On the interaction between cultural and biological evolutionary processes in generating artistic creativity

A standard approach to the topic of artistic creativity would begin with definitions of art and creativity, and an attempt to analyse the causes and mechanisms of each. We propose however to set out in a slightly different direction. It may help to use the comparative method, and examine the arts and creativity in a wider context, that of the production of works of the intellect more generally, and specifically, in relation to creativity in the sciences.

The comparative method as a means of discovering cultural origins in anthropology has fallen into disfavour. However, it has its uses in the present connection. Viewing the arts alongside the sciences may suggest questions that help in understanding the arts themselves, but would not occur in a more narrowly focused approach. For example, are the arts unique, or do they share many aspects with the sciences? How does creativity arise, and are there any common features in artistic as compared with scientific creativity? What if any brain functions are common to both?

Perhaps the most important benefit arises from cross-fertilization between the work of philosophers and sociologists in studying how art and science develops. Individual studies, and indeed individual careers, have generally been confined to one or other of these two fields. The scope of such over-arching reviews of development in the field of science has perhaps been broader than in the arts, if only because philosophers and historians of science have tended to treat the topic as a unified whole. In the arts, the visual, literary and (in the broadest sense) performing arts have generally been examined separately.

In studies of scientific development there has been a wide spectrum of views, each leading to different conclusions and each giving rise to its own school of thought. Some writers, such as Feyerabend and Kuhn, have emphasised social and contextual influences on science, seeing scientific theories as context-driven and contingent. In contrast, Popper and the Realist school believe that science aims at, and progressively grows closer to, objective truth. However, a common theme in these different n accounts is that science is essentially a socially mediated activity.

By contrast, the traditional romantic notion of art has been that it is the lonely product of tortured and tormented genius, misunderstood and ahead of its time – possibly, indeed, outside of time altogether – and not the mere product of social forces. The artist might be a prophet, or a person who diagnoses and lays bare the ills of society, and may have a profound effect on it, but the influence of society on the artist is seen as much less important. When Shelley called poets “the unacknowledged legislators of the world” or when O’Shaughnessy claimed “we are the movers and shakers of the world”, the influence was represented as being all one way. Just as Archimedes stated that with a fulcrum he could move the earth, the role of the artist as seer, or as the conscience of society, and having the capacity to change society, seems to be predicated upon a standpoint or fulcrum outside society itself. In this view, a necessary mark of genius is a certain freedom from social norms and constraints.

In more recent times, this view appears to have shifted towards a more socially determined one, but the artist is still assumed, and almost expected, to be a maverick. Some interesting work has been done in comparing aspects of scientific and artistic creativity, and this suggests that there are common processes to creativity across the arts and sciences, but that the "romantic myth" of the artist may have some evidential basis. However, we would like to propose that the two extremes are on different locations of what is essentially the same spectrum.

All this bears on questions about commonalities and differences in the arts and the sciences. For example, do they have different aims, does their development depend upon the recruitment of different intellectual and emotional processes, to what extent are they dependent on social feedback and conversely, and what is their broad social impact. We believe that the evidence suggests that the arts and sciences share important features at both micro and macro levels. The micro level encompasses mechanisms of creativity, whilst the macro level encompasses ways that social structures and relations lead to change over time. In fact, we will argue that the main driver for change in the arts is cultural evolution, and that a societal response is an essential part of how the arts develop. We will conclude that biological and cultural evolution both play an important role in the arts, as well as in the sciences.

An interesting, fairly contemporary view, put forward by a number of workers (Gintis, 2011; Laland, et al., 2010; Loritz, 1999; Richerson, et al., 2010) is that brains and cultures coevolve over long time periods. According to such accounts, the early emergence of large, socially interdependent and complex groups, drove the development of sophisticated language centres in the human brain. In this view, social evolution, which in the broadest sense of the term is also cultural evolution, was followed by biological evolution towards the acquisition of the neurological correlates of language. Language, the product of biological evolution, then facilitated a runaway process of social and cultural development resulting in the society of the present.

