

Integrating Programmatic Optimization and Learning Through Art

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ABSTRACT

The orthodox view of the computer as a medium or medium of media (ie. “new media”) is perfectly justified in colloquial discussions, but is hardly evident as an objective fact. This does not imply that computers are employed in the making of art, rather we are investigating a means of initiating the occurrence of an artistic experience for the audience, with whatever tools are convenient, in this case computers. We leverage the feature that logical syllogisms can be articulated such as to create systems that act as catalysts for Constructivist learning to take place within the individual minds of audience members. These concrete, but unobservable synaptic adjustments are subsequently displayed via unpredicted idiosyncratic behaviours. In short, whether or not a computer can choreograph a dance, we describe how automated machines can coerce humans to dance. In doing so, we uncover mysteries as to the ubiquity and influence of art on our species.

Keywords: *Art-ness; Cognition; Development; Interactivity; Modelling; Tool-use; Perception*

1 | INTRODUCTION

An orthodox view regarding computer art that considers the machine to be medium, namely “new media” is perfectly justified as a matter of faith.

However, when we embark on investigations into the details of cognition, we can no longer make assumptions about the existence and role of art and aesthetics in communication. This is one of several problems in Semir Zeki’s theory of *neuroaesthetics* (1999), but is also rooted in much of web art (Greene, 2004) and the more technical examples of bio-art (described in Shasha & Lazere, 2010). Because art is so deeply entrenched in culture, this distillation is much more difficult in practice than it sounds in theory, particularly for those of us who are rather invested in time and effort in an art-centric culture. Throughout recent history, and easily before that, though relevant records prior to the nineteenth century that are mostly unavailable to historians, the public has continually viewed unprecedented feats by novel technologies as having a magical mystique that promises to defy physical limitations (Marvin, 1988; Nadis, 2005). Nonetheless, we need to, at least temporarily, avoid the idea of media, as it assumes art-ness in ways we aim to clarify. It is only incidental that many artists use the computer, directly (eg. on the screen), or indirectly (eg. printed), as a medium for exhibiting art, the topic under investigation.

The computer was originally designed by and for mathematicians, to aid in performing faster, more complex calculations with greater consistency than humans could accomplish. For instance coordinating remote radar signals from around the

US (Waldrop, 2001, p. 101). Combining this utility with graphics has proven particularly useful for displaying multi-dimensional information, such as in weather forecasting.

Though many may justifiably insist that the computer can also be used as a medium of self-expression, this is ultimately a matter of faith. Not that it is less valid as such, but this belief is not available as a premise to us for the purposes of this discussion. Generally we might invoke Kurt Gödel's Incompleteness theorem (1962), that the vocabulary of art is insufficient in isolation to explain art. However, we must be cautious, as it is easy to apply his notion too broadly, as he referred to mathematics postulates and not to reasoning.

If taken as fact, the nature of art becomes a circular argument, where art is an inherent property in artefacts, because artefacts are evidence of art. So long as art-ness is regarded not treated as conclusive, such a paradox is rendered inconsequential.

Nonetheless, computers are employed in this discussion, not as media implicating matters of faith, but merely as flexible calculating devices.

The term "self-expression" is problematic. A similar problem has plagued linguistics in recent decades. There is no possibility of an ideally executed expression that is inherently interpreted "correctly." A listener, including one who does not share the language as spoken, must be accounted for as much as the speaker. There is no universal self-expression that can be distinguished from say, a seizure, without the implicit cooperation of another self, with shared cultural influences. Furthermore, these influences are highly arbitrary and highly variable, such that sharing must also depend on mutual agreement between selves. How might the artist convince others, who are not already previously prone to accept expressions from within a chosen culture, that the object is somehow expressive and not exclusively a product of accidental forces?

It behooves us at this point to set aside more recent examples of computer art. Generative works may indeed qualify as art, but before citing these more complicated cases, we first must investigate what constitutes art, not as an intellectual exercise, but and how it might serve some neurological and/or evolutionary function (as considered in Bjorklund & Pellegrini, 2002; Deacon, 1997). Despite the recent history of computer uses by artists and others, which perhaps might be seen as the complexity concealed by this metaphorical rock, we propose

a means of utilizing code as a lever to assist in overturning conceptual rocks.

