Weak vs. Strong Computational Creativity

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Abstract. In the spirit of Searle's definition of weak and strong artificial intelligence, this paper presents a discussion on weak computational creativity in swarm intelligence systems. It addresses the concepts of *freedom* and *constraint* and their impact on the creativity of the underlying systems. An analogy is drawn on mapping these two 'prerequisites' of creativity onto the two well-known phases of exploration and exploitation in swarm intelligence algorithms, followed by the visualisation of the behaviour of the swarms whose performance are evaluated in the context of arguments presented in the paper.

1 INTRODUCTION

In recent years, studies of the behaviour of social insects (e.g. ants and bees) and social animals (e.g. birds and fish) have proposed several new metaheuristics for use in collective intelligence resulted from social interaction.

Among the many works in the fields are research on swarm painting (e.g. [24, 7, 34, 35]), ant colony paintings [19, 23, 31]) and other multi-agent systems (e.g. RenderBots [29] and the particle-based non-evolutionary approach of Loose and Sketchy Animation [15]).

In most of the swarm-based work mentioned above (e.g. [24, 7, 34, 35, 19]), the painting process does not re-work an initial drawing, but rather focuses on presenting "random artistic patterns", somewhere between order and chaos [35]. Other classes of research (e.g. by Schlechtweg et al. [29] and Curtis [15]) are based on reworking an initial drawing. There is a significant number of related papers in the area of non-photorealistic rendering; particularly, many papers approach drawing and painting using the optimisation framework. Furthermore, particles have been used for stippling and other aesthetic styles in numerous papers. Turk and Bank's work [33] is an early example of optimising particle positions to control a stroke-based rendering. Hertzmann [21] optimised a global function over all strokes using a relaxation approach. In one of his works, Collomosse [14] used a global genetic algorithm to define a rendering algorithm. More recently, Zhao et al. [38] deployed an optimisation-based approach to study the stroke placement problem in painterly rendering, and presented a solution named stroke processes, which enables intuitive and interactive customisation of painting styles.

This work is an extension of ideas first presented at the Computing and Philosophy symposium at AISB 2011 [1] and subsequently published in the Cognitive Computation journal [6]. In the work discussed herein the impact of freedom and constraint on the concept of 'creativity' is discussed, followed by a discussion on the creativity of swarm intelligence systems. This paper also addresses the issue of weak verses strong computational creativity.

2 ON CREATIVITY, FREEDOM AND ART

For many years there has been discussions on the relationship between art, creativity and freedom; a debate elegantly encapsulated in the famous German prose by Ludwig Hevesi at the entrance of the Secession Building in Vienna:

> *"Der Zeit ihre Kunst*
> *Der Kunst ihre Freiheit"*

That is: "To Time its Art; To Art its Freedom".

Which, centuries after, resonates an earlier observation from Aristotle (384-322 BCE) [17] emphasising the importance of freedom (here, having "a tincture of madness") in presenting a creative act.

> *"There was never a genius without a tincture of madness."*

On the other hand Margaret Boden, in [9], more recently argues that creativity has an ambiguous relationship with freedom:

> *"A style is a (culturally favoured) space of structural possibilities: not a painting, but a way of painting. Or a way of sculpting, or of composing fugues .. [] .. It's partly because of these [thinking] styles that creativity has an ambiguous relationship with freedom."*

Considering the many factors constituting the evaluation of what is deemed 'creative', raises core issues regarding how humans evaluate creativity; their aesthetic capacity and potentially that of other animals (e.g. as exhibited in, say, mate-selection). Galanter [18] suggests that perhaps the 'computational equivalent' of a bird or an insect (e.g. in evaluating mate selection) is all that is required for [computational] aesthetic evaluation:

> *"This provides some hope for those who would follow a psychological path to computational aesthetic evaluation, because creatures with simpler brains than man practice mate selection."*

In this context, as suggested in [16], the tastes of the individual in male bowerbirds are made visible when they gather collections of bones, glass, pebbles, shells, fruit, plastic and metal scraps from their environment, and arrange them to attract females [10]:

> *"They perform a mating dance within a specially prepared display court. The characteristics of an individual's dance or artefact display are specific to the species, but also to the capabilities and, apparently, the tastes of the individual."*

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However the question of whether *'mate selection behaviour in animals implies making a judgement analogous to aesthetic judgement in humans'* is perhaps (pace Nagel's famous discussion 'What is it like to be a bat? '[25]) a fundamentally unanswerable question.

