application within the Gomeran community, where results are rather directed towards further disseminating the application. In this sense, design as professed by designers has common ground with a

anthropological approach to 'design-based research' within the learning sciences, not only due to the use of ethnographic methods during early research phases but also when delivering designed interventions to a community of users (Bell 2004:18). This is not to say that other ways of utilizing 'design based research' are inappropriate – such as the psychological, cognitive and social approaches (Bell 2004) – the question is rather which one is pertinent when tackling the working hypothesis as presented by this thesis.

Taking the Gomeran educational community as central to the further development of the project, the scheduling and location of the experimental sessions was largely influenced by the necessity of working with the same group of children over a reasonable period of time, the ability of the selected school to provide time and space for this process of experimentation and finally the interest in the proposed project. Taking these factors into account the school CEIP El Retamal provided the necessary means. This was also tied to the fact that I had established a closer contact, early in 2007, with *Maestro* Isidro who directs the *Silbo* classes in this school. All of the schools on the island were taken into account during this period, but more time was spent in this one. And even though the initial goal was to test the application within the *Silbo* class, lack of sufficient time was an inherent obstacle. This meant that in addition to testing the application amongst the children I also tried to find ways in which other teachers might use it.

With this in mind, the experimental sessions were divided between two groups, composed by third and forth grade students (with ages 8 to 9) and second grade students (7 years of age) who took the class of Ms. Perés, a teacher who was interested in the project. While the first group treated the application as an extra-curricular activity when afternoon classes were over, the second group incorporated it into the context of the language model, one devoted to both Castilian Spanish and the *Silbo Gomero* and in which the younger children have developed an ongoing narrative project that incorporates spoken and whistled forms of language.

When developing these activities, the first concern was to uncover the children's potential to understand the application and the hope of instigating playfulness, particularly when incorporating the *Silbo* into everyday learning processes and exploring the sonic environment to its fullest potential and exploring the reverberant qualities and non-linear nature of the interface, especially when creating and hearing other children's narratives. On a second and broader level, attention was directed towards an understanding of the ways in which the interrelations might sustain the development of the *Silbo's* '*audile*' culture. While the initial features were incorporated and explored with a certain ease, particularly in relation to the ways in which words should be uttered – here one group explored certain features a bit more than the other. A more solid impression of these effects culminated in the final session where the third and fourth grade groups exchanged narratives and the second graders further explored a piece designed by Ms.

Perés. This process was developed while using the 'invisible mode', one that faints the graphic interface while allowing the user to interact with narratives as he or she deploys an auditory channel. This gave some very pertinent cues towards the potential of using the application in the development of forms of 'active listening'.

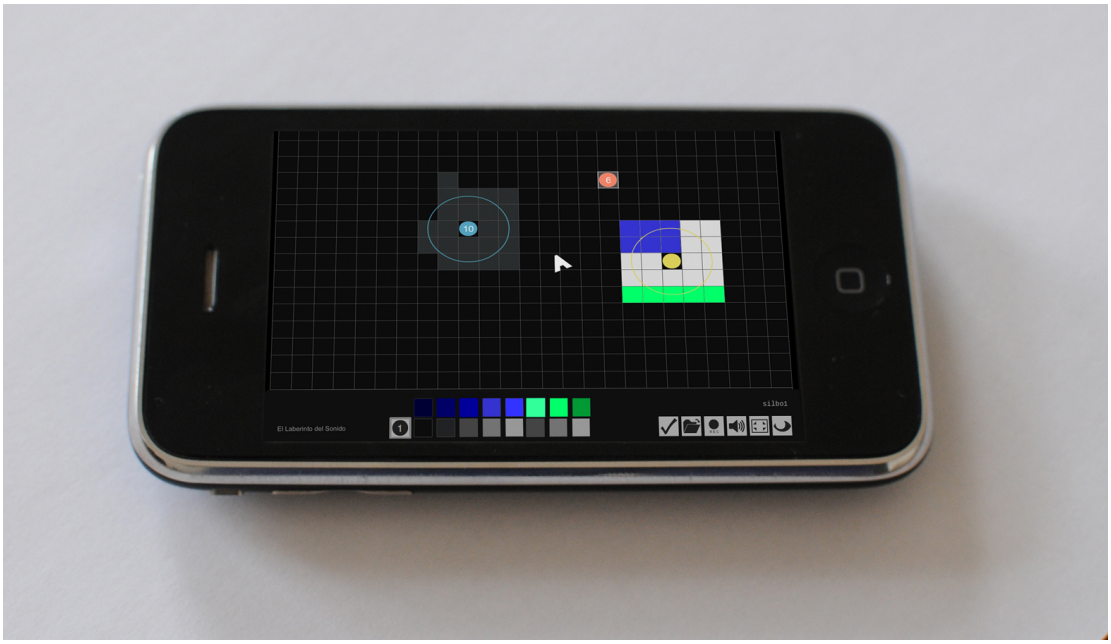
4. Future Directions

When developing educational projects a main challenge appears when one attempts to shift from a process of experimentation into what the learning sciences would qualify as 'the reality principle' (Brown 1992:171) where the final intent is to mobilize the interventional design – its research questions and results – to levels of dissemination (Brown 1992:171). And while the working hypothesis proposed by this research attempted to provide an ecological approach to the *Silbo Gomero*, one that would inform the design of didactic materials, it also attempted to draw future directions since it seems to open up possible new paths for design experimentation, intervention and dissemination. Here, the application *El Laberinto del Sonido* appears as a particular outcome among an array of possibilities.