It is not yet clear how this social/cultural evolution feeds back into the generally slower processes of biological evolution. Views differ on how modern healthcare and the ability to control reproduction, both social or cultural artifacts, have affected the rate of genetic change among humans. Yet it seems likely that even if the effect on biology is present, biological evolution operates several orders of magnitude more slowly than cultural change. The causes of ongoing cultural evolution should therefore be sought in the existing cultural and biological foundations of society. The effects of cultural evolution will feed back into the social context and will prepare the way for subsequent cultural evolution, but in the shorter term, the biological foundation may be assumed to be constant and unchanging.

In what follows it may be worth distinguishing, at least at the outset, between two components of human culture. A field such as science may be viewed as an intellectual culture, with its own practitioners, paradigms and domain of accepted knowledge. But it only survives as part of a greater cultural unit, that of the nation or society within which it flourishes. As cultural units each have their own norms and conventions, scientific activity may be described as cultural. Therefore science, as well as the arts, can be described as an intellectual culture, interacting with a social culture. Ultimately, human activities can rarely, if ever be understood in isolation of their cultural contexts.

To begin with, we will outline a very simple causal model that might serve as a basis for describing how intellectual cultures, including the sciences and the arts, evolve. This model contains three nodes: human biology, social culture and intellectual culture. In the short time scales under consideration here, there are unidirectional causal arrows leading from the biological node to each of the social and intellectual nodes. The latter two, however, are connected to one another by two-headed arrows, reflecting the way each feed back into the other. Causality due to the biological node operates in a conventional manner, with cause leading to effect. However, causality between the social and intellectual nodes is circular, with changes in culture inducing changes in society and vice-versa. We do not rule out causal loops at both the cultural and societal nodes, that is internal causes of change within both culture and society. The model in figure 1 includes the essential factors to be considered in this chapter.

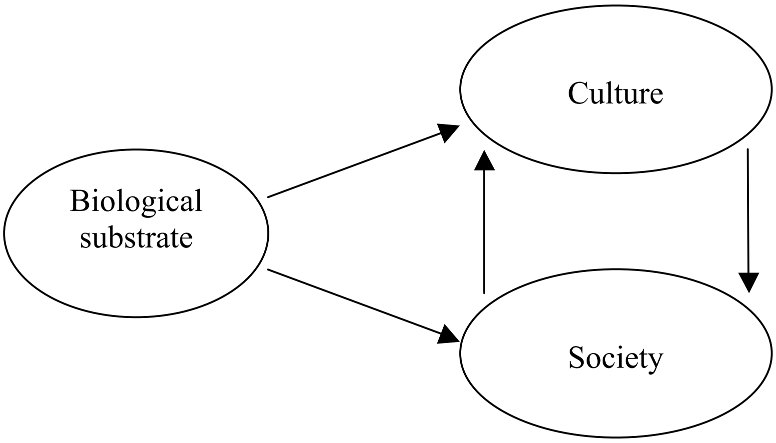

Figure 1: causal model of influences between biology, culture and society

With this model, culture is influenced by both biological and societal influences, but changes in culture – what we have called cultural evolution – can only be due to causes within culture itself (produced by society). This is because the biological substrate can be considered within the short term at least to be relatively constant, biological evolution operating too slowly to cause cultural change.

Although previous studies considering the arts from a scientific viewpoint have concentrated largely on the biological to cultural link, we suggest that this argument justifies placing more emphasis on the two-way link between social and cultural aspects, taking in the biology-culture connection as one of the assumptions of the argument. We do not intend to spend much time on the link from the biology node to the social node, not because it is unimportant, but because it is believed to be relatively constant over evolutionarily short time periods.