In contrast, the role of education (or training) in recognising 'good' and 'bad', 'creative' and 'non-creative' has been experimentally probed. A suggestive study investigating this topic by Watanabe [36] gathers a set of children's paintings, and then adult humans are asked to label the "good" from the "bad". Pigeons are then trained through operant conditioning to only peck at good paintings. After the training, when pigeons are exposed to a novel set of already judged children's paintings, they show their ability in the correct classification of the paintings.

This emphasises the role of learning training and raises the question on whether humans are fundamentally trained (or "biased") to distinguish good and/or creative work.

Another tightly related topic to swarm intelligence in this context is the creativity of social systems. Bown in [11] indicates that our creative capabilities are contingent on the objects and infrastructure available to us, which help us achieve individual goals, in two ways:

> *"One way to look at this is, as Clark does [13], in terms of the mind being extended to a distributed system with an embodied brain at the centre, and surrounded by various other tools, from digits to digital computers. Another way is to step away from the centrality of human brains altogether and consider social complexes as distributed systems involving more or less cognitive elements."*

Discussion on creativity and the conditions which make a particular work creative, have generated heated debate amongst scientists and philosophers for many years [27]; for a theoretical review on 'conditions of creativity'; the 'systems' view of creativity; cognitive approaches, etc. see also [32]. Although this article does not aim to resolve any of these issues (or even suggest that the presented work strongly fits and endorses the category of the 'computationally creative realm'), we investigate the performance of a swarm intelligence sketching system which, we suggest, highlights core issues inherent in exploring conceptual/artistic space(s).

3 CREATIVITY IN SWARMS

3.1 Freedom vs. Constraint

Both freedom and constraint have always been at the core of several definitions for creativity. Philip Johnson-Laird in his work on freedom and constraint in creativity [22] states:

> *"... for to be creative is to be free to choose among alternatives .. [] .. for which is not constrained is not creative."*

In swarm intelligence systems, the two phases of exploration and exploitation introduce the freedom and control the level of constraint. Pushing the swarms towards exploration, freedom is boosted; and by encouraging exploitation, constraint is more emphasised. Finding a balance between exploration and exploitation has been an important theoretical challenge in swarm intelligence research and over the years many hundreds of different approaches have been deployed by researchers in this field. In the presented work, two swarm intelligence algorithms are deployed: the algorithm which is responsible for the "intelligent" tracking of the line drawing is Particle Swarm Optimisation (PSO). This well-known algorithm, which mimics the behaviour of birds flocking, has an internal mechanism of balancing off the exploitation and exploration phases. However due to the weakness of the exploration in this algorithm, our system also deploys another nature inspired algorithm to overcome this weakness, Stochastic Diffusion Search (SDS), which mimics the behaviour of one species of ants (*Leptothorax acervorum*) foraging. Therefore, exploration is promoted by utilising the SDS algorithm, whose impact on different swarm intelligence algorithms has been scientifically reported using various measures and statistical analysis in several publications (e.g. [2, 3, 4, 5]) and the technical information on the integration of the two algorithms can be found in al-Rifaie et al. [2].

In the visualisation, the swarms are presented with a set of points (which constitute a line drawing – see Fig. 1) and are set to consider these points (one at a time) as their global optimum. In other words, the global optimum is dynamic, moving from one position to another and the swarms aim to converge over this dynamic optimum (Fig. 2).

As stated in the introduction, there have been several relevant attempts to create creative computer generated artwork using Artificial Intelligence, Artificial Life and Swarm Intelligence. Irrespective of whether the swarms are considered genuinely creative or not, their similar individualistic approach is not totally dissimilar to those of the "elephant artists" [37]:

> *"After I have handed the loaded paintbrush to [the elephants], they proceed to paint in their own distinctive style, with delicate strokes or broad ones, gently dabbing the bristles on the paper or with a sweeping flourish, vertical lines or arcs and loops, ponderously or rapidly and so on. No two artists have the same style."*

Similarly if the same line drawing (see Fig. 1) is repeatedly given to the swarms, the output sketches (e.g. Fig 2) made by the swarms, are never the same (see Fig. 4 to compare different sketches). In other words, even if the swarms process the same input several times, they will not make two identical sketches; furthermore, the outputs they produce are not merely randomised variants of the input. In order to demonstrate this claim qualitatively in an experiment, the output of the swarm-based system is compared against a simple randomised tracing algorithm, where each point in the line drawing could be surrounded with lines at a random distance and direction.