With this in mind, it seems relevant to first consider technical limitations, where the laptop, mouse or, drawing pad, constrained the simultaneous interaction of several children with the application. Such limitations could be mitigated by using a multi-touch screen, enabling a larger number of children to participate when creating the narratives. Mobile devices could also be used, although the complex audio processing required by the application becomes more fragile as devices become smaller. However, and considering new generation of mobile devices will have greater capacity, it will be interesting to test the application and the quality of its performance within such technological milieus.

In fact, a mobile device could instigate the exploration of this form of communication and its auditory ecology in the actual spaces where the *Silbo Gomero* was most commonly used. This is one major consideration, giving the possibility of directing children's sensibility towards such environment. This seems even more important as performing in the fields continues to decline[171], according to *Maestro* Isidro and *Maestro* Lino. Confirming what anthropologist Wade Davis (2009) suggested as the main loss when forms of language are drawn to extinction, which he says affects not only the linguistic form but also entails the eradication of a way of life and its relation to the vaster ecosystem. It implies a slow ruin of 'other ways of thinking and interacting with the world'.

[171] This process is tied to immigration but also to the dependence on new economic models of subsistence as provided by tourism, now in opposition to previous agricultural models. In fact, this shift and the continual abandonment of agricultural land have, as *Maestro* Isidro suggested, caused a series of land fires over the past few summers.



62. Mock-up of the application '*El Laberinto del Sonido*' for a mobile and handheld device.

As exemplified by the visual mock-up displayed above, it is important to take into account the possibility of incorporating other 'sound effects' such as 'echo'. As presented earlier on, the 'reverberating effect' explored by the children rarely lead into interesting 'echo effects' as experienced in the *barrancos* of the island. It would also be interesting to extend the reverberation effect in the opposite direction while creating situations of extreme 'dullness' or 'total absence of reflected sound signals' (Augoyard & Torgue 2005:46). This could be achieved while adding a wider array of reverb paint options – the grey squares – and a new echo paint option – the blue squares. It would also be interesting to add other effects that are related to reverberation such as 'resonance' here represented by the green squares. This effect might enhance the playful character of reverberation while allowing the children to create spaces that are "filled with sounds with exceptional amplitude" (p.109).

While experimenting with ways in which the application can be used with different technological platforms, it is also important to consider a vaster terrain of possibilities of the ecological approach to the *Silbo Gomero* and its auditory culture. In this sense, the suggested ecological framework should also be delivered to the *Silbo's* educational community, where technological apparatuses and distinct scientific approaches – such as the phonological, bioacoustic and neurological – have provided a broader spectrum of intricate readings of the communicational phenomena. If the small publication containing didactic suggestions concerning the *Silbo Gomero* (Brito et al. 2005) would further delineate the importance of learning such form of language while visually demarcating on topographic maps the places where

this form of communication was once used or using spectrograms to understand the auditory movement of an utterance, it seems relevant to ecologically situate such didactic apparatuses.

This whistled form of language should not only be learned but also its history should be studied as part of a contemporary conception of knowledge, what Whitehead (1920) qualified as a shift from 'homogenous' to 'heterogeneous' (p.3) bodies of knowledge. With this in mind, and while presenting the successive interpretations that the *Silbo* has gone through – from phonological, biacoustic, neurological and indigenous – students are given the possibility of understanding the 'history of epistemic things' (Latour 2007:6). While recommendations provided by the small publication described above would outline the importance of providing the student an enrichment of linguistic capacities, an expression of social and cultural value (Brito et al. 2005:90), as well as the rich, complex and dynamic ways in which knowledge is co-constructed. This would be extremely valuable in drawing up a curriculum for older students of 16 to 17 years old to be incorporated into the Gomeran educational system.

To finalize this text, it seems relevant to develop the proposed ecological framework as it traverses the idea of an '*audile*' culture as one that not only sustains the transmission of wealth and skills that compose this intangible form of heritage but also supports the development of potential 'intelligences' in the space of the classroom. Without thinking of the most obvious relation to musical education, it seems relevant to think of expanding techniques of scientific investigation where data is commonly explored through auditory means. This approach, most commonly known as data sonification, has provided great insights, particularly in fields that deal with complex temporal phenomena not easily differentiated in visual terms (Baier & Hermann 2004; Bovermann et al. 2007; de Campo 2008). Directing the whistlers '*audile*' body to distinct spheres of application could provide interesting ways in which one might cross-pollinate indigenous forms of knowledge with contemporary techniques of scientific investigation.

