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SCIENCE IN THE FOREST, SCIENCE IN THE PAST II

As perceived, not as known: digital enquiry and the art of intelligence*

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> ἐὰν μὴ ἔλπηται ἀνέλπιστον οὐκ ἐξευρήσει, ἀνεξερεύνητον ἐὸν καὶ ἄπορον. ('If you do not expect the unexpected, you will not find it; for it is hard to be sought out and difficult')
>
> Heraclitus (DK 18).

1. Introduction

What happens when you use a digital machine to explore a serious question and somehow, during the interactions that follow, find yourself with a result that is or promises to be significant? What role might the rule-bound machine have? For the last several decades, work in the cognitive sciences and in anthropology has variously argued for embodied, extended or distributed systems of doing thinking with the world's affordances; in his influential theory, Gibson compared such thinking with the life of an animal in its ecological niche.[1] What part might the switching circuits of the digital machine be playing in our niche, and how do they play it?

Though these are not particularly easy questions, their aim is relatively modest and has been pursued for decades. But my reason for posing them is only preparatory, to elicit sufficient knowledge about the machine that will allow me to shift attention from the usual subject–object perspective to the cognitive betweenness of the human–machine relation. What I mean by this will become clear, or at least clear enough for me then to advance the question I really want to ask: how might the combinatorial potential of these switching circuits be deployed, not merely to vend information (what we usually do with them) or mimic some aspects of human behaviour (the dominant aim of AI),

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[1]Gibson 2015/1979, 120–1. For the 'extended mind' hypothesis, see e.g. Jianhui (2019), Menary (2010) and Lenoir (2007); for the related 'distributed cognitive systems', e.g. Perry (2017), Giere (2002) and Hutchins (1995); for 'embodied cognition', Wilson and Foglia (2017). In anthropology, see Ingold (2010) and Gell (1998, Chapter 9). The phrase 'doing thinking' is Mahoney's (2011, 87).

but to meet an enquirer's thought-processes half-way, with all the alterity of a very differently constructed and surprising 'intelligence'?[2]

Full disclosure: I start from the simplifying assumptions that the user is an allegorical Euro-American Everyman and that the machine in question is the current model, designed to match Everyman's needs if not awaken or even create them. My wager is that these parochial assumptions will allow me economically to reach to something that is not so culturally limited as I am apt to be, indeed to something fundamental. To make this reach, I call for help on three analogies – to ordinary conversation, laboratory research and traditional divination.[3] My belief is that by drawing them together 'some understanding is possible, however incomplete, provisional, and revisable that is' (Lloyd 2019, 38).

Background to my bridge-building attempt is an interdisciplinary effort over a number of years to bring long-established disciplines within reach of the nascent digital humanities in order to suggest new possibilities of action for a more broadly conceived and intellectually serious discipline. Hence, most obviously, the length of the study, its bibliographic exuberance, the necessarily brief treatment of several areas of research and the not inconsiderable risks.

First, in Sections 2 and 3, I scrutinize those switching circuits and what can or might be done with them. Then, in Sections 4–6, come the analogies. Conversation leads off. I consider work in sociolinguistics and in the evolution and development of intelligence to bring out aspects of 'talk-in-interaction' (Schegloff's term), especially important for modelling human–machine relations.[4] Laboratory science comes next. Studies in its history and cognitive psychology illumine the obvious parallel to computing in the investigative, epistemic use of physical instruments. Finally divination. Its primaeval, world-wide and highly diverse practices likewise offer a way of seeking answers to questions by physical means. But crucially these practices add the badly needed reach beyond the parochial, to the historical and cross-cultural depth of an intensely studied anthropological phenomenon. Divination thus challenges and enriches current, differently technological means. I consider these analogies one by one, then I align them, in Section 7, to sketch out a possible common ground. Section 8 concludes.

2. The machine

The standard account of enquiry by computer centres on *modelling*, that is, recursively making, probing and changing a digital likeness of something.[5]

[2]From the perspective of computer science, see Winograd (2006). On alterity, see Taussig (1993), Castoriadis (1987/1975, 178), Levinas (1999/1995), cf. Auerbach (2003/1953).

[3]Other analogies than the ones I have chosen would be fruitful to explore but could not be included for want of space, e.g. weaving and related practices, with connections to studies in symmetry, art history and anthropology, among several other fields.

[4]Turing (1950), Kay (1969) and Hutchins (1987). See also Neale and Carroll (1997).

[5]See McCarty (2019b), Ciula et al. (2018), McCarty (2014/2005) and Morgan (2012). For simulation, in relation to modelling, see McCarty (2019a).

I prefer 'modelling' to 'model' because the verbal noun places strong emphasis on an open-ended, enquirer-inclusive process and the ongoing manipulation of software with which it is done. 'Model' suggests a stable, theory-like object, something that will suffice. Modelling, closer to metaphor in its instability and emphasis on difference,[6] creates a dynamic three-way relationship of object, model and modeller and so is interpretative at every step. It happens in three normally recursive phases: translating the object of interest into binary data and one's questions into software; manipulation of the data by hardware; and interacting with the machine to make sense of the results. This essay is concerned primarily with the last and least well-understood phase, when scholar and machine get close, and something involving both takes place. Rather than focus on interaction with an autonomous AI, such as may be, I prefer to think towards a *relational* intelligence, created in the asymptotic and asymmetrical convergence of human mind and computational affordance.[7]

To get there, I begin with Edsger Dijkstra's good advice: to shift attention from the user-friendly interface back towards the hardware, bypassing the many layers of accommodating software (1986: 48). I stop, short of the electronics, at the 'level of abstraction' (Colburn and Shute 2007) at which the machine's unaccommodated and unaccommodating contributions to such relational intelligence become visible. Of course, we need these layers of systems software in order to render the power of digital computation usable for the kinds of problems that concern us. But at the same time, their net effect, indeed their purpose, is to hide what the machine actually does, and so to conceal any 'implementation trace' or imprint the hardware might have on what the machine does.[8] Although whatever may be said to be *of* the machine must also be *of* its human maker, the machine as a work of art is paradoxically capable of deeply estranging effects. Polish artist Bruno Schulz once described the role of art as 'a probe sunk into the nameless' (1998, 369–70). I argue for the machine's potential to play a like role in relation to ourselves. It can indeed *surprise* us (who know not ourselves terribly well). By means of it, *we* can surprise us in surprising ways.

In his 1950 provocation on machine intelligence (Gandy 1996), Alan Turing wrote that if we are caught in error by the machine, or if we take the occasion to surprise our conscious selves, 'no credit on the machine' accrues, but when by its relentless thoroughness, it illumines that which our expectations prevent us from seeing, we glimpse a different vista of mind (Turing 1950, 450–1). Why is

[6]I echo Evelyn Fox Keller's insights in Keller (2020); see also the commentary on it in *Interdisciplinary Science Reviews* 45.3.
[7]On human relations (which is where we begin), see Strathern (2020); with machines, Goffey (2008).
[8]There is an argument here, for which see Turner and Angius (2020, 50) (pdf version). I side with Colburn and Shute (2007); see also Kittler (2013, Chapters 15–16), Kirschenbaum (2008), Evens (2015), Chesher (1997); also Parhami (2003) for a specific example.

this so? Expectations are not the problem, for without them is no surprise, no hinterland at the liminal borders where the new can be perceived or created.[9]

Another way of dealing with the human–machine relation is to take it in the same way Evelyn Fox Keller suggests we consider the question of whether molecular biological constructs are alive: that it is not so much a philosophical as 'a historical question, answerable only in terms of the categories by which we as human actors choose to abide, the differences that we as human actors choose to honor, and not in either logical, scientific, or technical terms' (2002, 294). The move that I will be recommending is to constrain choice by the specific determinants of the machine and the differences these make, then to work out what sort of a cognitive relation is possible.

Before that, however, we must remain focused on the machine at that level of abstraction, to consider its hardware-determined *nómos*.

