Introducing quantitative cognitive analysis: ubiquitous reproduction, cognitive diversity and creativity

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Abstract

The rise of ubiquitous computing has cemented ubiquitous reproduction (UR) as a defining feature of contemporary human environments. UR is most obvious on our televisions and smartphones but has homogenised most material aspects of our lives. Emerging technologies such as 3D printing and robotics will ensure that this trend intensifies. UR is an issue of global scale that is relatively intractable to qualitative treatment. This paper introduces a novel *quantitative* approach to cognitive science and to analysis of UR. The approach uses the finiteness of cognition to establish a minimal ontology with which to model cognitive diversity under UR. It demonstrates that, despite widespread valorisation of diversity, cognitive diversity must be declining at a global level. The implications of this for creativity are that the arc for creative impact is growing shorter as the need to be immediately intelligible promotes the formulaic at the expense of the interpretable.

Keywords: ubiquitous computing; ubiquitous reproduction; cognitive diversity; creativity; intelligibility

Introduction

Ubiquitous reproduction (UR), a feature of contemporary society accelerating under ubiquitous computing, has brought an unprecedented rise in the homogeneity of human environments. Our attention is increasingly occupied by images and sounds reproduced synchronously and asynchronously in millions of widely dispersed locations – on mega-screens that tower over us in cityscapes (as in Figure 1); on televisions and monitors in our homes; and on smart devices in our pockets and on our wrists. Within the cocoon of our digital habits we are now as likely to be glued to our favourite online resources and entertainments walking through a Bangkok market as a Finnish airport.

The material effects of UR are far from straightforward or short term. The digital reproduction of images and sounds has provided the scaffold for broader standardization of our physical world. Human environments are now measured, planned, designed, manufactured, distributed, and assessed with digital assistance. Our experience, derived from objects on computer screens in environments of computational origin, is becoming more and more homogenous. Everything from our first appearance *in utero* on ultrasound screens, to the digital curricula of the schools we attend, to the 3D printed artefacts we use, to the temperature and humidity of the air we breathe is melding into a common background.

Figure 1. Ubiquitous reproduction (UR) is occurring in many forms and on many scales in human environments.

The identical representations information technology makes possible are certainly a boon for productivity. They are also often touted as a godsend for creativity. Indeed, the ease with which digital amateurs can create and disseminate images and sounds has progressed to the level of "deep fakes" that threaten to undermine, as Baudrillard (1981/1994) foresaw, trust in reality itself. Thanks to UR there have appeared many new and popular activities to stock the digital repository. Entire new genres such as emoji, gifs and memes have emerged, and as technology progresses no doubt these will be joined by other technologically defined creative – if similarly pastiche-based – categories.

Alloyed to claims that UR promotes creativity is the promise (often promoted in marketing of new technology) that UR is a breakthrough for cognitive diversity. The argument is that UR allows us to learn about (or even virtually experience) other viewpoints, expand our cognitive degrees of freedom, and so overcome the ignorance that engenders bigotry. This meshes well with the conjointly valorised idea that creativity necessarily involves an increase in cognitive diversity. Afterall, if nothing new and hence expansive of diversity appears, how can creativity have taken place? In terms of cognition under UR, however, a worthy question is whether rising environmental homogeneity carries broader, unrecognized structural contractions actually inimical to *global* cognitive diversity. This paper introduces a quantitative view, based simply on the finiteness of cognition, that localized and anecdotal creative benefits of UR disguise a broader pattern of

reduced cognitive diversity and an inflection point in what is possible in, or even meant by, creativity.

Quantitative cognitive analysis

A common difficulty in cognitive science, and one perhaps retarding analysis of UR at present, is achieving ontological agreement. Cognitive science often ignores thorny philosophical dilemmas to concern itself almost entirely with *qualitative* aspects of cognition, which are typically treated as self-evident. It is, however, specious to claim that we know or can infer what a particular individual or group of individuals is thinking, or that any symbolic representation of cognition is meaningful outside symbolic systems, which rely themselves, after all, upon cognition. Well over sixty years ago, Quine (1951), as part of his critique of "modern empiricism", pointed out the circularity of assuming cognitive synonymy. Yet such assumptions continue to underpin psychology and cognitive science and are rarely challenged.