As proposed by Ron Eglash (2003) in a review of David Turnbull's 'Masons, Tricksters, and Cartographers: Comparative Studies in the Sociology of Scientific and Indigenous Knowledge': one rarely thinks of indigenous knowledge as a techno-science in its own right. In fact, it is most often the case that ecologically situated knowledge systems are generally conceived as local phenomena, largely submitted to processes of folklorization, understood as 'things' of the past as opposed to present and mobile forms of knowledge that transverse various geographical and 'scientific' – and so to say, technological – settings. It is also here, that the author figures a pertinent approach to indigenous knowledge systems as 'transmodern' events. This term conceals a hybrid space, most necessary in the organization of the techno-scientific world, of which, indigenous forms of knowledge are intrinsically part of.

With this in mind, it is important to finalize this thesis by emphasizing that the mobilized ecological direction does not necessarily offer a remedy in the safeguard and effective teaching of the *Silbo Gomero* in the space of the classroom. My point has rather been a shift in perspective when designing didactic materials for this unique form of language, one that attempts to move beyond its surrogacy to speech or even beyond its characterization as a local folkloric practice. This thesis has attempted to mobilize a cultural reading of the *Silbo Gomero* while offering an ecological framework that is both rooted in local forms of embodied '*audile*' knowledge while mingling with contemporary technological platforms and the challenges they carry. However, I would like to think that this same framework and the application *El Laberinto del Sonido* that accompanies this thesis are not only directed to the children that attend the schools of the island but to the *Silbo's* educational community in general. Here, I am also thinking of ways in which the application might be taught to teachers of *Silbo* and primary teachers of the island at the *Centro de Profesorado de la Gomera* (The Centre for Teachers of La Gomera) in the village of San Sebastián alongside the *Silbo* classes for adults. Finally instigating future directions that traverse the community. And while an older generation of whistlers might see in this whistled form of language the transmission of a culture of the past, I hope that the work developed so far might actually enhance the fact that they contribute towards the preparation of an '*audile*' culture for the future.

GLOSSARY OF TERMS

Barranco

Spanish word for abrupt mountain terrain leading to a precipice or ravine.

Bioacoustics

"A branch of zoology that investigates sound production and reception in animals" (Beer & Immelmann 1989:329).

Ethology

"The biological study of animal behavior" (Beer & Immelmann 1989:92).

Frequency

Corresponds to the number of periods occurring in a sine wave, a unit that is measured in hertz (Hz) per second (Moore 2003:401). Here, the sine wave corresponds to a waveform representation of an auditory signal, whose variation is a sine function of time (p.403).

Maestro

Spanish word for teacher.

Pitch

In psychoacoustics, it is an attribute of auditory sensation through which one might order sounds on a musical scale (Moore 2003:402).

Phonetics & Phonology

While phonetics is concerned with the range of human vocal sound making and can be subdivided into articulatory, acoustic, auditory and instrumental (Crystal 2003:349); phonology is concerned with the study of a sound system of each given language as they are composed by distinct contrasting phonemes [p.350].

Psychoacoustics

Might be understood as the "interdisciplinary study of sound and hearing" and largely informed by "physics, psychology and physiology" (Corsini 2002:778).

Silbador

Spanish word for whistler.

Spectral Information

"The spectrum of a sound wave is the distribution in frequency of the magnitudes (and sometimes phases) of the components of the wave. It can be represented by plotting power, intensity, amplitude or level as a function of frequency." (Moore 2003:404)

Tone

In psychoacoustics, tone corresponds to "a sound capable of evoking an auditory sensation having pitch" (Moore 2003:404).

ANNEX I

1. Description of Attached Audiovisual and Audio Documentation

1.1 Movie 1 '*Aqui No Se Habla. Aqui Se Silba*' (Here We Don't Speak. Here We Whistle)

This documentary, which has the same title as provided by the textual component of this thesis[172], can be found in the attached DVD 1 and is based on audiovisual material recorded with one electronic camcorder in the island of La Gomera during the month of February and October of 2007. During the first month, research was conducted in four schools of the island. In CEIP El Retamal in the small village of Valle Gran Rey, located in the southwestern coast of the island (*Silbo* classes coordinated by *Maestro* Isidro); in school CEO Santiago Apóstol in Playa de Santiago, located in the southern coast of the island (*Silbo* classes coordinated by *Maestro* Isidro); in CEIP Ángel Moreno Urbano/ IES Poeta García Cabrera in the village of Vallehermoso (*Silbo* classes coordinated by *Maestro* Lino), in the *Centro de Profesorado de la Gomera* (The Teacher Centre of La Gomera) in the main village of San Sebastián in the east coast of the village (*Silbo* classes for adults coordinated by *Maestro* Isidro); in school IES San Sebastián de La Gomera (*Silbo* classes coordinated by *Maestro* Lino Rodriguez) and finally in school CEIP Aurea Miranda Gonzalez in the village of Agulo (*Silbo* classes coordinated by *Maestro* Lino Rodriguez). The documentary focuses essentially on the material collected in the first four schools.