One longstanding view of intellectual activity is that it can be divided into two categories. In “A Defence of Poetry” Shelley argued that there are two functions of the mind: reasoning and imagination, or analytic and synthetic thought. Here, imagination involves the production of ideas, whilst reasoning considers the inter-relationships between ideas. Shelley’s account implicates multiple mechanisms in intellectual endeavour, and this contrasts with a commonly held view, that science involves reasoning, and the arts depend on imagination. We believe that this reflects an impoverished view of what is involved in artistic and scientific thinking and propose that that both functions are needed in the arts and the sciences.

In Shelley’s sense, “imagination” is effectively the same as creativity. Nobody disputes the importance of creativity in the arts, but we will outline the case for why it is also central in scientific endeavour. We will make this case, and then present a current model for creativity and apply it to both the sciences and the arts.

Creativity in science

We will argue that creativity, seen as the key feature of the arts, cannot be understood without an appreciation of its wider context, and specifically, of its importance in science. One misunderstanding of this is well expressed in Wordsworth’s poem, The Tables Turned: “ … Our meddling intellect / Mis-shapes the beauteous forms of things: / We murder to dissect.” Science is seen, in Shelley’s terms, as purely a function of the reasoning, analytical function of the mind.

This misconception was perhaps fed by a dominant philosophical view of the scientific process, which was largely held in one form or another up until the influence of Karl Popper made itself felt. This view is sometimes attributed to Francis Bacon, though how far it really represents his views is debatable (Gower, 1997, particularly p.53). Somewhat simplified and charicatured, the picture is as follows. Science is above all objective, not subjective. It involves the observation of facts, free of prejudice or presuppositions. From these facts, when we have enough of them, universal laws will emerge by a process known as induction, which is supposed to be analytical, and whose laws can be clearly set out (most famously in J S Mill’s “canons of induction” (Gower, 1997, pp. 114-119). Laws are seen as something inherent in the nature of the universe, and as therefore *ipso facto* as universally true. Laws are as it were “out there”, as opposed to human feelings and emotions, and ideas which are the product of creativity in the arts, which are essentially “in here”.

Clearly if this version of science is accurate, the process is objective: the personality of the scientist does not come into play. In theory, two scientists working independently on the same area of science should come up with the same conclusions. Creativity or imagination not only has no role, but would indeed contaminate the whole process by introducing a random element which has nothing to do with the facts of how nature really is. In this view, calling a scientific claim “imaginative” would be like calling a witness’s testimony in court “imaginative”: it would be close to an accusation of dishonesty. This view of science feeds perfectly into the misconception that the science – arts dichotomy is one between objective and subjective, between the analytic and synthetic functions of the mind.

But now let us look at more recent ideas of how science works. These ideas are, incidentally, shared between the Kuhnian and Popperian ends of the spectrum, however much they may differ in the details. In contrast to the Baconian narrative, in which facts come first and theories come at the end, the modern view is that the theories, or rather hypotheses, come first and that empirical data are gathered only later. This approach is well summarized by Charles Darwinm who remarked : “How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service!” (cited in Medawar, 1984, p.80). With this approach one typically begins with two or more hypotheses. An experiment is designed to generate data that will enable one, ideally, to distinguish between competing hypotheses and allow the scientist to eliminate all but one of them. According to this view, the collection, analysis and interpretation of data, come towards the end rather than the beginning of the investigative process.

The generation of the hypotheses will probably involve a creative process. Considered in the context of Shelley’s account of creativity, the process involves seeking inter-relationships between things. A hypothesis is likely to arise from the scientist’s synthesis of what is and is not known about a given phenomenon, so the hypothesis is not necessarily wholly “out there”. Like any other work of the imagination, it is partly “in here”. A scientific programme does not begin with a blank slate. The first step is to develop a tentative model, or more usually alternative models, about how the world works. The process of developing models or hypotheses is not that different from the creation of an imaginative painting, or the imaginary world which comprises the heart of a piece of fiction. This property of a hypothesis is more often highlighted if it turns out to be justified by the evidence of a scientific experiment. The conclusion to a scientific paper is often in the form of an explanation which gives insight into the ways that previous research into the topic in question drove the research hypothesis tested in that paper.

