AISB/IACAP World Congress 2012

Birmingham, UK, 2-6 July 2012

TURING ARTS SYMPOSIUM

Cate Dowd and Klem James

Part of

Published by
The Society for the Study of
Artificial Intelligence and
Simulation of Behaviour

http://www.aisb.org.uk

ISBN 978-1-908187-13-0

Contents

Foreword from the Congress Chairs

For the Turing year 2012, AISB (The Society for the Study of Artificial Intelligence and Simulation of Behaviour) and IACAP (The International Association for Computing and Philosophy) merged their annual symposia/conferences to form the AISB/IACAP World Congress. The congress took place 2–6 July 2012 at the University of Birmingham, UK.

The Congress was inspired by a desire to honour Alan Turing, and by the broad and deep significance of Turing's work to AI, the philosophical ramifications of computing, and philosophy and computing more generally. The Congress was one of the events forming the Alan Turing Year.

The Congress consisted mainly of a number of collocated Symposia on specific research areas, together with six invited Plenary Talks. All papers other than the Plenaries were given within Symposia. This format is perfect for encouraging new dialogue and collaboration both within and between research areas.

This volume forms the proceedings of one of the component symposia. We are most grateful to the organizers of the Symposium for their hard work in creating it, attracting papers, doing the necessary reviewing, defining an exciting programme for the symposium, and compiling this volume. We also thank them for their flexibility and patience concerning the complex matter of fitting all the symposia and other events into the Congress week.

John Barnden (Computer Science, University of Birmingham)
Programme Co-Chair and AISB Vice-Chair
Anthony Beavers (University of Evansville, Indiana, USA)
Programme Co-Chair and IACAP President
Manfred Kerber (Computer Science, University of Birmingham)
Local Arrangements Chair

Turing Arts Symposium 2012

The Turing Arts symposium has grown connections between Turing's digital computing machines and the arts. The symposium opens up a discussion about mimicry, competition and random elements of machines introduced by Turing and the crossover with man/machine ideas in science fiction films, Surrealism, digital music, drama and art. Turing's thought that machines might learn and compete with humans at select tasks has provided creative triggers for artistic motifs, pushing mimicry much further than 'machines mimicking machines'. In science fiction films genetically engineered 'replicants' (distinctly digital creatures) compete in chess and for life itself. Likewise, contemporary music software competes with humans as it turns voice into song and aims to sound better than humans. Turing's ideas for learning machines also raised questions of how 'critical' a machine might become, alongside contemplation of random elements. The latter is also seen in Surrealism within fantasy man-machine concepts, alongside the interplay of meaningful and meaningless random events. Generative art produces similar outputs.

Turing's life was situated between automata of the machine age and the digital age, which he created himself via mathematical abstractions and a substitution system of symbols in 1936. Turing missed the space age of the late 1950s but his digital applications soon extended beyond the planet. Science fiction films from the 1960s then planted seeds for extending Turing's digital ideas of machine consciousness to outer space, including artificial dialogue and synthetic emotions in outer space, taking the potential of machine intelligence to new levels of mimicry of human behaviour. Science fiction films also picked up on Turing's 'screwdriver intervention' for motherboards prone to programming errors, but failed in some stories to create genetic fitness tests for machines with expiry dates. The ebb and flow between Turing's ideas and the arts, and back into scientific research are profound. The conversation across these zones has only just begun in this year of Turing's 100th birthday celebration.

On behalf of the organising committee of this first Turing Arts symposium, I would like to thank the reviewers, the authors and all the members of the programme committee for their contributions. I hope that the Turing Arts symposium inspires further dialogue and greater appreciation for Turing's digital technology across disciplines, as well as awareness of the extent of Turing's intellectual life, beyond code-breaking.

Cate Dowd
University of New England, Australia

Chair of the Turing Arts symposium

Cate Dowd (University of New England, NSW, Australia).

Turing Arts Symposium Committee

Klem James (University of New England, NSW, Australia).
Cate Dowd (University of New England, NSW, Australia).
Ioan Despi (University of New England, NSW, Australia).

Reviewers

Kathy Cleland (University of Sydney, Australia)
Deb Verhoeven (Deakin University, Australia)
Kevin Brophy (University of Melbourne, Australia)
Bill Blakie (Charles Sturt University, Australia)
James Boaden (University of York, UK)
Russell Goodwin (Monash University, Australia)
Declan Humphreys (University of New England, Australia)

SCIENCE FICTION & TURING

The judgement of emotion and intellectual ability in character dialogue of *Blade Runner* and *Star Trek: The Next Generation*

Grainne Kirwan[1] and Brendan Rooney[1]

Abstract. While the Turing test is regularly cited as a measure for determining the achievement of artificial intelligence, it has been suggested that the ability to demonstrate emotion, rather than advanced intellectual abilities, is more important in deceiving a judge regarding the humanity of an artificial agent. This paper examines two portrayals of artificially intelligent agents in the media – the replicants in *Blade Runner* and the androids (particularly Data) in *Star Trek: The Next Generation*. The replicants demonstrate emotions, while possessing a level of intelligence similar to humans. Data does not demonstrate emotion, but has intellectual abilities otherwise superior to humans. A sample of undergraduate students (N = 27) were provided with short excerpts of script dialogue between characters from both sources, with identifying information removed. Participants were asked to indicate the likely genus of the character, as well as deciding if the character was intelligent or not. In *Blade Runner*, the majority of participants could not indicate if they thought the characters were intelligent, but they mistook android characters for humans. On the other hand, Data was considered intelligent, but was not mistaken for human. Overall, participants were better at identifying the genus of human characters than that of androids.
Keywords- Turing test; Artificial Intelligence; Anthropomorphism; Simulated Emotional display: Natural Language Processing

1 INTRODUCTION

Artificially intelligent beings have been portrayed in many science fiction films and television series through the history of such forms of entertainment. Within such media, the artificial intelligence depicted has varied greatly on many dimensions: some are stationary, while others are dynamic; some are humanoid while others have animalistic physical features; some are benevolent while others are malevolent. There is also great variation in how such beings are perceived by others, and how they are treated by other characters. Finally, there is also considerable disparity in how the viewers of the media perceive the characters. Psychologists can contribute to the field of artificial intelligence by exploring the basis for judgments regarding intelligence. If intelligence and humanity lie in the eyes of the beholder, then it is important to explore the criteria that form the basis for the beholder's decisions. This paper identifies examples of representations of artificial intelligence from popular science fiction and attempts to isolate the ways in which they differ. For each difference we speculate, based on previous psychological theory and research, the ways in which these differences might impact upon the particular example's ability to pass a modern Turing test.

[1] School of Creative Technologies, Institute of Art, Design and Technology, Dun Laoghaire, Dublin, Ireland
Email: grainne.kirwan@iadt.ie, brendan.rooney@iadt.ie

1.1 Artificial Agents in *Blade Runner* and *Star Trek: The Next Generation*

The film *Blade Runner* [1] is set in a dark futuristic 2019 where robot technology has advanced to the point of creating bioengineered beings (replicants) who appear identical to humans. While these replicants have superior strength to humans, they are of equal intelligence and due to their short four-year life span, cannot experience emotions. The plot of the film revolves around the efforts of the main character, Rick Deckard, a 'Blade Runner' (a law enforcement official who tracks down and destroys rogue replicants), to identify a group of four exiled replicants that have illegally returned to Earth to try to extend their life beyond their pre-programmed four years. Given the similarity between the replicants and real humans, the difficult detection of artificial intelligence is a central theme in the film, resulting in the need to develop a type of Turing test which will allow humans to differentiate between replicants and other humans. Detection requires the blade runners to hone in on one major way in which replicants differ from the humans; their lack of emotion. Replicants can be detected using what their creator (Dr. Eldon Tyrell) refers to as an "empathy test". This test involves recording the subject's physiological responses (pupil dilation, blush response) using the "Voight-Kampff device" while they respond to a series of emotionally loaded questions. A traditional replicant will show no emotional response towards the questions and so they can be identified. Thus the creators of *Blade Runner* identify the role of emotion in distinguishing person from machine.

The distinction between humans and artificially intelligent beings has also been repeatedly addressed in the *Star Trek* franchise, most notably in *Star Trek: The Next Generation*'s [2] Lieutenant Commander Data. Data, like the replicants, is an artificially created being that cannot experience emotions and is of superior strength to his human colleagues. However, unlike the replicants, Data has superior intellectual/ computational abilities to his colleagues and, with shiny yellow skin and eyes, he is exceptionally unusual in appearance. Throughout the entire series of *Star Trek: The Next Generation*, a key defining feature of Data is his continuous quest to become more human. Yet Data was not overly concerned with the materials of which he was composed, but strived to be human by understanding humans. This meant that Data explored many different facets of humanity such as relationships, culture, communication, ethics and entertainment. Lacking in emotions, Data could only explore humanity on an intellectual level, continuously asking questions of his colleagues as a naive and ignorant outsider. These qualities, in addition to his appearance, easily distinguished Data from his human colleagues. However, it is Data's inability to experience emotion that seems to be the single biggest barrier to achieving his goal. Once again, emotion serves as an important distinction between artificial and natural intelligence.

While Data and the replicants share some identifiable differences from a "real" human, Data is very different from the replicants. In addition to their obvious differences in appearance, Data did not experience emotion, nor did he express it. Data was played by Brent Spiner, who was required to strip himself of any expressions, intonation, gestures or speech that expressed emotion. On few occasions Data would demonstrate displays of behavior that might be used by humans to express emotion, such as smiling. But these occasions often served primarily to remind us that Data did not experience emotion. He never really got it quite right. Everyone around Data felt great affection for him, but everyone knew he was an android - naïve and inquisitive, but an emotionless android nonetheless.

This is not the case for the replicants in *Blade Runner* [1]. The replicants by design were intended to fit in, to appear human and thus they were much more difficult to spot (therein lies the premise of the film). This was because they looked and acted much more like other humans than Data, including their display of emotions. While the replicants did not experience emotion, they were very talented at simulating emotional expression. This ability often served them well to remain in disguise but also to manipulate the unsuspecting humans. The replicants would commonly laugh or persuade humans using emotional expression, flirting, or other human-like behaviors. However, as soon as they achieve their goal their emotion fades immediately. *Blade Runner*'s replicants and *Star Trek*'s [2] Data are both examples of artificially created beings that do not feel emotion, yet the former can display emotional expression while the latter does not. By using examples of artificial intelligence that do not experience emotion but differ in their emotional expression we can consider the importance of these characteristics in the identification of AI, and specifically in how the Turing test may be useful (or flawed) in this regard.

1.2 The Turing Test

Alan Turing [3] proposed 'The Imitation Game' – a test to determine if a machine could pass as a human using an interrogative technique. In this paper Turing indicates that the test should be conducted through text, to avoid the confounding variables of seeing, hearing or touching the candidates (although it has been argued that other elements such as robotics and audio-visual input could be included [5]). Science-fiction film and television rarely allows such stripping away of confounding variables – in many cases the AI character is noticeably different from humans (even if they are in the form of an android), with the notable exception of the replicants in *Blade Runner* [1]. For example, Data is noticeably different from humans – his skin color and intonation of voice makes it clear that he is an artificial being. This study aims to investigate if, should such confounding information be removed, observers could differentiate between humans and artificial beings. It is also interesting to determine which characteristics of the beings are of most importance in successfully passing the imitation game – intellectual superiority or emotional reactions.

While the Turing test is probably the best known test of Artificial Intelligence, to the extent that a variation of it actually appears within the film *Blade Runner* [1], there are many criticisms of the Turing Test as a measure of artificial intelligence. These have been considered in detail elsewhere (see for example [5]). Churchland [6] argues that the Turing test is insufficient for really identifying conscious intelligence – while also arguing that our current understanding of what constitutes naturally occurring conscious intelligence is insufficient. He indicates that "the wrangling over his [Turing's] celebrated test has deflected attention away from those more substantial achievements, and away from the enduring obligation to construct a substantive theory of what conscious intelligence really is, as opposed to an epistemological account of how to tell when you are confronting an instance of it" (p. 107). On the other hand, Franchi and Guzeldere [7] describe how the Turing test attempts to show in which things (organisms or artifacts) thought does exist (p. 43). Both the replicants and Data are portrayed as being conscious entities, with independent thought, and so in theory both should pass a Turing test.

This consciousness of the replicants in *Blade Runner* [1] is also noted by Roese and Amir [8], who describe how psychology will face new challenges at the time when an android is indistinguishable from a human. They note that in *Blade Runner*, "the androids were fully conscious, highly intelligent individuals with distinct personalities. They not only spoke fluent conversational English, but also exhibited goal-directed behavior, visual-scene understanding, and recognition of others' intentions and beliefs, all motivated by their own personal agendas"[8].

Such characteristics are also considered by Edmonds [9], who emphasizes the importance of emotion, empathy, free will and self-modeling in passing the Turing test. He suggests that in order to pass the Turing test, the entity would need to be embedded into society. He argues that "intelligence is better characterized by tests of social interaction, especially in open-ended and extended situations". It can be argued that both the replicants and Data have been embedded into society, with differing implications. The replicants are terminated after four years in order to ensure that they do not develop emotion, whereas Data interacts within society for many years without developing emotional responses.

Carter [10] argues that "it is almost always emotional engagement that is used to blur the line between humans and artificial intelligence in science fiction… we are led to being emotionally disposed towards the artificially intelligence protagonist by virtue of coming to believe that it is capable of having emotions" (p. 205). Carter specifically uses *Blade Runner* (amongst other examples such as *Terminator II: Judgment Day* [11] and *I, Robot* [12]) as an example of this. Carter goes on to ask if an AI displays a range of emotional responses, but these are simply a display, rather than an actual emotional experience by the AI, would a human judge consider the AI to have a mind? One method of determining sentience is to provoke anger, and 'Turing-anger' – a Turing test built on an angry attack, would test the ability of the AI to grasp complex emotions [8]. A variation on this does occur in the film 'I Robot', where an interrogator evokes an angry response in a robot during an investigation.

The detection of intelligence thus seems to have several determinants, including the detection of emotionality in the target. This premise is worthy of deeper consideration, particularly in relation to the empathy which such emotional reactions can evoke in a viewer.

1.3 Empathy and the Detection of Emotional Reactions in Others

Psychological research has demonstrated that the presence or absence of emotion is an important way in which humans can gain information about each other and has important implications for our relationships [13, 14]. Psychologists have used the concept of empathy as the psychological mechanism by which we can detect the presence or absence of such emotions and make inferences about the target based on emotional information. While empathy has been defined in various ways [15, 16, 17, 18], Zillmann [19] provides a useful account of the construct. He reviewed and integrated various definitions of empathy and concluded that it is an emotional response to information about circumstances presumed to cause acute emotion in the target, to all perceived expressions of emotion in the target and to the behaviors that are presumed to be a result of emotion in the target.

Analogous to the task of experiencing empathy towards an artificial target, is the way in which viewers can experience empathic emotions towards characters from fictional entertainment (particularly film and television) despite the fact that they know these representations to be fabricated and artificial. Presumably the processes of emotional detection involved in engagement with such fiction would also be utilized in a test for AI. So how does empathy explain emotion towards fiction? To address this question, Zillmann [20] reviewed the major components of empathy and the empirical evidence that supports their operations and he concludes that the same empathic processes that are used to explain how someone can feel emotion towards a non-fictional situation can also be employed to explain how viewers can experience emotional arousal towards fictional film. That is, people are equipped with a set of innate, socially acquired and actively initiated empathic mechanisms to facilitate understanding and sharing of emotional experiences with the characters. Thus Zillmann argues that audience members respond emotionally towards fiction due to a combination of these empathic response dispositions.

According to Zillmann [20] when a viewer is presented with a fictional character (and presumably an artificially intelligent target too) the information they have about the character and associated emotions can be actively exploited or regulated using cognitive techniques such as perspective taking (i.e. putting yourself in their shoes). In addition, viewers also bring with them their acquired responses based on previous emotional experiences. Thus fiction appeals to our empathic response and generates emotional arousal that is associated with the characters. When the characters are subjected to emotional circumstances the viewers' normal empathic mechanisms are activated and the viewer experiences an emotional response. Drawing from this conclusion, Zillmann [20] argues that if empathy is the primary vehicle for engagement with film then a good film must present the viewer with the opportunity to experience empathic emotions. By extension, we might predict that, a good replicant/android will be one that will present information that is emotionally engaging. If Zillmann's argument can be extended to apply to artificial intelligence then we can consider its implications for our example androids, the replicants and Data, and their ability to pass an (emotional) Turing test. We might predict that Data is less likely to pass the test due to his inability to express emotions, whereas the replicants will be harder to distinguish from a real human due to their ability to express emotion.

1.4 Agent Movement and Interpretation of Intelligence

Until now, we have considered the importance of emotion and emotional expression in the target for identifying them as either human or AI. However, it is also possible to consider that the presence or absence of emotion in the target is not relevant in such a decision. Instead it is possible that the appearance of the target, or the way it moves might provide enough information upon which to base a decision. For example, research has shown that subjects can attribute animacy (sentience) to very simple emotionless stimuli, such as basic circles and squares [21, 22, 23]. Furthermore, the cues needed for perception and attribution of animacy to an object are very primitive, such as a simple change in movement direction [24]. Once animacy is attributed to an object, subjects readily classify such animacy cues into further more elaborate social information. Research has demonstrated that subjects readily attribute emotions to objects such as cars [25], cell phones [26] and automatic doors [27]. Thus people attribute sentience, social behaviors and emotions to simple objects that show very basic similarities to human behavior, even in the absence of explicit emotional displays.

While it might seem extreme to suggest that humans attribute life to any object, it is possible that a relationship exists between the degree to which an object appears to move like a human and the degree to which people attribute human characteristics. Nikolas Frijda who formulated a set of laws or "empirical regularities", which he argued, guide and predict human experience [28]. Among the laws proposed by Frijda, and of particular relevance to the current discussion, is "the law of apparent reality". It proposes that "Emotions are elicited by events appraised as real, and their intensity corresponds to the degree to which this is the case" (p. 352). Thus the more real a situation is perceived to be, the stronger the associated feelings. Extending this point to the appraisal of artificial intelligence, we might predict that people respond more emotionally when the target appears realistic, regardless of their display of emotion. This point is directly addressed by the uncanny valley hypothesis [29] which predicts that, for the most part, there is a positive relationship between the degree to which a robot appears human and how endearing it is. However, there comes a point on the spectrum where increasing the realness of the robot repels the viewer, until realness is increased so much that the viewer can no longer tell the difference. In light of these ideas, perhaps empathy is not a useful psychological construct to explain how we might feel or detect emotions when engaging with an artificial target. The idea of identification is perhaps a more useful construct in this case.

1.5 Identification and Perspective

Originally Freud [30] conceptualized identification as the unconscious process of adopting valued qualities and traits from another person (the target). Since then however, the construct of identification has been expanded and is perhaps one of the most widely used constructs in the exploration and explanation of how the audience interact with films. According to Zillmann [20], the specific nature of the identification processes were never explicitly proposed by Freud and for this reason the definition of identification and its underlying nature has been subject to various reinterpretations since the Freudian model. Central to these later extensions of Freudian Identification is the suspension of one's own identity so as to temporarily experience the world in the identity of another person or see the world from their point of view [31, 32, 33]. After identifying valued traits in the target, the subject's own self-awareness is suspended and they adopt the perspective of the target. By seeing the events from the target's perspective and having their own self-awareness suspended, viewers will naturally experience the relevant emotions for that situation, regardless of whether the target experiences emotions or not. Thus emotional arousal in the target is not a pre-requisite for identifying with character.

Based on previous accounts of identification, Cohen [34] extrapolates the predictable and common preceding factors to identification with a character in fiction. Presumably, these can be extended to other artificial targets. Among the factors Cohen lists is the perceived similarity of the character to the viewer. Viewers are more likely to identify (and more strongly) with characters that they perceive to be similar to themselves on a particular dimension of importance. This is not restricted to basic demographic variables, a viewer might identify with iconic representations, turn of phrase, single personality attributes and/or situations in which that characters find themselves. Extending these claims to the current discussion, one might predict that the presence or absence of emotional displays is not necessary for engagement with artificial intelligence. Instead, the perceived similarity of the target to the viewer is important.

1.6 The Present Study

Evolving from the arguments above, the present study attempts to determine the relative importance of emotional displays and intellectual superiority in determining intelligence in sample scripts from *Blade Runner* [1] and *Star Trek: The Next Generation* [2]. While *Blade Runner* includes a type of Turing test within the plot (the Voight-Kampff device), and several episodes of *Star Trek* examine the humanity and rights of Data as an android, the current study attempts a different approach to the problem of determining intelligence in the artificial agents depicted in these fictional settings. Excerpts from the scripts of the film and shows were selected, and using these, participants were asked to make judgments about the intelligence and genus of the characters. While the use of text scripts limits the number of possible elements or characteristics that participants might empathize or identify with, they will offer a necessarily controlled comparison between conditions and the contribution of character dialogue to assessments of humanity. It is hypothesized that where text alone is provided and other cues are removed, judges are more easily persuaded of the humanity of an artificially intelligent agent by the simulation of emotion than the simulation of advanced intellectual capability. As such, it is hypothesized that the replicants in *Blade Runner* will be more frequently mistaken for humans, whereas Data in *Star Trek: The Next Generation* is identified as intelligent, but is also more readily identified as an artificial being.

2 METHOD

This study utilized a within-subjects experimental design. Participants were provided with six short excerpts from scripts, each involving a dyadic interaction, and were asked to identify the nature of the characters (human, alien or artificial intelligence).

2.1 Participants

A convenience sample of undergraduate psychology students took part in the study (n = 27). Thirteen males (48.1%) and fourteen females (51.9%) between the ages of eighteen and thirty-six years participated (mean age = 20.6296; sd = 4.17085). No incentives were offered for participating in the study, and participation was entirely voluntary.

2.1 Materials

A printed questionnaire was developed to gather data. This questionnaire included six scripts, which had been extracted from the source media (*Blade Runner* [1] and *Star Trek: The Next Generation* [2]). These extracts were selected by identifying pieces of scripts which were at least five lines long, involved dyadic interactions, and did not include information regarding overall plot lines or character descriptions. In some instances minor identifying details (such as character names) were removed from the script, but no other changes were made. Three scripts were chosen from each source, and a mixture of human-human, android-human and android-android dyads were included.

Three scripts were included from the film *Blade Runner* [1]. The first of these involved an extract from the scene outside J.F. Sebastian's apartment where he (human) meets Pris (a replicant) and invites her in (android-human dyad). This script was six lines in length, three for each character.

The second was an extract from the scene when Rachel (a replicant) first visits Deckard (a human) in his apartment and offers her assistance, while also describing her confusion at another (unnamed) character's actions (android-human dyad). This script was six lines in length, three for each character.

The final scene used from *Blade Runner* [1] involved a brief discussion between Leon and Roy (both replicants) before they enter a laboratory, where Roy asks Leon if he retrieved some 'precious photographs' (android-android dyad). This script was five lines in length (of which three were Roy's). Of these three excerpts, only one participant recognized the third scene as being from *Blade Runner* (although they did not accurately identify the characters) – this participant's answers for this script were removed from the analysis.

The first script extract from *Star Trek: The Next Generation* [2] involved an android-android dyad from the episode "The Offspring" (Season 3, episode 16). In this episode Data creates another android, Lal, who he refers to as a daughter. The extract used in this study involves Lal seeking advice from Data about interactions with children in her class. This script was six lines in length, three for each character.

The second extract is from the episode "The Measure of a Man" (Season 2, episode 9) and involves a conversation between LaForge (a human) and Data. During this conversation LaForge indicates that he is unhappy that Data has to leave, and Data describes how he will miss LaForge (human-android dyad). This script was eight lines in length, four for each character.

The final extract from *Star Trek: The Next Generation* [2] is a human-human dyad between Beverley Crusher and William Riker (from "Frame of Mind", Season 6, episode 21). In this interaction Riker expresses worry about being ready to perform in a play, while Crusher attempts to build his confidence. This script was six lines in length, three for each character. Again, this was the only script from *Star Trek* which was recognized by a participant, and that participant's answers for this script were removed from the analysis.

2.1 Procedure

Participants were presented with a briefing sheet and a consent form. They were then presented with the scripts sequentially, and were informed that the scripts were excerpts from science fiction films and television series. The scripts were modified slightly to remove character names. All participants received the scripts in the same order, as outlined below:

- J.F. Sebastian- Pris
- Data – Lal
- Rachel – Deckard
- Data – LaForge
- Crusher- Riker
- Roy – Leon

For each of the six extracts, participants were asked to consider how well a number of descriptions applied to each of the two characters. In particular participants were asked to indicate whether they believed each character was a human, an alien, or "a robot, android or computer". No aliens were actually included in the scripts – this option was included as a control measure. Participants were also asked if they felt that the character was likely to be intelligent or not. As a distractor, participants were also asked to indicate if they felt that the character held a number of other traits, including friendliness, ambition, compassion, anxiety, depression and being

Table 1. Species of characters suggested by participants

			Statistics by Character					
Source	**Character Name**	**Actual Species**	**Designated Alien**	**Designated AI**	**Designated Human**	**Chi-Square**	**Df**	**Sig.**
Blade Runner	Sebastian	Human	0 (0%)	1 (3.7%)	26 (96.3%)	23.148	1	<.0005
	Pris	AI	8 (29.6%)	4 (14.8%)	14 (51.9%)	5.846	2	0.054
	Rachel	AI	3 (11.1%)	0 (0%)	24 (88.9%)	16.333	1	<.0005
	Deckard	Human	5 (18.5%)	2 (7.4%)	20 (74.1%)	20.667	2	<.0005
	Roy	AI	5 (18.5%)	3 (11.1%)	16 (59.3%)	12.250	2	0.002
	Leon	AI	5 (18.5%)	6 (22.2%)	12 (44.4%)	3.739	2	0.154
Star Trek: The Next Generation	Data	AI	11 (40.7%)	2 (7.4%)	14 (51.9%)	8.667	2	0.013
	Lal	AI	14 (51.9%)	10 (37.0%)	3 (11.1%)	6.889	2	0.32
	Data	AI	4 (14.8%)	12 (44.8%)	11 (40.7%)	4.222	2	0.121
	LaForge	Human	1 (3.7%)	3 (11.1%)	23 (85.2%)	32.889	2	<.0005
	Crusher	Human	0 (0%)	0 (0%)	26 (100%)	-	-	-
	Riker	Human	0 (0%)	1 (3.7%)	25 (92.6%)	22.154	1	<.0005

energetic. Finally the participants were asked if they recognized the source of the script, or either of the two characters. As outlined above, in two cases participants recognized individual scripts, and their answers were removed from the analysis. In a small number of other cases participants indicated that they recognized the scripts, but gave incorrect identifications. Participants were debriefed and told the correct answers.

3 RESULTS

The results of the study were analyzed for two principal factors – species designation and determination of intelligence.

3.1 Species Designation

Goodness of fit chi-square tests were completed to analyze the species that participants assigned to characters, and several significant results were noted. Table 1 describes how the characters were designated.