Before considering what/how computers are capable of (ie. recursion, quantitative measures of topology), no doubt anxiously anticipated topics for many readers, we need to first reconsider what we might learn from our own devout faith in precision itself, in order to render our tools relevant in a particular cognitive arena, as *catalysts* of experiences we will identify as Behavioural Art.

2 | BEHAVIOURAL ART

To begin, we might say that Behavioural Art (BA) is similar to Performance Art, but rather than enacted on the stage, it is enacted within the audience members' minds. In BA, the artwork is not an object, nor happens on the screen (ultimately, also understood as an object), but the ongoing conversation process between the experience within an audience member's mind and the inanimate system (Wright, 2010). This system may include a computer as a convenient means of designing complex nested conditionals. In BA, these mazes of if-then statements are hardly intended to synthesize intelligent behaviours. They merely provide the initial cues that we humans interpret as a potential "message" worth our further attention.

BA is hardly exclusive to computers. With *Reversible Destiny/We Have Decided Not to Die* (1997) Arikawa and Gins created painted canvases that implied both board games and logical puzzles, inviting the viewer to "play" with these pieces. However, by using the medium in expected ways (eg. paint), the artist often inadvertently sets a strict limit to the level of interactivity (Wright, 2012). Duane Hanson's *Museum Guard* (1976) may also qualify. This figurative sculpture is so realistic, that often gallery visitors ask it questions. Though realism is hardly important in BA, there occurs a key exchange. The person speaks, then waits. No reply is forthcoming. The audience member is actively engaged, if only privately in the mind, awaiting the response. A subsequent behaviour occurs when the person must then solve the problem of why the guard does not react.

Marcel Duchamp's *Fountain* (1912), though an extremely influential piece for Visual Art, works in the opposite way as Hanson's. Whether this was an authentic *readymade* or not (Danto 2000), his observations about the culture of a historical art-world he was a part of are just as valid. By transforming the fixture into a symbol, it hardly matters now what life was like for that original fixture. The symbol is

the same, referring to a role of such fixtures within a particular culture. "Elevating" a urinal at the lower end of the social totem pole of man-made stuff to a precious work of art in gallery setting, Duchamp is essentially saying "this looks like something banal, but it is far more important. So resist the urge to pee on it!" Reinforced by the gallery presentation, the message is "you may be tempted to interact, but that would be inappropriate." We are invited to imagine using the urinal to go to the bathroom, but are expected not to act on it.

Similarly, at the Exploratorium science museum in San Francisco there is a drinking fountain which looks like a toilet (Oppenheimer, 1976). There is nothing unsanitary about it, and is easily accessible to visitors. In this way, it has the *opposite* effect as Duchamp's piece, by inviting the audience to physically engage despite their conceptual urges not to.

Call-and-response in Gospel music is an extremely interesting means of interaction in music. But once the audience responds, it is unlikely that the caller will alter the planned next line of the song. Though digital technology is hardly required for BA, to achieve the level of interaction sufficient for gross motor coordination, in order that Piagetian investigation/exploration can occur, this degree of responsiveness is rather convenient to accomplish via computer programming. Without coded instructions, namely complex nests of conditionals, neither digital media, nor electronics are sufficient in this respect.

Finally, we consider a dance performance by Chunky Move called *Mortal Engine* (2008). In it, the dancers wearing black spandex body suits are monitored by a camera. The computer performs minimal processing to this data before sending it on to the display. In this case, the display is a projector, which was aimed onto the stage and the dancers themselves. Thus, the animation appeared to the audience as a very clever shadow. The interaction between the dancers and the computer is certainly much deeper than say a light switch or list of a few menu options. But the BA-esque aspect of this piece lies with the audience. Observers presented with distinct, independent stimuli were prompted to mentally see the synchronization of the dancer and the shadow as somehow unified, and further interpret meanings from their interplay.