The interview conducted with *Maestro* Isidro in Playa de Santiago was conducted during the month of February 2007 and recorded with a recording audio device (M-Audio, model Microtrack 24/96). The audiovisual material collected during the fieldwork with *Maestro* Isidro when recording whistled utterances in Barranco de La Matanza (GPS coordinates 28°06'293" N, 17°18'233" W) near the small village of Chipude took place during the month of October 2007.

Considering the extensive amount of collected audiovisual documentation – nine tapes of sixty minutes each – I decided to work with a documentary format that exhibits two windows through which relevant recorded material is displayed. This design of this layout was largely influenced by an attempt to 'rebuild' the dynamic nature of the *Silbo Gomero* classes as well as relevant footage from the island's environment. A delicate balance between both elements constituted the main guiding line when editing the collected material. Taking this decision into account, not all schools are represented in the documentary. This considering that the final

[172] '*Aqui No Se Habla. Aqui Se Silba*' (Here We Don't Speak. Here We Whistle) refers to a sentence I commonly heard in *Maestro* Lino's class whenever the children started speaking in Castilian Spanish as opposed to using the *Silbo Gomero*.

intention was to show the distinct methodological approaches to the teachings of this whistled form of language while avoiding repetitions of material, classes and examples.

1.2 Movie 2 '*El Laberinto del Sonido'* I (The Sound Labyrinth I)

This documentary can be found in the attached DVD 2 and is based on audiovisual material recorded with one electronic camcorder during a visit to the island of La Gomera in April 2009. This material refers to the introduction of the designed application *El Laberinto del Sonido* to the Gomeran educational community, more specifically, to the school CEIP El Retamal in the village of Valle Gran Rey. This process was divided into different experimental sessions and developed with two groups of children with ages eight to ten – third and fourth grade students. In terms of temporal progression, this documentary presents the appropriation of the software by these two groups of children – from an initial introduction to its complete appropriation. This activity culminated in the exchange of narratives by the children in the last programmed session and where they were motivated to explore such narratives through auditory means. Considering the amount of collected data (eight tapes of sixty minutes each) and the compositional coherence of the audiovisual part that composes this thesis, the documentary displays the same layout as presented in the previous description of movie1. However, here the main focus was to display all the phases of experimentation while concentrating on the children's interaction with both software and colleagues.

1.3 Movie 3 '*El Laberinto del Sonido'* II (The Sound Labyrinth II)

This documentary can be found in the attached DVD 2 and is based on audiovisual material recorded in the island of La Gomera during the month of April 2009 at the school CEIP El Retamal in the village of Valle Gran Rey. This material, recorded with one electronic camcorder by the third and fourth grade students refers to a short series of interviews conducted by the same group of children during the last session that contemplated the exchange of created narratives between each group. Considering that we only had two computers for nine children during the last session, this camera was provided with the intent of affording a means through which the children could actively engage in a process of documentation. The outcome was, to a certain extent, unexpected, this considering that I did not intervene in their documentation process. This material collected by the children became a valuable asset for this thesis, this considering that through the construction of this same documentary the children had the opportunity to reflect on the usability, comprehension and utility of the application.

1.4 Movie 4 '*El Laberinto del Sonido'* III (The Sound Labyrinth III)

This documentary can be found in the attached DVD 2 and is based on audiovisual material recorded with one electronic camcorder during a visit to the island of La Gomera in April 2009. This material refers to the introduction of the designed application *El Laberinto del Sonido* to the Gomeran educational community, more specifically, to the school CEIP El Retamal in the village of Valle Gran Rey. The documentary shows the development of a class project developed by teacher Mrs. Marisa Blanco Perés and her second grade students with age seven. A project that encompassed the development of a collective narrative for the language module – and where both Castilian Spanish and the *Silbo Gomero* are taught – and the appropriation of the software by the teacher while creating a small interactive project, based on the previously recorded narrative. Considering the amount of collected data (eight tapes of sixty minutes each) and the visual coherence of the audiovisual material that composes this thesis, the documentary displays the same layout as presented in the previous descriptions of movie 1 and 2. However, in movie 4, the main focus was directed towards the display of all the phases of experimentation, particularly while concentrating on the children's interaction with the software as they explore the application's auditory mode.

1.5 Movie 5 Interview with teacher Mrs. Marisa Blanco Perés

This interview can be found in DVD 2 and is based on the audio material recorded with a sound recorder (M-Audio, model Microtrack 24/96) on the island of La Gomera during the month of April 2009 at the school CEIP El Retamal in the village of Valle Gran Rey. This material comprises an interview with the second grade teacher Mrs. Marisa Blanco Perés. This interview was devoted to a discussion concerning the introduction of computational based materials within Gomeran schools.