Historically, however, qualitative enquiry is not the sole – or even foundational – charter of either psychology or cognitive science. James (1890/2012, p. 9), for example, defined psychology as "the science of *finite* individual minds" [emphasis added]. This underexplored distinction has been examined recently by Shackell (2018, 2019, in press) in an attempt to bring clarity to information age challenges in semiotics. The bootstrapping move is to first treat questions of cognition *quantitatively* in order to derive a minimally committed and hence maximally surefooted ontology of cognition. For the present analysis, this "quantitative cognitive science" approach can be summarized in three axioms that can be confirmed from common experience:

1. Cognition is finite (i.e., we do not know everything; what we never think we never know)
2. Cognition can be similar or at least closely related (e.g., communication is possible)
3. Over time, common environments produce similarly structured cognition and behaviour in a population (e.g., many people in Paris speak French)

Most crucially, from the first of these axioms the construct of a global human cognitive field can be derived, which is simply a space-time concept of cognition occurring at a species level. This simple construct, shown in Figure 2, is the blank slate for quantitative analysis of cognition. Further explicit ontological commitments can be carefully introduced to examine various phenomena, among which the rise and role of UR is our present focus.

An attentional definition of environment

Environments that humans create and customise for themselves are more complicated than their appearance at any one moment in time suggests. Human environments are cognitive, defined just as much by habits of attention as possible targets of attention. Habits of attention, in turn, are shaped by perceptual processes over time – largely by what changes or modulates in an environment. Many people who live in sight of some remarkable wonder such as the Grand Canyon, for example, may nonetheless currently devote much of their time to Facebook or Twitter.

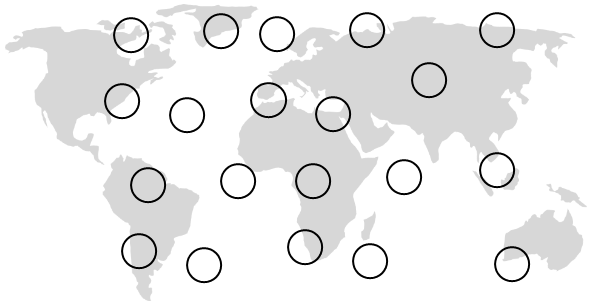

Figure 2. The cognitive field, a minimal construct facilitating careful *quantitative* analysis of cognition. Each circle represents a single agent's thought at a point in space and time. Adapted from Shackell (2018).

Our experience is a complex function of the attended and unattended stimuli we inhabit. UR brings determinative constraints to this function in ways that are difficult to perceive. An initial reaction to email in the 1990s, for example, may have been that it brings some incidental, standardising reproduction to our experience but ultimately is a source of extremely varied stimuli (e.g., words and images). However, if we examine the email of a large number of people today, will we find a rich and open-ended diversity of images, words, and most importantly, habits of interpretation? More likely we will find a quite clustered, reducible set of generic artefacts such as advertising, jokes, school news and so on. In fact, spam filters rely upon the very fact that email messages at a global level are not very diverse.

The issue of material homogeneity interacting with attentional proclivities to determine cognition is a complex one. For example, a hotel room containing a large television that is switched *off* has a very high level of material homogeneity relative to other hotel rooms but nonetheless allows many degrees of freedom for cognition. An agent sitting in that room may be thinking about a passing car, the colour of the carpet, a memory from childhood, rice salad recipes et cetera, each with a low degree of predictability. In contrast, the same hotel room with the large television switched *on* is less materially homogenous – the light and sound emitting from the television are dynamic and change the environment constantly. Cognitively, however, it is *less* diverse as a large proportion of people in such a situation will be on very similar trajectories promoted by the modulating television (e.g., experiencing an episode of *Seinfeld*). Such attentional and focus dynamics have a historical or formative component and are in a sense nested within one another (the homogenous, generic hotel room nests the seemingly diverse television output, which is itself derived from a restricted content set e.g., *Seinfeld* episodes). Cognition, therefore, can be homogenised by dynamic as

much as static stimuli according to prevailing attentional habits.