Sebastian and Deckard were both correctly identified as humans by the majority of participants at a highly significant level ($p < .0005$). However, all four androids in the *Blade Runner* scripts were also identified as human by the majority of participants. For Rachel and Roy, this was at highly significant levels ($p <.0005$ and $p = 0.002$ respectively). This finding also approached significance for Pris' character ($p = 0.054$) but it was not significant for Leon ($p = 0.154$). For the *Star Trek: The Next Generation* characters, all the participants correctly recognized Crusher as human, and the other two humans (LaForge and Riker) were both identified as human by the majority of participants (both at $p < .0005$). During the Data-Lal dyadic interaction, Data was significantly less likely to be identified as human ($p = 0.013$), although many participants identified him as an alien. No significant findings emerged for either Lal, or for Data in the Data-LaForge dyadic interaction.

In total, the scripts included seven androids and five humans. The mean number of correctly identified androids was 1.444 (sd = 1.36814), while the mean number of correctly identified humans was 4.4815 (sd = 0.80242). Participants correctly identified humans significantly more often than they correctly identified androids ($t = 8.629$, $df = 26$, $p < 0.0005$, two tailed). The effect size was large ($d = 2.798$).

3.2 Determination of Intelligence

Goodness of fit chi-square tests were completed to analyze if participants considered the character to be intelligent. Table 2 describes how the characters were designated.

For all the *Blade Runner* characters, the majority of participants indicated that they were uncertain from the script if the character was intelligent or not. This finding was significant for all the characters except Deckard. In both cases where Data appeared in the scripts, he was significantly likely to be designated as intelligent ($p < 0.0005$ in both instances). Similarly, Crusher (a human) was significantly likely to be designated intelligent ($p < 0.0005$). The majority of participants were unsure as to whether LaForge or Riker were intelligent ($p = 0.0003$ and $p = 0.004$ respectively), while no statistically significant result was found for Lal, although the majority of participants also indicated that they were unsure as to if she was intelligent or not.

4 DISCUSSION

The findings of this study support the hypothesis that judges are more easily persuaded of the humanity of an artificially intelligent agent by the simulation of emotion than the simulation of advanced intellectual capability. In *Blade Runner* [1], the majority of participants could not tell if the characters were intelligent, but they correctly identified humans while simultaneously mistaking replicants for humans.

As the replicants displayed emotional characteristics in the excerpts of the script this finding supports the hypothesis. At the same time,

Table 2. Determination of intelligence of characters by participants

			Statistics by Character					
Source	**Character Name**	**Actual Species**	**Yes**	**No**	**Can't Say**	**Chi-Square**	**Df**	**Sig.**
Blade Runner	Sebastian	Human	6 (22.2%)	2 (7.4%)	19 (70.4%)	17.556	2	<.0005
	Pris	AI	6 (22.2%)	2 (7.4%)	19 (70.4%)	17.556	2	<.0005
	Rachel	AI	9 (33.3%)	2 (7.4%)	16 (59.3%)	10.889	2	.004
	Deckard	Human	7 (25.6%)	6 (22.2%)	14 (51.9%)	4.222	2	.121
	Roy	AI	9 (33.3%)	1 (3.7%)	16 (59.3%)	13.000	2	.002
	Leon	AI	5 (18.5%)	6 (22.2%)	15 (55.6%)	7.000	2	.030
Star Trek: The Next Generation	Data	AI	22 (81.5%)	2 (7.4%)	3 (11.1%)	28.222	2	<.0005
	Lal	AI	9 (33.3%)	5 (18.5%)	13 (48.1%)	3.556	2	.169
	Data	AI	21 (77.8%)	2 (7.4%)	4 (14.8%)	24.222	2	<.0005
	LaForge	Human	7 (25.9%)	3 (11.1%)	17 (63.0%)	11.556	2	0.003
	Crusher	Human	21 (77.8%)	2 (7.4%)	4 (14.8%)	24.222	2	<.0005
	Riker	Human	9 (33.3%)	2 (7.4%)	16 (59.3%)	10.889	2	.004

while Data was considered to be intelligent by the participants, he was not identified as human. Due to the lack of emotionality displayed by Data, this also supports the hypothesis. Overall, participants were better at identifying humans than artificial agents.

There are a number of flaws in the current study. Firstly, and most significantly, a true 'Turing test' was not completed during this experiment. The participants were not given the opportunity to interrogate the characters in question, but were simply provided with sample excerpts. Ideally it would be interesting to create a database of responses from the scripts and to allow the participants to carry out a 'conversation' with the character, but this was impossible due to the limited bank of scripts available, especially in the case of *Blade Runner* [1]. Unlike a traditional Turing test, there was no direct interview of two hidden entities, so participants had no real opportunity to compare the responses of both in order to draw a conclusion. In an effort to hold conditions constant, the study was also required to restrict the materials to scripts from films rather than video clips. As previously stated, this was necessary so as to render the conditions comparable. However, this does limit extent to which the findings generalise to full film representations. Instead, the current results say more about the contribution of dialogue to the films scenes in which the characters were presented. Nevertheless, the results of the current study contribute to our understanding of the information upon which decisions of humanity are made, by the human. The current study identifies the importance of emotion in the characters' dialogue and thus the conclusions are still of interest and relevant to debates about the creation of believable human-like robots/AIs. Finally, the scripts used in this study were chosen based on interesting interactions between characters, lack of specific identifying information, and occurrence of sufficiently lengthy dyadic interactions. The relatively short script of *Blade Runner* [1] precludes the selection of many other excerpts, but the large bank of scripts from the films and television programmes of *Star Trek: The Next Generation* [2] would allow for much more thorough analysis.

While there are several methods by which this research could be extended, it would be of particular interest to examine how differently Data is perceived when his 'emotion chip' is installed (this chip is introduced in a number of the episodes in the television series, and it is finally permanently installed during the film 'Generations'). Comparison of participant judgments on Data's humanity and intelligence with and without this chip would provide for greater controls in determining which of these characteristics is more important in ascertaining success in the Turing test.

While dependent on the script writers interpretation of the characters, and the selection of suitable script excerpts for inclusion, this study found that it is the emotionality of the target, rather than their intellectual superiority, which best predicts whether they would pass a Turing test. Further studies are required, using a wider variety of sources, in order to determine the reliability of this finding.

5 REFERENCES

[1] M. Deeley, (Producer) & R. Scott. (1991). *Blade Runner: The Director's* Cut [DVD]. USA, Warner Brothers.

[2] G. Roddenberry, M. Hurley, R. Berman, M. Piller, J. Taylor (Producers) & J. Frakes, R. Scheerer & J. L. Conway (1987 - 1994). *Star Trek: The Next Generation* [Television Series]. USA, Paramount Television.

[3] A. M. Turing "Computing machinery and intelligence." Mind, vol. 50, pp. 433-460, 1950.

[4] H. Loebner "How to hold a Turing Test contest", in Parsing the Turing Test, R. Epstein, G. Roberts and G. Beber, Eds.Springer, 2009, pp. 173-179.
[5] J. Friedenberg, Artificial Psychology: The Quest for What it Means to be human. New York: Psychology Press, 2008.
[6] P.M. Churchland, "On the Nature of intelligence: Turing, Church, von Neumann and the Brain", in Parsing the Turing Test, R. Epstein, G. Roberts and G. Beber, Eds.Springer, 2009, pp. 107-117.
[7] S. Franchi and G. Guzeldere, "Machinations of the Mind: Cybernetics and Artificial Intelligence from Automata to Cyborgs" in Mechanical Bodies, Computational Minds: Artificial Intelligence from Automata to Cyborgs. S. Franchi and G. Guzeldere, Eds. Cambridge, MA: MIT Press, 2005, pp.15 -149.
[8] N.J. Roese and E. Amir "Human-Android Interaction in the near and distant future". Perspectives on Psychological Science, vol. 4, pp. 429-434, 2009.
[9] B. Edmonds, "The Social embedding of intelligence: Towards producing a machine that could pass the Turing Test", in Parsing the Turing Test, R. Epstein, G. Roberts and G. Beber, Eds.Springer, 2009, pp. 211-235.
[10] M. Carter, Minds and Computers: An Introduction to the Philosophy of Artificial Intelligence. Edinburgh: Edinburgh University Press, 2007.
[11] J. Cameron, S. Austin, B. J. Rack, G. A. Hurd, M. Kassar (Producers) & J. Cameron (1991). *Terminator II: Judgment Day* [DVD]. USA, Carolco Pictures.
[12] L. Mark, J. Davis, T. Dow, W. Godfrey (Producers) & A. Proyas (2004). *I, Robot* [DVD]. USA, 20th Century Fox.
[13] L. Harker and D. Keltner "Expressions of positive emotion in women's college yearbook pictures and their relationship to personality and life outcomes across adulthood." Journal of Personality and Social Psychology, vol. 80, pp. 112-124, 2001.
[14] M.J. Hertenstein, C.A. Hansel, A.M. Butts and S.N. Hile. "Smile intensity in photographs predicts divorce later in life". Motivation and Emotion, vol. 33, pp. 99-105, 2009.
[15] J. Decety and P.L. Jackson. "The functional architecture of human empathy". Behavioral and Cognitive Neuroscience Reviews, vol. 3, pp. 71-100, 2004.
[16] J. Decety and P.L. Jackson. "A Social-Neuroscience Perspective on Empathy". Current directions in Psychological Science, vol. 15, pp. 54-58, 2006.
[17] M.L. Hoffman, "The contribution of empathy to justice and moral jugdment" in Empathy and its development: Cambridge Studies in social and emotional development, N. Eisenberg and J. Strayer, Eds.New York: Cambridge University Press, 1987, pp. 47-80.
[18] C.D. Batson, J. Fultz and P. Schoenrade. "Distress and Empathy: Two Qualitatively Distinct Vicarious Emotions with Different Motivational Consequences". Journal of Personality, vol. 55, pp. 19-39, 1987.
[19] D. Zillmann "Empathy: Affect from bearing witness to the emotions of others" in Responding to the screen: Reception and reaction processes, J. Bryant and D. Zillmann, Eds. Hillsdale, NJ: Erlbaum, 1991, pp. 135-167).
[20] D. Zillmann. "Mechanisms of emotional involvement with drama". Poetics, vol. 23, pp. 33-51, 1994.
[21] F. Heider and M. Simmel, M. "An experimental study of apparent behavior." American Journal of Psychology, vol. 57, pp. 243-249, 1944.
[22] A. Michotte. "The emotions regarded as functional connection" in Michotte's experimental phenomenology of perception, G. Thinès, A. Costall and G. Butterworth, Eds., Hillsdale: Erlbaum, 1950 [1991].
[23] V.T. Visch, S. Tan and D. Molenaar, D. "The emotional and cognitive effect of immersion in film viewing". Cognition and Emotion, vol. 24, pp. 1439 – 1445, 2010.
[24] P.D. Tremoulet and J. Feldman, "Perception of animacy from the motion of a single object". Perception, vol. 29, pp. 943-951, 2000.
[25] M. Sheller. "Automotive emotions: Feeling the car." Theory, Culture & Society, vol. 21, pp. 221-242, 2004.
[26] P. Fagerberg, A. Ståhl and K. Hôôk. "eMoto: Emotionally engaging interaction." Personal and Ubiquitous Computing, vol. 8, pp. 377-381, 2004.
[27] W. Ju and L.Takayama. "Approachability: How people interpret automatic door movement as gesture". International Journal of Design, vol. 3(No. 2), 2009
[28] N.H. Frijda. "The laws of emotion." American Psychologist, vol. 43, pp. 349-358, 1988.
[29] M. Mori. "Bukimi no tani" [The uncanny valley]. Energy, vol. 7, pp. 33–35, 1970.
[30] S. Freud, Group Psychology and the Analysis of the Ego. London: Hogarth, 1948.
[31] B. Bettelheim, The uses of enchantment: the meaning and importance of fairy tales., 1st ed.. New York: Knopf, 1976.
[32] A. Friedberg, "A denial of difference: Theories of cinematic identification" in Psychoanalysis & Cinema, E. A. Kaplan, Ed., New York: Routledge, 1990, pp. 36-45.
[33] R. Wollheim, "Identification and imagination" in Freud: A collection of critical essays, R. Wollheim, Ed., New York: Anchor/Doubleday, 1974, pp. 172-195.
[34] J. Cohen. "Defining Identification: A Theoretical Look at the Identification of Audiences with Media Characters." Mass Communication and Society, vol. 4, pp. 245-264, 2001.

Turing's creativity and Science Fiction films: Abstractions and hidden layers

Cate Dowd[1]

Abstract. Alan Turing's logic for digital machines and the imitation of other machines, including possibilities with human parts, are reconfigured in numerous Science Fiction films. Machine and human intelligence, including embodiment, are partly shaped by the ebb and flow across Science Fiction and Computer science. Turing's digital concepts and the influence of numerous ideas from Science Fiction films can be better understood firstly via a closer look at the hidden layers and abstractions of digital computers which Turing conceived in 1936. By understanding Turing's binary digits and the convergence of numbers it is possible to see how Turing entertained the notion of digital mimicry of other machines and even humans. The mimicry of human traits since Turing's time is evident in many scientific innovations and abundant in Science Fiction films. Both Science and Science Fiction films perpetuate the idea of 'thinking machines' raised by Turing in a moment of realisation about his binary system for digital computing, that is its flexibility to mimic almost anything. In contemporary time there is as much focus on the integration of intelligence into machines that serve human purposes as there is on activities that aim to distinguish humans from computational machines. Cyborgs, on the other hand, can extend a third hand, arm or ear to improve embodiment, action or art, whilst robots use vision sensors and other sensory systems to mimic human features. Turing was the first to link mimicry of humans using digital machines with cameras and microphones towards the possibility of simulating human senses, an application idea which continued into robotics. These ideas were in addition to his instructions on how digital computers should be set up and run, which later became known as 'computer programming'. The combination of his work and ideas provided the base for Artificial Intelligence and Robotics. In the early 21st century the increasing power of microchips, sensor technologies and machine intelligence, echo Turing's notes on storage, speed and methods for programming digital machines. It was the sum of Turing's work that led him to produce the question 'Can Machines think?' and this paper suggests that Turing's question remains a worthwhile conjecture. The question revisited has new contexts at the intersections of digital technology and media, scientific innovation and Science Fiction films. Turing's foresight of mimicry via his digital computing concepts continues in many diverse applications into the 21st Century.

1 INTRODUCTION

This paper acknowledges the significant abstractions by Alan Turing in 1936 that informed the creation of general-purpose computers. Such computers are distinct from specific-purpose machines even though specific purpose machines combined with electronics motivated Turing towards implementation of his general-purpose, or universal computer abstractions.

A core idea of Turing's for digital machines was the notion that machines could imitate human beings in various ways. Science Fiction films do well at the appearance of machines imitating human beings, but in reality there is a much bigger gap. Sci-Fi films also show advances in science that are not yet popularised and sometimes presents suggestions for scientific research. Then notion of imitating humans via machines is evident in Science Fiction stories before and after Turing's time, from the drama of Rossums's Universal Robots [1] in 1920 to Science Fiction films of the late 20th century, such as *Terminator 2; Judgement Day* [2].

In real world applications, beyond film, machine parts are actually embedded in human beings to replace or simulate various bodily functions. These are Cyborgs as such but experimentation across these areas can inform Artificial Intelligence (AI) research. These intersections open up the dialogue about 'thinking machines' and broad features of technology, embodiment and transformation of the body. The imitation of human 'thinking' is a challenge for AI with different meanings according to ones leanings for either "classic AI or Connectionist AI [the latter] concerned to bring about machine intelligence regardless of whether it resembles human intelligence' [3]. This divide is also present in Science Fiction films and actually began with Turing's somewhat controversial question - 'Can machines think?' [4:433]

Turing explained this question via a game called the Imitation Game, which aimed to explore the possibilities of digital machines imitating and competing with humans, and to consider how machines might learn. There are various versions of the Imitation Game, also referred to as the Turing Test. The imitation of humans by machines is the background for exploring mimicry, embodiment, skin, brain metaphors, consciousness and emotions. It is a discussion with numerous crossovers between Science Fiction films, such as genetically engineered Replicants from the film *Blade Runner* [5] and Turing's ideas for intelligent machinery, including his idea of replicating a human being as a machine.

As part of a new discussion it is useful to bring to the foreground the broad features of Turing's digital computer such as sequences, inputs, storage and search concepts and consider the influences at these levels in Science Fiction films as well as contemporary computer science. These features are relatively hidden layers of Turing's digital machines, alongside more explicit suggestions for using cameras & microphones for imitating human senses as part of machine intelligence. These ideas are visible in fictional machines and central components of robots in the 21st century. The examples in this paper serve as an introduction to programmed behaviour of machines and bring to

[1] School of Arts, University of New England, NSW, Australia.
Email: cdowd2@une.edu.au

the foreground the influence of evolutionary biology, genetic fitness and natural coding on computing and intelligent machinery, all of which began with Turing. In Artificial Intelligence genetic algorithms are used for various purposes, such as the fitness of a synthetic player in a computer game whilst Science Fiction films extend the idea of genetic mutations to rogue machines, which are assumed to be digital machines, even though they are indeed fictional characters.

2 TURING'S ABSTRACTIONS: TOWARDS DIGITAL COMPUTERS

In 1936 Turing wrote a paper titled 'On Computable Numbers, with an Application to the Entschiedungsproblem' [6]. In this paper, not published until 1937, Turing identified that irregular numbers required solutions if they were to be processed via a machine. For this end he worked on mathematical functions to allow for computable numbers, which at that time of his writing, were confined to an abstract machine. Turing's conceptual ideas for 'computable convergence with numbers' [6] was the base for a machine that could process zeros and ones and finite symbols. The abstract machine was conceived as a system of inputs and outputs in which symbols would be scanned, erased and recorded via a tape. Turing described this abstract machine as 'a digital tape, the analogue of paper, divided into squares, each with a symbol, that can be identified, read and stored by the machine'[6]. These abstractions are the base of a Turing Machine, which was realised in the first 'automatic' computing machines[2] and early digital computers.

Without Turing's work on computable numbers and the identification of the need for finite symbols, numbers such as Pi (π) with infinite decimal places were problematic. A computing machine had to know when to stop and this required computable numbers. Turing devised the logic and maths solutions as abstractions for computing using a single machine, one that could do what it was instructed to do i.e. whatever it was programmed to do. Turing's grid of finite symbols made up of decimal numbers and characters which could be converted to binary digits and vice versa, were the base for machines that could be configured. It was the possibility of multiple configurations that made Turing's digital machine ideas stand out from other machines. Turing's system of binary digits led him to believe also that a universal machine could theoretically imitate any other machine.

Turing's notion of 'symbols in a scanned square, read by a machine' moving from one state to another is echoed in Science Fiction films via visual digital effects of rapid data scanning. For example, *The Terminator* [2] character in the various films of the same name include visual effects of rapid data scanning across a screen, as if from The Terminator's vision. The Terminator appears to process and generate data in a computational read-write process on screen whilst searching for, and matching, data, before executing what it is programmed to do.

Turing envisaged digital machines as universal machines, but it was not until after the war in 1950 that Turing actually articulated 'the three parts of a digital computer: (i) store, (ii) Executive unit (iii) Control' [4] and opened up a much wider discussion on Computing Machinery and Intelligence. Prior to 1950 he was subject to the codes of wartime secrets, yet as he began to articulate a limited base of ideas about the implementation of digital computers, he moved to new abstractions, for intelligent machines. In this discussion he acknowledged various arguments against the possibility of intelligent machinery and simultaneously debunked the myths posed by those arguments. A strong key point of his discussion was on the potential of mimicking discrete state machines, alongside further explanation of binary digits first introduced in his 1936 paper. The detail in Turing's 1936 paper had showed originality of ideas and creativity towards computations for the purpose of realising digital computing machines. Between writing these two papers, Turing had worked at Bletchley Park where he devised methods for searching for patterns in encrypted messages sent via the German Enigma machines.

Turing's digital abstractions were partly realised by others in specific purpose computers, but no one had created a universal machine until Turing. Likewise, few had approached ideas for intelligent machinery as Turing did in 1950. In 1948 Turing had realised a digital computer integrated with electronics, which was also a general-purpose computer i.e. a universal machine. He achieved this whilst working at the National Physics laboratory in the UK, where he built two machines known as the ACE (Automatic Computing Engine), one of which was a pilot. His abstractions and ideas were finally 'put into application… and embodied in electronics" [7] and his many ideas for intelligent machinery, discussed later in this paper have had a profound influence on the computers of today.

3 SEQUENCES, INPUTS, STORAGE, DATA PATTERNS AND SEARCH: THE HIDDEN LAYERS

In the early 1950s Turing worked with emerging computer systems at Manchester University. At this point Turing was setting the standards for early computers on a wide range of matters, from the division of storage for routines and functions to guidelines for electronic tube and magnetic storage, as well as rules for setting up machines i.e. programming them. By 1951 digital machines could send outputs for printing. It was still early days for digital machines, but the integration of electronics was another advance from specific purpose machines of the 1940s. Storage was still very limited by today's standards and Turing could not have imagined early 21st century research on 'dense atom level ferromagnetic storage for data bits' [8], but his work indeed gave rise to the very notion of 'data bits'.

In 1936 Turing articulated the need for a practical split of his abstract binary digits (see introduction) into 5 block sequences of zeros and ones, so that they would be easier to read. In the 21st century humans generally don't read binary data, but this point highlights how close Turing was to the creation of data, ultimately referred to as data bits. The sequences still represent characters, numbers, mathematical formulas and functions, and continue to be the 'hidden layers' between the inputs and outputs of digital machines. Turing's creativity with binary data towards application and his standards for configuring digital machines in universal ways is, as noted earlier, has set the benchmark for computers.

A Turing Machine is any realisation of Turing's abstract machine ideas. The early Turing machines used conventional symbols and characters derived from the typewriter as well as a

[2] The first 'automatic' computing machine in the UK was the ACE computer set up by Turing at the National Physics Laboratory in 1948.

number of Greek symbols used in the convergence process of symbols for sequences of meaningful zeros and ones. In contemporary time the reading, erasing and sorting of symbols, and generation of invisible code is done via a processor and microchips, which are the refinements of Turing's original concepts.

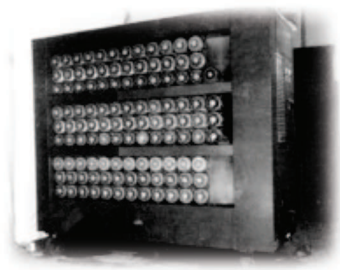
Prior to digital machines, and in Turing's life, office workers who carried out typing and calculations with non-digital machines were actually called 'computers'. Turing envisaged that such human tasks and calculations could be automated, and indeed the digital computer freed up the pool of workers who previously carried out various repetitive tasks.

In hindsight, Turing must have speculated on the design of computer inputs as he reflected on the function of typewriter. By the late 1930s there was no doubt that he saw the keyboard as an input layer for his digital machine, which was not yet realised. To celebrate Turing's observations and the invisible layers that would become part of his digital machines, this paper proposes another abstraction, an Invisible Universal Keyboard (IUK) (see Figure 1). The idea for this keyboard is based on an inverse neural network, which means the inputs are not actually visible, but that there is knowledge of the middle layer i.e. it is made up of binary sequences. Normally, the middle layer in a neural network is hidden and positioned between inputs and outputs. Turing's zeros and ones as a 'middle layer' reinforces the idea that digital machines can be configured with any kind of input and output.

Figure 1: The Invisible Universal Keyboard (IUK) designed by Dowd to highlight Turing's hidden layers of digital computers.

The IUK signifies the reconfigurations of digital computers, first conceived by Turing and transformed with contemporary interpretations from touch screens to electronic brain caps as inputs for digital systems. The blank inputs via the IUK are reminders of the reconfigurations also of digital machines portrayed in Science Fiction films. Here the keyboard quickly fills with symbols for the simulation of human emotions e.g. Replicants programmed with 'emotionally charged memories' [9] triggered via pattern recognition of an image stored in a machines memory, such as in *Blade Runner* [5]. Such configurations are a long way from Turing's work at Bletchley Park, but the principles of configuring digital machines, data storage and the use of search algorithms and pattern recognition are shared features across Turing's ideas and Science Fiction films.

At Bletchley Park in the late 1930s Turing worked with machines that were types of rugged search engines (see Figure 2). These were large machines with cables, jacks, boards and magnetic drums. The latter was part of the search and deciphering process of encoded messages sent by the Germans during World War 2. An important part of Turing's work was searching for patterns in encoded messages, which he and Welchman partly achieved by simulating the wheel settings and board configurations of the Enigma machines used by the Germans. The Bombe and Spider[3] machines together simulated and deciphered many messages from the enigma machines. In addition decoding was informed by identifying 'cribs' i.e. known words that were clues in a message. This helped to identify lexical patterns, but Turing also used mathematical approaches for code breaking.



Source: Bletchleypark.org.uk

Figure 2. A Bombe Machine with magnetic drum storage used at Bletchley Park in 1940 for search and deciphering the messages sent via the Enigma machine.

Turing's work at Bletchley Park ultimately helped turn his abstract ideas into realised digital computers. He knew the limits of stored information on magnetic drums and electronic storage, alongside the rules for setting instructions (programming). In addition he had developed practical skills with sorting, erasing and storing data. He knew the details of search mechanisms and pattern matches developed via code breaking. In contemporary time online searching and matching techniques are obvious extensions of these early concepts, evident in search engines e.g. Google, but the concepts as noted here preceded the Internet.

Turing's approach to search methods and intelligent machinery also included random elements and other ideas that later informed Connectionism, which is 'the science of computing with networks of artificial neurons' [10:402]. The latter can be applied to cognition patterns and for training agents in machine processing, via the associated mathematical patterns of neural networks that can be modelled. The study of neural networks looks at activation across the human brain, body and senses. These levels of research continue to inform Computer science and AI, as well as medical research. Likewise they inform other areas of technology and science, as well as science fiction films and literature.

4 MIMICRY AND EMBODIMENT: SKIN, BRAINS, CONSCIOUSNESS & EMOTIONS

By 1950, once Turing had realised the digital computer, he was aware that computers could mimic almost anything. In particular this would be true if greater storage capacity (memory) was available, and if the process of what was to be mimicked

3 Turing's notes on the Bombe and Spider are partly explained and edited by Copeland. See [10:313].

was also understood. This was a slight extension of Turing's thinking that digital machines could do many things, by programming it to do different things. His idea of programming other machines was profound because at that time separate machines did different jobs. He articulated his vision for digital computers in the following way:

> [The] special property of digital computers is …that they are universal machines…it is unnecessary to design various new machines to do various computing processes. The can all be done with one digital computer, suitably programmed for each case'. [4:441]

For Turing, greater storage was one of the key factors that would determine the possibility of digital machines going even further and competing with humans. In 1950 he discussed how much storage capacity would be needed for a computer to be successful in his proposed Imitation Game. He started with a calculation for the amount of storage required for an Encyclopedia [4]. For a machine to compete with a human Turing was also keen to understand the human brain and the way in which humans learn. He imagined the structure of the mind and brain in terms of layers and compared the speed of human nerve cells to operations of the machine required to compete in the Imitation Game.