1.6 Movie 6 'Project Presentation in Gomera'

This documentary can be found in the attached DVD 2 and is based on audiovisual material recorded with one electronic camcorder during a visit to the island of La Gomera in September 2010. This material refers to the presentation of the conception and use of the designed application *El Laberinto del Sonido* to *Maestro* Isidro Ortiz Mendonza and the Insular Director for Education and Culture Ms. Jeannette Plasencia Moreno. While the first interview took place in *Maestro* Isidro's home in the village of Chipude, the second interview took place in

the director's office in the main village of San Sebastián. Considering the visual coherence of the audiovisual material that composes this thesis, the documentary displays the same layout as presented in the previous descriptions of movie 1, 2 and 4. In movie 6, the main focus was directed towards the display of the crucial parts of these presentations while simultaneously drawing attention to the children's interaction with the software at CEIP El Retamal.

1.7 Movie 7 '*El Laberinto del Sonido'* - a Walkthrough

This documentary can be found in the attached DVD 3 and provides a description of the designed application, including aspects of usability. A two-dimensional document that portrays this audiovisual walkthrough is provided in the Castilian Spanish language in the same DVD (in the 'Spanish' folder, file 'guia_usuario.pdf'). The decision for creating distinct formats for both languages is based on the accessibility of a portable document format (PDF), important feature when disseminating the project amongst the educational community in the island of La Gomera.

2. Attached Documentation – the Sound Files

- DVD 1, Track 1
Description: recording of a whistled utterance of the Castilian Spanish name 'Octavio'.
Recording position: GPS coordinates 28°10'813" N, 017°12'430" W, village of La Palmita in the municipality of Agulo in the north and interior part of this island. The village where *Maestro* Lino Rodriguez lived for thirty years and where he learned the *Silbo Gomero* with neighbors and family while working in the fields.
Altitude: 1991 Ft.
Time of recording: 14:49
Recording device: Sound Devices 702 digital recorder.
Microphone: DPA 4060, omni-directional microphones.

- DVD 1, Track 2
Description: recording of a whistled utterance concerning a funeral message. Intense 'mourning whistle', as explained by *Maestro* Lino, followed by the sentence: '*Alfonso Herreras que va abajo qui si morrio Alberto Madalena. El enterro es a las 11*' (Alfonso Herreras please go down that Alberto Madalena has died and the funeral will be at eleven'). This message would be whistled from house to house, from La Palmita down to Agulo.

Recording Position: GPS coordinates N 28°10’813” N, 17°12’240” W, village of La Palmita in the municipality of Agulo, in the north and interior part of this island. The village where *Maestro* Lino Rodriguez lived for thirty years and where he learned the *Silbo Gomero* with neighbors and family while working in the fields.
Altitude: 1973 Ft.
Time of recording: 15:04
Recording device: Sound Devices 702 digital recorder.
Microphone: DPA 4060, omni-directional microphones.

- DVD 1, Track 3, 4 & 5
Description: recording of whistled utterances of the Castilian Spanish name ‘Ana’, the Guanche name ‘Itaica’ and the Castilian Spanish name ‘Urbano’.
Recording Position: GPS coordinates N 28°10’813” N, 17°12’240” W, village of La Palmita in the municipality of Agulo, in the north and interior part of this island. The village where *Maestro* Lino Rodriguez lived for thirty years and where he learned the *Silbo Gomero* with neighbors and family while working in the fields.
Altitude: 1991 Ft.
Time of recording: 14:33
Recording device: Sound Devices 702 digital recorder.
Microphone: DPA 4060, omni-directional microphones.

- DVD 1, Track 6
Description: recording of impulse response testing in the Barranco de La Matanza near the village of Chipude. This file was recorded while popping a balloon, a common procedure in acoustic impulse response testing, and in the attempt of capturing the reverberant qualities of this particular location where agriculture and goat herding once thrived and where the *Silbo Gomero* was commonly used. Due to the amount of acoustic detail I recommend the use of headphones while listening to this recording.
Recording position: GPS coordinates N 28°06’158” N, 17°18’461” W
Altitude: 2835 ft.
Time of recording: – –
Recording device: Sound Devices 702 digital recorder.
Microphone: DPA 4060, omni-directional microphones.

- DVD 1, Track 7

Description: recording of man whistling (not to be confused with the *Silbo Gomero*) while herding animals in Barranco de La Matanza near the village of Chipude. This file was recorded while conducting experiments with previous impulse response testing. Even though not intentionally orchestrated, this recording displays interesting reverberant qualities of this particular location where agriculture and goat herding once thrived and where the *Silbo Gomero* was commonly used. Due to the amount of acoustic detail I recommend the use of headphones while listening to this recording.

Recording position: GPS coordinates N 28°06'158" N, 17°18'461" W

Altitude: 2835 ft.

Time of recording: – –

Recording device: Sound Devices 702 digital recorder.

Microphone: DPA 4060, omni-directional microphones.