3. Multiple choice, revision, complexity and combinatorics

To strip away familiarity, we begin with digital hardware and logico-mathematical software (footnote 7). Hardware provides software with a remarkably frugal set of instructions. Roughly speaking, these allow a programme to carry out primitive arithmetic and logical operations on binary data, store the results in memory, move data from one location to another, change the order in which operations are performed and handle input and output.[10] That's all. But perhaps the starkest and for the scholar, the most immediate lesson is delivered by preparing an object of study for processing, i.e. translating it for input according to the machine's Procrustean all-or-nothing template (cf. McCarty 2019c, 153). This template requires that everything to be processed, in every detail, must be rendered according to what I call the axioms of digitization: *complete explicitness and absolute consistency of representation.* Doing that should effectively shatter 'the idealised and serene process that we imagine' or comfortably assume computing to be (Hasslacher 1995, 391).

The question then to be asked hardly needs spelling out: what contributions to a relational intelligence can possibly emerge under those conditions? In what terms can we conceive a relation between ourselves and such a device? But a better question is Marilyn Strathern's: 'the kind of connection one might conceive between entities that are made and reproduced in different ways – have different origins in that sense – but which work together' (2005, 37).

[9]See e.g. Kolmogorov's notebook entry in 1943 on the 'fine layer between the "trivial" and the impossible' where mathematical creativity takes place (Shiryaev 2000, 50); Huron on listeners coming to expect the unexpected in modernist music (2007, 333 and *passim*; cf. Merton 1968, Chapter 13); also the literature on creativity, e.g. Kaufman and Sternberg (2010) and Kirsh (2014); Hyde on the cultural history of the trickster (1998).

[10]Thanks to Manfred Thaller for this point (private e-mail, June 10, 2020), given detailed exposition by Hennessy and Patterson (2012, Appendix A), and broader context in relation to combinatorics by Fodor (1983, 29). I consider only the so-called von Neumann architecture of hardware here.

In his last lecture, John von Neumann laid down the implicit challenge in physico-mathematical terms. Based on 'logics and mathematics in the central nervous system … viewed as languages', he concluded that 'whatever the system may be' by which the brain communicates, 'it cannot fail to differ considerably from what we consciously and explicitly consider as mathematics' (1958, 82). This difference remains 'one of the outstanding unsolved problems of theoretical neuroscience'.[11] It suggests a trajectory for our enquiry that, unlike much current work in artificial intelligence, strives to highlight rather than downplay or ignore fundamental differences (cf. Watson 2019). Brought to light, such differences would provide a cogent basis from which to imagine and develop a relation that entails neither a distortion of the human nor a diminishing of the machine. What do we see when we get close enough to the machine to see these differences?

3.1 The semi-opaque 'black box'

The frugal vocabulary of hardware (its 'instruction set') does not give us much help in understanding what software can do, likewise the severely reductive constraints of its binary template. Understanding comes, rather, from the art of programming, that is, from the skilled making of things, step by step, with that vocabulary of instructions under their defining constraints. For my purposes, the most economical statement is provided by Herman Goldstine's and John von Neumann's 1947 report on what programming the machine might involve.[12] Their central insight was that programming the machine 'is not a static process of translation, but rather *the technique of providing a dynamic background to control the automatic evolution of a meaning*'.[13] This background can specify a linear, fixed sequence of operations to be followed, mimicking the simplest mechanical device. But the power special to the digital machine, they point out, is realized when software allows non-linear operations by exploiting two crucial abilities provided in hardware: first, to interrupt the sequence of instructions conditional on the outcome of prior events, such as results from computations or (especially significant in later developments) external triggers or 'interrupts'; second, to rewrite instructions during the course of programme execution.[14]

[11] Wells (2007, 1); cf. Israel and Millán Gasca (2009, 162–5).
[12] Goldstine and von Neumann (1947); cf. Goldstine (1972, 266–70). The machine they had in mind had not yet been built and was not operational until ca. 1952. See Knuth and Pardo (1976, 16–20), Aspray (1990, Chapters 3–4 and esp. 63–72), Campbell-Kelly (2011, 24–8); Gramelsberger (2011, 138–9), Chun (2011, 25, 191 n. 27), Israel and Millán Gasca (2009, 149). Hagen compares their flow-diagrammed scheme to a musical score (2006, 167–8).
[13] Goldstine and von Neumann (1947, 2, my emphasis). They do not stop to define 'meaning' but seem to have in mind something like significance for the problem at hand.
[14] Mark how close these non-linear operations are to what we do in conversation and in other uses of language (J. C. Meister, e-mail, December 27, 2019). The analogy to conversation is indeed quite strong.

When fully realized, that is, although the capabilities of hardware, the data to be worked on, the software instructions that might be executed and the results are all knowable, how these results are achieved is not, nor in general can we reliably predict what they will be. One could step the machine through each instruction one by one; the instructions could be printed out for inspection; but the complexity of the whole at speed would overwhelm any observer. Note especially 'complexity' and 'at speed'.

3.2. Complex, chaotic, random

When our purpose in using such a machine is to match whatever it models closely (e.g. tomorrow's weather), reliable prediction is primary; surprises are likely to indicate deficiencies of information, errors in software or the need to adjust or rethink the model. But when the aim is to work out what something might be were conditions other than they are, to help imagine what we do not know (McGann's phrase), then software can be tuned, as hardware makes possible, to admit surprise, to edge somewhat closer to disordering or innovating randomness 'at *the edge of chaos* … the constantly shifting battle zone between stagnation and anarchy, the one place where a complex system can be spontaneous, adaptive, and alive'.[15] In consequence of this controlled tuning or relaxation of constraints, the system becomes capable of manifesting 'complexity' in the technical sense: in simplest terms, the behaviour characteristic of a non-linear system in which interaction among components predominates.[16] As a complex system, given the speed at which machines now operate, its actual operations are doubly unknowable, that is, unpredictable and irrecoverable after the fact. But the important point for the questions I am raising here is that precise knowledge of the sequence is irrelevant.

Ordinary online searching provides a familiar example. It is enacted by two agents: the search engine, whose strategies are defined and carried out by its algorithms, and the enquirer, whose words or phrases indicate or gesture towards something. Both query and strategy evolve as the enquirer adjusts the search and tries again. In very different ways and senses, both engine and enquirer learn, each from the response of the other. In addition, an engine (such as Google's) 'learns' from the queries and responses of all who have used and are using it and register their preferences silently by the choices they make.[17] Within calculated limits, uncertainties and surprises, once regarded as problems to be solved by supplying better information, become possible opportunities. For most of us doing research with the aid of online resources, the former goal (to converge on a right or optimal answer) has

[15]Waldrop (1992, 12); see also Chapter 6 and Langton (1992).
[16]Holland (2014) and Gallagher, Appenzeller, and Normile (1999). For self-organization, see esp. Keller (2008; 2009).
[17]Brin and Page (1998). For 'machine learning', see Watson (2019).

been overcome or at least seriously demoted in consequence of the literally exponential growth of data in volume, dynamics and variety. In this way, we are nudged if not pushed to go wide rather than deep and so to act in accord with the belief that 'the more integration between … [diverse] descriptions, the better is our understanding of the object identified by any of those descriptions' (Rorty 2004, 24).

In general, then, vast amounts of data and fast machines are capable of constituting and modelling phenomena described in the vocabulary of 'complex systems'.[18] These systems (such as the Internet or phenomena we view as systems, e.g. the weather, eddies in a stream, an ecological niche or social group) are characterized by 'chaotic', seemingly 'random' behaviour. In complexity theory, these terms are used neither in the ordinary nor metaphysical senses; rather they denote unpredictable behaviour observed to arise in deterministic systems that are very sensitive to small changes.[19] Such systems turn out to be where you may not expect them to be (e.g. the swirling water in your kitchen sink), once you look with complexity in mind.

For the outsider, this terminology throws up difficulties. The three key words – 'complex', 'chaotic', 'random' – are rarely explained. No one definition of any of them has achieved consensus. Usage differs considerably across the mathematical, physical and computational domains in which they are to be found.[20] Nevertheless, they are about something recognizable and important; their study has changed the natural, social and computational sciences radically and has had considerable influence more broadly. Allow me to suggest that historically the invention of the digital machine led to rapid growth of studies in what became the sciences of complexity by providing a matrix (as if made for the task) within which dynamic models of systems perceivable or discoverable as 'complex' could be constructed. To put the matter another way, it seems evident that the non-linear modelling power of the computer provided nigh irresistible inducement to look at old things in a new way, as *complex*, and to bring to light complexities previously unnoticed in the sciences – phenomena that are orderly but 'chaotic', paradoxically revealing structure and evading closure.