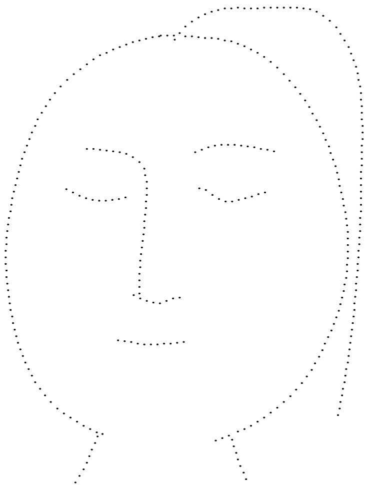
In Fig 3, only PSO algorithm is used to producing the sketch. This experiment is run in order to highlight the exploration (i.e. 'freedom') impact induced by SDS algorithm on the final sketch.

3.2 Swarmic Freedom versus Random Freedom

This part presents an experiment with the goal of contrasting the behaviour of the swarms to that of a group of random agents. In this experiment, the freedom of the swarm (i.e. *Swarmic Freedom*) is maintained by the swarm intelligence algorithms used in the system, whereas the freedom of the agents in the randomised algorithm is controlled by what we call the *Random Freedom*. These definitions are utilised here to highlight the potential of the swarms in exhibiting computational creativity.

The sketches in Fig. 5 (top and middle) show two outputs from a simple randomised algorithm when configured to exhibit limited 'random' variations in their behaviour (i.e. there is only small random distance and direction from the points of the original line drawing); comparing the two sketches, we note a lack of any significant difference between them. Furthermore, when more 'freedom' is granted to the randomised algorithm (by increasing the range in the

Figure 1. This figure shows a series of points that make a line drawing; sample line drawing after one of Picasso's sketches.

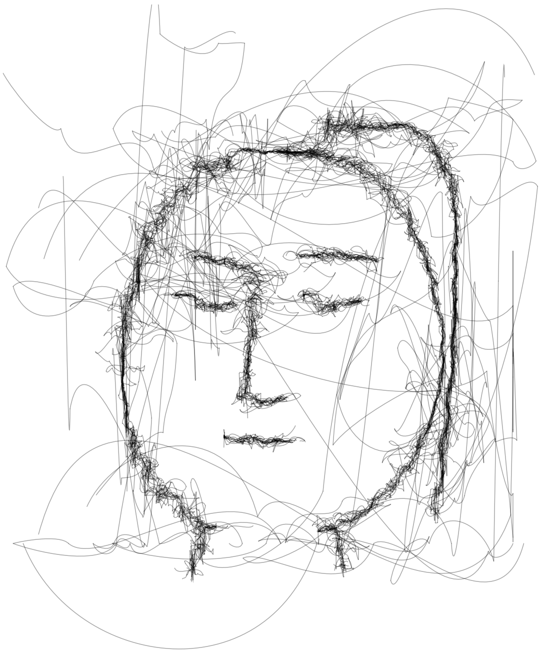


underlying random number generator, which allows the technique to explore broader areas of the canvas), the algorithm soon begins to deviate excessively from the original line drawing. For this reason such randomisation results in a very poor - low fidelity - interpretation of the original line drawing (Fig. 5-bottom). In contrast, although the agents in the swarms are free to access any part of the canvas, the swarm-control mechanism (i.e. Swarm Freedom) naturally enables the system to maintain recognisable fidelity to the original input. In the randomised algorithm, contra the swarms system, it can be seen that simply by giving the agents more randomised behaviour (Random Freedom), they fails to produce more 'creative sketches'.

The Swarmic Freedom or 'controlled freedom' (or the 'tincture of madness') exhibited by the swarm algorithms (induced by the stochastic side of the algorithms) is crucial to the resultant work and is the reason why having the same line drawing does not result in the system producing identical sketches. This freedom emerges, among other influencing factors, from the stochasticity of SDS algorithm in picking agents for communication, as well as choosing agents to diffuse information; the tincture of madness in PSO algorithm is induced via its strategy of spreading the particles throughout the search space as well as the stochastic elements in deciding the next move of each particle.