If a hypothesis is broad enough and is sufficiently well confirmed then it may be considered as having attained the status of a theory, and a key attribute of a successful theory is that it “tells a good story” (Medawar, 1984, p. 40). A powerful theory which gives a single, united explanation of what appeared previously to be disparate facts has something of the compelling, satisfying nature of a powerful work of prose fiction, and in its elegance and parsimony it may also partake of the aesthetic power of good poetry.

We believe that the aesthetic aspects of science have been largely overlooked by those who have examined the matter. The aesthetics of pure mathematics has a long history, perhaps going back as far as Pythagoras. Given that mathematics plays a core role in the hard sciences, it is especially surprising that the aesthetic appeal of scientific theories has been so neglected. If we accept that one significant aspect of science is that it tells good stories, the aesthetic characteristics of scientific endeavour become more explicit. In discussing reasons for preferring once scientific theory to another, Thomas Kuhn wrote that “… aesthetic considerations can sometimes be decisive…”. (Kuhn, 1962, p.156). Kuhn regarded aesthetics as a valuable guide to scientists who are undecided about rival hypotheses: elegance and parsimony in a model might be a good indication that they are on the right track. Another insight into how scientists think about theory comes from Thomas Huxley who remarked on “The great tragedy of science – the slaying of a beautiful hypothesis by an ugly fact." (Huxley, 1870). The note of regret here indicates the importance of beauty in a scientific idea. The resignation in the face of the death of an idea that cannot be supported by facts, represents the necessary subordination of unrestrained imagination to external constraints. We will argue that these constraints, in a different form, exist equally in the field of the arts as in the sciences.

Enough has been said to substantiate the claim that the sciences rely on internal as well as external processes: on creativity and aesthetic judgement, as much as on the observation of empirical data. It is now necessary to summarize one leading current theory of the nature of creativity and how it operates.

The BVSR (Blind Variation and Selective Retention) model of creativity
This model is based on ideas first presented by Campbell (1960) and developed in a series of papers by Simonton (Simonton, 1999, 2010, 2011) The model proposes that creativity includes two necessary processes: blind variation followed by selective retention. It is claimed that this mechanism can operate within both the arts and the sciences. BVSR has strong similarities to Darwinian evolution, though the concept of BVSR does not depend on this: rather, Darwinism can be seen as an application of BVSR to one particular field, the biological.

In outline, it works as follows. Creativity may be defined as the generation of novel and valuable ideas. But the novelty part involves something more than simply producing thoughts which add to existing knowledge. It is argued that truly original ideas cannot arise through the application of standard analytical processes to an existing body of thought. This is because analysis is seen as being in some sense deterministic. Something whose outcome is determined in advance is not the result of creativity, though it may give rise to new knowledge. If you are asked to manually calculate the product of two three-digit numbers, you would probably be unable to give the result without some minutes' work with pencil and paper. You would not know the answer at the outset, although the answer is nevertheless determined in advance. Any sensible definition of creativity needs to exclude this possibility.

If creativity does not arise through a procedure whose outcome is determined in advance, how can it come about? The answer of Campbell and Simonton is that it must be the result of a process which generates variation (otherwise it has no novelty) and is blind (in the sense that the process of generating it is not the result of a series of steps which can be laid out in advance). An illuminating analogy is that of a radar which scans the sky looking for aircraft whose position is unknown. The scanning process is systematic, but blind in the sense that the location of the aircraft it is not known in advance.

Simonton emphasises that blindness does not require randomness, though randomness does ensure blindness. One very basic example of this (and not one given by Simonton) might be the use of the random drawing of Oblique Strategies cards[1], which are claimed to be useful in resolving creative deadlock. If the claims of the originators are to be believed, these cards represent a way of externalizing the creative

[1] See, for example, https://en.wikipedia.org/wiki/Oblique_Strategies

process, and certainly they are a good example of how the blind variation component of the BVSR model might be achieved.