In the hands of its developers, the machine did more than that, however, as Peter Galison tells the story of its earliest uses: 'In the baldest possible form: the computer began as a "tool" – an object for the manipulation of machines, objects, and equations. But bit by bit (byte by byte), computer designers deconstructed the notion of a tool itself as the computer came to stand not for a tool, but nature itself' (1996, 156–7). The blurring he describes – or, one might say,

[18]For observations from the mid-nineteenth century, see Alligood, Sauer, and Yorke (1996: vi–vii) and Keller (2009). For 'chaos', see Bishop (2017, 3–6 (pdf)) and Smith (2007); for 'complexity', Holland (2014).

[19]Stewart (1989, 16f); Hao (1989, 1–4), Lorenz (1993); for the history of the idea, Keller (2008; 2009) Alligood, Sauer, and Yorke (1996: vi–viii).

[20]On the difficulty of definition, Hao (1989, 4) and Shermer (1995, 71f); on mathematical, physical and computational definitions of chaos, Smith (2007, 53–7, Chapters 4 and 6).

following Lloyd (1991) and Rochberg (2016), the recovery of 'nature' as an invented, culturally contingent way of seeing the world – is the further point. For this reason, I suspect, we find a qualifying language of *seeming* running through explanations in the empirical sciences of complexity: the language of what can only be known *from appearances*, the observable result of unknowable operations. I note the crucial importance of visualization (i.e. making visual by mathematical means) to the spread of these sciences; the lack of agreed definitions and diversity from discipline to discipline; the inclination to settle for 'a working or operational definition' of key terms (Hao 1989, 4); and the 'I know it when I see it' defence (Miller and Page 2007, 4). All these, I suggest, point to the uncertainty fundamental to a world seen as complex and to the modeller-builder's approximate, incomplete but progressive step-by-step depicting of how it works. Consider that a machine which to be useful requires us to engage in modelling, and which thus weakens the nature/culture dichotomy, frames a constructivist's perspective on everything.[21]

As with the molecular geneticist Jacques Monod's elegant scheme of the complex adaptive machinery of life (1972/1970), in which genetic necessity is animated by cosmic chance, all complex adaptive systems are in their way made possible by boxing in the randomness of the chaotic that animates them. But note: like 'chaos', 'random' eludes agreed-upon definition; it frustrates 'our pattern-finding instincts', throwing up a barrier to an intuition that has been shaped by our natal culture.[22] 'Random' is further refracted necessarily in its mirroring of the differing concepts of order it violates across particular needs, disciplines, historical periods and cultures. In ordinary usage, 'random' denotes the haphazard, the aimless, directionless and purposeless (*OED*; Keynes 1921, chapter 24). In computer science, it is, again, a term of seeming, qualified to mean the absence of any *discernible* relation between a number or object and any other in a digitally generated sample.[23] Hence, a provisional definition of 'random' might simply be the state of something beyond our ability to conceptualize, and 'randomization' the process of approaching or achieving that state.

We are left, then, with the dialectic of surprise and expectation, or in the language of complexity theory, at 'the edge of chaos', in 'an essential tension which keeps the ongoing dynamics on an indefinitely extended transient, far from equilibrium'.[24]

One further bit of mathematics remains.

[21]For a lucid account of computational worldmaking with 'complex adaptive systems', Lego-like brick by Lego-like brick, see Holland (1998), cf. Miller and Page (2007) and for the relevance of Lego, Cook and Bacharach (2017) and Dawson, Dupuis, and Wilson (2010).

[22]Seife (2014, 50). On randomness, see Beltrami (1999), Bennett (1998), Lorenz (1993), Brown and Keene (1957), Keynes (1921, chapter 24) and Poincaré (1914/1908, 64–90). Cf. Johnson (2015), Wagner (2012) and Dennett (1995). Note Thom's demand that we scrap the whole idea of randomness (1980: 1).

[23]Knuth (1998, 2); also L'Ecuyer (2004, 37) and both for the practical uses of random number generation.

[24]Langton (1986, 129) and all of *Physica D* 22 for context; cf. Waldrop (1992).

3.3. Combinatorics

To review: 'complex' characterizes phenomena considered as systems of interrelated parts in non-linear relation to each other; 'chaotic', a dynamical state complexity makes possible; 'random', the apparently disconnected relation of one datum to another. To these, I add 'combinatorics', or analysis of 'combinations of objects belonging to a finite set in accordance with certain constraints'.[25] It is the mathematics closest to what the enquirer does with the help of software (cf. von Neumann 1951, 16; Fodor 1983, 29). It is, Claude Berge explains, 'a matter of "configurations" which arise every time objects are distributed according to certain predetermined constraints'.[26] 'With combinatorics, one looks for their intrinsic properties, and studies transformations of one configuration into another, as well as "subconfigurations" of a given configuration' (Berge 1971/1968, 1–2). If you see serious, studious play at work here, you understand.

Again my question: how can behaviour we recognize as intelligent arise from or in relation with a device restricted to a radically frugal instruction set and restricting all input to complete explicitness and absolute consistency? We have unnecessary difficulty with this question, I think, because we expect theoretical depth as a precondition of significance and a sign of intelligent behaviour. We tend to look for explanation of computational results supposing that they are governed by fundamental law-like abstractions, but what we get, in the situations of complexity normal to the machine (Goldstine and von Neumann 1947, 2), is not like that: no law-like adherence, rather constraints which define the machine's recombinatorial potential. In any case, combinatorics in its simplicity and practicality rules out theoretical depth, hence the long-standing complaint of mathematicians.[27] But with the spread of digital computing and cross-cultural studies in the history of combinatorics and anthropology of mathematics (Pais 2013), denigrations have become ever less credible and ever more difficult to hear. Insofar as computing is concerned, attention needs to shift from explanation and search for meaning in the results to their utility, from the depth of theory to breadth and power of utility.

Consider combinatorial board games – draughts, chess and *go* (Chinese *weiqi*), for example.[28] Studies of these illumine how genuinely creative scholarly enquiry with the digital machine is possible. The board game gives us the

[25]*OED* s.v. See Wilson and Watkins (2013) and Lovász (2005); for computer science, Lovász, Shmoys, and Tardos (1995).
[26]For Berge, see https://bademian.wordpress.com/2012/10/06/a-tribute-to-claude-berge/ and Rota's Preface in Berge 1971/1968. Berge was a founding member of l'Ouvroir de Litterature Potentielle (Oulipo) and its most important mathematician; see Motte (1998/1986).
[27]Kleitman (2000, 124); cf. Berge (1971/1968) and Kung (1995). For its history, see Bréard (2015), Wilson and Watkins (2013), Netz (2009) and Biggs, Lloyd, and Wilson (1995). For combinatorial reasoning, DeTemple and Webb (2014); for the relation to ethnomathematics, Ascher (1991); for the relation to games, Conway (2001) and to divination, David (1962).
[28]Fairbairn (2007) and Finkel (2007 *passim*), Conway (2001), David (1962), cf. Nicolau (2009) and McCarty (2019, 154).

physical constraint of the board and the objects to be rearranged on it; in addition, it gives us a set of simple rules to be followed in rearranging them and a definition of a winning configuration. Complexity, sometimes profound, sometimes innovative, follows, as the histories of chess and *go* demonstrate. 'As with seeds', Holland observes, 'much comes from little' (1998, 1). To follow his metaphor, if the seed's genomic material is the board, game-pieces and rules, then the player is the epigenetic environment shaping how the possibilities of development play out (but cf. Keller 2020). Note that randomization, productive of surprise, is only sometimes explicit (e.g. in Snakes and Ladders and Monopoly) but is plausibly among the cognitive factors in a player's choice of moves in such games, given that these factors are unobservable and so may appear 'random' to observers, or indeed to the instinctual player.