In other words, the reason why the swarm sketches are different from the simple randomised sketches, is that the underlying PSO flocking component-algorithm constantly endeavours to accurately trace the input image whilst the SDS foraging component constantly endeavours to explore the wider canvas (i.e. together the two swarm mechanisms ensure high-level fidelity to the input without making an exact low-level copy of the original line drawing). Although the algorithms (PSO and SDS) are nature-inspired, we do not claim that the presented work is an accurate model of natural systems. Furthermore, whilst designing the algorithm there was no explicit 'Hundertwasser-like' attempt [26] by which we mean the stress on using curves instead of straight lines, as Hundertwasser considered straight lines not nature-like and tried not to use straight lines in his works to bias the style of the system's sketches.

Figure 2. A sketch produced by the swarms.



3.3 Weak vs. Strong Computational Creativity

Before approaching the topic of weak or strong computational creativity, the difference between weak and strong AI is highlighted. In strong AI, the claim is that machines can think and have genuine understanding and other cognitive states (e.g. "suitably programmed machines will be capable of conscious thought" [12]); weak AI, in contrast, does not usually go beyond expecting the simulation of human intelligence. I.e. instantiating genuine "understanding" is not the primary concern in weak AI research.

An analogy could be drawn to computational creativity, extending the notion of weak AI to weak computational creativity, which does not go beyond exploring the simulation of human creativity; emphasising that genuine understanding is not the main issue in weak computational creativity. In strong computational creativity, the expectation is that the machine should be creative, have genuine understanding and other cognitive states as well as being capable of conscious thought.

Having a machine with conscious thought has provoked many critics, among whom John Searle made the most famous attack against strong AI in his Chinese Room argument [30]. Bishop [8] summarises Searle's Chinese Room Argument (CRA) as follows:

> "In 1977 Schank and Abelson published information [28] on a program they created, which could accept a simple story and then answer questions about it, using a large set of rules, heuristics and scripts. By script they referred to a detailed description of a stereotypical event unfolding through time. For example, a system dealing with restaurant stories would have a set of scripts about typical events that happen in a restaurant: entering the restaurant; choosing a table; ordering food; paying the bill, and so on. In the wake of this and similar work in computing labs around the world, some of the more excitable

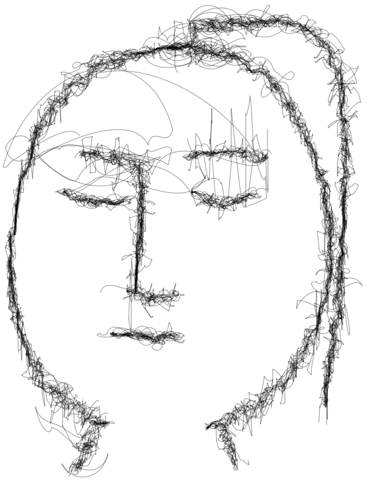


Figure 3. A sketch produced by the swarms without SDS exploration.

proponents of artificial intelligence began to claim that such programs actually understood the stories they were given, and hence offered insight into human comprehension.

It was precisely an attempt to expose the flaws in the statements emerging from these proselytising AI-niks, and more generally to demonstrate the inadequacy of the Turing test[3], which led Searle to formulate the Chinese Room Argument.

The central claim of the CRA is that computations alone cannot in principle give rise to understanding, and that therefore computational theories of mind cannot fully explain human cognition. More formally, Searle stated that the CRA was an attempt to prove that syntax (rules for the correct formation of sentences:programs) is not sufficient for semantics (understanding). Combining this claim with those that programs are formal (syntactical), whereas minds have semantics, led Searle to conclude that 'programs are not minds'.

And yet it is clear that Searle believes that there is no barrier in principle to the notion that a machine can think and understand; indeed in MBP [Minds, Brains and Programs] Searle explicitly states, in answer to the question 'Can a machine think?', that 'the answer is, obviously, yes. We are precisely such machines'. Clearly Searle did not intend the CRA to target machine intelligence *per se*, but rather any form of artificial intelligence according to which a machine could have genuine mental states (e.g. understanding Chinese) purely in virtue of executing an appropriate series of computations: what Searle termed 'Strong AI'.