Pre-UR environments

Natural, pre-modern environments provide a baseline (or at least a point of comparison) for homogeneity. UR is limited in nature. No two mountains are the same. Nor any two rivers or places in them. Moreover, in nature there is little opportunity to view things habitually from the same perspective, or to view the same event repeatedly[1]. Importantly, there is a close linkage in pre-modern environments between stimulus and response. In pre-modern environments, if you saw a tiger you would think to run. Today you will likely just turn your head away and dismiss the vision as an advertisement for sneakers or a charity. Even in the nineteenth century, despite the rise of newspapers, museums and public libraries, it was relatively rare for large numbers of human beings to have encountered identical objects. Human cognition in the past likely exhibited a high level of idiosyncratic abstraction derived from variant stimuli. One person's concept of a mountain or a steam engine may have been much different than another's without ever causing economic or social friction. In other words, economic and social functions were performed despite quite a high degree of cognitive diversity.

Formalising cognitive diversity

To derive a formal model of cognitive diversity based on the axioms of finite cognition, we can begin by formalising the cognition of a population with *n* members over a chosen time period. Let *P* be the set of *n* contemporaneous thought sequences *s* in the population over the period:

$$P = \{s_1, s_2, s_3 \dots s_n\}$$

C can be defined as the set of distinct thoughts of *s*, a member of *P*, over the period.

The total cognitive diversity of *P* can therefore be expressed as the union of all *C*:

$$\bigcup_{1}^{n} C$$

Conversely, the total cognitive commonality of *P* can be written as the intersection of all *C*:

$$\bigcap_{1}^{n} C$$

A more meaningful measure of cognitive diversity for *P*, however, must include an awareness of the distribution of similar and different cognitive states among agents. A number of metrics are available in statistics for comparing set similarity. The Jaccard index, for example, is the size of the intersection of two sets divided by the size of the union. For *P*, a useful metric of similarity is the mean of the pairwise Jaccard indices of all *C*, which we can call that population's cognitive similarity *z*:

$$z = \frac{\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \frac{s_i \cap s_j}{s_i \cup s_j}}{\left| \binom{n}{2} \right|}$$

A *z* value of 1 would indicate a complete lack of cognitive diversity while a value of 0 would indicate complete cognitive diversity. While *z* can perhaps never be directly measured except in some future dystopia, it does give us a formal tool with which to reason about certain situations in which diversity is at issue, and more broadly the effects of phenomena such as UR.

Modelling cognition in increasingly homogenous environments

It would be difficult to sustain the argument that human beings living in environments that are increasing similar will not tend to think in increasingly similar or at least related ways. Even if thoughts do not circulate in an epidemiological manner, disparate reactions to common artefacts must lead to thoughts falling into finite patterns and hence concentrating within generic categories. For example, while everyone may not have positive emotions around the massively reproduced images of the last FIFA World Cup, large numbers of people will have some *species* of reaction such as disappointment, outrage, respect, indifference et cetera. Moreover, these reactions will be patterned in very broad ways, with people in the winning country, France, more likely to exhibit one of the more positive cognitive states. Such "made for television" events are often lauded, and indeed sought after, for bringing the world together and creating *connection*.

A connected world or a homogenous world?

In analyses of technological change, a common assertion is that cognition is changing because individuals are now highly "connected". This idea of connection, however, despite having the appearance of explanatory power and finality, bears some deconstruction. If we probe a little deeper into the material nature of increased connectivity, we find that UR is the enabling mechanism. Connection is possible because a message on a device at one location can be reproduced at another. More subtly still, reproduction of any image at different locations creates a connection *potential* between individuals by synchronising their experience to some extent – that is, by honing their ability to receive a related image later.

[1] This point is illustrated by the debate that raged for millennia as to whether, and at what point, all four of a horse's hooves leave the ground while galloping. The debate was resolved by Muybridge's 1878 *Sallie Gardner at a Gallop* photographs.