The machine's combinatorics at speed offer a uniquely practical way of applying the mathematics to those phenomena that, in the words of the Manhattan Project historian David Hawkins, are 'too far from the course of ordinary terrestrial experience to be grasped immediately or easily', or, indeed, at all.[29] From that thought, it is a short step to prosthetic, tele- or microscopic metaphors pointing into a future (in the language of the later *Star Trek*) 'where no one has gone before'.

In sum, the mathematics of the machine shows us, for indefinitely many worlds constructible in its terms, a tunable, agile ability to defamiliarize what we thought we knew and how we knew it – indeed, to unsettle knowing, to knock us back to perceiving. It is at such moments, wondering how to grasp the situation, that the interdisciplinary and cross-cultural imperative points the way.

It's time, then, to tune in to those analogies and the immensely helpful worlds of scholarship they bring into focus. But I must ask for your patience. I make my case for their relevance at the end.

4. Conversation

Conversation, especially the ordinary kind, is a seemingly humble subject. But it is a rich and consequential area of study, relevant to the third phase of computing, when we cast it as interactive *languaging* with others and ask what comes of such talk. Languaging became a sociolinguistic specialism in the wake of J. L. Austin's work on 'performative utterances'[30] and the subsequent writings of Emmanuel Schegloff and others in the field that emerged from their empirical attention to 'talk in interaction', finding in it a site of coordinated and

[29]Hawkins (1946, 76); cf. https://www.atomicheritage.org/profile/david-hawkins (March 4, 2019).
[30]Austin (1962). See Wisdom, Austin, and Ayer (1946, 173ff) for the philosophical context; cf. Swain (2006) and Markoš, Švorcová and Lhotský (2017). On recent cognitive neuroscience of languaging, see Anderson (2014, Chapter 7).

contextually rich social action.[31] Hence, Conversation Analysis (CA). But however rich a lode, empirical observation of conversational exchange gets us only so far (Dale et al. 2014): the participants' frame of reference remains tacit,[32] and in what can be observed, Esther Goody notes, there is 'strong evidence for the patterning of interaction *on a level of which we are not aware* … communicative microstrategies which permit delicate adaptation to each other's responses … ' (1995, 22; cf. Pask 1961, 35). The 'recipient-designed' conversational moves discovered in CA point off-stage to more than can be transcribed, including but not limited to the conversational actors' physical response, e.g. in expressions or gestures (Turnbull 2003, 42; Anderson 2014, 256–7). Nevertheless, as I suggested earlier (footnote 14), the non-linear possibilities permitted by computational hardware and the common experiences of talk-in-interaction align. Can we pick out an originating imprint of ordinary human conversation in Goldstine's and von Neumann's conception of that 'dynamic background to control the automatic evolution of a meaning'?

CA, valuable as it is for my concerns here, does leave us wanting at the threshold. We need to stretch the notion of the interaction which it documents in order to capture the cognitive intimacy, moment-by-moment coordination, synchronization and performative modification that close analysis of conversation actually suggests.[33] Perhaps an analogy to musical performance in terms like 'resonance' and 'improvization', suggested in the mid-1970s for human–computer relations (Thompson 1974, 227) and subsequently for conversation,[34] is much closer to what happens, more *conversational*, more faithful to the 'mutual *tuning-in* relationship' or 'repertoire in action', than 'interaction'.[35] But, given that the word is everywhere in use, I recommend stretching rather than abandoning it, to include both improvization and resonance.

Coming from a very different direction, recent evolutionary research on the startling growth of hominid intelligence reinforces the creative role of conversation. This research shows that the evolution of primate cognition may well have been powered by languaging and other communicative actions in the negotiation of social encounters among gregarious hominids. Thus, the so-called Machiavellian Hypothesis that 'social intelligence' originated in efforts

[31]For early attention to conversation as a model of interactive behaviour, Reichman (Adar) 1986. For a history of conversation analysis (CA) in linguistics, see Fox et al. (2013); for CA overall, Sidnell and Stivers (2013) and Schiffrin, Tannen, and Hamilton (2001); in studies of intelligence, Goody (1995); in anthropology, Moerman (1988) and Clemente (2013); in cognitive and developmental psychology, Turnbull (2003), Edwards and Middleton (1987) and de Rosnay et al. (2014); improvization, Sawyer (2003).

[32]Pask (1961, 35). On Pask's cybernetic theory of conversation, see Pickering (2010), and on its relation to Pask's 'aesthetically potent environment' of the arts, Reichardt (1971).

[33]Hence, Schegloff's 'talk-in-interaction' (1991, 152 n1) and Laurel's reference to 'common ground' in the context of the theatricality of graphical interfaces (2014, 3–5); cf. te Molder and Potter (2005, 26–28), Streeck (1995), Drew (1995) and Newman-Norlund et al. (2009).

[34]Duranti (1997, 2015), Duranti and Burrell (2004), Duranti, Ochs, and Schieffelin (2012) and Sawyer 2003.

[35]On the tuning-in, Schütz (1951); repertoire in action, Faulkner and Becker (2009). Cf. Johnson-Laird (2002), Wagner (1996, 88), Winch (1959, 93f); music and interaction, Mukerji (1998), Star (1998); conversation as metaphor in improvisational music, Berliner (1994), Sudnow (2001), with Gibbs (2005, 75–77). Klerer suggests the 'non-separable and usually non-linear way' interaction is understood in physics (1968, 3).

of languaging to gain the upper hand maintain position or secure cooperation.[36] Capacities that evolved in verbal and gestural exchange with others allow also for Gerd Gigerenzer's 'fast and frugal' responses in human interactions, seemingly without thought, to dangers and opportunities now as once upon a time (2004, 2008). 'Programs' that we inherit or develop can then simply be 'run' without time- and resource-consuming deliberation whenever needed. Our proto-automation of responses (hear the echo of the computational model) renders them habitual, increasing chances of survival, but also creating a problem against which the creative urge rebels. More about that later.

The use of conversation as a benchmark and model for the machine began as early as Turing's 'imitation game' (1950; cf. Gandy 1996). Some years later, Joseph Weizenbaum demonstrated with ELIZA how urgently and readily we attribute true conversational abilities even to a rudimentary simulation.[37] Nevertheless, the realization 'that computational artifacts just are interactive, in roughly the same way as we are' took years more to develop.[38] In the 1990s, CA came into focus as a source for interaction design, but as Lucy Suchman put it, 'remarkably little substantive effect on discourses and practices of the so-called conversational machine' has resulted.[39] In the two collections she cites approvingly, it is notable that attention to the differences between human conversation and digital communication is rare.[40] Ignoring the differences in order simply 'to get on with it' is not futile, but it bypasses questioning the relation.

How, then, does the analogy to conversation help us with the human–machine relation? First and simplest of all, it connects that elusive relation to an extensive body of scholarship elsewhere – and gives back the non-linear possibilities of software as a model for the unobservable cognitive events of talk-in-interaction. Second, it juxtaposes two black-boxed (or semi-opaque) sites from which something new arises, and in doing so aligns and brings both unknowns to the attention of both fields. Third, it illumines the social, competitive, political role that the rule-bound machine (with no small amount of desiring and fearful accommodation) is already filling – and in this role suggests the possibility of an adaptive alteration of human intelligence over time in interaction with the machine as their *relational* intelligence evolves.

Alignment of conversation with digital enquiry is about far more than the design of interfaces. I will have more to say about the alignment of unknowns later.

[36]Whiten (1999), Byrne (1996) and Baron-Cohen (1997, 13–20).
[37]Weizenbaum (1976). On current sophistications (e.g. Alexa), see Karppi and Granata (2019) and Levesque (2014).
[38]Suchman (1998, 5). Cf. Norman and Draper (1986), Shneiderman (1980) and Kay (1970); also note 44.
[39]Suchman (2007, 30 n. 2). Since then see Woodruff and Aoki (2010), Perez-Marin and Pascual-Nieto (2011) and Tudini and Liddicoat (2017).
[40]See esp. Button (Chapter 4) and McIlvenny (Chapter 5) in Luff, Gilbert, and Frolich (1990) and Button and Sharrock (Chapter 6) in Thomas (1995). Note Weaver (1949) for the unfortunately persistent confusion of conversation with exchange of 'information'.