3 | A HISTORY OF A PERSPECTIVE

Given only consistently verified physical laws, thus disqualifying the notion that art-ness could be considered as an extrinsic property, how might communication between organic minds be

accomplished? Consider William James famous notion of "psychic pressures," that impulses are the embodiment of strategies employed by the brain to relieve internal, somewhat mechanical, conflicts (James, 1892). Behaviours, desirable or not, are thus by products of psychological needs.

We might now describe art-ness as a common result of a species-specific ability, rather than as a feature of some remote object. This object might be an event on the computer screen, broadcast from speakers, shared amongst nodes of a network, and so on, but it remains an event that is treated conceptually as a *thing*, tangible or not. Rather than a task in detection, perception becomes a task in distinguishing amongst the chaos of sensory impulses, that constitute our models of culturally defined environments (Wright, 2013). If art is anything, it is this projective system.

Not without important caveats, computers offer the unprecedented possibility of eliminating non-objective data in calculation. However, this is not true of humans determining (a) which aspects of the results are relevant, and (b) what the output of the computer signifies. Independently, without the aid of attention to 'curate' the data (Chang, 2002; Schmeichal & Baumeister, 2010), the computer remains fundamentally incapable of demonstrating this ability. This limitation was an important insight Alan Turing described as *the halting problem* (Koch & Tomoni, 2011; Turing, 1939). While at first this may seem disheartening, that objectivity is an impossible ideal the moment that the data reaches human apprehension, it does open up a more practical, approach to *man-computer symbiosis* (Licklider, 1960; Waldrop, 2001; Weiner, 1950). J.C.R Licklider foresaw a prosthetic strategy whereby calculation and subjectivity could be integrated, neither the machine nor human components of which need be expected to accomplish both approaches.

3.1 CONSTRUCTIVISM

In the Piagetian model of cognitive development, the child who constructs (as in Constructivism) a strategy necessarily involving gross motor coordination say, to overturn a rock, in order to view the complex life thereby revealed. The child learns not only by passive observation, but more importantly for us here, by determining a course of action that will result in revelation.

For readers less familiar with the debate between Constructivism and Platonism (an introduction to

this debate occurs in Changeux & Connes, 1995), we must first provide a brief frame for this epistemological argument. The issue of what constitutes an objective reality or if it even exists is not actually our concern here, but the issue that there is such a debate, often invoking passionate tenacity, is. In some cases, particularly the 'hard sciences,' this debate is ignored stubbornly. It is immediately disposed of, as if any discussion regarding alternatives to that believer's root premises about belief itself is irrelevant, a waste of time, and serves no purpose in furthering scientific inquiry. While this is all somewhat true, this reaction also helps us to explain the precise limits of human cognition.

Initially, this line of reasoning begins from the (implicitly assumed) premise that we are entering such a debate, that our objection is philosophical. Thus, we might safely conclude any such mention is irrelevant before we even begin! However, we take an alternative approach and begin by asking specifically: why might we insist on believing that more precision is synonymous with greater accuracy? Furthermore, what we are asking is why we might assume (a) that these questions, though perhaps not worth considering, do have an answer, (b) that the answer is either yes or no, (c) that the answer is determined according to some inaccessible ultimate perspective, that is somehow not a matter of religious belief and (d) we are fairly certain that the answer is obvious, that precision is a quantifiable gradation leading to objective truth. Before slipping into the quagmire of philosophical supposition, an endless meandering endeavour, we wish to return to biology and cognition (which will eventually lead us to computer art).

By — even temporarily — adopting an approach where Constructivism (Piaget, 1971), more precisely radical Constructivism as discussed by Ernst von Glasersfeld (1995), we have a theoretical description of how ideas could be assembled by bootstrapping and inherently customized for profoundly personal use (Gardner, 1983).