The mind and the brain were not well understood in Turing's time, but he suggested brain mechanisms for understanding how a child might learn, comparing the process to a 'notebook from the stationers…with lots of blank sheets' [4:456]. This was Turing's second reference to paper for recording and storage, and for reading. His first was the digital tape concept as the 'analogue of paper' (see section 2). Paper resonates differently in the 21st century, but Turing's use of paper as an analogy was central to his emerging creativity for envisaging future digital machines, in particular machines that had memory and could mimic other machines.

The potential of mimicry via digital machines raises ideas about machines and embodiment, which is familiar in contemporary Science Fiction films and Robotics. Whilst there are still many gaps between the two, the gap is perhaps closing in some regards, compared to Turing's time. Embodied machines in Turing's life were in the realm of early Science Fiction literature, drama and film, or manifest as integrated hydraulics and springs of the mechanical man, lingering from the mechanical age. Turing's digital technology took the notion of mimicry to a new level, leaving behind the 'impact of automaton technology on 19th century machines [such as that] found in the works of Charles Babbage, the designer of the calculating machines' [11:228]. Turing ideas for future machines focussed on understanding the human brain. His notion of the child's brain being a 'tabula rasa' was just one part of a whole theory that he envisaged for how machines might learn. The metaphor of the blank sheets of the child's brain may be equivalent to storage space on a disk that fills up with the child's experiences like the formation of memory. Turing's discussion about learning machines opened up new intersections across genetics, machines and evolutionary biology. Science Fiction authors extended the mix to genetically engineered machines including generations of machines. These are evident in the literature of Asimov and Dick, in works such as *I, Robot* [12] and *Do Androids Dream of Electric Sheep?* [13], which then turned into the Science Fiction films, *I, Robot* [14] and *Blade Runner* [5].

4.1 Turing on Skin & the Imitation Game: Towards Science Fiction & Inkjet Printers

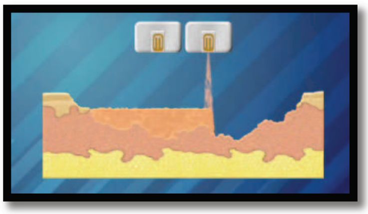
Although Turing considered that parts of a human being might be imitated, he noted 'there is little point in trying to make a 'thinking machine more human by dressing it up in such artificial flesh' [4:434]. However, that is exactly what Science fiction films do. They create the illusion of artificial flesh regenerated by machine characters, including Cyborgs[4], such as the Terminator character in the film *Terminator 2: Judgement Day* [2]. The mechanical body parts of the Terminator are created by digital compositing (See Figure 3). These are digital applications made possible by the extension of Turing's binary concepts into film editing software, which includes tools for overlaying multiple images.

Source: Terminatorfiles.com

Figure 3. The Terminator character (played by Arnold Schwarzenegger) is a Cyborg with digitally erased skin and composite machine features.

The digital machine as an agent embodied in human flesh was not that important to Turing, but he didn't discard the possibilities of generating artificial substances that would be indistinguishable from human skin. He stated that 'no engineer or chemist claims to be able to produce a material which is indistinguishable from human skin' [4:434]. With his characteristic visionary thinking he added that 'it is possible that at some time this might be done' [4:434]. Indeed, in the 21st century skin tissue is produced using stem cells for regenerative medicine. Stem cells are used to grow skin tissue, which is then printed onto damaged skin via the cartridges of an inkjet printer (see Figure 4). The regeneration of skin using the inkjet process also involves the use of a digital camera and laser, which scans and maps the three main layers of the skin through to the subcutaneous levels of skin, so that the correct stem cell tissue is printed onto the correct area of damaged skin [15].

[4] The word Cyborg was first coined by Clynes and Kline in 1960 and is a portmanteau across cybernetics and organisms. See http://sciencefictionlab.lcc.gatech.edu/SFL/doku.php/cyborgs.



Source: US Department of Defence

Figure 4. Skin tissue application via an inkjet printer cartridge.

The application of skin using an ink jet printer is not Science Fiction, but may have influenced this combination of digital technology for regenerative medicine. The example shows that Turing's machines continue to grow in surprising ways at the intersections of humans and machines. The inkjet printer application in some ways outsmarts machines of the future that might 'do well' [4:442] in the Imitation Game. The printer in this instance has done better than what humans could do with the application of skin tissues. This suggests some redundancy about the question 'Can machines think?' [4]. Turing's question was perhaps a conjecture, which to echo his own words, are 'of great importance since they suggest useful lines of research' [4:442]. Indeed Turing had started a dialogue about intelligence for future machines, which then spawned new understanding of language, semantics, emotions, artificial dialogue and various intersections between humans and machines.

Turing's ideas for intelligent machinery integrated with the human form, beyond Science Fiction films, raised points of distinction about growing organs from stem cells. His ideas for the Imitation Game were to test 'thinking' based on 'a particular kind of machine…[namely] a 'digital computer' [4:435]. The distinctions are clear in so far as he even restricted the possibility of future individuals derived from biological cell techniques from the Imitation Game, even though he considered that 'rearing a complete individual from a single cell of the skin (say) of a man' [4:436], might one day be possible. His primary point was to envisage future digital machines in the Imitation Game, along the lines of 'imaginable computers that would do well' [4] competing in the game.

4.2 Elements of Machine Consciousness

It appears that conjecture was also at play in Turing's idea for a conscious state of a machine. His ideas on the topic were quite grounded, in spite of the appearance that any idea of consciousness of a machine was absurd. At this level Turing considered the possibility of knowledge depths that might build up within a machine, matched with a machine's programmed capability to reason. His thinking was concerned with logic, rules and accumulated exchanges. It would be a mistake to think that he thought that the sum of these factors was equal to human consciousnesses. He was referring to consciousness in context of 'machines', and this brings his ideas closer to contemporary ideas of machine awareness using sensors and programmed logic to reason about a situation. In several Science Fiction films certain digital looking machines appear to have human desires, if not emotions, such as the NS-5 generation of rogue robots in the film *I, Robot* [14], who set about destroying older robots. Desires and emotions that are integral to normal human consciousness, once merged via fiction into digital machines, gives rise to new interpretations of consciousness. However, even if emotions and desires could be programmed into machines, they would still be artificial emotions and desires. This suggests that future machines, in the extreme situation of coming closer to mimicry of humans, would still have a different kind of consciousness to human consciousness.

A conscious state for a human also includes speech, but the integration of the human voice or speech via a machine alone does not make for consciousness. In Science Fiction films where there is artificial speech and dialogue it can also be as hollow as 'surface acting' [16], and as frustrating to watch as it is to wait on actual voice recognition and speech agents used in contemporary telephony. Even where artificial speech via machines is injected with emotional tone humans know that 'to say "something with feeling" can indeed mean not to feel anything at all' [16], as was observed about the computer HAL9000 in the Science Fiction film *2001: A Space Odyssey* [17]. In the film a certain tone is projected for artificial dialogue via HAL and one could be forgiven for thinking that Dave, a human astronaut in the film, had a similar tone to HAL. Both were somewhat deadpan, but not quite monotone. The dialogue between them introduced a number of tensions about reasoning and emotions, a set of complexities between machine and man certainly not considered by Turing in his discussion on consciousness and the usefulness of artificial dialogue.

Humans in the 21st century have adapted to artificial speech via machines and tend not to respond with great emotion, other than with occasional frustration. Artificial speech combined with artificial emotions can be linked to visual symbols for emotions via digital machines for creative and educational purposes, but clearly this is not the sum of consciousness. The problem of a conscious machine for AI is that it cannot be realised without emotions and 'a sense of selfhood…[as] emotions are intersubjective… emerging from the process of meaningful exchanges between conscious entities that take feelings to be located in understandings of selfhood' [16]. Even where machines are aware of an environment or a situation they don't have that sense of selfhood that is bound to feelings. The appearance of feelings via machines as stereotyped emotions are mapped and programmed actions, according to set conditions.

There is no doubt that Turing knew that a conscious machine was not plausible in the usual sense of the word 'conscious', but he sparked an age old debate as he pursued ideas for 'intelligent' machinery'. He was quick to confront his opponents and denounce extreme views such as the 'solipsist[5] point of view that makes communication of ideas difficult' [4:446]. He was determined to keep open the possibility of understanding how 'man thinks…and to include [artificial dialogue] mechanisms in devices…without denying the mystery of consciousness' [4:445-447]. He introduced examples of dialogue that could be used to test someone's actual knowledge of a topic. The text extracts contained known interpretations, beyond the literal text, which he used to demonstrate the issues of how conversation between humans and machines would need to be considered, as they evolved. This was the start for artificial dialogue and speech that has evolved into computer 'chatbots' and voice recognition systems. Turing also signalled early ideas about digital

[5] The solipsist point of view suggests that one can only know one's own mind, not that of another. This view had the potential to block research for finding universal patterns related to mind processes.

machines that executed semantic functions, which provides a link to contemporary Semantic Web contexts. In particular he mentioned 'suitable imperatives expressed within a system…[including] those that regulate the order in which the rules of a logical system concerned are to be applied'. [4:458]. It is via such imperatives and propositions that reasoning via logic begins in the Semantic Web. This is an approach that in recent years has also been taken up by large corporate search engines for search optimisation, such as the semantic search engines used by Google™ and the British Broadcasting Corporation.

Internet connectivity itself is like a distributed brain, and it may be tempting to think that consciousness is lurking amidst such collective intelligence. However, even alongside digital microchips embedded in flesh and a pale mimicry of human consciousness there is very little to suggest that we live in a post-human era. Human consciousness and life remains unique. Nonetheless, the digital age has produced strong Descartes' tones. Turing could barely have imagined his digital concepts reaching outer space let alone digital machine applications working in space.

The first Sputnik satellite was not launched until 1957, three years after Turing's death and human landing on the moon was another 12 years after the first satellites. Science Fiction authors like Arthur C Clarke [18] and Isaac Asimov [12] had ideas for machines in outer space and if still alive they might be surprised by today's lack of 'ability to send one's consciousness to the outer planets and beyond' [19] independent of an actual human body. It appears that human beings and their consciousness are bound to one another, even if undertaking 'Whisky experiments on a Space Station to test the effects of gravity on maturation' [20], for new research carried out in 2012. Turing's digital technology has truly extended to outer space, but his ideas for conscious machines have not yet been realised.

4.3 Sign of the Times: Turing & flowers in the Atomic Age

Turing's depth of enquiry into the physical sciences, and his awareness of nuclear bombs and mass destruction were at a peak in his lifetime. These were the signs of the time that no doubt influenced his thinking. Late in life his intellectual focus shifted from the mimicry of machines towards computational research on chemical changes associated with morphogenesis, and the mathematical patterns in nature such as the Fibonacci numbers in flowers. He carried out much of this work on the first large computer installed in Manchester in 1951, the Manchester Mark 1, where he 'set about using the machine to model biological growth' [10:508]. The early 1950s was also the era in which DNA was discovered and the revelations of life where perhaps more than equal to the parallel destruction of the Atomic Age.

Turing had achieved a new synergy with digital machines and biology models, which opened the way for evolutionary programming concepts for learning machines, produced by random and small shifts in input values across networks of machines. Copeland explains Turing's ideas for networks as 'unorganised machines' [10:403], which Turing first introduced in his 1948 paper *Intelligent Machinery* [21]. In the late 20th Century these ideas inform artificial neural networks for computation and the understanding of brain processes. For example, mapping parts of brain function as mere representations that have connections to certain regions is too simplistic. The connections are somewhat unorganised, which is consistent with connectionist models where 'information is in a constant state of transformation, and therefore it is artificial to separate representations from the processes that transform them' [22:83]. Turing's attention to unorganised systems and patterns in nature for modelling computations continues today.

Since the late 20th century digital machines in Science Fiction films appear to be programmed to recognise and respond to patterns, compete with humans and complete their goals. This core of ideas for digital machines is derived from Turing's work, which since then has grown via 50 years of AI research. Turing could not have imagined that machines of the future, even within Science Fiction films, would grow in so many different ways from his abstractions, applications and imagination. Furthermore, digital computing and AI research has achieved the construction of life-size robots such as the robot Asimo™ [23] built by the Japanese company Honda. Asimo™ recognises patterns, computes sensory data inputs and is programmed to learn. It is a digital machine that responds to humans using pattern and speech recognition and makes matches with stored data, before producing outputs at sensory levels. It records facial gestures via cameras for vision and simulates movements of human limbs. Asimo™ is a complex system built on the core of Turing's digital technology and integrates cameras for intelligent sensing, an idea first mentioned by Turing in 1950, explored in the following section.

5 CAMERAS & MICROPHONES FOR SENSES: MIMICRY IN MACHINES

The imitation of machines using Turing's binary concepts for digital machines had barely begun in Turing's lifetime, but by 1951 Turing seemed confidant that machines could imitate one another if programmed to do so. This is reflected in the following statement:

> The imitation of the machine by a computer requires not only that we should have made the computer, but that we should have programmed it appropriately. [24:483]

In Turing's time there were a limited number of digital computers. It was several years before multiple computers emerged and it was not until the end of the 20th century that computers became consumer commodities. By the start of the 21st century digital programmes and computing devices were pervasive and used for both industry and personal purposes. The film industry up until the 1980s carried out sound and picture editing on machines like the *Moviola* or *Steenbeck,* and by the 1990s editing was mostly done with digital software. Software was also introduced to simulate and manipulate sounds of musical instruments via digital music, which is a story of its own. Digital navigation systems in aeronautics including GPS systems[6] also do more than imitate maps and charts of earlier times. Satellites themselves also depend on digital technology.

Digital technology continues to grow in every field of life, which Turing predicted, even though he would have had no

[6] GPS is the acronym for Global Positioning System, which determines location of a digital device using a system of satellites orbiting the earth. The system allows for real-time communication between mobile devices.

grasp of how widespread his ideas and thinking would become. The realisation of so many machines imitated by digital technology is matched by advances for thinking machines, which Turing first thought might be possible by 'taking a man as a whole and replacing his parts with machinery' [Image 20, Ref 21]. The robot Asimo™, discussed in the previous section, is testament to a stunning start for this idea. Science Fiction films have also created impressions for complex digital machines, including rogue machine that drives dramatic plots and display a gamut of human emotions.

The various man-machine creatures in Science Fiction films also include representations of reconfigured human body parts, illustrated earlier, such as seen in *Terminator 2: Judgement Day* [2] [see section 3]. Typical body parts in Science Fiction films include artificial eyes and robotic arms that help machines to achieve particular goals, some of which conflict with human goals. These traits are in abundance in films such as *Blade Runner* [5], *2001: A space Odyssey* [17] and *I, Robot* [14]. The man-machines in Science Fiction films gather and processes information by artificial vision. Here we see the use of the camera for sensing, represented in what would otherwise be eye sockets of artificial creatures. Such creatures also appear to have sensors to avoid collisions, or smash through walls. A Science Fiction author decides what the fictional man-machine can do and creates the illusion that a creature appears to be programmed, which is realised via digital effects in the film production process.

Actual robots are sophisticated machines and yet quite limited compared to their fictional counterparts. They are programmed for a variety of purposes and achieve many goals dependent on cameras for vision and communication systems, in addition to physics systems for refined action and motion. Turing first saw the possibility of thinking robotic machines in 1950, which included amongst various ideas, observations about cameras and microphones. No one at that point had conceived of the lateral use of media technologies. At this level his continual reflections on the relationship between technology and humans is part explanation towards his ideas for thinking machines, evident in the following:

> A great positive reason for believing in the possibility of making thinking machinery is the fact that it is possible to make machinery imitate any small part of a man. That the microphone does this for the ear, and the television camera for the eye, are commonplaces. One can also produce remote controlled Robots whose limbs balance the body with the aid of servo-mechanisms. [Image 20:Ref 21]

In the 21st century machine vision in robotics extends Turing's ideas for the camera and microphone as prominent features of thinking machinery. In Turing's time such ideas were hardly even found in Science Fiction literature, film or drama. The popular culture of the day still looked to 'mechanical forms'. Turing's ideas for thinking machinery drew on logic, maths, psychology and media, as well as ideas and curiosities about the human brain. Through the combination of his invisible digital abstractions and informed observations, Turing started a new science, which later became known as computer science. His ideas also informed the start of AI research and robotics, which began only a few years after his death. His understanding of the human senses and ideas about what might be possible in the future were explicit and informative for what was to come. The use of cameras for eyes and microphones on a par with the human ear, for listening are still evident in vision and communication systems of intelligent machines, such as the Mars Space Rover (see Figure 5), which uses multiple cameras to guide navigation and for collision avoidance purposes.

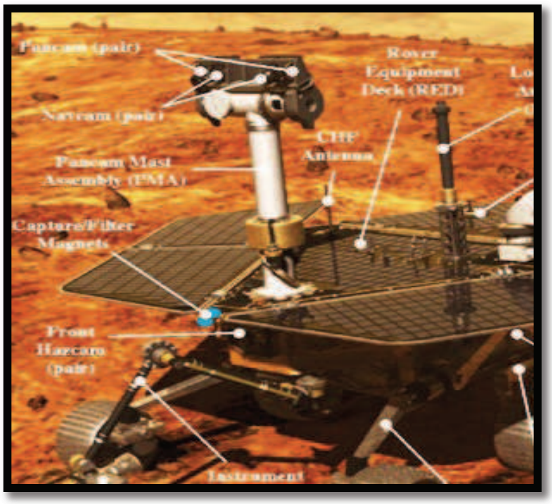


Image source: NASA

Figure 5. The Mars Space Rover uses multiple digital cameras for navigation, panning and detecting hazards.

Intelligent machines are designed to function in particular environments and complete set goals. They have awareness using sensors and cameras, but not consciousness. The processing parts of intelligent machines are often described as the brain. In Science Fiction films robots often display behaviours that are more human-like than a machine. In reality, simulating behaviours involves understanding the connections between the brain of machines and associated actions of multiple human systems, which are complex systems. Understanding brain function and activation of artificial human organs for medical purposes is ongoing research, which continues the mimicry or imitation of machines and humans. But what happens where machines are unstable by design? For example, the machine follows a rule that matches a certain situation, which turns out to be a misreading of the situation because of a lack of data? Turing posed a similar question in 1950 - 'Can a machine be made to be super-critical?' [4:454]. In other words, could humans rely on a machine that has accumulated knowledge, perhaps via networks of machines trained according to certain rules, which are then modified by small shifts in input values, causing them to behave differently over time? The Internet comes to mind alongside Science Fiction literature, film and drama to continue the tease of super-critical machines. The instability of digital code and biological processes is at work in both Science and Science Fiction films.

6. COMPETITION & PROGRAMMED BEHAVIOUR: MOTHERBOARDS AND SCREWDRIVERS

The Voight-Kampff test in the film *Blade Runner* [5] is designed to detect machine creatures that look like humans. The machines are called Replicants and are genetically engineered by the fictional Tyrell Corporation. They are rogue machines. The Voight-Kampff test is used in several scenes in the film, and in the opening scene it is used to check if an employee called Leon is a human or a Replicant. At the mention of the word 'mother' by the interrogator during the test triggers a violent outburst in which Leon suddenly shoots the interrogator. Leon is indeed a Replicant and his actions add dramatic effect to the film. Such actions also open up a discussion about what triggers emotions and the complexity of human systems and process towards *action(s)*, including the challenges of synthetic emotions. In spite of such complexity, research on emotions for machines is ongoing and this paper only highlights some gaps between emotions in Science Fiction films, and it points to the pursuit of emotion connectivity to machines via AI and Computer Science research. In recent years, research on emotions also extends to online technologies, via programming languages to represent emotions. This includes languages such as EARL, the Emotion Annotation Representation Language [25], which is a type of mark-up for emotion representations. We don't know what Turing would make of this research, but we do know that he favoured 'unemotional channels of communication' [4:457] in context of machine learning, to reduce complexity.

When Turing posed the question 'Can Machines think?' [4] he was not seeking a simple yes or no answer via a 'Gallup poll…[indeed not, he even stated]… this is absurd' [4:433]. Rather he was eager to see how humans and machines might compete in the Imitation Game, hence his articulation of 'imaginable computers that would do well' [4] in the game. Competition between man and machines was not new in Turing's time, but by 1950 he was pointing to 'abstract' activities for digital machines, and was not suggesting ideas made earlier in 1948 such as 'taking a man and replacing his parts with machinery' [see section 5].

> We may hope that machines will eventually compete with men in all purely intellectual fields. But which are the best ones start with? Even this is a difficult decision. Many people think that a very abstract activity like playing chess would be best'. [4:456]

Science and Science Fiction films picked up on many of Turing's ideas for building human-like machines, and ran with them. Likewise they took up the notion of competing machines. In 1968 the idea that a machine might be smart enough to calculate and anticipate the next move on a chess board, and win, was depicted in the film *2001:A Space Odyssey* [17]. The victorious computer was HAL 9000. In reality it was 1997 before the first computer beat a human at chess, that computer was known as *Deep Blue*.

By the late 20th century the game of chess was a 'motif' in Science Fiction films from *2001:A Space Odyssey* [17] to *Blade Runner* [5]. In *Blade Runner* the game was a symbol for competition between a machine and a human. The game appears late in the film where the Replicant Roy, played by Rutger Hauer, plays chess with his human creator, the executive genetic engineer of the fictional Tyrell Corporation. Roy is a competing machine to the end and appears to know that he is only programmed to last for a limited time. As Roy's life span looms he tries to hold on to machine life. In Turing terms, Roy may have accumulated memories similar to 'human experiences' but it remains a mystery as to how and why would he be programmed with a desire for life. Roy's expiry date drives the plot and he pursues an extension of his machine life, at any cost. His creator tells him that they can't make changes to his programming as this would lead to deadly permutations. Roy then terminates the executive responsible for genetically engineering him. Roy himself dies in a later scene, holding onto a symbolic dove. In 'genetic algorithm terms' [26] if Roy had artificial genetic inputs they were weighted to fail a 'fitness' test. He also was not 'a learning machine with any particular advantages' [4:456] if thinking in Turing's terms.

In *2001:A Space Odyssey* [17] the computer HAL might have passed a fictional fitness test, had there not been intervention by humans. The astronaut character Dave in the film had no choice but to switch HAL off with a screwdriver after the computer made an error of judgement about communication systems with earth. There is a direct link between this scene in the film and Turing's methods for 'modifying machines, which includes 'paper interference'… and 'screwdriver interference' where parts of the machine are removed' [10:419]. Science Fiction adds emotion at this point. As astronaut Dave dismantles each section of the motherboard HAL protests as if pre-programmed with emotions. HAL was scripted to respond with emotional lines such as "Dave, I'm afraid my mind is going. I can feel it" [17]. In the end, even as Science Fiction machines neither Dave nor Roy was programmed to be 'super-critical'.

Science Fiction drama in Turing's time included robots and rogue machines, but they were not digital in nature. The drama Rossum's Universal Robots [1] (RUR) written in 1920 was popular at that time in both Europe and the USA. In 1938 the BBC also broadcast a live adaptation of the play, which is regarded as the first Science Fiction television show [27]. Whether Turing ever saw the play RUR remains a mystery. He would have been 8 years old when Capek wrote the script for RUR. The play is famous for introducing the word *Robot* into the English language. It has an imaginative plot with manufactured machines that resemble human beings – they are the 'robots' that speak, reason and display emotions, and ultimately plot to get rid of humans. A few years later in 1927 in the film *Metropolis* [28] it is humans who plot a revolution because they have become too much like machines.

In the 21st century Science Fiction drama continues the paradigms of competition and revolution across machines and humans. In reality humans also compete amongst themselves via digital technology, as they are torn between freedom and enslavement. Some people might even rethink notions of machines competing with humans in purely intellectual fields. So, which ones would we stop? This is not a difficult decision. Some people think abstract and arbitrary social activities online would be best.

7 CONCLUSION

Turing's imagination and abstractions are not necessarily easy to see or grasp, but from them has emerged the digital systems that we use everyday. Turing created a base for computers that have been configured, reconfigured and programmed many times, truly satisfying over time a notion of a universal machine. The configurations and reconfigurations continue to satisfy a long list of human traits that draw on ideas of mimicry, towards creativity, healing or destruction.

From digital sequences, inputs, storage and cameras Turing looked to mimicry and simulation, ideas that were evident in Science Fiction stories before and during his life. His observations and articulations about the brain, learning, the body, skin, emotions, evolution, consciousness, media and maths are profound in the trajectory of computing. His ideas and work not only informed the design of digital computers, AI, and morphogenesis, but have influenced many themes in Science Fiction literature and films, including competitions and tests. His ideas have inspired many forms of mimicry, and even parody, all of which contribute to the distinctions to make sure that we know the difference between 'them' and 'us', the machine and the human.

It may be some time before we lose our capacity to make discernments between a human and a machine. Nonetheless IBM has already 'simulated parts of the brains of a cat, a mouse and a rat, towards supercomputer chips, [but] they have only simulated one percent of the human cerebral cortex' [29]. Perhaps in light of this it would be best to conduct Turing's Imitation Game in another hundred years when the brain of the machine will be far more developed. In the interim we can reflect further on mimicry and parody of emerging digital morphing forms. This might include software from the 2012 Designs of the Year Digital Award, via the Design Museum of London [30], which enables face substitution using digital video tools. This software extends the idea of digital compositing of images already used in Science Fiction films, with potential to mimic almost anyone. Such software would allow images of Turing to be layered over an actor's face to recreate a digital version of Turing himself, but we would be no closer to the hidden layers of Alan Turing's mind.

REFERENCES

[1] K, Capek, R.U.R., Rossum's Universal Robots, Prague: Aventinum, 1920.

[2] J. Cameron, (Director). (1991). Terminator 2: Judgement Day [DVD] Tristar Pictures, USA: Carolco Pictures

[3] Lister, M., Dovey, J., Giddings, S., Grant, I., & Kelly, K. (2009). *New Media: A critical introduction*. London: Routledge.

[4] Turing, A.M., 'Computing Machinery and Intelligence' in Mind, Oxford, p, 437. 1950.

[5] M. Deeley, (Producer) & R. Scott. (1991). *Blade Runner:The Directors* Cut [DVD]. USA, Warner Brothers.

[6] A.M. Turing, "On Computable Numbers, with and Application to The Entscheidungsproblem" in Proceedings of the London Mathematical Society, s2- 42 (1): 230-265. 1937.

[7] Hodges, A, Alan Turing — a Cambridge Scientific Mind, [online] http://www.turing.org.uk/publications/cambridge1.html, 2002

[8] BBC "IBM researchers make 12-atom magnetic memory bit" [online] http://www.bbc.co.uk/news/technology-16543497, 2012

[9] H. Heyck, *Embodiment, Emotion, and Moral Experiences: The Human and the Machine in Film*. In: Science Fiction and Computing, Essays on Interlinked Domains, D.L Ferro & E.G Swedin, Eds., McFarland & Company, North Carolina, 2011

[10] J. Copeland, *The Essential Turing*, Oxford University Press, Oxford, 2004.