5. Cognitive-historical studies of experimentation

Although we may be able to pick out a logical step-by-step 'investigative pathway' in scientific research after the fact, normally it is not known from the beginning but made up, advanced uncertainly, often against unpredictable obstacles and with unanticipated changes of direction (Holmes 2004: xvi). Experimentation is a kind of wayfinding rather than map-following. It is, if you will, a strenuous *conversation* with matter – something Francis Bacon understood, as we will see.

For the historian of experimental science, focusing on a pathway may illumine significant patterns but tends also to direct attention away from the messiness of typically open-ended, experientially driven research, or what geneticist François Jacob has called 'night science' (1998/1997, 126). Keller has argued that from the seventeenth to the nineteenth centuries 'the first-person narrator of the scientific text [was] effectively replaced by the abstract "scientist" … who could speak for everyman but was no-man'. Thus 'the embodied crafter, interpreter, and reporter of experiments … the viewing, acting, and doing subject' was effectively erased from the standard account (1996, 418–19) and the cognitive processes involved in the research obscured.

I am concerned to undo the disastrous exclusion of 'night science' – without turning away from 'day science' – in order to throw light on the relation between enquirer and machine. Especially useful for my purposes is the 'cognitive-historical' approach to laboratory work, which proceeds speculatively from 'detailed records of problem-solving behaviour found in diaries and laboratory notebooks' towards the thought-processes responsible for the traces they record.[41] There are, of course, problems. Two of these, the self-reporting bias of the experimenter and dependence on a close fit of historical and contemporary ways of reasoning,[42] are serious enough but I leave them alone here. The third seems to me too highly problematic to pass by: elusiveness of a coherent theory for what happens.[43] Much depends on the meaning of both 'coherent' and 'theory' – surely we do not want a theory that attempts to nail down the creative imagination, rather a way of seeing (*theoría*) as clearly as possible to the horizon. The scholarship from laboratory notebooks in the natural sciences suggests that these problems could gain a new wind once, or if ever, we were to have the equivalent from the computational enquiry of scholars.[44] The hope for progress rests on conceiving this enquiry as exploratory use of technoscientific

[41]The term 'cognitive-historical' is Nersessian's (1987); cf. Gooding (2004, 580). Studies with a strong psychological focus on cognition are particularly valuable for my purposes; see e.g. Feist and Gorman (2015, Chapters 4 and 15), Gorman (2009), Gorman et al. (2005), Giere (1992), Gooding (1990) and John-Steiner (1985). I have not made much use of studies orientated primarily to history or to biography.

[42]For self-reporting bias, see Klahr (2000, 8) and Nersessian (1992, 36). For the fit of historical to contemporary reasoning, Nersessian (1992, 36) and Tweney (2013, 87f); also Simon (1986/1983, 159), note Einstein (1950/1936, 59) and Osbeck et al. (2011, 221–6).

[43]Holmes (2004) is particularly concerned. For his attempt at a synthesis of his many historical studies of individual experimenters, see p. 98, also Chapter 1.

[44]My interest here is in the psychology of scholars using the machine to do their research; the psychology of programming and programmers is tangential at best; Hjørland (2013) comes close but still is not it.

equipment to 'experiment' (in the broad sense of that word), though the many differences in assumptions, methods and criteria of the natural vs the human sciences must be taken into account.

For my purposes, the best example for experimental science is David Gooding's landmark studies of Michael Faraday's meticulously kept laboratory notebooks (among the most detailed that have survived).[45] Gooding distinguishes three phases of exploratory enquiry, of which I will consider mostly the first. These are: interactive manipulation of phenomena; their isolation from the instruments and actions which produce them; and the 'semantic ascent', or shift from 'a private world of percepts and objects to … a public world of talk about objects'.[46] The crucial matter here is the role which first-phase agency, ambiguity and uncertainty play in the science that comes from this work. Hans-Jörg Rheinberger, quoting Jacob's metaphor, describes what goes on during it as combinatorial play: 'an exploratory movement, a game in which one plays with possible positions, an open arrangement … a game of combinations still unrestricted by the rigorous limits of stringent compatibility' with established findings.[47] The central question is how we get close to the liminal play out of which communicable moves emerge? How do we find out what happens inside the play of the game?

Gooding's keyword for this ontologically ambiguous activity is 'construal':[48] more action than thing, a phenomenon in the active sense of something an experimenter brings to light or makes appear (*phaínei*). Gooding orbited the idea again and again:[49] as a name for a feeling of a way towards a communicable representation of experience during experiments, prior to interpretation, at the pre-hypothetical stage (1990, 71); as a quasi-linguistic messenger 'between the perceptual and the conceptual' (1986, 208), impossible to grasp 'independently of the exploratory behaviour that produces it or the ostensive practices whereby an observer tries to convey it. … ' (1990, 87); as an action that '*creates* communicable representations of new experience and at the same time integrates these into an existing system of experimental and linguistic practices' (1990, 87). But an unanswered question remains: how the tried and tested construal, accepted and integrated into the science of the day, somehow 'retains enough of its anomalous character [enough of its 'shock of the new'] to promote changes in a … system that has apparently assimilated it'.[50] To what extent, I wonder,

[45]See also esp. Steinle (2016/2005), on Gooding's work, 11, 245–7, 322 and esp Chapter 7; cf Holmes (2004, 96–8). On the notebooks, see Gooding and James (1985).
[46]Gooding (1986, 209), where, as elsewhere, he uses Quine's term (Quine 2013/1960, 249–54).
[47]Rheinberger (2010, 246f), cf. Steinle (2016/2005, 1–3). Such is the way, I would hazard to guess, in which using computers encourages us to talk.
[48]See esp Gooding (1986 *passim*; 1990, xv–xvi, 23, 25–7, 74, 82, 85–8, 115–16, 124–8, 142, 271; 1992a, 102–4), Gorman et al. (2005, Chapter 9), Gooding (2007) and Gooding and Addis (2008). Cf. Tweney (2002, 288, 300), Gorman et al. (2005, Chapter 7) and Beynon (2012). Gooding evidently seems to have taken this term from social psychology of the 1950s; see Ross, Lepper, and Ward (2010, 8).
[49]Cf. Hacking's quite similar 'topical hypotheses' (1992, 45); Tweney's 'inceptions' (2013, 85); Nersessian's 'generic abstractions' (2002, 2008, 191–200).
[50]Gooding (1990, 87 and 29). On 'the shock of the new', see Hughes (1991/1980). Note Gooding's parallel with the arts, 2003: 262, and cf. Gombrich (1961, Chapter 6).

is this anomalous character in all things potentially? Is it, as I have hinted, visible when we are knocked back from knowing a thing to the untrammelled perceiving that precedes knowledge of it?

Gooding's meticulous attempt is ultimately frustrated, hence the orbiting that never lands and the irresistible turn to metaphor. Simply put: he halts at the threshold 'of actions in material and mental space' from which construals emerge and declines to go further (1990, 142). Although he disappoints, Gooding is in good company. The elusiveness of his protean 'construal' marks a threshold beyond which psychology has struggled convincingly to go in its long history of taking up metaphor after metaphor.[51] James Clerk Maxwell likewise turned aside from the 'still more hidden and dimmer region where Thought weds Fact'. 'Does not the way to it pass through the very den of the metaphysician', he asked, 'strewed with the remains of former explorers, and abhorred by every man of science?' (1965/1870, 216). His solution was to use analogy, 'the partial similarity between the laws of one science and those of another which makes each of them illustrate the other' (1864/1855–6, 28). Changing what needs to be changed ('laws' especially), this approaches what I am doing here by aligning digital enquiry analogically with more thoroughly explored kinds.

> 'Emergence' is often used when something intelligible appears from origins into which we have no direct insight. The analogy of experimentation gives us an example. I have so far emphasised the solitary and personal phase, but experimental results must also demonstrate reliability and acceptance; they will inevitably have political implications if not effects. Thorough discussion of these I must leave to another occasion.

6. Divination

Divination is a highly diverse, culturally institutionalized and learned practice, 'extremely widespread, possibly even universal' to *Homo sapiens* from the beginning.[52] In a nutshell, the diviner uses rule-governed apparatus, his or her own body or spontaneous events, to elicit or discern responses to a client's dilemma from forces beyond human control, interpreting these responses with reference to a corpus of traditional knowledge. Here, I am interested specifically in those practices in which the diviner manipulates physical tokens, then draws meaning or an index to it from their configuration.[53]

[51]Danziger (2008, esp. Chapter 2), Draaisma (2000/1995, esp. Chapter 6); Leary (1990) and cf. von Neumann (1945, esp. Section 12).