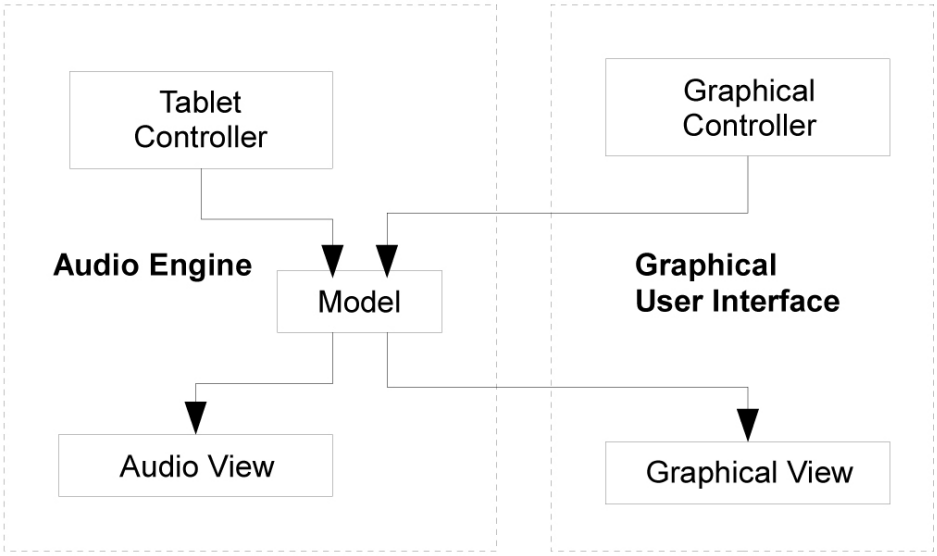
ANNEX II

The following description of the application's system architecture is largely based on the original document provided by Theo Burt (2009). This document – 'Laberinto_TechnicalOverview.pdf' – can be found in DVD 3 in the folder 'LaberintoV1.4_source'. In the same folder you will find the installation material as well as the source code of all the components that integrate the application.

1. Description of the Application's System Architecture

As response to an initial conceptual design model, one of the main concerns, when developing the overall application, was to generate a 'real-time' auditory experience. Here the design of a stable architecture appeared as one of the most pertinent features. Taking this into account, computer engineer Theo Burt used the 'model-view-control software architecture' (Burt 2009) or 'paradigm' when further developing the proposed application. Initially developed at Xerox PARC as a main computational guideline in the development of the Smalltalk-80 user interface, this paradigm, in opposition to the classical central control model, presupposes a distribution of the user's input, the virtual model and the visual and auditory feedback throughout various objects.

Here, the 'view object' (see image in the following page) manages the graphical and auditory output. The 'controller object' interprets the mouse and keyboard inputs that are triggered by the user and the 'model' and/or the 'view' changes as appropriate. Finally, the 'model object' manages the behavior and data of the application domain while responding to requests for information about its state (as required by the 'view') and responds to instructions to change state (as required by the 'controller'). This computational interaction provides a more flexible and powerful system. (Burbeck 1987) Such model not only holds all data that is relevant to the developed application, it also contains the necessary functions for distinct 'controllers'. To set an example, when the user is creating a new project or adding a new sound source to the grid, distinct functions and 'controllers' are at work. And whenever, any particular change is called upon one of the 'controllers', the output will be sent out to both 'views' as schematized by computer engineer Theo Burt in the figure below.



51. Drawing of System Architecture, provided by Theo Burt (2009).

Each 'view' displays a representation of the data stored in the model. The 'audio view' builds the binaural audio model while the 'graphical view' builds the grid-like structure of the graphical interface plus the sound sources' circular forms. The 'audio view' handles the inserted sound sources (or nodes) within the gird space, the position of the 'avatar'[173] and any 'painted' reverb preset. These two communicate in a real-time sequence. While manipulated and triggered by the user, the 'graphical view' and adjacent 'controller' are sending commands to the 'audio engine', a task that is executed by the 'graphic controller' and the 'graphical view'. Despite this dual nature, the user will always perceives their interaction as a whole, this considering the overall integrative quality provided by the design of the 'graphical user interface', a feature that is visible in the application's flexibility when providing both the creation of input and interaction with the created material. This same 'graphical user interface' is separated from the 'audio engine', and both behave as independent executable programs that communicate with each other via a TCP/IP network connection[174]. In case of using a graphic tablet instead of the mouse pad, the 'tablet controller' will send the required information – here, the position of the avatar – to the overall model. (Burt 2009)

The 'audio engine' was developed by computer engineer Theo Burt while using the 'Cycling '74s Max/MSP'system[175], an interactive graphical programming environment. This choice was based on the flexibility provided by this same application, particularly when

[173] Here 'avatar' should be understood as a first-person experiential account of the interactive space.
[174] The "TCP/IP network architecture refers to an Internet architecture. The Transmission Control Protocol (TCP) is a transport layer protocol and Internet Protocol (IP) is a network layer protocol. Both protocols were evolved from earlier packet switching network called ARPANET" (Chen 2005:990).
[175] For more information go to: http://www.cycling74.com/

developing audio processing techniques. The audio engine consists of three basic elements. First, the overall 'model' where all the relevant data concerning the application *El Laberinto del Sonido* is stored; this 'model' also handles all the saving and loading functions associated with the creation of project files and sound files. Second, there is the 'audio view' an element that is responsible for generating the binaural sound feature. Finally, the third element consists of a tablet controller, and as explained above, this element is responsible for tracking the movements executed with a graphic tablet.