[11] M. Kang, *Sublime Dreams of Living Machines, The Automaton in the European Imagination*, Harvard University Press, Cambridge,

[12] 2011.I, Asimov, *I, Robot*, New York, Bantam Books, 2008, c1950

[13] P.K. Dick, *Do Androids Dream of Electric Sheep* in Four Novels of the 1960s, Library of America, New York, 2007.

[14] A. Proyas, (Director). (2004). *I, Robot*, [DVD] 20th Century Fox Film Corporation, USA:

[15] US Department of Defence (2009), 'Printing New Skin: Saving Lives with Ink Jet Printers' Video Clip [online] April 3rd 2012

[16] Nofz, M.P. & Vendy, P., "When Computers Say it with Feeling: Communication and Synthetic Emotions in Kubrick's 2001:A Space Odyssey" in Journal of Communication Inquiry, Sage. (2002)

[17] 2001: A Space Odyssey, (Kubrick), Length: 142 minutes, America, MGM, April 1968.

[18] A.C. Clarke, *2001:A Space Odyssey*, Orbit books, 1st Ed. Hutchinson (1968)

[19] P.E. Ceruzzi, *Manned Space Flight and Artificial Intelligence*, in Science Fiction and Computing: Essays on Interlinked Domains, D.L Ferro & E.G Swedin, Eds., McFarland & Company, North Carolina, 2011

[20] BBC News, 'Space station used for Ardbeg distillery experiments' Accessed 10th April, 2012 http://www.bbc.co.uk/news/uk-scotland-glasgow-west-17657804, April 10, 2012.

[21] Turing, A., Intelligent Machinery [online] http://www.turingarchive.org/viewer/?id=127&title=20, 1948M.

[22] Iacoboni, J. Kaplan & S. Wilson, *A neural architecture for imitation and intentional relations*, in Imitation and Social Learning in Robots, Humans and Animals. Eds., C.L. Nehaniv & K. Dautenhahn, Cambridge University Press, Cambridge, 2007

[23] Honda, Asimo Technical Information, [online] Accessed 20th March 2012, http://asimo.honda.com/Abstract-Technical-Information/ 2007

[24] A.M. Turing, "Can Digital Computers Think?" In The Essential Turing ed. Copeland J. (1951)

[25] Schrőder,M., Devillers, L., karpouzis, K., Martin, J.C., Pelachaud, C., Peter, C., etal. What should a Generic Emotion Markup Language Be Able to Represent? (Vol.4738). Berlin:Spinger-Verlag. (2007)

[26] Rowland, Todd and Weisstein, Eric. Genetic Algorithm." From MathWorld - A Wolfram Web Resource. [online] Accessed April 8th, 2012. http://mathworld.wolfram.com/GeneticAlgorithm.html

[27] BBC, "Rossum's Universal Robots", on My Science Fiction Life: The Story of Science Fiction in Britain. [online] 28 Feb 2012 http://www.bbc.co.uk/dna/mysciencefictionlife/A19547274. 2007.

[28] Metropolis, (F. Lang), Length: 153 minutes, Universal Film AG (UFA), 1927

[29] Robertson, J., "IBM Pursues Chips that behave like Brains". 18 August 2011 [online] http://finance.yahoo.com/news/IBM-pursues-chips-that-behave-apf-1651580574.html?x=0&sec=topStories&pos=7&asset=&ccode

[30] Face Substitution, Castro A, & McDonald, K., Length: 1 minute 55 seconds. [online] Accessed May 2012 http://www.designsoftheyear.com/2012/01/31/face-substitution-new-york-usa-arturo-castro-and-kyle-mcdonald/ 2012.

SURREALISM & TURING

Turing's Thinking Machines: Resonances with Surrealism & the Avant-Garde of the Early 20th Century

Klemens E. James[1]

Abstract. This paper examines the thinking machines depicted in the visual and theoretical works of Surrealism and other avant-garde movements of the early 20th century. The aim is to establish to what extent the conceptions of these machines prefigure Turing's ideas about the mechanical brain. Whereas Surrealism and its artistic antecedents (such as the Dadaists) are generally thought to have been uninterested in or mistrustful of such technological developments, it will shown that a number of artists/theorists (Ernst, Duchamp, Picabia, Hausmann, Matta, Dalí, Caillois) envisaged the notion of the thinking machine in a manner which anticipated a number of Turing's ideas (the gendered machine, machine consciousness, the child-machine, pleasure-pain systems, randomness).

1 INTRODUCTION

In his 1950 article 'Computing Machinery and Intelligence' Alan Turing asked the question 'can machines think?' and predicted that 'at the end of the century the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted'[1]. His statements were visionary, the product of a mind very much ahead of it time, especially given today's reliance on computers to conduct intellectual operations that were previously the work of the human mind. This paper aims to show how Turing's vision of a thinking machine was the preoccupation of many of his contemporaries and his immediate antecedents, not in the scientific world but in the European avant-garde, particularly in Dada and Surrealism. In so doing I want to challenge two principal assumptions: that of the irreconcilability of the sciences and arts, but also that all voices within Surrealism and its immediate precursors were uninterested in or opposed to the evolution of technology, and the further modelling of machine upon man.[2] Whereas it is true that two of Surrealism's founding fathers, André Breton and Max Ernst, were somewhat dismissive of science, they, like all Surrealists, were profoundly influenced by the scientific writer Gaston Bachelard in *Nouvel Esprit Scientifique* [2] (1934) which situated Surrealism and modern physics 'in a non-classical, non-Cartesian, non-Newtonian, non-Kantian epistemology'[3] and showed how the imagination could yield new scientific paradigms, news forms of architecture and space, new forms of poetry and thinking; this, according to Bachelard, occurred at the threshold between the conscious and subconscious mind, and the inner reality of the self and materiality of the outer world. Inspired by Bachelard's theories, the Surrealists attempted to harness the knowledge gleaned from these liminal states not only for their creative projects but also to intuit and depict a vision of the future (and the role of machines and robots within it).

The Surrealists took on Bachelard's merging of the conscious and unconscious mind as part of a broader project to reconcile the antinomies of nature [4,5] (this not only fitted in with their belief in a Hegelian-inspired dialectics but formed the basis of their aesthetic). In their iconography and writings, experiments in reconciling oppositional concepts resulted in depictions of man merging with machine. The man-machine hybrid could be seen in the works of Max Ernst, Marcel Duchamp, Francis Picabia, Roberto Matta, Salvador Dalí and Roger Caillois – and although Ernst and Duchamp were deeply mistrustful of machine technology, the others viewed it in a rather more nuanced (and even more positive) light, even going so far as to postulate the future development of an intelligent machine.

Surrealist scholar Dawn Ades interprets Breton's underlying message in the *First Surrealist Manifesto* as '"we as poets have just as much right to do research and do experiments in this field as the scholars and scientists do". And so, he was setting up Surrealism [...] as a kind of arena for experiment'[6].

2 THINKING MACHINES IN THE EUROPEAN AVANT-GARDE OF THE EARLY 20TH CENTURY

2.1 Artistic consciousness in the Machine Age

This paper begins by surveying the general view of thinking machines within the cultural and artistic movements of early 20th century Europe – and how this helped pave the way for the Surrealists' conception of such an invention. Historically speaking the early 20th century coincided with the end of the Second Industrial revolution (also known as the Machine Age). This saw the rise of mass consumption and the production line, Herman Hollerith's tabulation machines [7] (first distributed by IBM in 1924), telephone and radio technology, industrial, printing and military equipment, as well as improved transportation (in the form of trains, automobiles and aircraft). Whether at work, in leisure or in warfare, this was an age which

[1] School of Arts, Universtiy of New England, NSW, Australia. Email: klem.james@une.edu.au

[2] In so doing, the paper develops the invaluable work already done in this field by Gavin Parkinson in *Surrealism, art, and modern science: relativity, quantum mechanics, epistemology* (2008) who has shown how Surrealists frequently drew on scientific theory to inform both theory and practice.

was to bring man and the machine inexorably closer together; an age which was also to forge the artistic and scientific conscience of the Western avant-garde and a generation of scientists to which Turing belonged (scientists who drew on the knowledge of this industrial age only to become pioneers of the information age).

According to Foster in *Prosthetic Gods,* the anticipation of a closer alliance of man and machine was common to avant-garde movements in many western countries, occurring: 'in Futurism in Italy, Vorticism in England, Purism in France, Precisionism in the United States, Neue Sachlichkeit in Germany, and Constructivism in Russia and elsewhere'[8]. Apart from Surrealism's prefiguration of a number of Turing's ideas, these movements did not generally demonstrate the viability of machine intelligence *per se*, but rather confirmed the fascination we have with human-like qualities of machine performance (as well as the machine-like, automatic qualities of humans). They also highlighted the encroachment of machines upon the domain of human industry, and the varying emotional reactions that thinking machines and mechanical men elicited. Individual members of the latter avant-garde movements reacted to these notions with a mixture of awe and jubilation, on the one hand, and extreme trepidation, on the other.

2.2 Futurism, Vorticism and the cult of the machine

One of the most confident predictions that machines would one day be able to think came from the Futurists whose spokesman Filippo Marinetti considered the oft-made assertion made by car owners and factory directors that vehicles appear to have 'a personality, a soul, will' to be indicative of a 'sensibility of the machine'[9]. In another Futurist manifesto of 1914, his colleagues Bruno Corra and Emilio Settimelli wrote 'there is no essential difference between a human brain and a machine. It is mechanically more complicated, that is all. For example, a type-writer is a primitive organism governed by a logic that is imposed in it by its construction'[9]. In addition to machines simulating organic life, humans were also encouraged by the Futurists to become more machine-like, denuding themselves of love, sentiment, filial attachments and irrationality. The Futurists also glorified the machine gun and war.

The Vorticists, who were based in Great Britain, denounced the Futurist's fetishisation of technology and their 'lyrical shouts about the God-Automobile'[10], which to them represented a cult that was no more credible than Voodooism. In a manner evoking the Futurists, however, they proclaimed that 'a machine is in a greater or less degree, a living thing'[10] while critiquing their depictions of machines in 'violent movement', which to them resulted in nothing more than a blur or a kaleidoscope; 'the very spirit of the machine is lost'[11] bewailed the movement's co-founder Wyndham Lewis.

In their assertions Filippo Marinetti and Wyndham Lewis were not unlike those of Turing, who also believed that machines had the potential to perform many of the cerebral operations of the human brain which were fundamental to intelligence. In his article 'Computing Machinery and Intelligence'[1], he also left open the possibility of machines developing conscience. He did this by arguing against his contemporary, the neurosurgeon Geoffrey Jefferson, who had insisted that computers would not become in any sense living until they were able to feel emotions or passions, succumb to flights of inspiration or become fallible like humans. Turing riposted that this would presume we could only truly know of someone else's feelings (machine or person), if we became *them*; and that such an argument amounted to nothing more than a defence of solipsism. This would mean that the only knowledge of which we could be certain would be derived from our own selves, our internal processes, our own thoughts and emotions. In making this a criticism, Turing tacitly entertained the possibility of a conscious machine, whilst conceding that there is some mystery about consciousness[1].

2.3 Machines out of control: World War One and *Metropolis*

Let us return to the attitude of the avant-garde towards the notion of the intelligent machine. Following the realities of World War One, and the devastating impact of military armaments upon human life, a number of cultural and artistic movements became ambivalent or critical about the prospect of further technological development and the creation of a thinking machine. Vorticists and Expressionists who previously extolled technology now became sceptical about it. Dadaists and Surrealists were publically dismissive of technology, though willing nonetheless to employ those new media, which had resulted from the Second Industrial revolution (such as film and photography as well as typing and printing machines). And, as we have already established, neither Dadaists nor Surrealists could escape the conceptualisation of man as machine (and vice-versa) in their works.

Significant reappraisals of technology's value occurred within the avant-garde of Germany, including those that helped to define Surrealism's view of a machine-driven future. In 1927, the film *Metropolis* [12], an Expressionist film vividly portrayed the bringing to life of a robotic woman who is cloned from the city's proletariat leader and visionary, Maria. Maria is so convincing in her femininity that she is first employed as a dancing performer for the men of the upper classes, fuelling their lust for her and aggression toward each other as they vie for her attention. She is subsequently sent by the city's evil capitalist leader to incite rebellion amongst the working classes, so that he has a pretext to crush their dissent and reinforce his power over the city. Somewhat ironically, she also urges the proletariat to destroy all the industrial machines, which they work on by day. Mankind's integration with the machine is presented as dystopic, though this is hardly surprising given the devastation wreaked upon the world by the killing machines of World War One.

The film can also be interpreted in the light of Turing's ideas, particularly his test for machines in order to establish whether they can be considered in any way intelligent. The so-called Turing Test requires the machine to fool a human interrogator into believing it is of one particular sex or another. The interrogator also questions another participant who is an actual human of the opposite sex to the one which the machine is assuming, though both the human and machine are concealed behind a screen so that the interrogator has no knowledge of who is who.

In *Metropolis*, a similar process takes place whereby the human heroine, Maria, is captured and thus taken out of the narrative only to be replaced by a robotic *Doppelgänger*. The responses the imposter elicits, both erotic and verbal, are sufficient to indicate that her audience (who have a similar function to the interrogator) have been totally duped into believing she is a woman. As Julia Dover states in her article on Turing and Metropolis 'the film plays disturbingly with the site of consciousness and authority in the relationship of human and machine (like the Turing test)'[13] – referring to robotic Maria's capacity to embody consciousness and to wield power, in a manner which makes her pass as human to all who encounter her.

3 CRITIQUE OF THE THINKING MACHINE: MAX ERNST AND MARCEL DUCHAMP

One erstwhile Expressionist who became a leading figure in both Dada and Surrealism was Max Ernst. In the immediate aftermath of the First World War, Ernst produced a series of 50 works based on machines and scientific instruments as a part of his early Dada phase. Dada was in rupture with those movements such as Futurism, which had sought to glorify the machine and foster its integration into human life. For this reason, a number of Ernst's diagrammatic works depicted machinery with human traits in a way that satirised or critiqued the notion of the living machine. As Foster affirms: 'this parodic presentation of the military-industrial subject is not only a riposte to fascist visions of war and masculinity. More generally, in keeping with German Dada at large ... , it is an insult to the humanist ideals of art and individuality cherished by the classes that forced the war in the first place'[8]. There was no doubt that Ernst perceived the realities of a fusion between intelligent man and machine, having been witness to the imperious role played by technology in the war and the increasing industrialisation of Europe. It was, however, the machine's capacity to dehumanise man (rather than its ability to become itself a thinking, sentient being) that Ernst found unsettling.

Two of Ernst's works reveal anthropomorphic machines, which are indicative of his attitude. The first, *The Hat Makes the Man*, reveals a human subject usurped on the one hand by phallic-shaped mechanical structures, all which are capped by the fetishised commodities of mass industrial production (in this case the hats, which also suggest a form of phallic embellishment). The second entitled *Fiat modes, pereat ars* represents the inversion of Latin saying *fiat ars, pereat vita* ('let there be art, life is fleeting'). The revised title translates as 'let there be fashion, art is fleeting', again, signifying the modern subject in the grip of commodity fetishism and conditioned principally by industrial and mechanical processes. The male tailor depicted in the drawing partakes in these processes by measuring up and working upon the model (both tailor and model appear as automata). Whereas Turing speaks about machines in terms of their future evolution as intelligent, reasoning entities, Ernst highlights the flipside of the equation – that as machines evolve, and become ever more intelligent, humans are stupefied, especially as their reliance on the latter grows.

As noted earlier, Ernst had allowed the mechanical structures of *The Hat Makes the Man* to appear phallic in nature; indeed many of his diagrammatic works had presented monolithic machines as precariously erected phallic edifices. Many of the gendered machines depicted in Surrealist and avant-garde artworks didn't resemble men or women in a physical sense (their gender being expressed by means of symbolism or metonymically). This brings us back to the Turing Test and the question of just how persuasive a machine must be as a man or woman in order to be considered intelligent. In fact, Turing believed that thinking machines could convince the interrogator of their gender irrespective of external appearances: 'No engineer or chemist claims to be able to produce a material which is indistinguishable from the human skin. It is possible that at some time this might be done, but even supposing this invention available we should feel there was little point in trying to make a 'thinking machine' more human by dressing it up in such artificial flesh'[1]. We thus have a further area of correspondence between the avant-garde and Turing whereby machines are portrayed as imitating human behaviour and intelligence in terms of their status as gendered beings without necessarily sharing all their physical attributes.

Marcel Duchamp and Francis Picabia, who were associated with both Dada and Surrealism also produced works depicting gendered machines. Duchamp's painting *Nude Descending a Staircase* depicts a female walking down a staircase in a manner that evokes stroboscopic motion photography (a photograph created by a succession of superimposed images). By his own admission he was influenced by the stop-motion photography of Étienne-Jules Marey, exemplified by the photo *Man Walking* [14,15]. *Nude Descending a Staircase* mediates a sense of kineticism, which seems redolent of Futurism, though Duchamp was by no means the technophile that Marinetti was (despite being knowledgeable about science). According to Linda Henderson the work 'stands as his first fully realized response to Cubism's pursuit of the invisible realities suggested by the discovery of X-rays in 1895. At the same time, Duchamp deliberately distinguished that work from the Cubist style by incorporating both a figure in motion (virtually never seen in Cubism) and the humorous implications of X-ray stripping (here both the clothing and flesh of the nude disappear)'[16]. Rather strikingly, the stripping down of the human subject to its skeletal form (whose kinetic energies are visibly highlighted) gives it a highly robotic appearance.

Duchamp's influences (x-rays, invisible realities, stroboscopic photography) are interesting in so far as they reflect the impact of the Machine Age upon human consciousness. His work expresses an ambiguity by which we are uncertain as to whether the female subject is a human depicted under its mechanical guise or a robot depicted under a human guise (an ambiguity which we will witness time and again in the works of the avant-gardists). While being dismissive of science and art's more grandiose claims, Duchamp aimed in his own words at achieving in his works a 'juxtaposition of mechanical elements and visceral forms'[17]. Up to the time he had produced the painting he had moreover been involved in another avant-garde movement known as the Section d'Or or the Puteaux group, an offshoot of Cubism, which sought to express geometrical perfection in its paintings and endorsed the achievements of science and technology

4 THE LEARNING MACHINES OF FRANCIS PICABIA AND RAOUL HAUSMANN

Strongly influenced by Duchamp, Francis Picabia produced many paintings in the years 1915-1922 whose imagery has been termed mechanomorphic, in other words, striving to imitate the forms of machines. This stylistic turn was first inspired by a visit to New York, upon which he remarked: 'I have been profoundly impressed by the vast mechanical development in America. The machine has become more than a mere adjunct of life. It is really a part of human life ... perhaps the very soul'[18]. Like Duchamp, Picabia emphasises the interconnectedness of man and machine, though unlike the latter (and very nihilistic spirit of Dada in general), he was willing to entertain the machine's more positive (functional and aesthetic) qualities. Moreover, to claim the machine constitutes the soul of human life does suggest a certain kinship with Turing's thinking. Picabia implies that the machine is not only man's central preoccupation, but that man's original preoccupations with himself and his own endeavours has been supplanted by the machine's capacities to perform so many of the tasks of everyday life (including, invariably, those which require intelligence).

A friend and associate of Picabia's, Paul Haviland, was a critical influence on the artist's life, especially in terms of how he theorised upon humanity's relationship to machines. Haviland and Picabia had collaborated on the same New York-based avant-garde journal 291, and Picabia had painted his friend in the form of an electrical lamp as if to pay testament to his ingenuity and interest in mechanical media such as photography. Commenting on the importance of the machine, Haviland had stated that:

> We are living in the age of the machine. Man made the machine in his own image. She has limbs which act; lungs which breathe; a heart which beats; a nervous system through which runs electricity. The phonograph is the image of his voice; the camera the image of his eye.[19]

There is a striking similarity between Haviland's words and another of Turing's texts in which he lays out a methodology for creating a thinking machine, involving the replacement of each part of the human body with machinery that performs the equivalent function:

> A great positive reason for believing in the possibility of making thinking machinery is the fact that it is possible to make machinery to imitate any small part of a man. That the microphone does this for the ear, and the television camera for the eye, are commonplaces. One can also produce remote controlled Robots whose limbs balance the body with the aid of servo-mechanisms. [...] The electrical circuits which are used in electronic computing machinery seem to have the essential properties of nerves.[20]

A further similarity between Haviland and Turing, as well as Haviland and Picabia is the engineering of a machine in the image of a human child, which is subsequently brought up and educated by its human creator, as noted by Haviland:

> The machine is his "daughter born without a mother". That is why he loves her. [...] But the machine is yet at a dependent stage [....] She submits to his will but he must direct her activities....[19]

Haviland's comments about the machine being man's 'daughter born without a mother' encapsulated one of Picabia's major preoccupations, as reflected in two of his works, which bore exactly this title *Daughter born without a mother*. The first, which is a drawing, represents an early attempt at developing his mechanomorphic style; the second, a painting, shows the style at a more developed stage of its evolution. Unlike in Duchamp's oeuvre, Picabia's subjects are not gendered in these and most of his other works. However, the notion of his machine as a child, which is still 'at a dependent stage' is certainly germane to Turing's thought.

Turing speculates that in order for a machine to become intelligent, it is preferable to train and educate it like a child. The process by which a machine is taught to think 'should bear a close relation of that of teaching.'[20] Starting from a tabula rasa the machine would thus learn behaviours and aptitudes that would lead to it becoming intelligent:

> Instead of trying to produce a programme to simulate the adult mind, why not rather try to produce one which simulates the child's? If this were then subjected to an appropriate course of education one would obtain the adult brain. Presumably the child-brain is something like a note-book as one buys it from the stationers. Rather little mechanism, and lots of blank sheets.[1]

Turing refers to the machines who follow such a program as 'child-machines', a term which evokes Picabia's idea of a 'daughter born without a mother' who is still in need of the guidance of her creator.

Turing's quasi-constructivist ideas about the development of the child-machine can be related to a Dadaist work: Raoul Hausmann's *The Mechanical Head,* which had the subtitle of *The Spirit of Our Age.* Hausmann, who was the leader of Berlin Dada, sought to challenge the notion that intelligence was innate and that the genius of artists and poets was an inexplicable god-given attribute.

Various objects have been attached to the surface of his assemblage, which resembles a robotic head, suggesting that humans (and, potentially machines, as there is an ambiguity here) are conditioned and educated principally by external influences. Significantly, many of the objects on the side of the head are employed for mechanical or scientific operations: measuring devices, ruler, pocket watch mechanism, typewriter and camera segments. Hausmann thus seeks to question both the nature of man's inner self in the Machine Age and the processes by which he evolves into a thinking, reasoning individual:

> What is the purpose of spirit in a world that proceeds mechanically? What is man? He can be both a happy and a sorry affair, and he is formed and spoken through his mode of production, his social environment. You see.... you believe you think and make decisions, you believe yourself to be original – and what happens? The social environment [...] has thrown the soul-machine into gear and the whole thing runs itself.[21]

The notion that intelligence evolves both as an upward expanding spiral from childhood and in relation to one's surroundings has resonances with important theories of education and cognitive psychology which were being developed at the time. The Swiss developmental psychologist Jean Piaget propounded the idea that children behaved almost like little scientists, making and testing hypotheses fairly independently in order to construct an understanding of the world [22]. In the process they would adapt their mental structures to meet the demands of the environment and progressively become intelligent, reasoning adults. Piaget's theories point to a remarkable confluence of ideas within art, science and developmental psychology, which take the tabula rasa of the child (and its subsequent epistemological evolution) as the basis for acquiring intelligence.

5 MATTA, DALÍ AND THE INSPIRATION OF SCIENCE

5.1 Matta, pain and consciousness

The painting of Roberto Matta, a Chilean Surrealist artist, extended the notion of the thinking machine by combining the concepts of psychoanalysis and science in his paintings. He affirmed that 'a new school of painters could evolve from contemporary physics, as an earlier school (Surrealism) had evolved from modern psychology'[23]. Having studied architecture, he attempted to depict the architecture of the soul in terms of non-Euclidean geometry in paintings known as 'inscapes'. The word inscape is a portmanteau term denoting the interiority of the self as expressed through landscapes of external morphology. Matta also depicted outer reality as a reflection of the latest scientific discoveries (such as relativity, sub-atomic quanta and the latest inventions of the Machine Age).

Many of his paintings showed the implications of these discoveries for the future, including the proliferation of biomechanical mutations. The future as he saw it could be both vital and menacing. In the painting *Octrui,* we witness a menacing scene: industrial robots working on a production line blur the boundaries between man and machine, displaying clear organic characteristics. As with the machine of the Turing test these robots are gendered, albeit that their sexual attributes similarly straddle the organic and the mechanical (their genitalia resembling mechanical spiders!). According to the Surrealists' spokesman, André Breton, these were robots 'carrying harrows on their backs and wearing crossbows round their necks..... but who nevertheless maintain a frenzied lingual and genital commerce'[24]. The harrows, crossbows and other sharp implements mediate an atmosphere that is violent, clinical and disturbing. In *Octrui* and *Wound Interrogation* (which typify Matta's iconography in the 1940s and 1950s), we even have the impression that robots are being controlled by pleasure-pain systems. Turing discusses such systems in relation to machine learning. If the machine is to be made to think in the manner of a child, then:

> The organisation of a machine into a universal machine would be most impressive if the arrangements of interference involve very few inputs. The training of the human child depends largely on a system of rewards and punishments, and this suggests that it ought to be possible to carry through the organising with only two interfering inputs, one for 'pleasure' o-r 'reward' (R) and the other for 'pain' or 'punishment' (P).[20]

In *Wound Interrogation*, we see a robot appearing to analyse a sizeable wound of the human flesh, which is nonetheless integrated into a network of robots surrounding it. The fact that the wound is being subjected to such scrutiny suggests that it is able to yield information and that the robot has something to gain from interrogating it. The process reminds one somewhat of Turing's comments on the value of pain in helping the machine to evolve:

> Pleasure interference has a tendency to fix the character i.e. towards preventing it changing, whereas pain stimuli tend to disrupt the character, causing features which had become fixed to change, or to become again subject to random variation.[20]

We are, however, confronted here with an ambiguity similar to that in the works of Duchamp and Hausmann, as we cannot be certain whether these figures are humans with mechanical properties, or machines with humanoid traits. If the former, then our future appears dystopian, with humans becoming slaves to industrial processes and barely distinguishable from the production line upon which they operate; if, on the other hand, they are thinking robots, then we can again see a prefiguration of the type of intelligent (and gendered) machine postulated by Turing, which is guided like a child and responds to stimuli of pleasure and pain.