When we draw connections as an edge on a social network graph (as is routinely done – see, for example, Baronchelli, Ferrer-i-Cancho, Pastor-Satorras, Chater, and Christiansen, 2013), we are abstracting a very complex structure of UR into a simple metaphor. In specific *qualitative* analysis this reduction is often not afforded enough scrutiny: the complexity of a single connection is enormous and drags with it an implicit micro-mechanics that has never really been made clear. In *quantitative* analysis, however, such edges can be given a very precise meaning at the systemic level as environmental commonalities occasioning synchronisation of thought. Edges with such a meaning can be assigned probabilities based on environmental commonalities and attentional factors (as indeed marketing and advertising already do in some situations e.g., Allenby and Rossi, 1998).

Diversity in the cognitive field under rising UR

Using the construct of the cognitive field and edges introduced above we can model the effects of UR by assigning discrete *values of difference* to cognition – that is, by marking cognitive states as different or similar without claiming to know anything qualitative about them. In Figure 3, the colour of circles in the field indicates the difference or similarity of cognition. The edges are indicators of common experience produced by UR. As per the discussion above, the edges do not necessarily "spread" a cognitive state but rather increase the tendency of other agents to assume some complementary state.

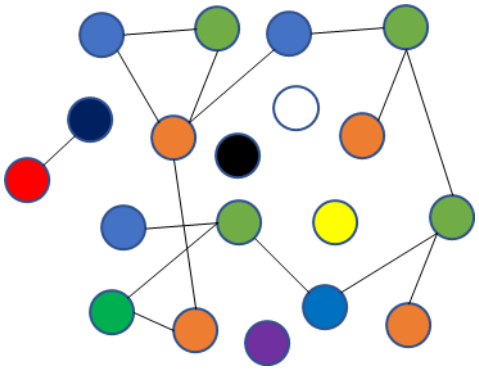

Figure 3. A cognitive field under low UR. Different colours represent different cognitive states. Edges represent common experiences facilitated by UR.

Figure 4 depicts a cognitive field under greater UR which facilitates more common cognition and hence less cognitive diversity. Notice that the "connections" between agents (the products of UR) are greater and hence the number of distinct states is lower than in Figure 3. The result is a move towards what is known as a "small world" graph.

Figures 3 and 4 show that if we stipulate that increasingly homogenous stimuli tend to produce less diverse cognition, then under global UR we can assume a falling cognitive diversity in human populations. The next question we may ask is why such a movement is underway?

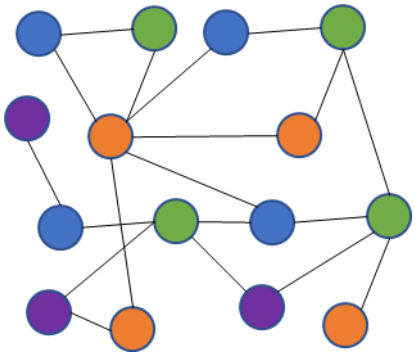

Figure 4. A cognitive field in an environment with a high level of UR. Greater "connection" leads to lower diversity.

The teleology of falling cognitive diversity

Falling cognitive diversity has one obvious cause: economics. As new methods for production and distribution of material goods and information evolve, these are quickly disseminated and adopted around the world. For example, producers will not continue to smelt iron in an inefficient and idiosyncratic way if a better method is obviously available. The adoption of the new smelting method, however, will require remote peoples to synchronise some of their cognition with others already using the method. This will also likely bring larger flow-on material changes: altered city locations and landscapes with smokestacks of a certain shape, new jobs with similar duty descriptions, and, most broadly, societal changes to do with increased availability of iron. The pace of economic change in regard to information technology is many times greater. Such changes are economically optimal but operate by decreasing cognitive diversity globally.

A counterintuitive view of diversity

With the current valorisation of diversity in race, gender, politics and religion, the conversation around cognitive diversity – which if one believes in the mediation of reality by cognition is the root of *all* diversity – turns quite counterintuitive. To anyone with a positive notion of truth or a commitment to democratic philosophy as espoused, for example, by Dewey (1916/2012), diversity is a fundamental value and a cornerstone of contemporary UR-dominated society. In fact, however, in terms of the analysis of diversity presented above, the rise of discourses about diversity – as for all *global* discourses – must be viewed as a symptom of *decreasing* cognitive diversity. Whereas a broad and idiosyncratic range of cognition around diversity once obtained, UR has brought global templates for cognition to every agent. Recently, for example, the #MeToo movement set the issue of gender into a certain polarised structure around the world. Whether this one phenomenon has reduced or increased cognitive diversity is

a moot, *qualitative* point. Taken as a whole, however, discourses that dominate globally via UR must have the *systemic* effect of reducing cognitive diversity overall.