The 'graphical user interface' (or GUI) was conceptualized by myself and further developed by computer engineer Theo Burt while using ActionScript3[176] scripting language. In order for this interface to interact with the Cycling '74s Max/ MSP system' the cross-platform runtime environment 'Adobe Air'[177] was used. This last application is a version of Adobe Flash platform that allows the creation of 'cross-platform standalone applications' as opposed to an initial version that was constrained to 'web-browser embedded applications'. Also, Adobe Air, is independent of the systems native window and interface design, this allows much more flexibility when designing a customized window, a point more than relevant when designing applications to be used by children. The graphical interface and the audio engine establish a connection from the very moment the application is initiated. This means that whenever a user updates a project, new data is sent to the overall model stored in the 'audio engine'. Once the model updates this data, the information is sent to the 'audio view' element and back through the established network to the GUI's 'graphical view' while updating the overall visual appearance. This same interaction is handled by the application 'flash-server' a Max/ MSP[178], object that communicates with *ActionScript3*. Access to the overall model is established while using a regular mouse or a graphical pen tablet[179]. (Burt 2009)

Before going any further, it is important to clarify what is here understood as the binaural audio model referred above. When a system computes real-time binaural audio this requires intensive calculating processing power. Considering that we were designing the application to be used on a standard laptop or desktop (taking into account that this is the most common setting in the island's schools and the childrens home computers) a simplified version was further required. To further clarify, the binaural model was used in the attempt to enhance the spatial quality of human hearing. A process that is achieved by taking a simple stream of audio, with no spatialized content, and transforming it, while using a 'Head Related Transfer

[176] For more information go to: http://www.adobe.com/devnet/actionscript/
[177] For more information go to: http://get.adobe.com/air/
[178] For more information go to: http://www.nullmedium.de/dev/flashserver/
[179] Today, there are various companies providing this same interface. During the development of the proposed project a Wacom tablet, model CTE-430 (Sapphire) was used.

Function', into spatialized content. Basically, the function is computing how the sound is ecologically heard by the human auditory system. This model is here described by Theo Burt in the following:

"Computing detailed real-time binaural audio is a highly math's intensive operation, and as the system is to be used on a standard laptop (with a limited CPU) and may require many binaural sound sources to be generated simultaneously, it is necessary to use a simplified binaural model. Detailed binaural models take an unspatialised stream of audio and use a *Head Related Transfer Function* to compute how that sound will be affected on its way to the ear. However, as well as requiring much CPU processing time, they are generally geared towards a particular individual's ear characteristics. The binaural model used in this software takes the following approach:

For each sound source in the same *room* as the listener:

1. The unprocessed output of the source is taken.

2. Each ear is calculated separately. This creates one of the most important binaural cues – interaural delays, where due to a different distance from the source to each ear, similar sound arrives at slightly different times at each ear. This helps judgment of angle.

For each ear, the following is calculated:

i. The relative position of the virtual source to the position of the avatar's virtual ear is calculated, with *d* being the distance between the source and ear, and *a* the angle that the source makes to the ear anticlockwise from the east.

ii. The sound is delayed by a time equal to *d* x *speed of sound.* This models both interaural delays, and the 'Doppler effect' which is noticeable when the avatar moves at a high speed.

iii. The inverse-square law is used to compute a (slightly exaggerated) approximation of the attenuation of the sound over distance. *gain = (1 / d)*

iv. Based on the calculated value of *a,* attenuation is applied to simulate obstruction of sound through the head. As the source moves around the ear, the attenuation is changed smoothly. This creates a smooth panning effect.

v. Based on the calculated value of *a,* a low-pass filter with a slight resonance and cut-off frequency of around 1500Hz is incrementally applied as the source moves *behind* the ear (180 < *a* < 360 degrees*)*. This helps in distinguishing sounds in front from those behind.