The second component of BVSR is selective retention. This is necessary because if creativity involves producing novel and valuable ideas, blind variation can only ensure novelty and not, by itself, value. Selective retention involves the culling of ideas which do not serve to advance the object of the exercise. In Darwinian evolution, this part is played by natural selection. In the BVSR model as developed in eg Simonton (2011), he cites the case of Picasso's Guernica, in which Picasso generated variations for each individual figure that later appeared in the painting, and selected those variations which best fitted the overall composition.

Selective retention can however take place both at the time when the creative process occurs and later, and independently of the generation of the original idea involved. This variation in how selection occurs takes place in both the arts and the sciences. In science, a novel hypothesis may be generated, with a view to testing it against experimental data. The hypothesis may be the outcome of blind variation, in the sense of a lucky or plausible guess at the mechanism for some phenomenon. Before testing it, the hypothesis will certainly have been checked and refined by comparing it with existing knowledge, and possibly modified by some kind of selective process. This hypothesis may then be tested against empirical data produced as the result of an experiment, and the experiment itself gives another form of selection. If the data refutes the hypothesis, the experiment may be considered a failure and never published. If the experiment does appear to work and is published, it may give rise to other research which eventually shows it to be unsound, and this selective outcome will be final.

A similar process may occur in the arts. Again taking the example of Picasso, we see that he selected specific variants of the figures he sketched out in advance, by testing their utility in the context of the composition as a whole. The finished picture then itself went through the test of its impact on the art world in particular, and public opinion in general. This process might have resulted in disapproval or neglect, but instead Guernica became one of the great survivors in art, not only continuing to exert its power directly but influencing artistic thought and production today, 75 years after it first appeared.

While this chapter places the main focus on the role of creativity in cultural evolution in the arts and sciences, we acknowledge that creativity is not the whole story. Developments in musical composition for example, may be partly driven by improvements in the technology of instrument manufacture. Some scientific programmes involve the working out of existing ideas, driven simply by putting more resources into them. So whilst Peter Higgs and his colleagues demonstrated creativity in their papers describing the Higgs bosun effect, it took a further 50 years and development of the Large Hadron Collider to confirm the boson's existence. One might call this the effect of technology. Although art and science can advance on the momentum of previous ideas using technology, new ideas are necessary to maintain momentum.

Egyptian visual art reached just such a static equilibrium in the era of the Middle Kingdom, and its style remained largely unchanged for a thousand years. Since creativity is therefore a necessary if not sufficient condition for cultural evolution, it is this aspect that we will consider in the following section.

Aims in science and the arts

If we accept that the production of novel and original ideas and methods is fundamental to both the arts and sciences, and that the BVSR model can describe in broad outline how the process works, we still need to factor in the element of intentionality. Darwinian selection can be seen as a form of BVSR process in which the outcome is an ever-changing collection of living beings. BVSR in the arts and sciences gives rise to a developing and expanding realm of intellectual products. The BVSR model may explain *how* these intellectual domains develop, but it does not throw much light on *why* they have arisen. The "why" question involves issues of value and utility, both as far as the creators themselves are concerned and that of wider society. Both the arts and the sciences exist in, and are nourished by, society. In this section we will attempt to show how society not only sustains, but also influences the cultural evolution of the arts and sciences.

To do this, we will adopt some of the terminology used in Simonton's model of creativity (Simonton, 2010). He uses three basic concepts: the individual, the domain and the field, and claims that creativity arises from their dynamic interaction. The individual refers to the artist or scientist, described by Simonton as "the locus of the cognitive processes" who generates new ideas. The domain is the set of ideas within a particular discipline; it is the intellectual or aesthetic foundation on which individual creativity must build. The last component is the field, or the set of individuals who are creatively active in a given domain. This aspect recognizes the importance of the social context to creativity, though "social" in this connection refers to the personal interactions to which an individual is exposed, rather than the more general influence of society at large. The field, in a scientific domain, may comprise fellow researchers, journal reviewers, departmental heads, and people serving on grant award committees. In the arts, it might include "a contingent of aficionados, patrons, connoisseurs, and critics who evaluate contributions without producing contributions."