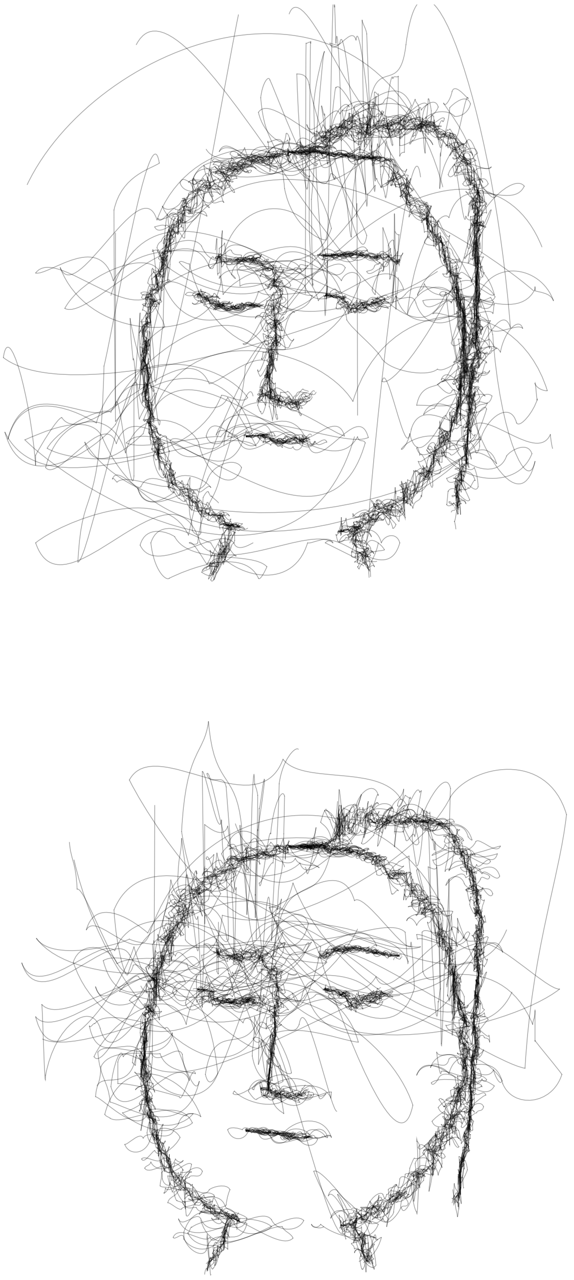


Figure 4. Different sketches of the swarms off a single line drawing.

Searle argues that understanding, of say a Chinese story, can never arise purely as a result of following the procedures prescribed by any computer program, for Searle offers a first-person tale outlining how he could instantiate such a program, and act as the Central Processing Unit of a computer, produce correct internal and external state transitions, pass a Turing test for understanding Chinese, and yet still not understand a word of Chinese.

Searle describes a situation whereby he is locked in a room and presented with a large batch of papers covered with Chi-

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[3] In what has become known as the 'standard interpretation' of the Turing test a human interrogator, interacting with two respondents via text alone, has to determine which of the responses is being generated by a suitably programmed computer and which is being generated by a human; if the interrogator cannot reliably do this then the computer is deemed to have 'passed' the Turing test.