In addition to this, a mix of all unprocessed outputs is sent to the *Room System,* which sends this unprocessed mix through a global reverb algorithm. The output of this reverb is mixed with the output of all spatialised sources and presented to the user. The relative volume of reverberated sound to dry sound acts as a further aural cue as to the distance of a source." (Burt 2009)

The design of the overall 'room system' had as central goal: to provide the user with a flexible and plastic medium, where one could subdivide the room into 'sub-rooms', allowing the user to add distinct spatial characteristics. Whenever the user 'paints' new rooms while using the reverb preset, the classic 'flood fill' painting software algorithm[180] is executed. This algorithm analyses the main grid space and divides it into rooms based on the painted selection of grey. In case the user paints one grey color, in one grid adjacent to other grey grid colors, and as long as it is not in a diagonal orientation, it will be incorporated in the overall grid coloring. Considering the interactive nature of the platform explored by the avatars movement, any room will be turned off once the avatar moves away from that given area. As explained above, all the audio information is mixed and sent to a reverb algorithm, the 'gigaverb~'[181] in the Max/MSP environment. Depending on the chosen shade of grey, the algorithm is changed in order to produce distinct auditory qualities. (Burt 2009)

[180] For more information on this algorithm go to: http://en.wikipedia.org/wiki/Flood_fill

[181] Developed by Juhana Sadeharju, the 'gigaverb~' is a mono in, stereo out reverb implementation, with extra long reverb times up to several minutes. For more information go to: http://www.maxobjects.com/?v=objects&id_objet=1205&PHPSESSID=6883fdf9e10e79f5d5c98f0cdb02b7f1

ANNEX III

1. Description of Children's Narratives

1.1 The First Group

Group Members: Andrea de la Noé, Andrea Correa, Inés, Carla and Daniela

Title: 'En Cada Puerta hay un Sonido' (At Each Door There is a Sound)

Narrative Structure:

Scenario/Door 1: *Barranco*
Whistled phrases: 'Buenos Dias……Ven paca!' (Good day…….Come here!)
Other Sounds: strong echo, frogs, wind, water

Scenario/Door 2: Palace
Whistled phrases: 'Te quieres casar conmigo? Sí.' (Do you want to marry me? Yes.)
Sounds: music, orchestra, people moving and a horse

Scenario/Door 3: Magical Forest
Whistled phrases: '1 – 2 – 3 ting (eco)' (one, two, three…ting (eco))
Sounds: birds, river, fairy, goblins

Scenario/Door 4: Jungle
Whistled phrases: 'PARAD!!!!!' (Stop!!!!)
Sounds: drums and animal noises

Scenario/Door 5: Library
Whistled phrases: 'Silencio en la sala por favor!!!!' (Silence in the room please!!!)
Sounds: flipping pages of a book

Scenario/Door 6: Ocean
Whistled words: 'Dame la toalha….' (Pass me the towel….)
Sounds: dolphins, birds and waves

Blue Sound Sources (triggered with proximity)	Orange Sound Sources (always looping)
1. Door (BBC royalty free sound)	1. Wind (my own recording)
2. Frogs (my own recording)	2. Dance ball (BBC royalty free sound)
4. Fairy (BBC royalty free sound)	3. Frogs (my own recording)
6. Pages flipping (my own recording)	4. Haunted Forest
	5. Ocean (my own recording)

1.2 Second Group

Group Members: Melani, Maday, Gustavo and Sergio

Title: 'El Silbo Gomero en Distintas Partes' (The Silbo Gomero in Different Parts)
Narrative Structure:

Scenario 1: Haunted House
Whistled Words: 'Socorro!!!!!!' (Help!!!)
Sounds: ghosts, steps on wood, chains and high reverb

Scenario 2: Jungle
Whistled Words: 'Ayuda!!!! Cuidado!!!! Los leones ven para arriba!!!!' (Help!!!! Be careful!!! The liones are on the way!!!!!)
Sounds: lions, birds and monkeys

Scenario 3: Forest
Whistled Words: 'A cortar árboles!!!! Vale!!!!' (Let's cut trees!!! O.k!!!)
Sounds: birds, trees, wind, people working and chopping wood

Scenario 4: Ocean
Whistled Words: 'Tira-te de cabeca! Vamos ha bañarmos!!!' (Dive!!! Let's swim!!!!)
Sounds: ocean, waves, birds and boat

Scenario 5: Lost in the Woods
Whistled Words: 'Donde estás???? Estoy aqui!!!!' (Where are You? I am here!!!!)
Sounds: music, people and fireworks

Scenario 6: farm
Whistled phrases: 'Las gallinas se salen!!! Ya le di un palo!!!' (The chickens are running away!!!! I have chased them!!!!)
Sounds: cows, chikens, donkey

Blue Sound Sources (triggered with proximity)	Orange Sound Sources (always looping)
2. Steps (BBC royalty free sound)	1. Haunted House (BBC royalty free sound)
5. Dog (BBC royalty free sound)	2. Jungle (BBC royalty free sound)
6. Fireworks (BBC royalty free sound)	3. Frogs (my own recording)
13. Water bubbling (my own recording)	4. Party (BBC royalty free sound)
15 & 16. Party sounds (horns) (BBC royalty free sound)	5. Ocean (BBC royalty free sound)
19. Seagulls (BBC royalty free sound)	7. *Pardelas* (local Atlantic bird) (my own recording)
20. Door (BBC royalty free sound)	6. Wind sound (my own recording)
23. Ghosts (BBC royalty free sound)	8. Farm (cows) (BBC royalty free sound)
26 & 27. Lions (BBC royalty free sound)	10. Night sounds (cicadas) my own recording
28. Dog (BBC royalty free sound)	

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