[52]Flad (2008, 403). For work on divination prior to 2005, see Johnston and Struck (2005, 1–10) and Lloyd (1989, 38–49); subsequently, e.g. Flower (2008), Johnston (2008), Flad (2008), Raphals (2013), Holbraad (2012), Zeitlyn (2012), Rochberg (2016) and Struck (2016); several entries in Selin (2016) and Loewe and Blacker (1981). See also Andrew (2018, esp. Chapters 2 and 3).

[53]Plato (*Phaed.* 244cd) and Cicero (*De div.* I.vi.11) divide divination into two kinds: the artificial or technical sort, which relies on human intervention and skill, and the natural, dependent wholly on unintentional, consciously unmotivated phenomena. For challenges to this division, see Rochberg (2016, 24), Zeitlyn (2012, 327), Flower (2008, 84–91), Struck (2016, 16–19), Raphals (2013, 1–2), Johnston (2008, 9) and Peek (1991, 1–22).

Historians and anthropologists have long discredited the view that divination is perilously pseudo-scientific. Nevertheless, this view is apt to gain new life from my alignment of divination with computing, so I had better answer for my use of it here.

Thus, to clear the air: *we do not need to believe in divination* in order to understand how it works, its crucial roles in the societies or communities in which it is practiced and in the historical development of science (Burkert 2005, 36). Belief – the 'mental conviction' that a divine or supernatural authority is manifested in the observables and 'trust, dependence, reliance, confidence, faith' in that authority (*OED* s.v. 1, 2) – is important here only as an historical, cross-cultural fact.

In those terms, then, divination has shown itself capable of systematic, rational and effective enquiry, with much intellectual progress to its credit (Lloyd 2002, 23). It has offered 'established forms of modeling reality and social interaction, of dealing with crisis and conflict … doing so with a high degree of rationality' (Burkert 2005, 30). It has also been bravely adventurous, advancing 'the ambitions of curiosity' (Lloyd 2002) in 'an attempt, perhaps a desperate attempt, to extend the realm of *ratio*, the realm of knowledge and control, beyond the barrier of the future, and the barrier of death, into the misty zones from which normal knowledge and experience is absent' (Burkert 2005, 30). Indeed, the drive to seek answers that human power fails to achieve would appear so strong, persistent and trans-cultural as to suggest that formal aspects of divination can inform, or at least cast light on, our most recent methods of research, including by digital means. What can we infer from divination about the value of enquiry by randomized mechanical means? What does it have to teach us? What has it done for those who have sought its help that other means do for us now?

A number of formidable challenges stand in the way of reliable answers: the tacit assumptions we are likely to project; the reliability of available evidence and the clarity of our objectives.

First, our likely assumptions challenge an attempt to reach beyond historically provincial selves. Unavoidably, or nearly so, we come to divination after a century and a half of having cleared a space for chance (Hacking 1990, 1), worked to tame it and, as a result of that, given to 'random' a key meaning in how we conceive the world. Earlier I focused on its technical meaning in complexity theory and in applications to the physical sciences. But, as I hinted, it has had much broader effects. These are strikingly visible, for example, in the reception history of the Roman poet Lucretius' poetic treatise *De rerum natura* from Marx, Coleridge and Maxwell onward across the natural sciences, arts and humanities,[54] and the board game as a figure of

[54]*De rerum natura* 2.289-93 and 254–7; see Fowler (2002, 342–7, 364–6), and on the overall interpretation, 327–30. A brief summary of the Epicurean argument is provided by Lloyd (1973, 23–5); for a fuller treatment, see Long (2006, Chapter 8), and O'Keefe (2009). For the reception history, see e.g. Lezra and Blake (2016), Holmes

thought in the natural sciences and a central model for intelligence in AI. In both, freedom is made possible by unpredictable occurrences or deviations occurring within a tightly ordered system: in Lucretius, by the *clinamen*, or random 'swerve' of atoms that at uncertain places and times breaks the decrees of the Fates and so makes free will possible; in the board game by a randomizing device, such as dice, or by the player's liberty of choice. Thirty years ago, contemporaneous with the fall of the Berlin Wall (1989), the dissolution of the Soviet Union (1991) and public release of the World Wide Web (1991), Hayles conjectured 'that disorder has become a focal point for contemporary theories because it offers the possibility of escaping from what are increasingly perceived as coercive structures of order' (1990, 265). She went on to note that favouring chaos energizes the reactive drive to order; a 'convoluted ambiguity' results, shifting with time. Thus, René Thom's apoplectic reaction ten years earlier, '*Halte au hasard, silence au bruit*' (1980), was not so much a rearguard action as a harbinger. Puzzling out our tendencies of thought from the convoluted ambiguities in the present is the first step in clearing a space for a study of how diviners, their clients and those who have written about them understood what they were doing (Lloyd 1990: 1–2).

Second, the study of divination is challenged by the reliability of evidence from a wide diversity of practices over millennia and across cultures, with an influence beyond reckoning. As Lloyd notes for cross-cultural study of ancient sources, the evidence we have has been filtered through numerous layers of reportage and differences in terminology and interpretation (2002, 1–2).

Third, the objective to see coherence in the variety of phenomena for purposes of comparison is difficult and perilous, to put it mildly. Lloyd has spelled out many if not all of the challenges under three questions that need answering: what is to be compared; what the questions are and what any such study can hope to achieve (1996).

My comparison, as noted earlier, is to the diviner's skilled manipulation of physical tokens in order to read from the resulting configuration a response to a client's dilemma. By focusing in this way, I have already taken my first bridge-building step, shaping the phenomena of divination into a conceptual model suitable to my purposes. My second step is to ask which of the well-attested features of divination come closest to the typical structure of digital enquiry. Approximately in the order I follow these are: (1) the diviner's equipment, method and aim; (2) the client and the question posed; (3) the outcome and (4) the gods or cosmic order to which appeal is made. The resulting model, like any such thing, is necessarily a simplification to be achieved at a minimum level of abstraction from what is being modelled.

and Shearin (2012), esp. the Introduction and chapters by Rzepka, Meeker and Holmes; Motte (1986). An online search will yield many examples of twenty-first-century Lucretian invocations.

The questions I am asking sum to this, previously asked but answered only in part: what happens when an enquirer uses 'randomizing' instruments to seek insight about something? What are the processes of thought involved? Why bother? Clearly, great differences separate the terms of the relation between computation and divination, but in both, as earlier, answers are sought deliberately by unpredictable means from sources assumed to be authoritative.

The hope of my stripped-down study is to put as much enlightening stress as possible on the lurking notion of discovery as the uncovering of something already there, ready and waiting. Earlier I suggested that the key to genuinely new and surprising results is the paradox of expectation: not simply the need for a fixed notion so that it may be violated, but the active role of something anticipated in the formation of something unexpected. Here, arguments to the effect that knowledge is in general 'made' or 'crafted' come in, and so Nelson Goodman's key exploration of how a world can be said to be well-made (1984, 30–9). What is the craftsmanship of knowledge-making with digital tools? The process of interest here is rational and systematic, but in the instances of most interest, it is very carefully followed in order to enable something other to happen, something that escapes a rational net yet turns out to be useful.