3.2 QUALIA

Our experience of colour is fundamentally different than mechanical representations of images. One difference is that, while for machines colours are represented by absolute values, human perception is profoundly relative to context (Albers, 1964; Gregory, 1966). An ideological fallacy in this respect is assumed within research on technological means of modality inspired sensation (for instance Rumelhart & Zipster, 1985). Human perception makes it difficult to appreciate that colour does not exist in the world outside of our minds. We might intellectually

appreciate that flowers evolved to be colourful in order to attract bees, which have co-evolved to detect colour (Dennett, 1991; Herrero, 2005). But the fact that we cannot verify that these colours appear to bees as to ourselves, is hardly cause to question if the flowers truly get pollinated.

Mathematics has worked well for us, and will certainly continue to be a useful strategy. We only wish to point out that one-ness, two-ness, and so on, are not an a priori givens. As far as we can possibly determine, these are akin to other qualia and/or emotion (Hohenberger, 2011), applied for the sake of enabling human cognition (Baars & Gage, 2010; LeDoux, 2002; Tooby & Cosmides, 2008).

We tend to view art as a 'celebration' of qualia and/or emotion, not that aesthetes necessarily favour *attractive* artwork, perhaps celebrating our "advanced" cognitive abilities. One way to interpret this is that other organisms are less cognitively 'powerful' than humans. Another interpretation, however, requiring far fewer assumptions, is that this symbol system is custom-created to the specifications of the host organisms. Upon deducing that some immediate problem faced can be solved with communication, and further that qualia is a rather convenient medium at human's disposal, we reinforce a species-centric, arbitrary association.

Sarah Shettleworth (1998) makes a complimentary point about nonhuman animals, that whatever their behavioural and motor abilities, these cognitive abilities only tend to be idiosyncratic strategies the organism uses given its own embodied resources, rather than any reflection of the degree of that organism's comprehension of the environment. There is no ideal vantage point from which to observe the universe. It must be taken as a premise on faith, that a world beyond the mind exists — roughly in the way humans describe it. This leaves functionalists in a quandary. If we learn imperfect instances of these idealized notions, how can we learn if these cannot be real? Jerome Feldman suggests a process by which the brain might construct networks exclusively via gradually accumulating *metaphorical* understandings (2008).

According to Piaget's famous approach... it entails the accommodation of those schemata that aren't able to assimilate a current information, that is: adaptation is required if a schema faces a serious problem. Those schemata and structures that cannot adapt will become "extinct". In other words: adaptation is a theory of selection and evolution — also during ontogeny. (Greve, 2013)

By adopting a Constructivist perspective, we reject the need to maintain the untenable assumption of objectivity. Optimization, implemented as game theory (pioneered by von Neumann & Morgenstern, 1944; since integral to programming design as in Horzzyk & Tadeusiewicz, 2005), and designed modularity (Izhikevich, 2007; but see also Newcombe et al. 2009) become artefacts of human behaviour. However, in his overview of neural networking, Olaf Sporns states that “Nervous Systems do not converge onto a final stable pattern of optimal functionality, rather, their connectivity continues to be in flux throughout life.” (2011, p. 252)

3.3 NUMEROSITY

Particularly when considering the effects perception has on our interpretations of number (Dehaene & Changeux 1993; Hubbard, et al. 2009), we are forced to consider the question: What aspect of our experience can we objectively determine is not yet another quale? Of particular relevance to our discussion, estimation is not a less accurate version of precise counting, but that subtizing is a quale that is often performed in tandem to the cognitive activity counting, Kadosh and colleagues findings speculate that this provides an explanation regarding competing perceptive cues in the Stroop effect (2011). Ordinarily, this effect is seen in slowed response times when subjects must identify words, such as “red,” that are presented in, say, blue letters. The experiment suggests that a momentary hesitation is caused by a cognitive strategy for automatically resolving, though not always accurately, conflicts between two perceptive systems. Just as the automatic apprehension of colour can be over-ridden but not suppressed, so too an estimation quale is likely involuntary, but can be upstaged by another conscious intentional process. This appears consistent with:

Is brain-and-mind based mathematics all that mathematics is? Or is there, as Platonists have suggested, a disembodied mathematics transcending all bodies and minds and structuring the universe — this universe and every possible universe?... The question of the existence of a Platonic mathematics cannot be addressed *scientifically*. At best, it can only be a matter of faith, much like faith in God. That is, Platonic mathematics, like God, cannot in itself be perceived or comprehended via the human body, and mind... The only mathematics that human beings know or can know is, therefore, *mind-based mathematics*, limited and structured by human brains and minds. (Lakoff & Núñez 2000, pp. 1 – 4)

What is actually meant when we ask whether an organism understands number (Schifter 2005; Sfard, 2008; Vallortigara 2009). This single word “number” is used to refer to distinct cognitive skills. What we are questioning here is that there is no actual non-subjective evidence that these integers are not simply a subjective description like that of colour, which exists only in the imagination, triggered by hardly-understood anatomical mechanisms. Though we do not absolutely discount the possibility of counting numbers, we also do not see any hard evidence of them ‘out there’ beyond species-specific perception.

We mentioned previously the ability to re-perceive multiple quantities as groups, as in subtizing (Baars & Gage 2010; Lakoff & Núñez 2000). Though it would be difficult to verify experimentally, consistent evidence occurs indicating that humans can increase this limit with years of extensive training in specific domains. Adults at the supermarket surely do not count every other customers’ items precisely to determine which register line will move the fastest.

The qualitative shift in effortful attention (Dietrich & Stoll, 2010; Searle, 2001) between subtizing and counting also indicates that this reflex applies more broadly to amounts than merely numbers. For example, we can consider the gradual learning progression in Western music from a non-musician primarily oblivious to the chords heard, the novice musician painstakingly determining such chord spelling with mixed success, and the master musician with years of experience who, upon hearing the pitches, apprehends the harmonic structure, with near-perfect accuracy and no intentional effort. Other animals demonstrate varying abilities here (Pierce, 1999). For instance, pigeons show a remarkable ability to recognize quantities, though most mammals do not (Thompson & Contie, 1994). As adults, developed from infants, we do not replace our ability to estimate, but it appears that we sometimes enhance it.

In contrast, we also have an ability, that tends to require a bit of effortful attention, to use precise counting, which is generally only reliably testable in language-using subjects. Delving more deeply into why this should be so, involves thinking about the way brains construct conceptualisations from linguistic cues (Feldman 2008; Lakoff & Johnson 1980; Seyfarth 1984; Vygotsky 1986), which differs radically from language determining how we think about things, such as numbers. Learning does take place without language, for instance to ride a bicycle. But often learning can be aided by utilizing concepts we already

understand, in ways that happen to recognize by their verbal role, namely embodied metaphor.

4 | DIGITAL FORMALIZATION

It often seems, even to scientists and engineers, as if the computer performs mathematics. The ambiguity (which is entirely subjective) is made clearer at the somewhat esoteric, absolute lowest level of the physical mechanics of the machine. The computer only accomplishes something like rote memorization. In education, a child may respond with the coincidentally correct number, parroted from a dictation exercise, but that child may have absolutely no idea how this answer was derived. Not unlike ELIZA's original ability to pass Turing tests (Weizenbaum, 1966), this often fools traditional educators into believing the child has learned to solve the problem.

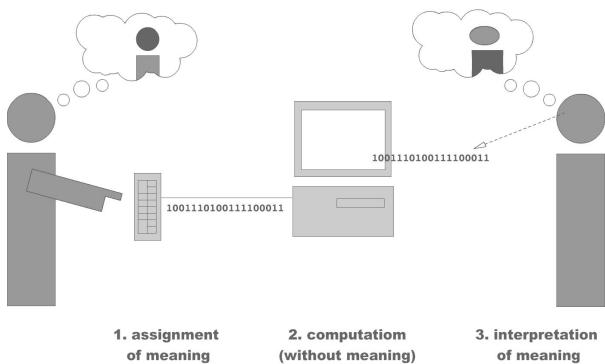


FIGURE 1 | This depicts our triadic relationship with computers. The computer has no sense of its own holism, its mechanical parts, or its own behaviour. As a middle, fairly optional, part of a three step process, the computer can only aspire to indirectly encourage the rudiments of meaning within cooperating human minds.