In this model, it is the domain, that is the publicly available body of knowledge and work that is the unit of main interest. The individuals that contribute to the body of knowledge and work are seen as the necessary means to ensuring the development of a given field. The contributions of the individuals may be accepted or rejected as a consensus judgement by the field. domain grows or changes in response to the creative contributions of these individuals.

Creativity in the sciences arises in the individual, and this only happens if the person has the will and skills that enable her/him to think about the questions arising in a given domain. The person needs to have enough background knowledge of the domain to be aware of what the key questions are, and sufficient drive to look for answers in the form of speculative hypotheses and explanations. This drive may arise from curiosity, a fascination with ideas for their own sake. Sometimes it arises at least partly from ambition and a desire to make a name for oneself. A person of the first type will not always focus on sharing their ideas as discovering and verifying them may be sufficient in itself. It is said that Edmund Halley had to persuade Newton to publish work showing how his theory of gravitation explained Kepler's laws of planetary motion, Most researchers however are keen to share their ideas, provided they are likely to be correct. In this, personal pride in good work may be part of the reason, but also the satisfaction of knowing one has added to the domain of existing knowledge and achieved, perhaps, a measure of immortality. The rare exceptions are by definition likely to be unknown to us, since they did not ensure that their work survived their own deaths. Such workers, however brilliant as individuals, did not influence the construct of main interest to us – the domain. Their intellectual DNA will not have been passed down, and so in a Darwinian sense they will have failed.

But though motives such as curiosity or ambition may be necessary at the outset, they are seldom sufficient. Most researchers must also have the courage and resilience to face some inevitable disappointments. New ideas are often criticised and discarded by the individual before they get any further. Simonton quotes Michael Faraday as evidence that hardly one in ten theories that may have passed through the mind of a scientific researcher, survive this first rigorous screening process. This is the first application of SR (selective retention) to BV (blind variation). But there will be more than one phase of SR to the ideas created by the individual. The next step in the sciences will typically be to create an experiment to test the truth of a speculative hypothesis that arose from the initial BV stage. If the empirical data show the hypothesis to be false, it will be dropped, though the data may themselves give rise to yet another hypothesis. The next step, if the hypothesis survives both self-criticism by the individual and testing against empirical reality, is to submit the results for peer review with an eye to publication. After a round of more or less bruising encounters with reviewers, work may or may not be published and may or may not make a new contribution to the domain.

In the arts, the process may seem quite different, though we would argue that there is an underlying similarity. A scientist may aim for an elegant hypothesis that proves consistent with fact, or that gives a parsimonious explanation that unites previously unconnected results, and that will be accepted by her fellow-researchers as valid. An artist may appear to be unconstrained by such mundane factors. However, an artist who dies in a garret without ever sharing her creations or discoveries will probably leave no mark on the domain of her art. Sometimes, work is discovered after death that ensures a posthumous reputation. Fernando Pessoa, who lived on the proceeds of his work as a freelance translator and published nothing in his lifetime, is now seen as the greatest Portuguese poet of the twentieth century. Such a fate is unlikely for a scientist because valid ideas and discoveries in science are likely to be made sooner or later by somebody, and so posthumously revealed work will probably already have been overtaken. But if Pessoa had not lived, “The Book of Disquiet” would never have existed, and having been revealed to the world, is still of interest today.