In the literature, randomizing in divinatory practice is said to accomplish two things:[55] to isolate the outcome of the ritual from prejudicial interference by the participants, providing resistance against a desired outcome, and to allow for communication with those forces beyond human control (a point to which I will return).[56] There are many complications: repeated asking of questions to get the desired answer;[57] the diviner's ambiguous role, sometimes derandomizing by spelling out a meaning, sometimes randomizing further by shifting the meaning (Johnston 2001, 109) and, for the Greeks and Romans, further randomizing by the fickle will of the gods (Raphals 2013, 147). Then there is a reliability of the response, especially problematic for a practice that begins in uncertainty and seeks answers from an imperceptible and perhaps indifferent authority by employing uncontrollable means. In predictive divination reliability is as straightforward as it gets. In ancient Mesopotamia,[58] for example, familiar markers of a science in our sense (or close to it) are evident in the careful observation of celestial phenomena and accumulation of reliable knowledge that make it possible. Reliability becomes much more

[55]On divinatory randomization, see Zuesse (1987) and Aubert (1959). In Greco-Roman divination, Flower (2008, 90, 221) (but cf. Raphals 2013, Chapter 5); Johnston and Struck (2005), Introduction (15–16) and chapters by Burkert (37f), Graf (60–2), Grottanelli (134–5), Frankfurter (235) and Johnston (299), Johnston (2003 and 2001: 109–13), Maurizio (1995, 81–6) and Lloyd (1989, 38 n. 120). In Chinese divination, Smith (1991, 19, 204) and Ahern (1981, 53). For anthropological studies of randomization in contemporary cultures, see Holbraad (2012, 149–50), Dove (1999, 378 and 1993, 146–7, 151–2), Zeitlyn (1995), Peek (1991, 203–4), Dove (1983), Park (1963, 198–200), Moore (1957, 71–3) and cf. Graw (2009).

[56]Johnston (2005, 299), cf. Johnston and Struck (2005, 15), Maurizio (1995, 81), Park (1963: 198f) and Dove (1993).

[57]Graf (2005, 52) and Aune (2004, 371). Cf. Kim (2018, 373).

[58]Raphals (2013, 2–3), Lloyd (2002, Chapter 2).

problematic when that which is to be divined involves biological, psychological or social phenomena.

We have to be cautious in seeing our knowledge practices in those of others. I just cited the close resemblance of modern science to predictive Mesopotamian divination, but it was practiced not to gain knowledge for its own sake, rather to foresee the future and so advise the monarch (Lloyd 2002, 28). We are apt to think that the ancients undertook individual consultations as we would, out of 'purely private interests in a modern, Western sense of the term', but this was rarely if ever the case for the Greeks and Chinese, for example.[59] Their motivating desire may have been to get out of a jam, or to be prepared for a difficulty, or to reach for the universal *sympatheia* that Walter Burkert sees as an ultimate objective. But they were not ruled by the same 'egocentric system' of modern lifestyle choices and agonies (Burkert 2005, 48; cf. Giddens 1991). Referring to the injunction to self-knowledge at Delphi, Peter Struck comments that 'for the Greeks it was not so much a question of knowing oneself as a sui generis individual but rather of developing an understanding of oneself as a member of the order of things'.[60] Alignment with and on behalf of others, alignment to the cosmic order, or the will of a god or the gods, however variable, was the norm.

Divination that was or is sought for the wisdom to attune oneself to the order of things brings us closer to the ends of exploratory enquiry in the human sciences and so is of particular interest here. Though doubtless sometimes confirmatory, attunement to a transcendent order is a serious, quite possibly upsetting matter, *mutatis mutandis* like the twentieth-century listener's assimilation to 'the shock of the new' delivered by 'the advent of musical modernism', for which the violent surprise caused by Stravinsky's *Rite of Spring* in 1913 is an example: a briefly estranging, traumatic, self-changing encounter.[61]

7. Alignment and relation

Now, as noted earlier, I want to look again at my three analogies to ask what kind of relation we might conceive by *aligning* conversation, experimentation and divination to digital enquiry. What were or are the practitioners of these activities doing or trying to do that illumines our uses of the machine? What about all of these casts light on the question of how we conceive and exercise intelligence, biological and artificial, in its use?

[59]Raphals (2013, 251); Rochberg comments for the Assyrian material that, 'There's virtually no evidence of private divining, and even when personal horoscopes come into the picture it's entirely unknown how far beyond the very most elite people the whole thing went' (private e-mail, March 25, 2019). Cf. Starr (1990). For the overall point, see Lloyd (2002, 21) and Vernant (1991/1974, 303).

[60]Struck (2016, 2). Cf. Strathern's use of the old term 'dividual' (OED 3, 'distributed among a number … held in common') in the context of recombinant Melanesian personhood (1999, 60) and Keller's argument for 'an innate (and near-universal) capacity for self-reflection underlying experiences of first personhood … of a core subjectivity', the turbulent changes afoot in how we construct ourselves and our ability to press this radically (2007, 354).

[61]Note esp. Huron's analysis of randomization in the divinatory rite (2007, 344–6); cf. Taruskin (2003, 281–3).

7.1. Conversation

Sociolinguistic analysis of ordinary conversation has shown it to be complex and unpredictable. Studies in the origins of hominid intelligence suggest its crucial evolutionary significance in the development social adaptation and negotiation. Conversation as metaphor and model supplies a nearly ubiquitous way of probing the relation of human to artificial intelligence and challenging efforts to implement it. But the evidence for how talk-in-interaction does what it does in meetings of minds seems out of reach (as it is in the analogous situations of digital enquiry, laboratory science and divination). So, we are forcibly returned to the question Erving Goffman asked of puzzling social encounters: 'What is it that's going on here?' (1974, 8)

We must be careful not to allow the attractive Machiavellian Hypothesis or in general the emphasis on doing things with words to obscure the kind of talking Gadamer called a 'genuine conversation … [which is] never the one that we wanted to conduct', rather the kind we fall into, the kind we are led by rather than lead, the kind that surprises rather than fulfils expectations or replays a conventional script (Gadamer 2004/1989, 385). *This* kind points to a metaphorical space between the two differently constituted agents created by their rapid back-and-forth exchange in which the intelligence of each is augmented by the affordance of the other. The analogy of conversation, that is, aligns to thinking which happens beyond the brain, in and with the world, and to computing that likewise takes place beyond the interface, in the niche augmented by the machine-in-use.[62]

On the face of it, even in the simplest exchange, face-to-face talk sets a *very* high bar. Computing systems can mimic verbal conversation and will undoubtedly get better at it. We may want to draw a line, but the attempt to fix one absolutely between human and artificial performance is not just in vain, it misses the point: *both are in reciprocal, co-evolutionary development*. Much more productive is to emphasize the figurative sense of conversation as 'Occupation or engagement *with* things' (*OED* 4), taking up the invitation to stretch the term beyond the observable to what we do in active and intimate relations with the people, institutions and material things that matter to us. Consider conversational relations in Tim Ingold's anthropology, in the human geography of landscape and in the work of early cybernetic artists and theorists,[63] whose projects strove to implement as well as understand the work of art in Gadamer's later view: 'a fruitful conversation, a question and answer … , a true dialogue whereby something has emerged and "remains"' (1985, 250). Intelligence *arte factum* – a *künstliche Intelligenz* – may not be here yet, but its non-imitative

[62]For the brain, Clark (2008) and Anderson (2014). For the machine, Goldin and Wegner (2006); note the latter's use of 'autistic' in Wegner (1998).

[63]Ingold (2011), Benediktsson and Lund (2010), Abram (1997), Pask (1971), Reichardt (1968) and Brown et al. (2008).

conversation must already be happening and, as I've argued, needs our attention to develop along its native lines.

'In inner speech and in conversation', Goody observes, 'dialogue and the dyad are built into human cognition' (1995, 12; cf. Simmel 2009/1908, 82–114). We talk to ourselves, to each other and sometimes, finding chance or other imponderables difficult to accept, posit a conversational Other (Goody 1995, 207–8). Or, we design and build them. The question now is how to design the things that we build to initiate conversations that would force us to rethink thinking – and rethink science – once again.

7.2. Experimentation

The parallel between digital enquiry and laboratory experimentation is close. But consider where this leads us: on the one hand, to examples of scholarship and artistic work exploring the relation of cultural artefacts to algorithmic 'natural law';[64] and on the other to the pluralization of 'ontology' in philosophy and computer science and, following Galison, the progressive substitution of the computer for 'nature itself' (1996, 157; McCarty 2018). But we can go even further. Lloyd's historical argument that 'nature' is itself an invention shows 'natural law' to be doubly metaphorical: codified judicial decision-making transferred from the court to the cosmos, historically in some instances by way of a divine judge. Perhaps we can say, then, that the digital machine has prompted or furthered the rediscovery of nature as a contingent hypothesis, or as Bacon wrote in *De sapientia veterum* (1617), a Proteus with whom we are in perpetual struggle.