5.2 Dalí, quantum mechanics and randomness

For the painter Salvador Dalí physics was 'the new geometry of thought'[25] and he too saw the artist as an interpreter of the scientific phenomena of his time. Like Matta, he had been inspired by Freudian psychoanalysis in order to depict the inner life and by scientific theory in order to represent external reality. He was influenced above all by Einstein's theory of relativity[26] and Heisenberg's Uncertainty Principle. Heisenberg had made foundational contributions to quantum mechanics, asserting that it was impossible to record simultaneously the position and momentum of a particle without the measuring equipment of one impacting upon the nature of the other. In other words, the observer had a direct impact on the phenomena he was measuring. Dalí used this idea to draw parallels between science and human conscience and create a new artistic style known as nuclear mysticism. He sought to show how the observer of the physical world could, from his own subjective viewpoint, also help to shape its reality (this idea extended his famed paranoiac critical method): 'From a quantum mechanics standpoint, Dalí's double [i.e. illusionistic] images perfectly reflect Heisenberg's Uncertainty Principle: what one sees depends on the observer. In the same way as he had done with Freud, Dalí assimilated a new scientific theory and reworked it visually'[6]. It must be stressed here that Dalí's eccentric mix of science and art takes us quite far from the quantum mechanics of the laboratory, becoming rather a science of subjectivity (which, as will shortly be demonstrated, is nonetheless germane to Turing's thought).

Dalí's interest in quantum mechanics was further reflected in his works by depicting his subjects as agglomerations of sub-atomic particles. As we will now see, these particles, which were shaped like rhinoceros horns (i.e. perfect logarithmic spirals), were shown to be common to material objects as well as human consciousness.

The painting *Raphaelesque Head Exploding* represents a head composed of a plethora of spiral-shaped particles. This image challenges our view of the integrity of matter and the appearance of coherent phenomena which are, in fact, totally fragmented. Whereas the painting represents a head in its externality, *The Disintegration of the Persistence of Memory*, portrays the interiority of the head, and specifically man's consciousness of the passing of time in its subjective, non-linear aspect. Significantly, this inner world is also shown as being composed of the same sub-atomic particles.

What interests us in Dalí's theories, especially in how they relate to Turing's, is this connection between thought and quantum mechanics. Turing believed that one component within a thinking machine had to be capable of random behaviour in order for it to imitate human thinking convincingly: Turing 'had a deep-seated conviction that the real brain has a ''roulette wheel'' somewhere in it' [20]. Although Turing affirms that a thinking machine should, to a substantial degree function according to predictable processes, being of a type that resembles a calculator (rather than a bulldozer), he concedes that this is not always possible:

> It was also necessary that this machine should be of the sort whose behaviour is in principle predictable by calculation. We certainly do not know how any such calculation should be done, and it was even argued by Sir Arthur Eddington that on account of the indeterminacy principle in quantum mechanics no such prediction is even theoretically possible. [27]

Interestingly it is on the basis of quantum mechanics that he casts doubt over the possibility of a machine operating entirely by deterministic principles. As scientists have discovered in quantum mechanical experiments, the behaviour of wave functions, when measured, appears to be quite random. Turing's reference to Sir Arthur Eddington and quantum theory to establish the limits of predictability in machine behaviour suggests that machines need to display signs of randomness if they are ever to simulate human intelligence. Randomness is a concept which Turing returns to time after time in his writings, and, in so doing, he underlines the wisdom of including a random element in a learning machine[20]. If, for example, a digital computer can perform the equivalent operation of throwing a die, it might produce numbers which can be kept in a store for future functions or can be helped to generate random approaches at solving a particular problem[20] (in other words, engage in trial-and-error style interrogations). Moreover, if a program allows for random behaviours it may even allow a computer to exhibit a certain amount of 'free will', though this is not a term, which Turing necessarily favoured [20].

Dalí effectively extends Turing's ideas by suggesting that the 'quantum' randomness of human thought not only determines behaviour but, much more radically, the nature of reality as perceived by the consciousness.

6 DALÍ, CAILLOIS AND THE PROPHECY OF THE MECHANICAL BRAIN

In addition to exploring the quantum nature of the human mind, Dalí shared Turing's conviction about the possibility of thinking machines. In an interview with Alain Bosquet he stated:

> People usually think of cybernetics as something abominable, they imagine that the world is being guided more and more by mechanical brains. They're afraid that the intervention of human genius is decreasing. But in point of fact, the opposite is true. Cybernetic machines are getting rid of the things that encumber us; until now, first-rate brains were stockpiling a mass of useless information. It's comforting to know that from now on the machines will be supplying the dimensions of the noses in all paintings and sculptures; all we'll have to do is press a button or develop a couple of microfilms. In other times, the same task would have taken experts and scientists decades to finish. The IBM machine will clean away all the drudgery and red tape of second-class human knowledge. Furthermore, the computers are already starting to act like human beings and with their own psychology.[25]

Although Dalí made these comments in 1969, they were still prophetic in nature given that machines were still a long way from their modern-day incarnations. Throughout the post-war period, Dalí maintained an interest in the very latest scientific developments commenting that 'literati can't give me anything. Scientists give me everything'[6]. He was therefore well positioned to gauge the scientific developments of the present and the near future. His comments also seem to mirror those of Turing in dispelling the scare-mongering about mechanical brains. Turing describes the argument that 'thinking machines are simply too awful to contemplate and can therefore never become a reality' as the 'head in the sand' objection, dismissing it as insufficiently 'substantial to require refutation'[1].

In the same decade, the sociologist and philosopher Roger Caillois, who had written widely on science in the Surrealist journal *Minotaure,* also posited the existence of a thinking computer. He considered its success in terms of its ability to compete in an 'absolute' chess game:

> It is not probable, but it is possible and perhaps theoretically necessary that there should be such a thing as an absolute chess game, i.e. one in which from the first move to the last no stratagem should work, since the best possible move is automatically neutralised. It is not too farfetched to suppose that an electronic computer having exhausted all conceivable combinations, could construct this ideal game. However, one would no longer be playing chess. The first move alone would determine the winner or perhaps the loser of the game. [28]

Significantly Caillois wrote this comment in a treatise on game-playing entitled Man, play, and games in which mimicry was foregrounded as one of four major characteristics of play[3] – a concept which was also seen by Turing to be fundamental for machines to succeed at the Turing test. Caillois seems to be even more positive than Turing about the prospect of a computer successfully playing chess. Indeed, his comments seem vindicated in as much as the reigning world chess champion, Gary Kasparov, was beaten by IBM's Deep Blue in May 1997. On the other hand, Turing believed a computer could evolve to play 'very good chess' despite making errors, and only after it had been programmed to display intelligence:

> Can the machine play chess?' It could fairly easily be made to play a rather bad game. It would be bad because chess requires intelligence. We stated at the beginning of this section that the machine should be treated as entirely without intelligence. There are indications however that it is possible to make the machine display intelligence at the risk of its making occasional serious mistakes. By following up this aspect the machine could probably be made to play very good chess. [29]

He was, however, very positive about the capacity of the machine to develop to such a degree as to make it extremely difficult for an interrogator to distinguish between human and machine in the Turing Test: 'I believe that in about fifty years' time it will be possible to programme computers ... to make them play the imitation game so well that an average interrogator will not have more than 70 per cent chance of making the right identification after five minutes of questioning'[1]. Both Turing and Caillois thus foresaw a vast improvement in the computer's ability to play games with human beings, even to the point of beating them.

7 CONCLUSION

Whether in its scientific and theoretical writings or in its visual works, the Surrealist imagination mediated a vision of man in symbiosis with the machine. This was not an attempt at proving irrefutably the viability of machine intelligence when regarded as equal or superior to human intelligence (such notions remain highly debatable given the limitations of machine intelligence). This was, rather, a vision that was inspired by the *Zeitgeist* of the Machine Age and creatively explored the ramifications of the scientific discoveries which defined it. Surrealism thus intuited facets of the thinking machine as described in Turing's writings. Its view of such a machine was more differentiated and critical than that of its avant-garde predecessors, who either idolised technology in the manner of Marinetti and the Futurists or dismissed it out of hand like the Dadaists. Ernst, Duchamp and Picabia's works were replete with mechanical organisms, which were depicted as gendered. These images hinted at the potential for machines to imitate human nature and sexual identity, bringing Surrealism and the ideas of the Turing Test closer to one another.

Whereas Ernst and Duchamp's mechanomorphic forms sought to critique the evolution of technology, Picabia's robots were conceived as children who were made in the eyes of their human creators and needed the latter's guidance for their future development; this notion was also advanced by Turing who believed that humans could help to train robots to become thinking, reasoning entities. For Matta and Dalí, the same energies and structures underpinned both human consciousness and technological processes. For Dalí the effect of the consciousness apprehending the world was analogous to the role of the observer of wave-particles in quantum mechanics, reflecting how randomness and subjectivity were an integral part of human thought. Turing similarly realised the importance of the capacity for randomness within intelligent machinery, especially in its simulation of human behaviour. Both Dalí and Caillois believed in the future evolution of thinking computers, which would replicate human thought processes in the context of game play. In their capacity to merge antinomies (such as human and machine) and establish conceptual connections between disparate disciplines, the Surrealists anticipated many significant aspects of Turing's thinking machine.

[3] These four characteristics were mimicry, agôn (competition), alea (chance) and ilinx (vertigo).

REFERENCES

[1] A. Turing, 'Computing machinery and intelligence' in *Mind*, Vol. 59, No. 236, pp. 433-460 (Oct., 1950).

[2] G. Bachelard, *Le nouvel esprit scientifique.* Paris. PUF. (2003)

[3] D. Ades, M. R Taylor, M. Aguer, *Dalí,* New York. Rizzoli (2004)

[4] A. Breton, 'Limits not Frontiers of Surrealism'. In: *What is Surrealism*, trans. by F. Rosemont, New York. Monad, distributed by Pathfinder Press (1978).

[5] A. Breton, 'Second Manifesto of Surrealism'. In: *Manifestoes of Surrealism*, trans. by R. Seaver and H. R. Lane, Ann Arbor. University of Michigan Press (1969).

[6] J. Úbeda, S. Marquès, E. Pons, *The Dalí Dimension, Script*, transcript of documentary 'The Dalí Dimension'. Media 3.14, Mediapro Group. http://www.dalidimension.com. (2004).

[7] H. L. Capron, *Essentials of Computing.* Redwood City, California. Benjamin/Cummings Pub. Co. (1992).

[8] H. Foster, *Prosthetic Gods,* Cambridge, Mass. MIT Press (2006)

[9] L. Rainey, C. Poggi, L. Wittman (eds.), *Futurism: An Anthology,* New Haven. Yale University Press (2009).

[10] W. Lewis, 'A Review of Contemporary Art'. In: *Blast* 2, No. 2, London, John Lane, The Bodley Head (July, 1915).

[11] W. Lewis, 'The Skeleton in the Cupboard Speaks'. In: *Wyndham Lewis, the artist: from "Blast" to Burlington House*, New York. Haskell House Publishers (1971).

[12] Metropolis, (F. Lang), Length: 153 minutes, Universal Film AG (UFA), 1927

[13] J. Dover, 'The Imitation Game: Paralysis and Response in Fritz Lang's Metropolis and Contemporary Critique's of Technology'. In: *Fritz Lang's Metropolis: Cinematic Visions of Technology and Fear*, eds. M. Minden and H. Bachmann, Rochester, N.Y. Camden House (2000).

[14] C. Tomkins, *Duchamp: A Biography*, New York. Henry Holt and Company, Inc. (1996).

[15] P. Cabanne, *Entretiens avec Marcel Duchamp*, Paris. Belfond (1967).

[16] L. D. Henderson, 'Marcel Duchamp's The King and Queen Surrounded by Swift Nudes (1912) and the Invisible World of Electrons'. In: *Weber Studies*, An Interdisciplinary Humanities Journal.14.83-101. (1997).

[17] A. D'Harmoncourt, K. McShine (eds.), *Marcel Duchamp*, Greenwich (Connect.). New York Graphic Society (1973)

[18] F. Picabia. 'French Artists Spur On American Art'. In *New York Tribune*, pt. iv (October 24, 1915)

[19] P. B. Haviland, statement. In: *291*, Nos. 7-8. (Sept-Oct 1915)

[20] A.M. Turing, *The Essential Turing: seminal writings in computing, logic, philosophy, artificial intelligence, and artificial life, plus the secrets of Enigma*, Ed. B. J. Copeland, Oxford. Oxford UniversityPress. (2004)
[21] R. Hausmann, 'Dada in Europa'. In *Der Dada* 3, Berlin. Der Malik Verlag (1920)
[22] A. Tryphon, J. J. Vonèche, *Piaget-Vygotsky : the social genesis of thought.* Hove, East Sussex, UK. Psychology Press. (1996).
[23] J. T. Soby, *Contemporary Painters*, New York. Museum of Modern Art (1948).
[24] A. Breton, *Surrealism and Painting*, trans. by Simon Watson Taylor, New York. Harper & Row (1972).
[25] A. Bosquet, S. Dalí, *Conversations with Dali* http://www.ubu.com/historical/dali/dali_conversations.pdf. Ubu Classics (2003).
[26] S. Dalí, 'Mystical Manifesto'. In *The Collected Writings of Salvador Dalí*, ed. H. Finkelstein, Cambridge. Cambridge University Press. pp. 363-366 (1998).
[27] A.M. Turing, 'Can Digital Computers think?' (1951). In *The Essential Turing.* Ed. B. J. Copeland, Oxford. Oxford University Press. (2004)
[28] R. Caillois, *Man, Play, and Games*, New York. Free Press of Glencoe (1961).
[29] A. Turing, 'Proposed Electronic Calculator'. In *Alan Turing's Automatic Computing Engine*, Ed. B. J. Copeland. Oxford. Oxford University Press (2004).

Turing and the early twentieth-century avant-garde: A Surrealist perspective

Jeremy Stubbs[1]

Abstract. This paper aims to bring to light certain correspondences between particular features of Turing's 1950 test and the historical and cultural context provided by the intellectual and artistic avant-garde movements of the early twentieth century. Turing's endeavour to overcome the general public's unwillingness to accept artificial minds is partly anticipated by movements like Italian Futurism and above all French Surrealism, preoccupied with the unconscious mind, artistic creation and the role of chance.

1 INTRODUCTION

When in 1950 Alan Turing published his proposal for what has become known as the "Turing test", his explicitly formulated intention was to influence the way the public perceived machines and to induce them to accept the latter as potentially thinking entities. He expressed the belief that in about fifty years' time computers would be able to play the game so well that an interrogator with no specialised training would only have a 70% chance of picking out the machine after five minutes of questioning. As a consequence, "general educated opinion would have altered so much that one will be able to speak of machines thinking without expecting to be contradicted". This emphasis on altering public perceptions is confirmed by his friend Robin Gandy, who reports that Turing considered his paper for *Mind* to be "propaganda" [1:433]. If he felt the need for such propaganda, it must have been because public opinion appeared deeply prejudiced against the notion of artificial thinking, that is to say thinking carried out, not by a human being, but by something created by human beings. In "Intelligent Machinery, A Heretical Theory", probably of 1951, he sounded a warning note about considering the consequences of building thinking machines, "To do so would of course meet with great opposition, unless we have advanced greatly in religious toleration from the days of Galileo" [1:475]. Already his 1948 paper, "Intelligent Machinery", which would only be published posthumously, began a list of objections with the following:

a) "An unwillingness to admit the possibility that mankind can have any rivals in intellectual power. […] The same situation arises in connection with the possibility of our being superseded by some other animal species. This is almost as disagreeable and its theoretical possibility is indisputable."
b) "A religious belief that any attempt to construct such machines is a sort of Promethean irreverence."

Email: J.Stubbs@ulip.lon.ac.uk

He described these two objections as "purely emotional" and not needing to be refuted [1:410-411]. However, he took them seriously enough to deal with them in "Computing Machinery and Intelligence" where they reappear as "The Theological" and "The Heads in the Sand" objections. If more technical objections to a thinking machine, such as that relating to Gödel's, Church's and his own work in mathematics, could be refuted in an *intellectual* manner, then the Turing test itself was more qualified to address the *emotional* facets of the way the public received new ideas.

The Turing test may therefore be situated in a wider context as an attempt to narrow the gap in people's minds between the human and the non-human. The test's ludic nature and use of trickery are specifically designed to get people to allow that machines may display intelligent behaviour precisely of the human sort. The years *circa* 1950 were those in which Turing devoted intense activity to his project of building a thinking machine. However, despite the fact that others such as Grey Walter and Ross Ashby would launch their own endeavours to construct artificial brains [2], this was nevertheless a time when the general sensibility of society was extremely reticent, if not hostile, when faced with the possible erosion of the barriers between the human, on the one hand, and the mechanical and the animal, on the other. This human/non-human divide, along with its attendant fears and nightmarish fantasies, has a long history. The period in which Turing grew up and matured intellectually, that between the two world wars, may perhaps be seen as a high point of Western anxiety about humanity's loss of its pre-eminence in the world, whether through unbridled technological development or animal degeneration. Yet paradoxically, this was also a time when certain avant-garde movements in the artistic and intellectual realms, particularly Futurism and Surrealism, were already working to break down the dichotomy between human and non-human. That dichotomy is expressed most often with reference to a series of elements which people have felt to be most characteristic of human nature at its noblest, to wit emotional sensibility, consciousness and aesthetic creativity. These factors arise in "Computing Machinery and Intelligence" under objection number four, "The Argument from Consciousness", where Turing cites "The Mind of Mechanical Man", the 1949 Lister Oration by Sir Geoffrey Jefferson, professor of neurosurgery and a Manchester colleague with whom Turing had debated:

"Not until a machine can write a sonnet or compose a concerto because of thoughts and emotions felt, and not by chance fall of symbols, could we agree that machine equals brain – that is, not only write it but know it had written it."[1:451]

Turing's own reply to this is based on the traditional philosophical difficulty of knowing other minds by any means other than their outward behaviour. He follows this with a highly amusing and playful sequence of dialogue from an imaginary

Turing test, in which someone – is it a man or a computer? – discusses with an interrogator the use of similes in Shakespeare's sonnet, "Shall I compare thee to a summer's day", and *The Pickwick Papers*. Nevertheless, the supposed human uniqueness of consciously felt, complex emotions consciously expressed in ingenious artistic uses of language, sound or visual form is a major cliché of objectors to thinking machines. In Alex Proyas's 2004 film, *I Robot*, loosely adapted from Isaac Asimov, the human hero, a policeman, asks, "Can a robot write a symphony? Can a robot turn a canvas into a beautiful masterpiece?" (To which the robot cleverly replies, "Can you?"). An aspect of this reappears in Turing's paper in the form of Lady Lovelace's objection, which is that computers can only do what they are programmed to do. Turing's dismissal of this objection opens the way for machine creativity. Yet here again we shall find that Futurism and Surrealism had already been working to undermine the assumptions of those who would invoke the combination of consciousness and artistic practice in order to maintain as wide a gap as possible between the human and the non-human. In doing so, these avant-garde movements specifically associated linguistic and aesthetic activity, not only with machines in general, but with automata in particular as dangerously representing artificial life at its closest to human life. The Surrealists indeed tended to reconstruct a historical genealogy of automata in order to reinforce their contemporary vision.

2 HUMAN/NON-HUMAN: THE CARTESIAN MOMENT

Why should such an antagonism ever have arisen in people's minds towards their own technological creations? Whatever the remote origins of this potential characteristic of human nature, it received a specific impetus and form in the early modern West. When Descartes introduced his Mechanical Philosophy in the seventeenth century, he preserved human free will from the general reduction of the universe to deterministic forces by setting human reason apart from matter. Animals famously were left on the side of matter and compared to automata. In his *Discours de la méthode* of 1637, he argued that human-looking automata could no more fool us into thinking them endowed with thought than could animals, since they would not be able to handle linguistic communication with our level of dexterity and in so wide a variety of situations [3]. Here humanity is set equally above all forms of non-human life, whether the natural but lower life of animals or the artificial life of machines. As has been pointed out [4], Descartes implicitly prefigures Turing's test, yet asserts the opposite conclusion. Whereas for Turing, intelligent machines will in time be able to fool us part of the time with their human-style verbal behaviour, for Descartes (although he does not introduce a time factor into his thought experiment) the test would always expose the machine as a fraud. The rational human soul rises up to God, while the unthinking automaton collapses into the material junkyard. However, not much more than a century later, the reassuring solidity of this distinction was beginning to crumble. The suspicion arose that human beings might themselves be no more than highly sophisticated automata. A major expression of this idea was *L'Homme-machine* (*Man the Machine*) of 1747 by the materialist thinker and physician, La Mettrie. The latter, contradicting Descartes, affirmed that thought was an inherent property of matter, that animals might be taught to speak, that man was a machine and that an artificial speaking machine might one day be manufactured by some "new Prometheus" [4]. This vision of things appeared to receive backing from the world of mechanical engineering, where automata were being designed and fabricated with increasing sophistication. La Mettrie cited the example of Jacques Vaucanson who produced a celebrated mechanical duck that gave the illusion of eating, digesting and excreting food. Vaucanson also produced two elaborate human-style automata, a flautist and a drummer. Music was a small step toward the production of intelligible signs. Vaucanson gave up this line of work when appointed by the King to the silk-weaving industry. Here he anticipated Jacquard's mechanical looms, which were to be so influential in Babbage's conception of a precursor to the modern computer. Although all these new machines were far from being genuine 'thinking' replicas, they acquired wide notoriety and fostered the view that intelligent life might one day be created. By the 1770s Wolfgang von Kempelen's famous chess-playing mechanical Turk was challenging and mostly defeating strings of princely and other celebrities across Europe. Many suspected that this was a hoax, and indeed there was a human chess master hidden inside the mechanism [5]. However, a doubt was sown in many minds, or at least the nagging thought that an artificial intelligence – a kind of Deep Blue *avant la lettre* – had already been created. The possibility was now in the air that humanity might one day be outstripped by its own creation, and to boot in the very realm of intelligence that humans felt was so peculiarly its own. Henceforth it was perhaps just a question of time.

3 THE DIRE WARNINGS OF MODERNITY

The prejudices that Turing was combating *circa* 1950 had been stoked for well over a century by a series of dire warnings. These had taken the form of memorable fictions which presented mechanical life as the blasphemous challenger to humanity. The founding text here was of course Mary Shelley's *Frankenstein* of 1818. The eponymous doctor creates what he intends to be an ideal companion in his quest to live in harmony with nature's fundamental rhythms. But he finds his creation so monstrous that he tries, rather unfairly, to destroy him, only to be dragged down into oblivion by his intended soul mate [6]. Towards end of the century, a similar warning was sounded in Villiers de l'Isle-Adam's 1886 novel, *L'Eve future* [*Tomorrow's Eve*]. Here again humanity's striving to overcome its own limits are punished. Thomas Edison, the embodiment of modern technology, manufactures a beautiful female android (an "andréide") for a love-stricken English lord. Its body is modelled on that of the lord's sculptural but tedious fiancée. It is magically animated by a spirit from the beyond and lent the personality of another woman who is interesting but suffers from depression. Edison and the lord are punished when their creation is lost in a shipwreck [7]. It is bad enough to violate God's natural order, but the mixing of love and beauty (the aesthetic) with technology (even partly magical) just won't work. Indeed in the course of the nineteenth century, mechanics and mechanical creations became identified with industry, capitalism and technology. Machines were part of humanity's epic struggle to harness the natural world to its material needs. At the same time, there arose an ethical opposition to the resulting tendency to turn working people into machines or treat them as such [8]. This vision reached a high in the 1920s and 1930s, with Chaplin's *Modern*

Times as one of its most memorable images. At the same time there arose a new vision of artistic activity and the aesthetic that was constructed in opposition to capitalist markets and industrial technology. This came about despite the underlying reliance of art on both the market and new technology (e.g. new printing presses for books; ever more elaborate stage machinery for the theatre; and by the end of the century a new mechanical medium, the cinema, soon to establish itself as the 'Seventh Art'). Alongside the moral criticisms of dehumanisation, the notion was propagated that everything industrial and mechanical was intrinsically ugly. The Arts and Crafts movement attempted to revive older approaches based on the artisan, while the curvilinear forms of Art Nouveau were intended to beautify the modern world with reminiscences of vegetal life and even the human nervous system [9]. Here no doubt lie the origins of art as encapsulating the essence of the human soul and embodying an irreducible opposition to machine intelligence. Artistic activity and reception was also established as the site from which to unmask the perilous ambitions of the technocrats, industrialists and 'mad scientists'. Indeed in the early twentieth century three further onslaughts on the automated future were delivered from within the avant-garde itself and doubtless were lent a special urgency by the increasing mechanisation of men in World War I.

The first was Karel Capek's play, *RUR*, performed in Prague in 1921, New York in 1922, London in 1923 and Paris in 1924. It not only coined the word 'robot' to indicate androids designed to relieve human beings of all tedious drudgery, but offered a future perspective in which humanity would be overtaken and annihilated by its own, mostly unfeeling creations [10]. Fritz Lang's 1927 film, *Metropolis*, co-scripted with his wife, Thea von Harbou, also presented a hellish picture of the future. This was in keeping with the German Expressionist tradition of opposition to modern, industrialised society. One of the most striking and destructive elements in this world, symbol of demiurgic blasphemy, is a female android, rather reminiscent of Villiers's future Eve. Here, as in Capek, eroticism and human reproduction play a vital role in the drama. The most curious attack on artificial life came from within the Italian Futurist movement itself, Ruggiero Vasari's play, *The Anguish of the Machines*, intended to be the first of a trilogy (only the second play, *Raun*, ever appeared). Published in 1925 and performed in Paris in 1927, it presented a nightmare world inhabited by exclusively male machines and human-android hybrids. One of these is its creator, Tonchor, who actually regrets his former human condition. When a woman arrives in his realm, representing the old human way of reproduction through love, he is prompted to destroy his creation [11:279-282]. Yet despite their minatory nature, the futuristic machine imagery in all these works remains highly memorable, including the various décors and costumes designed for Vasari by Ivo Pannaggi, Vera Idelson and Edouard Autant [12:87-89]. That Turing was himself aware of this strain of futuristic fiction is shown in his "Intelligent Machinery, A Heretical Theory" paper, which ends by explaining the hostility of intellectuals to machine intelligence in terms of their belief that their own role in society would be rendered otiose by the mechanical usurpers. He apparently reassures them by insisting that there would be plenty to do just interpreting the superior ideas that the machines produced. He concludes, "At some stage therefore we would have to expect the machines to take control, in the way that is mentioned in Samuel Butler's *Erehwon*." Turing uses Butler's 1872 novel, itself satirical, to satirize those who would spread catastrophic visions of the mechanical future [1:475].

4 THE AVANT-GARDE SEEKS TO CLOSE THE DIVIDE

Yet just as the bleakest of the modernist jeremiads were being produced, the avant-garde was also anticipating Turing's more positive slant on the mechanical. For certain movements during and just after World War I, the mechanical was to be the model for superior human activity and in particular for the aesthetic. In a complete reversal of the general public attitude, two hitherto incompatible words were joined to create the expression "machine art" [13]. Along with this went a new approach to humanity: women and men were to aspire to imitate the higher powers of the machine – its energy, its swiftness, its ability to conquer distance. Aspects of this tendency can be found in Futurism in Italy, Constructivism in Soviet Russia, certain aspects of Cubism and post-Cubism in France and even the short-lived Vorticism in Britain. The welding together of the mechanical and the artistic falls essentially into three categories in the works of the 1910s and 1920s. Firstly, the reproduction of the forms of machines in painting and sculpture is found frequently in Futurism. Secondly, the adoption in art of the simplicity, geometry and rationalisation of the mechanical world is seen for example in Le Corbusier and Ozenfant's *L'Esprit nouveau*. Thirdly, the ironic, ambiguous parody of machine forms are also found in the work of Marcel Duchamp and Francis Picabia [14:49].