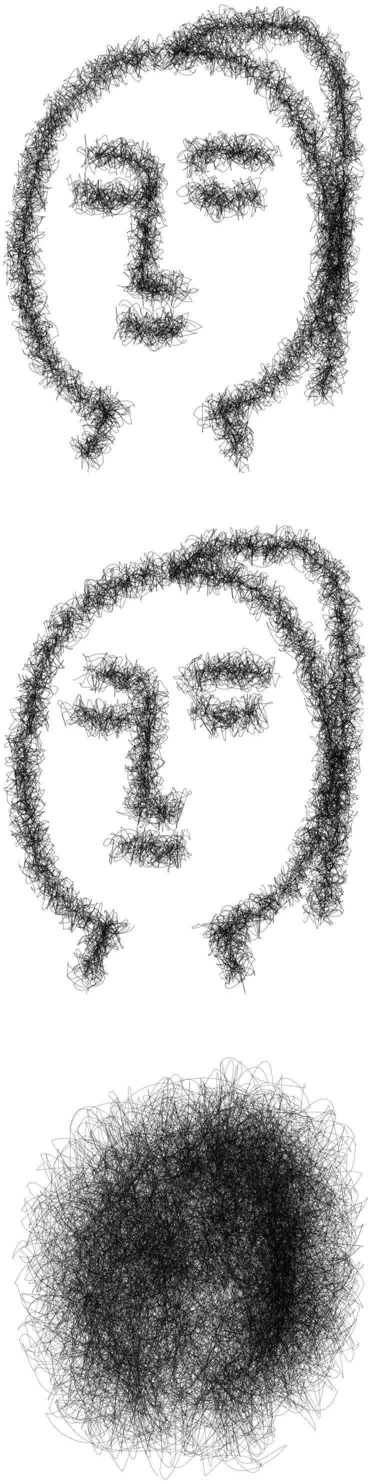

Figure 5. The sketches of the swarms with random behaviour: This figure shows the sketches made with a simple randomised tracing algorithm, using random distance and direction from the lines of the original line drawing. The first two sketches (top and middle) use the same random distance (e.g. d) and the bottom sketch uses the random distance of $d \times 6$.

> nese writing that he does not understand. Indeed, the monoglot Searle does not even recognise the symbols as being Chinese, as distinct from say Japanese or simply meaningless patterns. Later Searle is given a second batch of Chinese symbols, together with a set of rules (in English) that describe an effective method (algorithm) for correlating the second batch with the first, purely by their form or shape. Finally he is given a third batch of Chinese symbols together with another set of rules (in English) to enable him to correlate the third batch with the first two, and these rules instruct him how to return certain sets of shapes (Chinese symbols) in response to certain symbols given in the third batch.
>
> Unknown to Searle, the people outside the room call the first batch of Chinese symbols 'the script', the second set 'the story', the third 'questions about the story' and the symbols he returns they call 'answers to the questions about the story'. The set of rules he is obeying they call 'the program'. To complicate matters further, the people outside the room also give Searle stories in English and ask him questions about these stories in English, to which he can reply in English.
>
> After a while Searle gets so good at following the instructions, and the 'outsiders' get so good at supplying the rules he has to follow, that the answers he gives to the questions in Chinese symbols become indistinguishable from those a true Chinese person might give.
>
> From an external point of view, the answers to the two sets of questions, one in English the other in Chinese, are equally good; Searle, in the Chinese room, have passed the Turing test. Yet in the Chinese language case, Searle behaves 'like a computer' and does not understand either the questions he is given or the answers he returns, whereas in the English case, *ex hypothesi*, he does. Searle contrasts the claim posed by some members of the AI community - that any machine capable of following such instructions can genuinely understand the story, the questions and answers - with his own continuing inability to understand a word of Chinese; for Searle the Chinese symbols forever remain ungrounded."

We suggest that Searle's famous thought experiment similarly targets the notion of 'strong computational creativity'. I.e. Searle using a similar "room" could gets so good at following the rules that the strings of symbols he outputs from the room successfully control a 'Strong computer creative art' system producing works judged to have artistic merit by people outside the room; even though Searle-in-the-room remains ignorant of art and art practise. Hence, until the challenge of the Chinese room has been fully met, the authors urge caution in predicating 'strong' notions of creativity to any computational system.

4 CONCLUSION

In this paper, we have discussed the potential of the swarms in exhibiting 'weak computational creativity'. This specific work described herein uses swarm intelligence techniques to explore the difference between using Random Freedom and Swarmic Freedom in the visualisation of the swarms 'tracing' line drawings; this work highlights the features of swarm-regulated difference versus simple-random difference in the production of such 'sketches' by computer. We stressed on the significant impact of both freedom and constraint on the emergent creativity, and presented a discussion on how these two concepts are mapped onto exploration and exploitation, the two most infamous phases in the swarm intelligence world. The so described computational artist is the result of merging two swarm intelligence algorithms (SDS and PSO), preserving freedom (exploration) and constraint (exploitation) respectively.

5 CODA

Leit-motif: Although we distance ourselves from claims of strong computational creativity, in faint homage to Turing's Imitation Game and Harre & Wang's physical implementation of the Chinese room experiment [20], we asked Chiara Puntil, a human artist from Goldsmiths, to adopt the 'style' of the swarms and to produce some sketches (Fig 6) based on the 'style' of the line drawing in Fig. 2.

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Figure 6. Two of the sketches are produced by the swarms and two are made by a human artist.