We've seen that digital enquiry, analysis of conversation and laboratory experimentation reach towards the unknowable but partially controllable source of new insights. And so Goody calls for more work on the common ground between interacting talkers; Gooding declined to enter the 'material and mental space' from which insights come; Maxwell wrote of a metaphysician's den, from which he advised we turn away. But that's not the end of it. There is (as anticipated) one further step to take along this path.

7.3. Divination

Having isolated the uncomputable by devising the eponymous abstract mathematical device on which the digital machine was later based (1936/7), Turing then imagined a special machine incorporating an 'oracle' to enable it to solve problems as a human mathematician would.[65] He proposed this

[64]For the creative arts, in addition to footnote 63: Funkhouser (2012), Boden (2011), Argamon, Burns, and Dubnov (2010), for literary studies, Burrows (2010), in which the 'balance between algorithmic analysis and questions of literary importance' is exemplary (David Hoover, private e-mail, November 27, 2019); Hoover (2016), Moretti (2013) and the pamphlets of the Stanford Literary Lab (https://litlab.stanford.edu/).

[65]Turing (2012/1938, 52–3) for his mention of the 'oracle'; note there the brief comments by Appel (7) and Feferman (22–3).

oracle not as an analogue to any human mental faculty (for, in Andrew Hodges' words, 'it does something no human being could do') but to facilitate the study of 'the mental "intuition" of truths which are not established by following mechanical processes'.[66] Later, four developments came to approximate or model the oracle's function: the non-linear design of digital hardware; the introduction of randomizing software (cf. Mirowski 2002, 148); online computing, in which the machine interacts with and is affected by the world (Soare 2009, 387–9); and, in game-playing and 'deep learning', the pattern-matching and self-modification which can come up with something that, as Turing foresaw, surprises us. In my sense, these latter two move the locus of machine 'intelligence' closer towards that cognitive, physical and social space where intelligence becomes relational (footnote 2). Conversation (again, setting its *very* high bar) suggests the further challenge posed by mistakes and their repair. Error that makes sense in context may, in the end, prove the greatest hurdle.

In the anthropology of divination, 'random' likewise steps in to gloss the outcome of the diviner's actions, which in Graf's words 'introduces a gap where the hand and mind of the divinity can interfere' (2005, 60–1). I prefer to avoid the common rationalization while respecting the sources, saying not that a divinity reaches down and *interferes* in the mechanics of casting tokens but that divine will or cosmic order is *manifested in*, *revealed by* and *read from* that which we call the 'randomness' of a configuration – and that (expecting the unexpected) first the diviner, then the client *makes* of or from the result what he or she can.

Looking now to computing from that perspective, it should be obvious that we do not need a corresponding ghost in the machine. As complexity theory tells us, the machine in its applications to ever more complex problems yields an ever clearer glimpse of a physical world not to be nailed down by an eventually complete body of 'natural law'; however useful, and productive this legislative metaphor may have been and may continue to be. Curiosity's ambitions exceed it. The machine that we have gives us an oracle by which a tamed chance can be put powerfully to work.

8. In illo tempore

In the three analogical cases I have reviewed, and in digital enquiry, an outcome undergoes 'the test of shareable experience', first by the participants, who act in the knowledge of their own constitution as persons in the regard of others, then by those other 'political animals', to which each is answerable.[67] But if the result is proved reliable and important, what then happens?[68]

[66] Hodges (2013, 15–17); cf. Cooper and Hodges (2016: Chapters 13–15).
[67] Gooding (1990, 85), Strathern (1988, 275) (paraphrased) and Aristotle, *Pol.* 1253a, respectively; cf. Fleck (1981/1935) and Keller (2007, 354).
[68] Latour and Woolgar (1986/1979), Gooding (1990; 1986). Cf. Goldman and O'Connor (2019); the journals *Social Studies of Science* and *Social Epistemology*.

Consider the epigrapher in Graf's account, who halts before an oracular pronouncement, 'rather puzzled by the occurrence of what we only can understand as scribal errors' but aware that the ancient reader was able to make sense of it (2005, 78). Graf celebrates 'the human capacity to find meaning in what seem to be or really are random phenomena'. But (as twice anticipated so far), there are two problems here, marked by 'find' and 'really are', both referring back to the ambiguity of 'invent' (*invenire,* to come upon, to make) that has been central to this paper throughout. Did the ancients *find* this new meaning, or *make* it, or did it *occur to* or *in* them, stimulated by those inscriptional signs the grammarian finds erroneous, and they meaningful? Again, what is it that's going on here?

In the cognitive sciences from Donald Campbell's 'blind variation and selective retention' (1960) to recent arguments for a 'predictive brain',[69] debate about this continues to circle the question of whether the new comes about through a 'sighted, guided, or directed' effort or a blind one (Simonton 2011, 159). In intercourse with the machine, it is surely both: the product of a blind-but-designed combinatorial cogitation triggering the curious mind – to '*invent*'. But what grabs us about the invented, exactly?

I have called its relevant quality 'new', but – I ask this again – how does anything 'new' qualify as such? Responding to this question in the workshop at which an earlier version of this essay was presented, Lloyd energetically asked in turn, 'What are the conditions of identity of a thought?'[70] What makes a new one new, considering that the sensorium is abuzz constantly with novel perceptions, the healthy mind filtering them to avoid hyperaesthesia but also staying alert for opportunities to improve the filtering, to let better ones (or better opportunities to fashion good ones) in? Gooding, you will recall, has asked and marked as unanswered the question of how the anomalous character of a new result survives assimilation so as to retain a yeast-like power to effect change. But perhaps we have the question the wrong way around. And I have asked, might this be true of all things?

It is time to stop swerving past the answer at which I have been aiming all along. My title, from the Russian Formalist Viktor Shklovsky's 'Art as technique' (1917), betrays it. In that essay, Shklovsky shakes his fist at comfortable, predictable but deadly habitualization – the algorithmization of life, we might say. He offers a way out – momentary because we perpetually fall back into habit:

> art exists that one may recover the sensation of life; it exists to make one feel things, to make the stone stony. The purpose of art is to impart the sensation of things as they are perceived and not as they are known. The technique of art is to make objects 'unfamiliar,' to make forms difficult, to increase the difficulty and length of perception

[69]On the career of Campbell's BVSR hypothesis: Simonton (2011), the debate in *Physics of Life Reviews* 7.2 (2010) with Simonton's reply referring to 'combinatorial models of exceptional creativity' (190–4); on the predictive brain: Yon, de Lange, and Press (2018); cf. Anderson et al. (2016) and Clark (2016) (in the present context note esp. p. 79 on 'very (agent-) surprising things', p. 129 n. 15 and Section III); Clark (2013).

[70]'Science in the Forest, Science in the Past II', Needham Research Institute, Cambridge, 14 June 2019. On the new, see North (2013), D'Angour (2011), March (2010), Crosby (2009) and Strathern (2005).

because the process of perception is an aesthetic end in itself and must be prolonged. (1965/1917, 12)

'Aesthetic ends' may not be what a digital enquirer would think of, but Shklovsky's остранение (*ostranenyi*), the 'defamiliarisation' of the familiar, rendering the ordinary uncanny, 'rendering the already nameable *only just* un-nameable'[71], is what the work of art can do, and what the *künstliche Intelligenz* I have been discussing can accomplish in the space of conversation with us (cf. McCarty 2019, 154).

Shklovsky wrote his timely but very old call to action at the beginning of the last century. Fifteen years ago, Burkert recommended the oracular sign's power to help the ancients 'to get out of a closed, egocentric system, to get into touch with "otherness," with the whole environment, to experience the all-embracing net of existence, nay universal *sympatheia*', then commented: 'This ought to challenge even the noisy self-resonance of contemporary society'. At the beginning of 2020, contemplating a telling expression of the then current political scene, James Lasdun urged on us as antidote 'anything that can shed light … on the processes by which groups of people seal themselves into airtight alternative realities' (2020, 27). I have argued that the relational intelligence of the human–machine coupling puts into our hands a tool of unsealing power at a time when its influence could make a difference. Our move.

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[71]Tim Smithers, June 29, 2020.

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