In this case, the computer processor executes a command, written in the form of binary code (this description closely summarizes Nisan & Schocken, 2005, and curiously remains only common knowledge to members of rather select fields).

The binary commands of fixed-bit-length are not numbers per se but notations of signals. Each delineated range of digits tells the processor how to manipulate on/off settings in specified memory slots (essentially a transistor). In the long list of commands, each one is of the form “memory address of some source value — operator — operand — destination memory address.” Furthermore, each coded command is strictly independent of other lines. In moving segments of binary settings from memory slot to memory slot, the processor looks

to the Arithmetic Logic Unit (ALU) to indicate which procedure to follow.

Moreover, the word “operations” is somewhat misleading, since these are only mathematical operations in the minds of the highest level programmers and engineers of the system, to the machine they are simply options of which mechanical steps to execute next. Similarly, if one got from say Kansas City to Tucson exclusively by following instructions “left,” “right,” or “straight,” given one instruction at a time, we would not say the driver “knows” the way to get from one city to the other. The ALU does not perform mathematics, but uses a “look up table” of instructions to parrot with near-perfect fidelity. Comparing each digit of the binary values from right to left, the ALU simply responds to the computer processor, where say 0101 translates to option number 5, with something like:

- If the digits are 0 and 0,
return value 0.
- If the digits are 1 and 0,
return value 1.
- If the digits are 0 and 1,
return the value 1.
- If the digits are 1 and 1,
return the value 0,
carry 1 to next digit comparison.

LISTING 1 | A rough approximation of the Arithmetic Logic Unit's look-up table, showing the processor performs arithmetical operations not by learning the concept, but simply executing instructions by rote.

Boolean logic coincidentally can be notated using a fixed binary configuration of digits. “Every Boolean function no matter how complex, can be expressed using three Boolean operators only: And, Or, and Not.” (Nisan & Schocken, 2005, p. 9) That a 0 tends to mean “false” and a 1 tends to mean true are entirely arbitrary, but by adopting this arbitrary scheme, we can further say a 0 tends to turn something off, while a 1 tends to turn something on. From there, most and syllogism can be associated with some mechanical execution.

The ALU iterates through these options, in lieu of actually ever understanding addition in even the simplest sense. Multiplication and other common arithmetic operations are passed off to the ALU in a like manner. The processor only derives all of the complicated functions of the computer by looking up this table, over and over. Though this description may strike the reader as criticism, actually this is a fundamental strength that results in the absolute consistency that makes computer processing so useful.

However, contrary to popular intuition, rather than complexity, the computer merely performs tediously long lists fast enough to be appear unpredictable, and unpredictably enough to appear complex. The result is not unlike a formation of dominoes, which merely obey a chain of physical laws. There is no optimal arrangement of dominoes possible that would yield a system capable of generating novel messages, thus the occurrence of expressiveness must lie outside of this system. Though the dominos might be arranged as a Rorschach test that triggers personal association in the audience member, further triggering observable behaviour.

5 | CONCLUSION

Our aim is to describe the subtle distinction between what we experience, as description of reality “out there,” and our very indirect systems for detecting specific aspects of our environments. Amazingly, from these imperfect clues, we manage to draw up a mental model we call reality. The fact that it corresponds to reality is simply philosophical, unprovable and irrelevant. However, by adulthood this model does function well enough *relative to a select current culture*. Specifically, culturally relevant questions must be synchronized with the fluid environment to be useful. As neither a culture nor environment is static, that model must be continually fine-tuned, but by what means? It is hardly novel to think of this learning process as art (Dewey, 1934), though the details of this process have remained vague, despite “advances” in psychology.

Nonetheless, as a tool, within a process yielding learning in an audience, the digital computer can be extremely useful. The resulting calculation is subject to context for interpretation by the audience. Though it is equally as unlikely that we could build a brain with bricks as with binary digits, it is no less handy to configure bricks in order to build useful things — such as a research gallery for computer art.

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