There was too a general conflation in imagery of puppets, dummies from shop windows or waxworks, automata and the newly named robot. All embodied the disquieting idea of artificial life. This found expression particularly in the avant-garde theatre where the human body was displayed and articulated in a mechanical way. Either costumes dehumanised it or marionettes and other devices replaced it altogether. The English director, Edward Gordon Craig, was influential here with his idea of the 'supermarionette' [15]. Yet what counted above all was a new cosmic vision of humanity. In his "Manifesto of the Variety Theatre" (1913), the leader of the Italian avant-gardists, Marinetti, listed among the essential Futurist marvels which the stage should cultivate, "deep analogies between the human, animal, vegetable and mechanical worlds" [16:159]. In 1912 he had proclaimed, "After the reign of the animal, behold the beginning of the reign of the machine" and announced "the creation of the *mechanical man with interchangeable parts*" [16:124]. Turing, in "Intelligent Machinery", entertained a kind of thought experiment in which all the parts of man were replaced by machinery [1:420]. Marinetti apparently believed in such an enterprise. Already in 1911 he had appealed to Lamarck's theory of transformism to pave the way for "the inhuman and mechanical type of the multiplied man" [16:90-91]. Yet what was envisaged was not just a physical union between human and automaton, but also a mental one. Human language, human thought even, was to become machine language and machine thought. The verbal productions of the Futurists were to aspire to a new kind of language. According to a poem by Paolo Buzzi in 1912, "The Lyre has become the machine / today" [17:285]. What they meant by this was a language that differed from all normal human exchanges hitherto. It was governed not by conscious choice, but by unconscious intuition. It scorned habitual syntax and the rectilinear unfolding of standard writing on the page. In a strange foreshadowing of the computer, this new language use made connections *more swiftly* between *more* ideas that were *more distant* from each other, leaving our traditional understanding of the world lagging way behind. The "spirit of the Machine" offered an ideal of "infinite analogies" [18:223]. A suggestive stage image of this ideal was Giacomo Balla's projected spectacle of 1912 entitled, "Macchina Tipografica" or "Printing Press". The Futurist painter, who left a sketch, imagined the performers transformed into the working parts of a printing press, their mechanically rhythmic gestures appearing to spell out words of some kind, while strangely onomatopoeic syllables were uttered [19:93-96]. In the imagination, machines were not just associated with physical work, but intimately bound up with language and even some higher function of intuitive thought.

5 SURREALISM AND THE LANGUAGE MACHINE

This attention to language and thought became especially intensive among the French Surrealists, for whom the machine was the metaphor that revealed what humanity actually was. In his *Anthologie de l'humour noir* [*Anthologie of Black Humour*] of 1940, André Breton, the leading theoretician of the Surrealist movement, began as follows a presentation of the work of the curious French writer, Raymond Roussel (1877-1933):

"The difficulty we have, from a certain distance, in distinguishing between an authentic automaton and a pseudo-automaton has kept human curiosity on tenterhooks for centuries. There has been an uninterrupted reign of overwhelming ambiguity between animal life, especially human life, and its mechanical simulacra, starting with Albertus Magnus's android porter, who showed visitors in with a few words, down to the chess-player celebrated by Edgar Allen Poe, and including Jean Müller's iron fly, which after flying around came back to settle on his hand, and Vaucanson's famous duck, not forgetting the homunculi from Paracelsus to Achim von Arnim" [20:1067].

The passage firstly offers a succinct genealogy of automata, real and fabled, from the Middle Ages to the Enlightenment. In doing so it shows the same positive tendency we find in Futurism to celebrate the "overwhelming ambiguity" between human, animal and machine. Breton also emphasises the on-going role of trickery and deception in the history of artificial life and intelligence, which was to find explicit and deliberate form in the Turing test. At the same time Breton offers a curious reversal of Turing's test. In the latter we are led to ask, "Have we taken to be a man what is actually a machine?" Breton's examples raise the opposite question, "Have we taken to be a machine what is in fact only a man?" The classic case he cites is that of von Kempelen's chess-playing Turk later celebrated by Poe. Turing may have been aware of the famous Turk, echoing the case in "Intelligent Machinery" when he discussed whether machines might be able to learn. In dismissing the specific idea of a prearranged series of experiences that would lead the machine to a pre-programmed outcome, he said, "This would obviously be a gross form of cheating, almost on a par with having a man inside the machine". For Turing, it would be wrong to reduce true machine intelligence, once it had been achieved, to mere human intention. So for Breton here it would be wrong to reduce human intelligence to conscious intention: inside the human brain there is an unconscious machine.

Breton's passage on the history of automata quoted above continues thus:

"This ambiguity [between human and mechanical life] has been characteristically transposed in our own era by sending the automaton from the external world into the internal world, calling on it to perform inside the mind itself" [20:1067].

The inner automaton here is another kind of consciousness. The Surrealists felt it was an *unconscious*, following not only Freud's psychoanalysis, but also all the other sources of that proteiform notion back to German Romanticism. It was above all a form of consciousness alien to the "normal" conscious thinking that we believe we know. A useful, more neutral term might be Georg Groddeck's "das Es", the "Id" (in English translation), the "it", the "thing" within. As with Marinetti, the mechanical becomes an exemplum for a new form of linguistic and artistic creation that bypasses a good deal of the traditional intervention of conscious thought. The founding technique of Breton's approach to poetic creation was a type of spontaneous writing which, following both French psychiatry and spiritualism, he termed automatic writing. His first manifesto defined Surrealism as "pure mental automatism" ("automatisme psychique pur"), despite the negative connotations that might attach to "automatism" [21:328]. In addition to the connotations of an increasingly mechanised society, automatism was a negatively charged word in the French psychological medicine in which Breton himself had been trained. Pierre Janet's work of 1889, *L'automatisme psychologique. Essai de psychologie expérimentale sur les formes inférieures de l'activité humaine*, influentially defined "psychological automatism" in terms of the lower, more mechanical operations of the human mind, in contrast to the supposedly noble workings of consciousness and the aesthetic sensibility [22]. In the 1920s, a similar term, "mental automatism", was still being used by French psychiatrists. The nineteenth century had witnessed not only a tendency to separate noble humanity from ignoble animal and machine, but also a tendency to separate man into noble and ignoble parts. Advances in neurology and brain anatomy seemed to confirm La Mettrie's vision of man as just a mechanism. In 1879, in the same philosophical review, *Mind*, that Turing would choose for the publication of his test, the psychologist William James had asked the angst-fraught question, "Are we automata", to which he comfortingly responded, "no", thanks to our consciousness [23]. The unconscious or automatic part of the mind was the lower part, where humanity was not yet truly human [24]. Breton's Surrealism deliberately rehabilitated the supposedly mechanical part of humanity, which lacked the virtues of consciousness but offered instead those of another, more complex way of thinking. Hence in Surrealism "automatism" came to denote new forms of creation – poetic and artistic – that used hidden resources within the mind. The language of such creation was freer than the ordinary use of language, more open to startling connections and apparently far-fetched analogies. It evoked the logic of dreams and the discourse of the insane. For Surrealism, the aim was to loosen up language in order to loosen up our vision of the world – and hence our potential for understanding it in new ways.

Curiously enough, the history of automata, real and imaginary, tends to associate such creations, less with purely mechanical action than with intelligent linguistic behaviour, just as in Turing's test. The earliest legends of automata in the ancient world involve the vaticinating statues of gods and the talking heads of oracles [25]. This fact was amply exploited by Breton's associate, Benjamin Péret, when in 1933 he published an article on automata, "Le Paradis des fantômes". It appeared in the same number of the avant-garde review, *Minotaure*, that carried Breton's own "Le Message automatique", a stocking-taking of what had been achieved by automatic writing [26]. Péret's article is an indirect justification of Surrealist ambitions. Amply illustrated, it benefited from a recent historical study of the subject by Alfred Chapuis and Edouard Gélis [27]. Péret reviewed the past through an imaginary dialogue between inventors of automata that included Hero of Alexandria, von Kempelen, Leonardo da Vinci and Vaucanson. However, he gave prominence to creators of talking automata: Albertus Magnus who created a walking, talking doorman (in some versions of the tale destroyed by his disciple, Thomas Aquinas, who considered it a blasphemy); Roger Bacon who made a talking head that eventually pronounced a great revelation while Bacon and his follower Bungay were momentarily absent; and the abbé Mical who in the late eighteenth century created a pair of ceramic heads that praised the King of France in dialogue. A special place is reserved for the Jaquet-Droz father and son team who, from the 1760s, created not only a lady organist, but also a mechanical man capable of executing four drawings, and above all another able to write out messages. It is the latter, still extant, who draws Péret's attention the most. Two photographic reproductions show the inner workings of the head and torso. Not only is the Jaquet-Droz writer a suitable symbol of automatic writing, but he is also shown writing the word "merveilleux", one of Surrealism's key terms. Indeed a piece of paper with the word is illustrated by Péret, along with another saying, "We are the androids" in German. The word is here said by Jaquet-Droz to be on the lips of all androids, and he repeats it when he is jostled by a robot at the end. "Merveilleux", evokes astonished wonderment, and here this can be seen to be provoked by what is as yet unfamiliar. In 1930 Breton defined the imaginary as "that which tends to become real"[20:50]. Automatic thought takes us out of the circle of what we already know. As Jaquet-Droz says of his automaton: "He knows all languages and teaches me everything of which I am ignorant. He thinks and writes for me what I don't dare to think. He dictates my ideas to me." We have here a source of wisdom that is at once beneath humanity, because mechanical, and beyond humanity, because more complex than conscious human thought.

Thus if humans are thus able to create thinking machines outside themselves, they also need to discover the thinking machine within. The necessity of this is shown by the Surrealists' creation of a kind of test of their own. In 1930 Breton and Paul Eluard published *L'Immaculée Conception* [*The Immaculate Conception*], the texts of which were written with "automatic" spontaneity and other techniques. One section, "Les Possessions", contained texts purporting to be attempts to simulate the delusional types of discourse associated with five categories of mental pathology in French psychiatry of recent decades [21:848-865]. The authors did not claim to share the states of mind of these pathologies, but rather the states of language. Although this exercise did not take the form of an actual test, it did contain an implicit challenge to psychiatrists: can you tell the "sane" from the "insane" using only verbal behaviour? Speech and writing had been a recognised diagnostic tool for detecting insane individuals simulating normality, as well as for classifying the insane [28:12-28]. That we are not so very far here from the Turing test itself is shown by Kenneth Colby's 'PARRY' test of 1972, which asked psychiatrists to distinguish between the texts of real patients and those of a computer programme [29:350]. The Surrealists' point was that seemingly aberrant linguistic behaviour could be creative, expanding the potential circle of our thinking. The final text in their series, that based on *dementia praecox*, degenerates like the disease at the end into increasingly meaningless symbols, but here implying that apparent nonsense may not be beyond our *future* comprehension. In reality, Surrealist automatism invites us to subject ourselves to a test. Turing's test, which avoids a fixed definition of thinking, has a typically behaviourist form: one mind attempts to attribute thought to another entity, or not, according to the observed behaviour and language use of that other entity. The implicit Surrealist test takes the form of one mind interrogating itself through language in the same way, as though it were itself "another". The conscious mind makes itself as passive as possible – Breton called practitioners of Surrealism, "modest *recording devices*" [21:330].

6 CHANCE AND DISCOVERY

One essential element that the unconscious brings to artistic activity and to more creative human thinking in general, according to Surrealism, is the random or arbitrary, which breaks up any form of predictable routine. Perhaps rather strangely, the random or arbitrary can be introduced in a relatively systematic way. Surrealist artistic practice might thus disappoint the exponents of Romantic inspiration, insofar as it seems to involve the application of preset formulae. In a published discussion between Pierre Janet and another distinguished psychiatrist, Gaëtan Gatian de Clérambault, in the course of an ongoing polemic between the Surrealists and the psychiatric establishment, Clérambault dismissed them with the diagnosis of "procédistes" – those afflicted with a desire to avoid the hard work of creation by the use of schematic procedures [21:330]. Yet the writer who Breton introduces with a discussion of automata his anthology of black humour, Raymond Roussel, used schematic procedures to compose many of his strange works around random elements. This was revealed in his posthumous volume of 1935, *Comment j'ai écrit certains de mes livres* [30]. In writing his novels, he made up two sentences that sounded very similar but had very different meanings, thus exploiting the arbitrary nature of signifier and signified in language, or sound and meaning. He then fabricated descriptive and narrative elements to link the sentences together. This approach was what, for Breton, suggested the workings of the automaton within. For chance elements thrown up by the unconscious were constantly given meaning by conscious fabrications, the constant rationalisation tempering the irrational to create fascinating new patterns. One image among many of this may be found in Roussel's novel, *Locus Solus* (1914), which describes the strange contraptions that a scientist, Martial Canterel, has built on his estate [31]. He has acquired a vast number of teeth, of varying hues thanks to their former owners' smoking habits, through the invention of a technique for extracting them painlessly. These are laid out on the ground. A special kind of paving machine resembling an automaton, able to float through the air thanks to a mechanism which periodically inflates a helium balloon, gradually picks up and positions each tooth to form a large and intricate mosaic. In doing so, its precise movements are governed by air currents, which for every short period have been exactly calculated in advance by the inventor. The latter has programmed in advance its seemingly unpredictable shifts and their relation to the pattern to be constructed. This vertiginous, impossible image shows the overcoming of chance by transforming random patterns into new meaning. Known procedures and the unexpected collaborate. In a perhaps somewhat analogous way, in "Intelligent Machinery, A Heretical Theory" [1:475], for example, Turing envisaged the deliberate incorporation of a "random element" in his machines, to render their learning and discovering process more interesting. Roussel himself suffered from depression and – ironically – was treated by Pierre Janet. Breton quotes the latter's account of Roussel the patient which emphasises how much for him his works must contain nothing real, only the imaginary – only ideas of an 'non-human world' [20:1070]. Breton would have said, a world probably yet to come.

7 CONCLUSIONS

From 1950 onwards, art itself suddenly became more open than ever before to the use of chance, just as it would soon start to be open to the use of computers. John Cage and those he inspired in the sphere of music and the other arts incorporated the random into their works. Another generation of French writers arriving after the Surrealists, the members of the OuLiPo, incorporated sometimes formulaic and random procedures into their compositions with very positive results. By 1968 an exhibition like "Cybernetic Serendipity" could open its doors. It was now accepted that machines could be creative. The Surrealists and the Futurists had shown that art is not necessarily opposed to machine intelligence. Jefferson's "chance fall of symbols" might for human artists form part of a constant interplay between apparently meaningless random events and the construction of meaning. Turing's own vision of human minds that were not put out of a job by the new thinking machines but occupied with understanding what the latter produce has in part come into being. Fifty years after the publication of "Computing Machinery and Intelligence", the divide between the human and the non-human has closed somewhat in a collective enterprise of collaboration between humanity and machine.

REFERENCES

[1] B. Jack Copeland Ed., *The Essential Turing: Seminal Writings in Computing, Logic, Philosophy, Artificial Intelligence and Artificial Life*, Clarendon Press, Oxford, England, U.K., (2004).

[2] Andrew Pickering, *The Cybernetic Brain. Sketches of Another Future*, University of Chicago Press, Chicago, USA, London, U.K., (2010).

[3] R. Descartes, *Discours de la méthode*, GF Flammarion, Paris, (2000).

[4] S. Shieber, Ed., *The Turing Test. Verbal Behavior as the Hallmark of Intelligence*, MIT Press, Cambridge, Mass., USA, London, England, U.K., (2004).

[5] Gerald M. Levitt, *The Turk, Chess Automaton*, 2nd edition, McFarland, Jefferson, NC, USA, (2007).

[6] Mary Shelley, *Frankenstein, or: The Modern Prometheus*, Penguin Classics, London, England, U.K., (2003).

[7] Villiers de l'Isle-Adam, *L'Eve future*, Gallimard, Folio, Paris, France, (2003).

[8] A. Rabinbach, *The Human Motor. Energy, Fatigue and the Origins of Modernity*, Basic Books, New York, USA, (1991); J.-C. Beaune, *Le Vagabond et la machine*, Champ Vallon, France, Seyssel, (1983).

[9] D. L. Silverman, *Art Nouveau in Fin-de-Siècle France. Politics, Psychology, and Style*, University of California Press, Berkeley, Los Angeles, USA, London, England, U.K., (1989).

[10] Karel Capek, *R.U.R.*, Dover, New York, USA, (2001).

[11] G. Lista, *La Scène futuriste*, Editions du CNRS, Paris, France, (1989).

[12] G. Lista, *Lo Spettaculo Futurista*, Cantini, Florence, Italy, (n. d.).

[13] M. Le Bot, *Peinture et machinisme*, Klincksieck, Paris, France, (1973).

[14] M. Collomb, *La Littérature Art Déco. Sur le style d'époque*, Méridiens Klicksieck, Paris, France, (1987).

[15] D. Plassard, *L'acteur en effigie. Figures de l'homme artificial dans le théâtre des avant-gardes historiques,* L'Age d'homme, Lausanne, Switzerland, (1992).

[16] C. Poggi, L. Rainey, L. Wittman, Eds, *Futurism. An Anthology*, Yale University Press, New Haven, USA, London, England, U.K., (2009).

[17] "Inno all Poesia Nuova", cited in M. Verdone, *Teatro del Tempo Futurista*, 2nd ed., Bulzoni, Rome, Italy, (1988).

[18] I. Pannaggi, V. Paladini, E. Prampolini, "Manifesto of Mechanical Art" (1923), in G. Lista Ed., *Futurisme. Manifestes, documents, proclamations*, L'âge d'homme, Lausanne, Switzerland, (1973).

[19] M. Kirby, *Futurist Performance*, Dutton, New York, USA, (1971).

[20] A. Breton, *Œuvres complètes*, vol. 2, Gallimard, 'Pléiade', Paris, France, (1992).

[21] A. Breton, *Œuvres complètes*, vol. 1, Gallimard, 'Pléiade', Paris, France, (1988).

[22] P. Janet, *L'automatisme psychologique. Essai de psychologie expérimentale sur les formes inférieures de l'activité humaine*, Alcan, Paris, France, (1889).

[23] W. James, "Are We Automata?", *Mind*, **13**, 1-22, (1879).

[24] J. Stubbs, "Between Medicine and Hermeticism: 'The' Unconscious in *fin-de-siècle* France", in P. McGuiness Ed., *Symbolism, Decadence and the Fin de Siècle*, University of Exeter Press, Exeter, England, U.K., (2000).

[25] J. Cohen, *Human Robots in Myth and science*, G. Allen and Unwin, London, England, U.K., (1966); M. Kang, *Sublime Dreams of Living Machines. The Automaton in the European Imagination*, Harvard University Press, Cambridge, Mass., USA, London, England, U.K., (2011).

[26] B. Péret, "Le Paradis des fantômes", *Minotaure*, **3-4**, 29-35, (1933).

[27] A. Chapuis, E. Gélis. *Le Monde des automates. Etude historique et technique*, 2 vols, Chez les auteurs, Paris, France, (1928).

[28] F. Gros, *Création et folie. Une histoire du jugement psychiatrique*, Presses Universitaires de France, Paris, France, (1997).

[29] M. A. Bowden, *Mind As Machine: A History of Cognitive Science*, Oxford University Press, Oxford, England, U.K., (2006).

[30] Raymond Roussel, *Comment j'ai écrit certains de mes livres*, Gallimard, L'Imaginaire, Paris, France, (2010).

[31] Raymond Roussel, *Locus solus*, Gallimard, L'Imaginaire, Paris, France, (1990).

DIGITAL MUSIC R.U.R. & ART

Guest Speaker: Dr Scott Wilson

Mimicry and Random Elements of the Laptop Ensemble:
Reflections on programming live musical improvisations.

The Truring Test

Colin G. Johnson[1]

Abstract. This paper introduces the video-art piece *The Truring Test.* This piece consists of a number of video fragments that are drawn from three sources: spoken lines from the script for Čapek's play R.U.R., lines from that script set to music, and lines that have been generated in response to the spoken lines via interaction with automated dialogue generation systems then automatically converted into melodies using pitch and rhythm tracking, which are then animated. The structure of the piece is described, the historical background provided and the motivation for the piece explored.

1 INTRODUCTION

The Truring Test is a video-art piece consisting of a mashup of two canonical symbols of machine intelligence: the play *R.U.R.* (*Rossum's Universal Robots*) by Karel Čapek; and, the quest to build machines that can engage in meaningful dialogue with humans, which forms a key component of the Turing Test.

2 STRUCTURE

The piece is presented using video projections. There are two possible presentation formats. The first of these is for the images to be projected onto three screens or projectors, with the audience free to wander around between the screens; alternatively, a single projector can project a single image divided into three regions with the audience in a more conventional seating arrangement.

The three screens (or sections of the single screen) play different material, each of which is drawn from a different source. Initially the recordings are timed so that Screen 1 plays a part of the material, then Screens 2 and 3 play material in response to this. As the piece progresses, material is exchanged and layered between the various screens; this gradually gets faster, breaking apart the meaning of the material and focusing on the sonic and visual effect of the material rather than its content.

In the current version of the piece there is no interaction with the audience.

Screen 1 plays a recording of various people asking spoken questions, in the form of video taken of head-and-shoulders or just of the performer's mouth. The text for these questions consists of questions asked by characters in the *R.U.R.* script, focusing on questions asked by a human character to a robotic character.

Screen 2 plays a recording of a person singing the original lines from the *R.U.R.* script that immediately follow the question being asked. The musical material is original material written for the piece.

Screen 3 plays computer generated material created in the following way. The questions from the R.U.R. script are input into various computer systems that are built to engage in general purpose conversation, as would be found in the Turing test and the various competitions inspired by the test such as the Loebner prize. These are converted into melodies using the pitch tracker *fiddle~* in *Max/MSP*, these melodies sung using the computer singing engine *Virtual Singer* (www.myriad-online.com/en/products/virtualsinger.htm) and an animation of a singer created using *Papagayo* (www.lostmarble.com/papagayo) with the mouth shapes created by Gary C. Martin (www.garycmartin.com).

Example. Take the following question from the R.U.R. script: "A lady? Who is she?". This was recorded as a spoken question and used as the material on Screen 1. The material on Screen 2 then consists of the following line in the script ("I don't know Sir. She brings a letter of introduction.") set to original music in the form of a cheap imitation of operatic recitative. The question is then fed into a spoken dialogue engine (for example, AliceBot (http://www.alicebot.org)) and the resulting line of dialogue (in this case, "I don't know what it is.") pitch and rhythm tracked to generate a melody sung by the *Virtual Singer* program, which is then lip-synced to an animation of a mouth singing the words. This provides the video and audio material for Screen 3.

Two example screen-shots from the single-screen version of the piece are given in Figures 1 and 2.

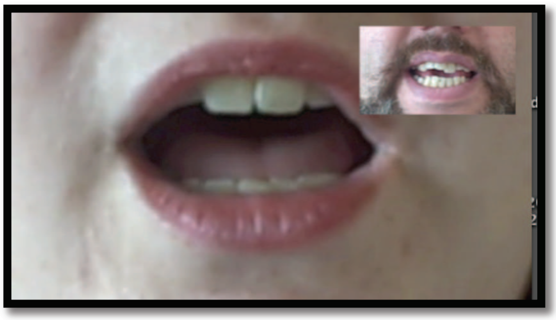


Figure 1. A screen-shot from *The Truring Test* showing material from Screens 1 and 2.

[1]School of Computing, University of Kent, Canterbury, Kent, UK. C.G.Johnson@kent.ac.uk

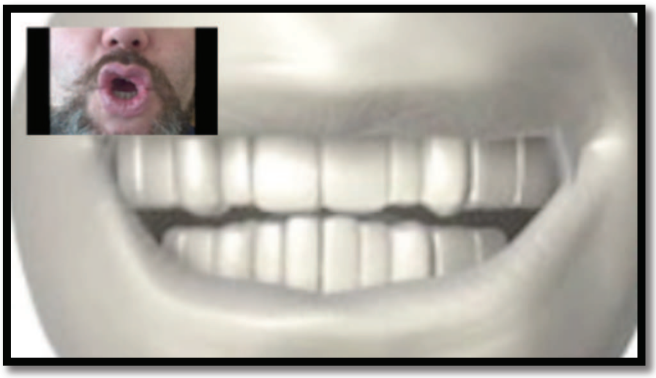


Figure 2. A screen-shot from *The Truring Test* showing material from Screens 1 and 3.

3 HISTORICAL REFERENCES

The piece draws upon two main sources of material, both of which are canonical items in the history of Artificial Intelligence. The 1920 play R.U.R. [4] is one of the earliest fictional attempts to portray robots in any sense. The Turing test is a pragmatic test designed to replace abstract questions such as "can a machine think?" with a concrete test that could be practically carried out [8]. There are many variants on the test, with most recent variants having a structure where a human "interrogator" engages in (usually typed) conversation with two unseen agents, one consisting of an AI program and one a human being. The interrogator attempts to distinguish between the computer and human.

The Loebner Prize competition [5] has been one of the most active forums for the testing of computer agents in Turing test scenarios, and a large number of programs have been written for this competition and related activities. It is a selection of these that are used as the generating engine for the material in this work.

4 MOTIVATION

The piece takes two source materials that are part of the canonical culture of artificial intelligence and bringing them together.

This is achieved by having the computer system and the human system (i.e. the original writer of the play) both attempt to create the same material, in the form of sung responses to questions drawn from the *R.U.R.* script. This points towards recent extensions of the Turing test that have focused on machine creativity rather than simply "passing off" as human [7,2,1]. These arguments have a number of forms, ranging from arguments that an agent much be able to create and evaluate novel content in order to be regarded as intelligent (rather than just responding reactively to provocation) to arguments that a more sophisticated, richer domain might provide an easier do- main in which to create intelligent action compared with a pared- down setting.

A little more deeply, the piece provokes thoughts about computational creativity. It seem ludicrous to assume that a machine incapable of creating meaningful dialogue could do something seemingly more sophisticated as to engage in a pseudo-operatic drama. However, the added complexity of the situation perhaps makes us more forgiving—does the increased complexity of creating a complex artistic piece actually provide more "room" for confusion about the source of the creativity? Clearly, there is no attempt to "pass as human" here in a literal sense—the computer creation uses obvious computational characteristics in it output. However, an audience might nonetheless regard the creation by the computer as being of equal or superior artistic merit—or else, regard the joint work with computer and human contributions as superior to either alone, which provokes further thoughts about human-computer co-creativity [3].