At the individual level, the immediate cause of creative activity is probably driven by a mixture of motives. In the sciences, curiosity and the desire to know the answer to some question may be enough to get the process started. But curiosity will eventually die unless it receives some satisfaction. Tackling a problem too difficult for any solution leads only to frustration. Anyone who has experienced any success in scientific work knows on the other hand the exhilaration which accompanies an experiment that attains its aims. Curiosity which is rewarded with an answer provides rewards which will ensure that an individual wishes to repeat the process. In the arts, the analogue of curiosity may be a need to make an imaginative exploration of human experience in a novel way. The ability to create something of beauty, which satisfies the aesthetic sense of the artist, is also an activity that gives satisfaction. The need to share a subjective experience with others, and perhaps to induce a similar vision or emotion to the one which inspired it in the creative artist, may also spur the process.

The research cycle and its artistic counterpart

It is tempting to spend more time examining the conscious aims which spur scientists and artists to be creative. The range of motives is probably wider in the arts than the sciences, where the objectives are more obvious and usually centre round the wish to contribute to a certain domain of knowledge, shared by a field of fellow workers. Artists may not even appear to care whether their work survives them. But in most cases creative workers in the arts are influenced by public response to their work.

However, our aim in this chapter is less a psychological analysis of the internal drives of creative workers than the form of the process by which creation is sustained by wider society. This process involves an application of the BVSR principle at a broader level than the individual, and requires an interaction of the individual with the field in the process of modifying the domain. This process takes a cyclical form, and this cycle represents the basic unit of cultural evolution.

The cycle can perhaps be best understood by illustrating the analogue in a simplified model of Darwinian evolution. Simonton (1999) describes the basic three step cycle as it applies to attempts to use computers to model creativity, based on a BVSR process which is close to Darwinian evolution. The first step is to generate variations on an existing set of options (the "population"), using the computer equivalent of genetic recombination and mutation. The next step is to test these variations through a form of natural selection, and the final phase is the incorporation of successful variants in the set of options (ie the new gene pool) for the next generation. The process repeats until a genotype has developed which is best adapted for the existing "environment". The equivalent cycle in science, which is sometimes known as the research cycle, involves as the first step, developing a plausible hypothesis from existing knowledge (the "domain") – this will usually involve a shuffling of existing ideas with possibly also some new ones, corresponding to recombination and mutation. The second step requires a dialogue between the hypothesis and reality, usually in the form of an experiment, which selects for the hypotheses that fit the empirical data and rejects those that do not. The final step involves publication of the result (perhaps incorporating a further phase of change and selection), which then becomes part of the domain, corresponding to a population or a gene pool in an ecological system.

What is the corresponding process in the arts? There is no obvious one to one map from the research cycle to the production of an artwork, though the creative part of a new work of art has similarities with the creation of a hypothesis. The selection phase consists, we suggest, in the critical response to an artwork when it becomes public. In science, confronting a beautiful hypothesis with the test of experiment often gives rise to an ugly fact which shows it to be false. The nearest thing to this in art is to confront the artwork with the "field" in Simonton's term, namely the collection of individuals that collectively exercise the selection pressure which determines whether or not the work will survive and become incorporated into the "domain".

The domain therefore changes every time a new artwork becomes part of it. All creation requires some knowledge of the relevant domain. Other creative artists, to the extent that they are familiar with the domain, will be to some extent affected by changes in the domain, in particular new art works which have survived the critical process. The domain will be the outcome of an interaction between the individual creator and the field.

The key test of validity of a scientific hypothesis is whether it can be put to empirical proof and be found to give correct predictions. If this is the case, then if the hypothesis is interesting, and if there is no suspicion that the empirical testing has been falsified or done incompetently, then generally the field will accept the result and the hypothesis will be incorporated into the domain. What is the equivalent of empirical testing with a work of art? If the truth of a scientific hypothesis can be defined in a single phrase as a correspondence with the facts, what is the analogue of truth for an artwork? Truthfulness comes into consideration in science at the stage of selective retention; a hypothesis is retained if and only if it corresponds to the facts. Truthfulness could therefore be equally defined as the property which enables a hypothesis to survive the SR step of the research cycle. This is close to C S Peirce's definition of truth in science as being that which was in the long run destined to be believed. If we mean by the domain of science "that which is believed", then truth is "that which in the long run will be part of the domain".