Although it will not be traced here, it would seem possible to reconcile the teleology of declining cognitive diversity with the rise in global discourses *about* diversity. Put simply, the drive to economic and social optimality gives rise to discourses that efficiently allocate – or at least *consume* – cognition in support of it.

Intelligibility

The counterintuitive result above is that while technology is providing information in seeming abundance via UR, this leads to increased homogeneity of environments which must lead to a decrease in cognitive diversity. This decrease is disguised by a perceived increase in intelligibility whereby we expect, and have patience only for, stimuli that fit immediately into our cognition. The rise of the "random" as a term in popular culture might be regarded as a symptom of this increase in intelligibility: what is not immediately recognizable and intelligible is pushed from cognition as "random" as the mind seeks to navigate only those states on the homogenous, highly connected network. The term "stranger", for example, has largely been replaced by "random guy/girl" in many idiolects. In such a context we must re-examine what creativity – once capable of generational, revolutionary effect – now means.

Schematisation

In work that is easily related to the rising trend to fast intelligibility, Stiegler (1994/1998) has criticised the role of technology in "schematicising" cognition – that is, patterning thought into generalisable routines, or, as Quine, his forerunner, defined it: "positing sharp boundaries where none can be drawn" (Quine, 1990, p.12). Schematisation leads to shortcuts in thought for activities as diverse as recognizing villains in a movie by their smoking habits; interacting with checkout staff in ways learned from vending machines; or calling one's memory one's "hard drive".

Via schematisation, UR impacts social relations by the spread of common experience. To navigate the common environment, one must learn and acquiesce to routines of thought and action or be nudged[1] into line with other members by shared norms. The paradox of diversity applies: if one wishes to increase diversity in UR contexts one must commit acts of rebellion which will only be noticed if they in fact fit current schemas. As a rebel against UR one is in danger of creating a rebellious movement that can only thrive on the commonality supplied by technology, which under UR will quickly normalize it.

A relevant metaphor for cognition in homogenous environments is the (integrally related, embodying) adaptive development of our bodies. When living in natural environments full of uneven and undulating surfaces, we can attain almost any position. We will of course begin to wear pathways, but these evolve with our activities and are not fully determinative. Our physiology adapts so that our feet retain degrees of freedom, develop callous from certain movements over rocks or sand, and our awareness of terrain is of a certain fluid kind. Consider, in contrast, a human built environment in which surfaces are generally flat and even and any obstacles are essentially vertical (such as the side of a building or house). Our movement becomes limited in absolute ways. If we wish to go to a certain place there are hard restrictions on what paths are possible. Our feet will adapt to walk on flat surfaces; our awareness of terrain will be of a more binary kind; and we will inhabit an area having experienced only a small fraction of its terrain or viewpoints (not many of us have seen inside all the houses or apartments within 100 metres of our own). The effects of UR on cognition are of a similar, schematicising kind, which has profound ramifications for creativity.

Creativity under declining cognitive diversity

Under the axioms of finite cognition introduced at the start of this paper, a very straightforward quantitative definition of creativity is possible. Creativity is the mechanism by which one agent induces, or more romantically *inspires*, new cognitive states in another agent. UR under this definition has obviously increased the creative potential of each individual enormously. Each agent has the means to offer images and sounds via telecommunications to billions of others and to create new cognitive possibilities for them. This is in stark contrast to the world prior to UR, when it was difficult to affect large numbers of people even over long periods. It may, for example, have taken centuries for any significant number of people to have heard of, or formed a view about, an enormous public creative work such as Chartres cathedral.