Furthermore, the piece comments on authenticity in theatre. In the play *R.U.R.*, as in almost all fictional depictions of robotic technology, the lines spoken by robotic characters are created by human authors. This is unproblematic: human authors regularly create dialogue for characters outwith their own experience. However, it is interesting to see whether a simplistic attempt to create dialogue by means of machine is seen as more realistic by the audience. It is entirely plausible that the "robot" responses created by the machine systems are less convincing than the responses written by the playwright.

This points towards paradoxes of artificiality, such as the "uncanny valley" effect [6], where a good but not perfect attempt at creating an artificial, robotic simulation of human life is seen as consider- ably more artificial than a weaker simulation, and which provokes a sense of unease and uncanniness. We can see this piece as exploring a similar question—does a human attempt to create a sense of "artificiality"/robotic-ness generate a better impression of that artificiality than a genuine but non-perfect robotic system?

5 CONCLUSIONS AND FUTURE WORK

We have presented a snapshot of the work as it currently exists, future versions of the work will be developed to explore different ideas and performance contexts. For example, a future version of the piece could explore interaction with a live audience, allowing the audience to ask questions and automatically generating the video and audio sequences.

REFERENCES

[1] M.A. Boden, 'The Turing test and artistic creativity', *Kybernetes,* **39**(3), 409–413, (2010).

[2] S. Bringsjord, P. Bello, and D. Ferruci, 'Creativity, the Turing test, and the (better) Lovelace test', Minds and Machines, (2012). In press.

[3] L. Candy and E. Edmonds, *Explorations in Art and Technology: Intersections and Correspondence,* Springer, 2002.

[4] K. Čapek, *R.U.R.*, Aventinum, Prague,1920.

[5] H. Loebner, 'The Loebner prize in artificial intelligence: "The first Turing test"'. http://www.loebner.net/Prizef/loebner-prize.htmlVisited April 2012, 2012.

[6] M. Mori, 'Bukimi no tani: The uncanny valley', *Energy*, **7**(4), 33–35, (1970). Translated by K. F. MacDorman and T. Minato.

[7] A. Pease and S. Colton, 'On impact and evaluation in computational creativity: A discussion of the Turing test and an alternative proposal', in *Proceedings of the AISB Symposium on AI and Philosophy.* AISB (2011).

[8] A. Turing, 'Computing machinery and intelligence', *Mind*, **LIX** (236), 433–460, (1950).

Turing and the Innovative use of Reverb in the film score of *Blade Runner*

Jenny Game-Lopata[1]

Abstract. In 1982 composer Evangelos Odysseas Papathanassiou (Vangelis) generated a vast spacial distance in his soundtrack to Ridley Scott's science fiction film Blade Runner by running his instruments through the first commercially available digital reverberation sound processor (the Lexicon 224). By using digital reverb to add depth and space to his instrumentation, he generated a rich musical milieu to complement the film's futuristic cityscapes, and redefined meanings associated with a reverb in music. The process by which reverberation algorithms were applied to an audio input signal was enabled by Alan Turing's digital computer outlined in 1936. Just as the Turing machine proved a harbinger of the digital age, Vangelis was a pioneer user of digital delay, which he helped to make famous in his soundtrack to Blade Runner. His use of digital signal processing and delay processes that imitate analogue audio signals and natural reverberation, parallels Blade Runner's narrative, which explores the replication of human behaviour in bio-machines or Replicants. Vangelis achieves this with a multi operational process of composition that relies on a highly interactive, creative spontaneity more than a clearly defined or imitable structure.

1 INTRODUCTION

When discussing the concept of digital computers in 1936, Turing explains, "these machines are intended to carry out any operations which could be done by a human computer" [1]. (The human computer referred to at this time is a person who does computations). His notion involves using the digital computer as a tool to relieve the human computer of arduous, or impossibly complicated mental tasks. The notion that the digital computer is a tool that automates and mimics human thought processes brings us to the realm of behaviour. In the film Blade Runner [2], Replicants (genetically engineered bio-robots) are comprehensive human tools; slaves, used for their physical and mental abilities to relieve humans of arduous mental and physical tasks. By imitating human activities and thought processes, the Replicants behave like humans. Turing's Imitation Game[2] tests whether or not a digital machine can behave in a way that is indistinguishable from humans. He argues that the best strategy for the machine is to "try to provide answers that would naturally be given by a man (person)" [1]. Blade Runner's Replicants achieve this with enough sophistication to demonstrate intense passions of romantic love and life itself.

In his score to Blade Runner [2], composer Evangelos Odysseas Papathanassiou (Vangelis) uses music on a number of levels. He uses it to: communicate ideas, in particular the notion of physical space; to enhance the emotive impact of the drama and to represent the themes, notably the idea that machines can imitate human behaviour. John Jacques Nattiez asserts, "a musical work is not merely a whole composed of structures. Rather, the work is also constituted by the procedures that have engendered it (acts of composition), and the procedures to which it gives rise: acts of interpretation and perception" [3]. We shall see that although Vangelis views his compositional process as constituting an organic, highly spontaneous, interactive method, it also involves numerous complex operations.

Music may be considered a universal activity not by its surface structure but in something deeper in the human psyche that is common to all cultures. It exists as a symbolic form, with the "capacity (with all other symbolic forms) to give rise to a complex and infinite web of interpretants" [3]. While music is not inherently narrative, it can be incitement to make a narrative, or to analyse. Composers and listeners will make their own associations and connections. Furthermore, we will see that many associated meanings in music are the result of acculturation.

This paper looks at the first commercially available digital reverb machine, released in 1978, the Lexicon 224 used by Vangelis in Blade Runner [2]. The ability to represent spaces, such as concert halls, landscapes and moods by adding artificial reverb to recordings, has imbued it with associated meaning. In Blade Runner, Vangelis's application of the vast new capabilities of digital reverb not only enhances the representation of a futuristic world populated with Replicants but also redefines and alters the perception and association of reverb in film music.

We will see how Vangelis' use of digital sampling and delay in the soundtrack is analogous to the on-screen story. Vangelis' use of a machine, which replicates human processes to communicate meaning through music, parallels the film's theme about Replicants; bio-machines that imitate human operations and desire human qualities.

[1] School of Arts, University of New England Armidale, NSW, Australia. Email jgamelop@une.edu.au

[2] The Imitation Game is played using: person 1 (A), a digital computer (B), and person 2, an interrogator (C). The interrogator is in a separate room and through asking questions, is required to determine which of the other two is the man and which is the digital computer

Communication via the transmission of radio signals had been extant for little more than 50 years and the recorded music industry was barely decades young when Alan Turing's concept of a digital computer heralded the electronic microcomputer. His vision was of a universal digital machine "that can mimic any discrete state machine" [1] to replicate human computers and by extension, their behaviour or as Turing states, "C [a particular digital computer] can be made to play satisfactorily the part of A in the imitation game, the part of B being taken by a man" [1] has since seen numerous applications. Digital signal processing (DSP), being just one of these applications, particularly as it is applied to digital reverb, is a focus of this paper. From Turing's notion that instructions can be broken down into discreet units we arrive at sampling. Sampling breaks an audio wave into small segments that can be represented digitally before being processed and reconstituted as analogue audio. As such, through DSP, the Turing machine is applied to replicate the human desire to communicate using music, a sophisticated human behaviour. Story telling in the form of film, another significant communication medium also utilises music to communicate, enhance drama and to represent themes.

In Blade Runner [2], the generous application digital reverb from the Lexicon 224 is used by Vangelis to magnify the city and the airspace above it, to give it an innovative highly surreal, space-age ambiance. By running audio signals from his analogue synthesisers, acoustic instruments and percussion (both analogue and digital) through the Lexicon 224 digital reverb machine, he also generated previously unheard sounds that added depth to the internal spaces of the futuristic city. Before digital reverb, natural spaces and relatively awkward analogue machines were used to generate limited echo effects.

The historical application of reverb in film and other forms of recorded music had earned it a somewhat poor reputation among audiophiles, and an association with 'schmultz' or soft focus scenes in the film world. In Blade Runner [2], Vangelis applied the Turing machine in the guise of digital reverb to challenge existing perceptions and, as a result, influenced the use of effects in film and recorded music to date.

In terms of Turing's conception of the digital computer, (Store, Executive unit and Control [1]) extant in today's microprocessor, we now have machines that can accept an audio signal, then sample, measure, store and filter it before outputting it as music. In this case, music that represents Blade Runner's dramatic themes focuses on the ability of Replicants to imitate human behaviour.

The term 'electronic music' includes electronic musical instruments, as well as electronic music technology. Analogue signals are commonly measured, filtered and compressed in the recording process. DSP in electronic music represents discrete audio signals as numbers and then processes them. Digital reverb is added to a signal to alter the output or sound of the audio signal, the resultant music.

2 DIGITAL SIGNAL PROCESSING

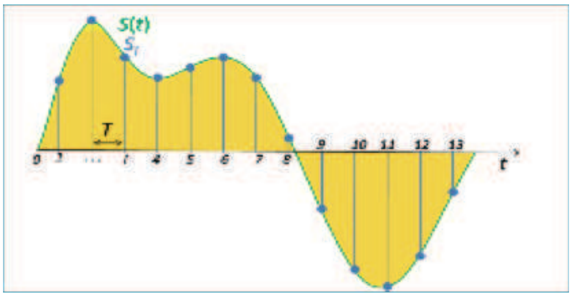
Turing refers to the digital computer's store as corresponding to the human computer's paper, and that "in so far as the human computer does calculations in his head a part of the store will correspond to his memory" [1]. He goes on to surmise that it "must be possible to write into the store any one of the combinations of symbols which might have been written on the paper" [1]. This connection between digital and human memory is explored in Blade Runner [2]. The Replicant known as Rachel is better able to imitate humans, taking longer to be detected as a Replicant in the film's version of the imitation game, as she has an implant containing false memories. She 'remembers' a childhood and family, even how to play piano.

The Replicants in Blade Runner are also superior in physical strength and mental abilities, as they are what Turing termed 'universal machines'. He reasoned, "provided it could be carried out sufficiently quickly, the digital computer can "mimic the behaviour of any discrete state machine. ... The imitation game can then be played with the machine in question (as B) and the mimicking digital computer (as A) and the interrogator would be unable to distinguish them" [1].

Similarly, the aim of digital signal processes is to measure, filter and/or compress continuous analogue signals, a tool, or machine, used for human communication, rather than an actual human behaviour. The first step is usually to convert the signal from an analogue to a digital form by sampling and then digitizing it using an analogue-to-digital converter (ADC), which turns the analog signal into a stream of numbers. The output signal, usually another analog signal, requires a digital-to-analogue (DAC). This digital computing process is more complex than analogue processing and has a discrete value range, but it has superior error detection and correction in transmission as well as data compression [4]. In this way the Turing machine is used to replicate the human activity of signal transmission.

The Australian built CSIRAC (Council for Scientific and Industrial Research Automatic Computer), one of the world's first stored-program, electronic-digital computers, is thought to have been the first computer to play music, as early as 1950-51. Originally known as the CSR Mk 1, Geoff Hill programmed it to play a musical melody, albeit with very crude sound production. Raw pulses of the computer's data words, the bit stream pulses, were sent directly to an audio amplifier with a loud speaker attached. The music was produced in real time, as there was no mass storage (such as magnetic storage tape) available at this time. Other challenges to overcome included significant timing issues and the mastering of complex sound generation processes, before a stable, pre-determined frequency output was generated [5].

Computers deal with numbers, or digits, and sound consists of continuously varying electrical signals. The challenge was to accurately link them together for direct computer sound synthesis. The waveform needs to be represented such that it can move and undulate in a seemingly infinite variety of ways, but with a finite string of numbers, with a finite number of digits. To achieve this, the wave is divided into a large number of segments, each being short enough in time that the waveform (or shape) does not change very much during the segment. The average amplitude of the waveform over each segment can then be converted into a number for the computer, and vice versa. The smaller the segments, the more accurate the imitation will be (see figure 1).



Source: Robertson.

Figure 1 Sampling as a continuous signal (the wave line) is reduced to a discrete signal (the vertical lines).

To convert sound waves into numbers, the waveform is sampled with a balanced modulator (or its equivalent). The sample pulse amplitudes are then measured with an analogue-to-digital converter (ADC), which is a fast voltmeter. Each sample thereby becomes a number that may be processed by a computer. Provided that the spectrum of the waveform has no frequency components above half the sampling rate, no information about the curve and undulations of the waveform are lost. As some natural sounds have energy above the audible range, a low pass-filter is needed to prevent these high frequencies from reaching the sampler and ADC. If signal frequencies higher than half the sample rate enter the sampler, the resultant copies will overlap the original spectrum causing alias distortion (where signals become indistinguishable) [6].

Conversely, the digital to analogue converter (DAC) accepts numbers one at a time from a digital source and generates one voltage pulse per number with a height proportional to the number [6]. Therefore, a DAC calibrated in volts would generate a voltage pulse of 2.758 volts in amplitude, if it were given the numerical input 2.758. The pulse width is constant, but will vary with different types of DAC[3]. Each pulse, or the number it represents, is called a sample, as it gives the waveform amplitude at a sample point in time. The frequency of the pulses is called the sample rate [6]. Figure 2 shows the process of analogue to digital and back again.

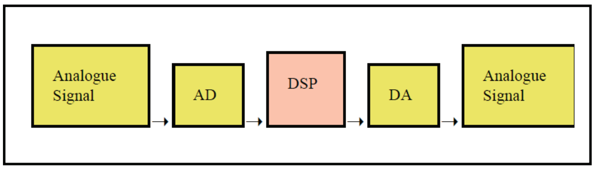


Figure 2. The process of analogue to digital and back again

In 1982, when Vangelis composed his score for Blade Runner [2], DSP applied to music was in its infancy. However, the effect of natural reverberation or echoes on the human voice and musical instruments was well known. People had been exploiting and trying to capture or replicate this effect in music for some time (see below). This is because the addition of reverberation (reverb) to musical sound can enhance the sound quality, and the affective communication of music. The human desire to imitate nature, a ‘natural effect’, for entertainment and communication through music, was strong enough to inspire the invention of analogue machines to capture the effect. Replicating reverberation using digital technology is a further application of the Turing machine. It demonstrates the universality of the digital computer or its ability to be programmed to imitate other machines. As a part of digital signal processing, reverb algorithms are applied to audio signals to alter the sound. The effect can simulate the reverberation of different rooms and spaces that in turn alters the musical atmosphere or milieu. We will see how this ability to replicate spaces and generate associative atmospheres was seized upon by Vangelis in his score for Blade Runner [2]. This human desire to replicate nature (reverb) with machines, and then machines with other machines in order to communicate music, correlates to the central theme of Blade Runner [2], as the Replicants increasingly seek to imitate more human behaviours. It is thereby fitting that Vangelis exploits the new digital reverb technology to represent and enhance this theme.

3 REVERBERATION

Musicians have responded to the reverberation levels and general acoustics of a given performance space for some time. For example, Gregorian chants and organ music are considered effective in medieval cathedrals, known for long-reverberation times. Some of the music of classical composers such as Mozart and Haydn was intended for performances in highly furnished chambers, and for smaller, intimate audiences. This music can be less effective when performed in highly reverberant spaces [7]. In addition, musical instruments were designed to capture reverb. For example, the Broadwood Piano Company of London introduced a ‘sustain pedal’ mechanism in 1783. Sympathetic vibrations would resonate throughout the full set of strings and across the soundboard. The success of these pianos was such that soon pianos everywhere came equipped with a pedal [8]. The ancient hammered dulcimer, some Baroque instruments (such as the lute), and many non-western instruments, such as the Indian sitar have sympathetic stings that generate resonance.

In the late 19th century early attempts to design a concert hall or opera house to achieve optimal acoustics began. The American Physicist Wallace Clement Sabine first measured natural reverberation, the result of sound reflecting off surfaces in a confined space, in the late 1890s [9]. He established the connection between the quality of a room’s acoustics, the size of the chamber, and the amount of absorption surfaces that were present. His formula for calculating reverberation time is defined as the number of seconds required for the intensity of the sound to drop from the starting level by 60 decibels. This reverberation time is still used for gauging a room or space’s acoustical quality. The sabin is the modern unit of sound absorption, is also still used architectural acoustics [9]. Sound emanates from its source at around 340 meters per second (the speed of sound),

[3] Resolution is the most important converter specification in data conversion technology (DAC/ADC). Resolution is measured in bits. It is the measure of the number of different voltage levels that a DAC can produce. For example, a 3-bit DAC accepts 3-bit binary numbers as input and can produce more than eight different voltage levels as its output See Ref 6.

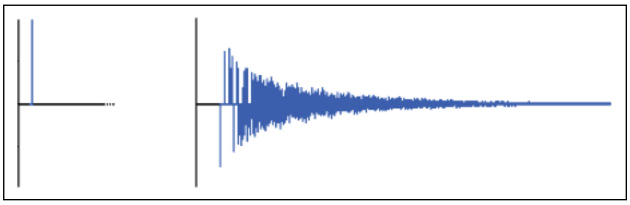
as sound strikes wall surfaces it will reflect, or echo off them at various angles. The sound then slowly decays, or decreases in amplitude. Some echoes will reach a listener's ears immediately while others continue to bounce off other surfaces before being heard. Hard, large surfaces, such as concrete walls, reflect the sound with modest attenuation, while soft surfaces will absorb a lot of sound, in particular the high frequency components. Consequently, it is the combination of a room's size, the complexity and angle of its walls, the room's contents (including people) as well as the density of the surfaces that will determine a room's individual acoustic or sound quality [7]. The optimum reverberation time for music depends on the instruments and style of music being played.

Before digital processing, reverb was created in a natural echo chamber or room. Audio was played through a loudspeaker and picked up with a microphone. This method is effective (and still in use), but reverb time cannot easily be adjusted, so rooms must be sound- proofed. Other methods involved transducers, similar to the driver in a speaker, to generate vibration in a metal plate or spring. While the spring was the most portable and affordable option, it was less effective as a device [7].

Turing may not have conceived of digital reverb, however in 1950 he believed that "in about fifty years' time it will be possible to program computers, with a storage capacity of about 10^9, to make them play the imitation game so well that an average interrogator will not have more than 70% chance of making the right identification after five minutes of questioning" [1]. He clearly conceived of the possibility of programmable digital machines that could store and execute complex operations such as those involved in DSP and digital reverb. In the digital environment, delay time is only contingent on available memory, while the number of reflections and simulation of frequency-dependent effects (filtering) is determined by processing speed [7].

Digital reverb is a dramatically more effective way to generate the effect than the previous analogue systems. It has enabled producers to easily place music into a variety of different rooms or spaces (acoustic environments). While Vangelis did not play a role in the invention of digital reverb, he quickly understood its potential and contributed its innovative application in the recording process.

Reverb is a time-invariant effect, that is, it does not matter when a sound (or note) is played, the same reverberation will result. Time-invariant systems can be completely characterised by their impulse response. The impulse response of an acoustical space (such as a room) can be measured to provide information regarding its acoustic qualities, such as the intensity of its reverberation and how long it takes to decay or die out. In its ideal form, an impulse is an instantaneous sound that carries equal energy at all frequencies, zero width, infinite amplitude and finite energy content. The echo, in the form of reverberation, is the room's response to that instantaneous, all-frequency burst [9]. A test signal such as a handclap, or a popping balloon, for example, can serve as an impulse. Signal analysis shows that after some density build-up at the beginning, the signal decays smoothly toward zero (see figure 3).



Source: Redman.

Figure 3. An impulse and its response.

Smoother sounding rooms show a smoother decay. In the digital domain, each sample point of the response can be viewed as a discrete echo of the impulse. Since, ideally, the impulse is a single non-zero sample, a series of samples or a sound played in a room is the sum of the responses of each individual sample at their respective times. Consequently, with a digitised impulse response, the exact room characteristic could be added to any digitised dry sound. By multiplying each point of the impulse response by the amplitude of a sample, a room's response to that sample could be calculated. If this is then applied to each sample of an audio signal, a collection of overlapping responses is generated that can be added together to generate reverb [9]. With the measurable formula for reverb in place, it would appear to be inevitable that a Turing machine will be able to perform these calculations and replicate the reverb effect. This may be so, however the calculations are immense. As it would entail an enormous number of multiplications, it has proved more practical to use multiple delays and feedback to build up a dense series of echoes that die out over time.

The simplest digital reverberator is the delay of 30 msec or more inserted into the signal path where delayed and un-delayed sound can be mixed. The audible effect is an echo [6]. Parameters for the echo will include the size of the delay as well as the relative amplitudes of the direct and delayed sound. Multiple echoes can then be simulated by feeding some of the delayed output back into the input of the delay unit [6].

Mixing in similar delays of different sizes would increase the echo density and get the effect closer to natural reverberation. In practice, however, it takes too many of these hard echoes to make a smooth wall of reverb. The delay lines with feedback (or comb filters) result in frequency cancellations that can mimic room effects, but can also result in ringing and instability. While useful, these comb filters alone are not effective [9]. In 1962 Manfred Schroeder developed a feedback/feedforward technique whereby the resulting delay line had a flat frequency response. This is now referred to as an *allpass* delay. Parallel comb filters and a series of all pass reverberators results in a constant echo density.

When the filter is stable, the signal is seen as a series of identical impulses decreasing in amplitude. Consequently, the response sounds like the original signal decaying over time. Real rooms or acoustic spaces have an echo density that increases with time. By placing the all passes in a feedback path, a more natural reverberation decay is created.

Variations in this process and how the multiple delays are stacked together, give particular digital reverb units their characteristic sound. The earliest digital reverbs units, the

EMT-250 and Lexicon 224, made use of several series all passes at the inputs of the reverberation algorithms to increase the echo density. The innovation of putting *allpass* filters inside delayed feedback loops was not only fundamental to the algorithms of Lexicon 224; it is still used today [10].

Particular reverb units have their own unique sound qualities and the sound from Lexicon 224 the sound is realistic and extremely spacious. Its DAC and ADC converter cards contain two input transformers (stereo) and four larger output transformers to enable quadraphonic operation. The transformers are balanced directly on the cards. The quality of the Lexicon 224 algorithms[4], the older-technology 12-bit converters and the transformer isolation for the analogue audio signals are all thought to contribute to its sound [11]. Steve Lenham suggests that the older ADC may also contribute to its unique sound, as the Lexicon's 12-bit successive-approximation converter is old technology. This architectural difference is thought to affect the sound. Lenham also suggests that the transformer isolation of the analogue signals (used by few more modern/lower-end pieces of equipment due to the high cost) could contribute. He points out that passing the signal through a soft iron core gives a subtle distortion, similar in effect to analogue tape [11].

Turing's concept of 'store' (discussed earlier) advanced enough in thirty years to support DSP for music. The digital memory or DMEM card contains the working memory for the discrete DSP 16K words of 16-bit wide storage and is implemented using 4116 DRAMs (dynamic random access memory) that requires three supply voltages. The base of Turing's 'executive unit' [1] is seen in the arithmetic logic unit (ALU) in reverb systems, including a 16-bit, fixed point DSP constructed predominantly from 74-series logic integrated circuits (ICs). Finally, the idea of Turing's 'control mechanisms' [1] include a timing and control card that provide all clock and control signals for the discrete DSP. A bank of 6810 static random access memory (RAM) devices store the program to be executed [11].

A single-board computer card (SBC) holds the microprocessor and associated peripheral ICs. These include a small amount of RAM and a bank of erasable, programmable read only memory (EPROM) for program storage. The Lexicon 224 has interchangeable programs to simulate different chambers, plates and rooms. The SBC card manages the unit, handling the user interface and loading the DSP with the selected effect algorithm. With a 20kHz sampling rate the audio bandwidth of the original 224 was around 8kHz [11].

With the Lexicon 224 Vangelis had access to a digital device capable of simulating natural reverberation. He was innovative in his use of the Lexicon throughout his score to Blade Runner [2]. He infused the score with digital technology that helped to tell a story that reverberates with themes of machines simulating people.

[4] The sample rate in the Lexicon 224 digital reverb machine is 20 kHz, and the DSP executes 100 operations per sample. The DAC and ADC converters contain the input, buffer/gain trimming circuitry, anti aliasing filters and 12-bit audio converters. See Ref 11.

4 EQUIPMENT

Vangelis owned his own studio (Nemo Studios) that contained much state of the art equipment [12]. While the EMT250 released in 1976 was the first digital delay unit; it was expensive ($20, 000) with only 250 units were built [13]. The Lexicon 224 was released in 1978 with the more affordable $7500 price tag (with two programs, four cost $7,900). It was the brainchild of Dr. David Griesinger, a nuclear physicist/musician/classical recording engineer. He had studied artificial reverberation (plates, springs and multiple head tape systems) and had been working on a digital solution when the EMT 250 as released. He merged an S100 microcomputer with his reverb design and included a separate control unit for parameter adjustment and program [14]. Vangelis was the one of the first producers to use digital reverb buying the first Lexicon 224 in 1980. It had the serial number 0002 (the first unit remaining with Lexicon) [15].

The Lexicon 224 was used prolifically and was a big part of the '80s music sound [16]. 'The Concert Hall A' program in particular is said to be one of the finest reverbs ever made, and its plate programs played a major part on creating the '80s drum sound. In addition to playing a significant role in Vangelis' ground breaking Blade Runner [2] soundtrack, the Lexicon 224 was part of the sound of highly influential classics such as Talking Heads' *Remain In Light*, U2's *Unforgettable Fire* and Peter Gabriel's *So* [16]. The significance of the Lexicon 224 can also be demonstrated by the fact that it is still in use, as well as being available as a plug-in.

Vangelis applied a generous amount of reverb, particularly to his (analogue) sythesisers and percussion instruments. The effect of this was to add depth and space to the music and enhance Blade Runner's [2] vast, futuristic landscapes. The dynamic was changed for the viewer, becoming more experiential and absorbing. Until Blade Runner [2], the music underscoring science fiction films had been more effect-oriented with gurgles, beeps and high-pitched sounds etc. Vangelis generated an emotive score with maximum atmosphere and depth. He had a large number of synthesisers and sequencers (much of his gear was analogue, such as the renown Fender Rhodes and Yamaha CS80), and he put them all through the Lexicon 224.

He had two other pieces of digital equipment at the time, including an early Japanese electronic toy. The electronic noises in the scene where the principle characters Deckard and Rachel meet come from one of the first hand-held electronic games, a device called the Bambino UFO Master Blaster Station [15]. The early 1980s also witnessed the introduction of digital keyboard samplers where a single musical note (or any sound) could be sampled and played back using different notes on a keyboard. Vangelis's first sampler (which he used in Blade Runner) was the E-mu Emulator keyboard. Vangelis originally intended it to replace his Linn LM-1 drum machine and make drum patterns and sequencers using his own drum samples. The E-mu Emulator could also store samples internally. The Emulator keyboard's reaction time was too slow, however, and on Blade Runner [2] it was used primarily as a percussive sampler providing more sounds ready at Vangelis' fingertips [12]. These Emulator samples are featured in the bar scene.