In the arts, "truth" in the literal sense has little meaning. There is no sense in which a cubist painting is more "true" than one produced according to the strict laws of perspective. But if the equivalent is "long run acceptance into the domain", the domain here being that of artworks accepted as having permanent significance, then many cubist paintings possess a quality which is the equivalence of "truth" in science.

In an objective sense the "aim" of art is to create works which will become accepted into the domain of art. Creative artists consciously or otherwise strive to achieve this. If truth is the quality of hypotheses that enables them to achieve long run acceptance, what is it about works of art that achieves the same aim? In science, acceptance is decided mainly by the nature of the area being investigated: it is this which determines whether the hypothesis will survive the test of experiment. Partly also, acceptance is decided by the field, of fellow researchers who are competent to judge what counts as valid, well-conducted research. But in the arts, the burden of determining whether an artwork survives rests entirely on the field, since there is no "nature", no realm of "objective fact" to which an appeal can be made.

Nevertheless, the BVSR model of cultural evolution still ensures the change over time of the domains in art, just as in the sciences. The "field" in the arts, described by Simonton as the "contingent of aficionados, patrons, connoisseurs, and critics who evaluate contributions", exercises the decisive voice in selective retention, and therefore shapes the way the domain evolves.

It may help to provide a more specific example of how the creative cycle might work. In the case of music, the selective role is exercised partly by the informed listeners who exercise an influence on taste and whose praise or criticism carries weight, and partly by members of the general listening public. In both cases, a piece of music that is to become popular enough to enter the domain probably has to induce a feeling or pleasure in the listener. It is this inducement which will lead the listener to wish to repeat the experience, and to describe it in positive terms. It may do so by various means. We have argued elsewhere (Allen, Walsh & Zangwill, 2013) that music induces pleasure in the listener by inducing “chimerical” emotions: that is, non-naturalistic emotional states which incorporate elements of naturalistic emotions. For example, Huron (2011) has made a case that sad music can be pleasurable to listen to precisely because it does not induce a natural emotion, that of sadness, in the listener.

It seems likely that creative composers learn by trial and error that certain artistic techniques work by influencing the human brain in ways that are pleasurable to the listener. Humans are primarily visual, but sound is also important to all mammals and an acute responsiveness to sound has been important in evolutionary terms to survival. Sound cues are used to help map out the auditory scene in naturalistic situations. Speech is a relatively late development in the evolution of humans, and for much of our evolutionary history sound was mainly a cue to the nature of the creature making it. Animals vocalize extensively, and these sounds give important cues to the type of animal emitting them, and possibly to its emotional state. Certainly with other humans, the voice conveys much information in addition to the meaning of the words uttered. Many vocalizations are non-verbal but indicate moods. Ugh! (disgust). Hey! (anger or surprise). Mmmm… (pleasure). Ruurghh? (Scooby Doo in interrogative mode). Between these extremes it is possible to use subtle cues to detect tension, boredom or arousal in voices. Voices also indicate the identity of the person speaking (conveyed mainly through timbral cues: most people are so good at this that they can identify a caller even through the very impoverished spectral envelope transmitted through a mobile phone).

All these features of sound induce neural responses in listeners, which may be similar to natural emotions. In Allen, Walsh and Zangwill (2013) we suggested that composers take the components of natural voices and sounds, and remix them in non-natural ways in order to induce different emotional responses. Taking listeners to different regions of their “emotion space” in this way can be rewarding. We do not suggest that composers have such an intention in any overt, deliberate sense, but we think that this provides some explanation of how the process operates. The creation of rewarding sounds gives a positive outcome to the SR phase of the process. Composers learn from both their predecessors, and their previous successes, and build on existing techniques to achieve further results. In an empirical sense, composers might be seen as attaining a degree of influence over the neural processes of listeners which makes them, in this purely practical sense, into far better psychologists than most of us.

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