There is a clear connection between the concept of digital sampling and replicating of sounds and effects for musical reproduction and the notion of Replicants that feature in Blade Runner [2]. Vangelis used digital replication of human communication via music to represent Replicants, who in turn desired the full gamut of human behaviours. The next section looks at some ways sound can communicate meaning.

5 ENHANCING THE DRAMA

This section demonstrates that by the time Vangelis produced the music for Blade Runner [2] in 1982, there were established ways of using reverb. Nevertheless, with the more realistic, and spacious digital version, he was able to extend and help re-define its application.

Reverb had been part of the recording process from its inception. By the time the major recording interests in the US and Britain began to adopt the electrical recording methods developed at Bell laboratories in the 1920s, radio broadcasting had already been using microphones for some years. The technical know-how and aesthetic premises for early music recordings came from radio broadcasting [17]. Microphones could pick up some room ambiance, but sound sources, whether vocal or instrumental, tended to be recorded directly in to the microphone (on-mic) in an acoustically dead (no reverberation) studio environment. The instruments and voices were approached the same way, with all voices recorded evenly. In radio dramas, sound effects were sometimes recorded slightly off-mic to produce an effect of aural depth (sounds would appear to be further away). This attaching of small amounts of reverb provided a life-like roominess to the recording.

The simulation of reverb as a part of radio communication points to the significance of abstract, symbolic imitation in human communication. By constructing tables of behaviour with his language of instruction, Turing was modelling the affective responses of the human mind. What about human reactions? Does this suggest that responses to abstract symbols might also be programmed into machines? This idea has creative expression in Blade Runner's Replicants. These bio-machines have human responses; they demonstrate fear of death in their quest for a longer life span as well as sexual responsiveness and love.

When Vangelis was adding digital reverb to his score for Blade Runner [2], he was contributing to and extending meanings previously associated with it, to the history human of responses to reverb. Through Vangelis's innovative application of reverb, Turing's universal machine is impacting the human experience audio entertainment. "Many meanings that we perceive as 'natural' are the result of codified systems to which we have become acculturated [3]." The early close-up flat-plane approach to recording mentioned above, was more intimate in style and led to popular music's crooner in the 1920s. It was the producers of classical music that first took advantage of the sense of physical space that 'off-mic' techniques enabled. The high art, concert going listeners, gravitated to the reproduction of reverberation as it simulated the concert hall. The extra-musical narrative of late romantic, program music was well suited to reverb. The sense of depth and space suggested by reverb suited the notions of program music and its allusions to countryside, wide landscapes and nature [17]. The continued influence of program music on film music is evident in Vangelis' application of reverb to enhance the vast futuristic city within which Blade Runner [2] is set.

This association of reverb with landscape was also evident in some early popular music. The crooner Gene Austin released My Blue Heaven in 1927 that sold more than five million copies. In stark contrast to the majority of popular recordings of the time, he used the off-mic and more reverberant technique for the instruments while still recording the vocals dry, on-mic [17]. The accompanying lyrics describe a soft twilight landscape which, when enhanced with the reverberation, deepens the sense of space.

Throughout the 1940s, reverberation effects were also selectively used to suggest dark spaces in horror movies such as Cat People, I Walked with a Zombie and The Body Snatcher [17]. Significantly, science fiction movies also tended to reflect outer space as a source of horror. This is evident in the early 1950s films such as It Came from Outer Space, Killers from Space, War of the Worlds, Man From Planet X, Phantom From Space and Invasion of the Body Snatchers. While the use of reverb in science fiction movies was not new, in his score for Blade Runner [2], Vangelis was able to undermine its association with horror spaces and extend its association with outer space to represent the future, thereby generating a subtle a paradigm shift.

Reverb also accumulated gendered meaning as it became associated with screen beauties in the soft focus shot throughout the 1950 and 60s. The term 'soft focus' originated in cinematography and refers to the fuzzy effect generated by diffused lighting. Soft focus shots were often used as the camera focused on a beautiful woman and was usually accompanied by high reverb music [8]. This standard coupling served a feminising function for filmmakers. Similarly, in Blade Runner, Vangelis applied generous amounts of digital reverb to the saxophone underscoring the romantic/sex scene between principal protagonists, Rachel and Deckard.

Western popular music of the 1950 and 60s also began to feature lush string arrangements that relied on heavy reverberation, as did 1970s mood music. These reverberent styles were enabled by the development of artificial reverb machines such as the plate and spring devices discussed above. This empahsised the hi-low art split, this time with audiophiles shunning the "distortion of authentic sound" [8]. Between 1953 and 1972, Annunzio Paolo Mantovani worked with Decca studio engineer Arthur Lilley to produce over 50 chart topping albums. A large part of this was due to the maximisation of echo effects applied to Mantovani's already lush, rich string arrangements. Lilley removed all absorbent materials, such as carpets and positioned ten or twelve microphones throughout the 28-piece string ensemble to reinforce direct and reflected sounds [8]. Hi-fi enthusiasts regarded the high amount of artificial reverberation such as that on Mantovani's recordings, to be excessive, deceptive and frivolous. By way of example, notable audiophile R. D. Darrel wrote in a 1953 article for Saturday Review that extrapolates on a letter from Mozart to his wife, where he commented on the immense enjoyment he received from hearing a performance of his music when seated close to the orchestra. Darrel imagines them engaged in a modern argument over hi-fi speaker placement: "I'd like to think that

Wolfgang's predilection for 'close-up' sound would ensure his voting for a wide-range corner horn and an easy chair.... But, undoubtedly, Constanze would crave, like so many others nowadays, the 'diffused' sound-source effect obtained by listening to a speaker in another room or oriented so that the high frequencies reached her ears only by 'reflection' . . . The great 'high fidelity' movement we helped to promote, but have been unable to control, is now winning a mass public only by reshaping its attractions so as to appeal to the Constanzes rather than the Wolfgangs" [8]. Darrel, with ideas typical of the mid-century audiophile, asserts that diffused sound is somehow tasteless.

This is the environment into which Vangelis launched the music to Blade Runner [2] and helped pave the way for digital reverb. With his application of the more powerful, extra long delay enabled by digital reverb, he managed to alter its perceptions and associations or even re-program the listeners' responses. His use of heavy reverb on synthesisers and a wide variety of percussion gave the futuristic cityscapes a depth and majesty never before witnessed. The highly spatial digital reverb increased the dramatic integrity and visual impact of the film. Vangelis embraced the power of digital technology, dismissed the notion of the reverb as somehow unsophisticated, negative or overtly gendered to generate evocative, new sounds and spaces.

6 COMPOSITIONAL PROCESS

While Vangelis was innovative with his use of reverb, he was building on the history of reverb and its associated meanings. We will see that he also used the saxophone and Middle Eastern music in ways that take advantage of established associations. Coker observed, "it is expected of the composer that he conceive the music's gestures and attitudes because he wishes to affect the behaviour of performers and listeners, and he knows these gestures affect him when he adopts the attitudes of other interpreters. Such role taking is needed for musical communication on the composer's part.... Music is, above all, addressed to us as listeners or performers, and intended to affect us" [18].

Vangelis did not prepare a detailed record of his compositional process while underscoring Blade Runner [2] in 1982. He had no desire for it to be stored or replicated. There is an amount of irony here considering Vangelis' organic against Turing's digital computer. He describes his process as "spontaneous and instinctive" preferring to use his first takes whenever he could, even if the recording contains small mistakes [19]. This might explain why, for example, he used the E-Mu Emulator keyboard as a sampler with sounds at the ready, rather than programming sequences. The compositional process for Blade Runner, outlined on Vangelis's Nemo Studios website, reveals a composer who believes "music is a natural creation, and, therefore... cannot be created as a consequence of past or active human thoughts" [19].

Nevertheless, musical composition entails a multiplicity of processes that can be perceived as complex systems involving different levels of operation. Vangelis' spontaneous and instinctive processes might also be seen as containing levels of operation including a dependence on previously stored easily retrieved knowledge, such as his knowledge of collectively understood musical systems and styles, as well associated meanings and interpretation. For example, in Blade Runner [2], the associations of reverb, the sensuous application of the blues scale to underscore the exotic, sexy, snake-dancer or the incorporation of aspects of Arab music to represent the Middle Eastern character who replicates snakes.

There is no compositional process without the use of some manner of representational processes. Musical ideas can manifest in many ways, including as Turing-inspired sets of instructions, or algorithms. However, even the role of algorithms in music is contingent on intervention or interaction from the listener/composer in the process of composition. Composers interact with computers while using them to process audio and generate musical outcomes. Vaggione comments that interaction is "an important feature of musical composition processes, giving room for the emergence of irreducible situations through non-linear interaction" [20]. Vangelis composed using a highly interactive process. He would play a scene from Blade Runner [2], and if he felt a strong connection to the moving images, he would create a composition as he considered the music to be integral and inseparable from the images [19]. If he wanted to add layers later, he would rewind the tape and add layers of sound electronically, through his synthesisers, percussion and acoustic effects. Actions and perception are clearly at play here. Choices are made contingent on musical arguments, musical systems and subjective interpretations of the composer. Vangelis composes as he responds to the music, in a kind of feedback loop not unlike the feedback/feedforward technique used to generate digital reverb. As such, composers can reduce or enlarge their operational categories at will or their field of control, producing and applying musical guidelines as well as making creative choices throughout the process(es). Vaggiona observed, "Musical processes can be produced using formal tools (algorithms) as generative and transformative devices, yet other compositional instances call for strategies relying on interaction in order to control and qualify results and choices. Using computers drives musical activity to an expansion of its formal categories" [20].

Vangelis' music in Blade Runner [2] was not created through a rigorous process where ideas and musical arguments are methodically thought out and arrangements are carefully laid down. For Vangelis, the acts of composing and performing are indistinguishable from each other. With this improvisational, organic approach, he acts as a participant in the film responding instinctively to the scene to allow his music to be driven by his first impression of the images [19].

7 CONCLUSION

Though subtle, and without the viewing public's conscious awareness, the Turing machine reverberates throughout Vangelis' Score for Blade Runner [2]. The music in Blade Runner underscores the film's themes of questioning human behaviour in bio-machines, while in turn, using applications of the Turing machine to replicate human behaviours. Turing revealed that complex human operations could be imitated and performed by machines. Blade Runner's Replicants explore this notion demonstrating complex human behaviours and responses. Through digital sampling [21] (discussed in section 2), and the processing of audio signals, machines have been created to facilitate and enhance musical communication. Vangelis used the then new digital reverb machines to alter the sounds he generated to represent the themes in the film and to communicate new meanings. Using the extra long delay times that digital processing and reverberation algorithms enabled, he generated a previously unheard sense of depth and space to magnify Blade Runner's futuristic cityscape and milieu. Vangelis' compositional process embraced the digital machine and formal musical processes while using interactive strategies in a perception and action feedback loop to alter the musical outcomes.

REFERENCES

[1] A.M. Turing. "Computing Machinery and Intelligence", Mind LIX (236): 433-460 (1950).

[2] R. Scott (Director). *Blade Runner* [film]. In M. Deeley (Producer). United States: Warner Brothers (1982).

[3] J-J Nattiez. *Music and Discourse: Toward a Semiology of Music*, Translated by Carolyn Abbate, Princeton, USA: Princeton University Press (1990).

[4] J. D. Broesch, D. Stranneby and W. Walker. *Digital Signal Processing: Instant access*, Burlington, MA: Elsevier Inc., (2009).

[5] P. Doornbusch. "Computer Sound Synthesis in 1951 the music of CSIRAC", Computer Music Journal, Vol. 28 (No. 1 Spring): 10-25 (2004).

[6] H. Chamberlin. *Musical Applications of Microprocessors*. 2nd ed., Indianapolis, Indiana, USA: Hayden Books (1987).

[7] M. Lucibella. The American Physical Society website. [Online]. http://aps.org/publications/apsnews/201101/physicshistory.cfm. (2012).

[8] R. Leydon, Rebecca. "The Soft-Focus Sound: reverb as a Gendered Attribute in Mid-Century Mood Music", Perspectives of New Music Vol. 36 (No. 2 Summer): 96-107 (2001).

[9] N. Redman. The Earlevel Engineering website. [Online]. Available: http://www.earlevel.com/main/1997/01/19/a-bit-about-reverb/. (1977).

[10] N.A. Vallhalla blog. [Online]. Available: http://valhalladsp.wordpress.com/2009/05/30/schroeder-reverbs-the-forgotten-algorithm/. (2009).

[11] S. Lenham. Benden Sound Technology website. [Online]. Available: http://www.lenham.clara.net/sound/lexicon224p1.html. (2009).

[12] K. Spencer Allen, R. Preston, J. Sutcliff. Nemo Studios. [Online] http://www.nemostudios.co.uk/nemo/tour/recording/recording_br.htm. (2012).

[13] W. Shanks. Universal Audio website. [Online] Available: http://www.uaudio.com/blog/emt-250-electronic-reverberator-overview/. (2009).

[14] G.Petersen. Techfoundation website. [Online]. Available: http://tecfoundation.com/hof/06techof.html. (2006).

[15] R. Clews. Sound on Sound Website. [Online]. Available: http://www.soundonsound.com/sos/1997_articles/nov97/vangelis.html. (1997).

[16] N.A. Universal Audio website. [Online]. Available: http://www.uaudio.com/store/reverbs/lexicon-224.html. (2012).

[17] P. Doyle. "From *My Blue Heaven* to *Race with the Devil:* Echo, Reverb and (Dis) ordered Space in Early Popular Music Recording.", *Popular Music* Vol. 23 (No. Jan): 31-49 (2004).

[18] W. Coker *Music and Meaning: a Theoretical Introduction to Musical Aesthetics,* New York: Free press (1972).

[19] N.A. Nemo Studios website. [Online]. Available: http://www.nemostudios.co.uk/bladerunner/. (2012).

[20] H. Vaggiona. "Some Ontological Remarks about Music Composition Processes", Computer Music Journal Vol. 25 (No. 1 Spring): 54-61 (2001).

[21] H. Robertson. Digital Audio Sampling website. [Online] http://www.videomaker.com/article/14524/ (2010).

Beyond Computable Numbers Revisited

Ernest Edmonds[1]

Abstract. This paper reviews the crucial influence that Alan Turing has had on art and, in particular on the development of the Generative Arts and the employment of automata in the making of art. The paper briefly reviews the concept of using automata in art and the extension of the basic idea to include interaction. The paper revisits an earlier argument and homage to Turing and brings it up to date.

1 INTRODUCTION

The most important contribution that Alan Turing made was in his 1937 paper [1], in which he proposed a full account of computation illustrated by what has become known as the Turing Machine. As Jack Copeland put it: this paper "contains his most significant work. Here he pioneered the theory of computation, introducing the famous abstract computing machines soon dubbed 'Turing machines'" [2:6]

Turing's contribution was his most significant to art as it was to our culture and our lives more generally. This abstract machine was shown to be able to compute anything that could be finitely defined, given a particular point of view. This point of view was subsequently taken as the received position and pointed directly to the possibility of constructing real machines. These machines became known as 'computers'. The abstract machine that Turing invented might more correctly be termed an 'automaton', a mathematical model of what we know as a 'computer'.

'Automata' comes from the Greek for 'self-acting'. Automata, then, are machines (sometimes abstract mathematical ones and sometimes physical ones) that perform some set of actions in sequence on their own, normally without human intervention. Automata, as real machines, are sometimes associated with surrealism and this raises the thought "what is the relationship between Turing's ideas and surrealism?" This relationship is curious, but interesting.

Wiszniewski, Coyne and Pierce addressed the issue, contrasting the Turing and surrealist positions: "Alan Turing worked with and invented machines … Though at opposite ends of the philosophical spectrum, aspects of Turing's machines also resonate with the quasi-mechanical devices of the surrealists." [3]. Of-course the surrealists were directly opposed to the rational use of logic that was central to Turing. However, in discussing dreams in *The Manifesto of Surrealism*, Breton said "… when it is subjected to a methodical examination, when … we succeed in recording the content of dreams … we may hope that the mysteries … will give way to the great Mystery" [4]. Breton might have been very surprised, but probably not very pleased, to see that the application of the automata that Turing gave rise to have contributed towards this methodological examination.

2 AUTOMATA AND ART

Crucial to the Turing machine was the concept of computation and the finite definition of processes that could 'calculate' any 'computable' number. These concepts arose out of a long and difficult journey that had taken place in philosophy and the foundations of mathematics in which, for reasons that we will skip in this short paper, even the reliability of arithmetic had been called into question. The history is briefly summarized, with references, in [5].

For art, computation introduced a wholly new possibility: that of defining a making, designing or construction process in a finite way that could lead to an automatic method of making the artwork itself. The possibility of automata making art became a reality. A certain mystery could be removed from aesthetic dreams.

In many ways the idea of automata making art could be seen as an answer to the constructivist dream of replacing 'composition' by 'construction' [6]. In 1921 the constructivists had turned their back on 'composition' and the strong concentration of the arrangements of colour and form that made up the appearance of the final art object. In stead they advocated a constructive approach in which, by one means or another, the artist defined the construction of the work and left the final appearance to be determined by the consequences of that process.

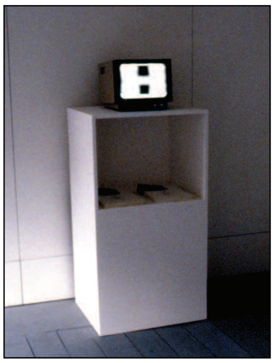


Figure 1. Fragment in Exhibiting Space, 1985

Once computers became used in art, and the consequences of Turing's ideas had been absorbed by artists, the form of art, now known as 'Generative', appeared [7]. Generative art is one of the notable new art forms that arose in the twentieth century. Here, the artist specifies a set of rules, they may relate to A-life that Turing also, in effect, researched [8]. A

[1] De Montfort University, Leicester, UK and University of Technology, Sydney, Australia. Email: ernest@ernestedmonds.com

computer then uses the provided rules to construct or compute the artwork Often it is time-based and the audience watches or listens to the generative process. Unlike a film, of-course, a time-based generative work can go on forever without looping.

The author's own first time-based generative work was made by recording directly onto video. It is called 'Fragment', made in 1984-5 and first shown in his one-person exhibition at Exhibiting Space, London, in 1985, see fig.1.

3 'BEYOND COMPUTABLE NUMBERS' REVISITED

In his 1937 paper, Turing recognized that a human could influence the processes defined for his machines to follow. In other words, he saw that an interactive version of the Turing Machine was possible, although he chose not to deal with it within that paper. This is much like the interactive computer of today.

The author gave an Inaugural Professorial Lecture on the topic of Alan Turing's influence on art at Loughborough University, UK, in 1987 [5]. The lecture was titled "Beyond Computable Numbers". In it, it was argued that the implications of Turing's 1937 paper went far beyond technology and its economic exploitation: "the most significant implication…might finally be seen in the constructs of the artist." The systems used by Kenneth Martin in his art were presented as an example and pointed to the importance of interaction and the interactive art that can be seen as an extension of such art practice.

Since 1987, Generative Art and Interactive Art have both grown very strongly. See, for example, the range of work reported in the recent book "Interacting" [9]. Burraston, for example, has worked extensively with automata (a kind known as 'cellular automata') in generating new music and has evolved new forms of music in that process. His research into the use of automata in music making has even extended our knowledge of the automata themselves [9:112].

Seevinck looked in depth at interaction with her computer-based artworks and considered some very specific issues in relation to participant experience [9:242-256]. She showed how the interactions with the automata like artworks could lead, for example, to the experience of 'emergence' by participants and she made this a central concern of her art. Participants can discover, or perhaps create, new forms as a result of the interactive process. So interaction with automata can yield new kinds of experiences in art.

In the author's own work, he has continued to make time-based pieces that use the generative processes that Turing's ideas enabled. The processes have been interactive ones where external events. Typically sound or motion, have modified the process or the rules determining that process.

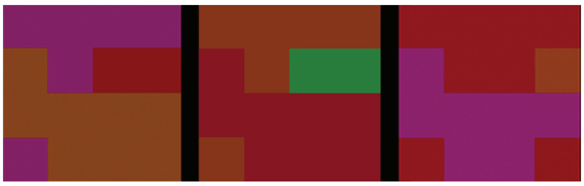


Figure 2. Three Stills from Shaping Form, 2012

These works are designed to interact with the environment in which they are found. They work with structural relationships between visual elements that determine how these images are constructed. The works are made to learn from external movement such as a hand waving or a person walking by. The way it 'learns' determines the choice of colour and pattern in the images displayed as well as the timing of changes. Fig. 2 shows some still images from one of these works.

The behaviour of the work is not intended to always be obvious, so that if you continuously try to force a response by waving or shouting, that might result in a period of stillness. A computer program continuously analyses movements detected in front of the work. As a result of this analysis, the rules are steadily modified in a way that accumulates a history of experiences over the life of the work. The shaping of the form is a never-ending process of computed development.

4 CONCLUSION

Alan Turing enabled the development of the generative arts, including interactive art. Whilst it is important to recognise the significance of Turing's vision and contribution to artificial intelligence and artificial life, for example, that vision was, in fact, a result of an open and intelligent deduction of the inevitable consequences of his discovery and inventions in formal computation.

The whole idea of formal computation, which is embodied in the machines that we know as computers, has brought a new form into art practice and continues to offer new directions for artists to explore and exploit. Artists are building automata that generate artworks. Far from being surreal, this is extending the role of the rational into deeper parts of the art making process.

REFERENCES

[1] A. M. Turing. 'On Computable Numbers with an Application to the Entscheidungs Problem' *Proceedings of the London Mathematical Society* Ser **2**-42. 230-265 (1937).

[2] B. J. Copland, (ed) *The Essential Turing*, Oxford University Press, 2005.

[3] D. Wiszniewski, R. D. Coyne and C. Pierce, 'Turing's Machines', *Proc. ECAADE99: Turing to 2000*, Liverpool. 25-32, (1999).

[4] A. Breton, 'Manifesto of Surrealism'. English translation in R. Seaver and H. R. Lane (translators) *Manifestos of Surrealism: Andre Breton.* University of Mitchigan Press, 2-28, 1972

[5] E. A. Edmonds, *Beyond Computable Numbers: Inaugural Lecture*. Loughborough University of Technology, 1987. Published in a revised form as 'Culture, Knowledge and Creativity - Beyond Computable Numbers'', *Languages of Design*, **1** (3), 253-261, (1993).

[6] M. Gough. *The Artist as Producer: Russian Constructivism in Revolution*, University of California Press. 2005

[7] P. Brown, (ed) Special issue on Generative Art. *Digital Creativity*. **14** (1) (2003).

[8] A. M. Turing. 'The Chemical Basis of Mophogenesis' *Transactions of the Royal Society*, Series B. 37-72, (1952).

[9] L. Candy and E. A. Edmonds (eds) *Interacting: Art, Research and the Creative Practitioner*, Libri Press, Oxfor. 2011.

Biographies

Keynote: Clare Beavan

Clare Beavan is an Emmy award-winning drama and documentary director and producer with 20 years experience. She was the director of the docudrama on Alan Turing, *Britain's Greatest Codebreaker* broadcast on Channel 4 in 2011 and SBS in 2012. Her works have been broadcast on major networks in the United States, the United Kingdom, and Australia.

Guest speaker: Scott Wilson

Dr Scott Wilson is a Senior Lecturer in the Music Department at the University of Birmingham, where he teaches composition and works with the Birmingham ElectroAcoustic Sound Theatre (BEAST).

Gráinne Kirwan and Brendan Rooney

Dr. Gráinne Kirwan and Dr. Brendan Rooney are Lecturers in Psychology in the Institute of Art, Design and Technology, Ireland. They both teach on the MSc in Cyberpsychology, as well as the undergraduate BSc (Hons) in Applied Psychology. Dr Kirwan's primary areas of research are forensic psychology, virtual reality and cyberpsychology. She has recently co-authored "The Psychology of Cyber Crime" with Andrew Power. Dr. Rooney has recently completed his PhD exploring perceived apparent reality and its relationship to emotional engagement with film. He is also currently chair of the Psychological Society of Ireland's Special Interest Group for Media, Art and Cyberpsychology.

Cate Dowd

Dr Cate Dowd is a lecturer in digital media studies at the University of New England, Australia. Her research is between media and computing with interests in the Semantic Web and social media alongside digital design concepts for journalists and public relations professionals as conceptual robotic agents. Cate has lectured at the University of Melbourne, Monash University and Swinburne University of Technology. She has a Master of Information Systems from Monash University on the digitization of television. She has also worked in broadcasting and film editing at the SAFC and Crawford Productions, and is a graduate from the Centre For Performing Arts, Adelaide, with a major in technical design. She is a member of the Society for Artificial Intelligence and Simulation of Behaviour and is the chair of the Turing Arts Symposium, conceived by her to celebrate Alan Turing's centenary.

Klem James

Dr Klem James studied French and German at the University of Manchester. His research focussed on the early twentieth century avant-garde, including Surrealist art and literature. His most recent research is on biomechanical hybridity in Surrealism including intersections with Turing's ideas. In Manchester he taught language and translation courses (in French and German) and engaged in research projects in literature at the universities of Oxford and Cambridge. He also spent a year at the Université de Bourgogne in France as part of his honours degree and a year at the Albert-Ludwigs-Universität Freiburg in Germany as a DAAD bursary holder. Prior to this, he completed a Postgraduate Certificate in Education at the University of Wales, Bangor. He is currently a lecturer in French at the University of New England in Australia.

Jeremy Stubbs

Dr Jeremy Stubbs teaches at the University of London Institute in Paris. He specialises in the twentieth century avant-garde, primarily Surrealism, and the history of psychology. Among forthcoming publications are a chapter on Surrealism in the *Cambridge Companion to the Literature of Paris*.

Colin Johnston

Dr Colin Johnson teaches in the School of Computing at the University of Kent in Canterbury. His research interests include bioinformatics, data mining, bio-inspired computing and computational creativity. He is also active in music and the arts, as a composer, multi-media artist and free-improvisation performer.

Biographies cont.

Jenny Game-Lopata

Dr Jenny Game-Lopata is a composer, saxophonist and lecturer with research interests in intercultural composition, music theory and improvisation. She has taught at universities throughout Melbourne and Sydney. She is currently a lecturer in music at the University of New England, Australia.

Ernest Edmonds

Professor Ernest Edmonds is founder of the Creativity and Cognition Studios at the University of Technology, Sydney. He is also Professor of Computational Arts at De Montfort University, Leicester, UK. He co-founded the ACM Creativity and Cognition conference series and has published widely on human-computer interaction, creativity and art. Recently he co-edited a book with Linda Candy: "Interacting: Art, Research and the Creative Practitioner". As an artist, he has exhibited and performed in the UK, USA, Germany, Belgium, Australia and Russia. His work can be found on the web sites of DAM in Berlin and the Victoria and Albert Museum, London

***

TURING ARTS SYMPOSIUM

Within The AISB/IACAP World Congress 2012
Birmingham, UK, 2-6 July 2012

Editors: Cate Dowd and Klem James

Keynote Speaker: Clare Beavan