We must pause to reflect, however, that, despite the new possibilities technology introduces, the total amount of cognition remains relatively constant. There are therefore two types of creativity that fit our quantitative definition. These roughly parallel Boden's (1990) psychological or "p-creativity", and historical or "h-creativity" but are worth reframing for the quantitative approach. Firstly, the new cognition need not necessarily be new in a global sense – only to one or more individuals. Creativity, therefore, involves, most minimally, a local increase in cognitive diversity that does not increase overall diversity. We might call this "zero gain" creativity and note that it tends to increase the *z* metric proposed above (makes cognition more similar). At the other extreme, creativity may involve provoking a completely new cognition never before attained by any agent (for example, Archimedes' eureka moment). We can call this "global increase" creativity and note that – at least initially – it tends to reduce *z* (makes cognition less similar). UR, by this distinction, overwhelmingly provokes a disproportionate amount of zero gain creativity.

[1] It is perhaps no coincidence that, in recent years, governments have formally embraced the notion of using UR to shape behaviour using techniques such as "nudging" (Thaler, 2009).

Diffusion and interpretation

A surfeit of zero gain creativity under UR has reduced the half-life of creative activity to very low levels. Anything new is quickly disseminated throughout the cognitive field. Novel thought is under pressure from (and likely to be displaced by) the next low gain stimulus. Moreover, the rapidity of dissemination discourages prolonged or novel interpretation of reproductions. Interpretation must be relatively shallow: the stimulus, as noted, must be immediately intelligible or will be simply ignored by the majority of receivers. It would seem absurd in the current context to spend years in careful interpretation of a single work of art to achieve something novel, but such activity was common and valorised in centuries past (as the long traditions of exegesis and hermeneutics attest).

In terms of the quantitative definition of creativity, under UR there is much creativity. Afterall, UR provokes new cognitive states in unprecedented numbers of individuals. The ubiquity and speed of that creative reception, however, is not growing the broader diversity of cognition as rapidly as the pre-UR age, which *ipso facto* lacked the apparatus of cognitive synchronisation.

Creativity, bending with the decrease in cognitive diversity, is becoming a short rather than long term possibility. Creative activity in homogenous environments is under pressure to be continuous and schematic or risk exclusion as "random". This leads to the increasing dominance of formulaic creativity. In Figure 5, for example, a piece of graffiti attributed to the artist Banksy combines simple images and colours. The placement of the graffiti in a drab urban context (not shown) draws viewers to its intelligibility and achieves – almost formulaically – a flash of creativity while also providing a ready-made meme for UR.

Should we limit environmental homogeneity?

Future historians may refer to our era not as The Information Age but as The Great Synchronisation. There exists a danger that the growing ubiquity of human interaction with technology and the homogenizing reproduction it enables may lead to restricted "closed" paradigms that we are not in control of – paradigms that are instead defined by the affordances and economics of the technology itself. The end result may be a counterintuitive and potentially pernicious reduction in cognitive diversity occasioning a new sterile aesthetics – an air-conditioned Dark Age in which there are no wrong clocks. Creativity expansive of human thought ("global gain") is at risk from creativity that is merely distributive ("zero gain"). We must beware that what is not instantly intelligible is not denied a place in the panoply of human cognition. A possible remedy that warrants further formalisation and research is the measurement and control of environmental homogeneity – something which must become a recognised parameter of our tolerance for ubiquitous computing.

Figure 5. Graffiti art attributed to Banksy known as *Girl with Balloon*. The image can be seen as an example of the trend to intelligible, formulaic, meme-friendly creativity.

Conclusion

This paper examined the paradox of cognitive diversity as a lauded societal value in the increasingly homogenous environments created by ubiquitous computing and the ubiquitous reproduction it allows. If we value diversity in any form, we must value cognitive diversity, for by definition all diverse reality springs from diverse cognition. The paradox is that ultimately our drive to communicate using reproductive digital means cannot be other than a force for reducing cognitive diversity to some optimally oscillating set.

The practical benefits of reduced cognitive diversity in the relation of humanity to its material needs – thriving in material terms with all resource exploitation and population itself optimized to maximum carrying rate – is unquestionable. Inefficient cognition leads to waste and error. We should question, however, whether we are ready to abandon some long-held commitments to our destiny as a species in order to embrace these benefits. For if creativity involves producing or inducing *new* types of cognition there can be only localized, short term creativity in a system that distributes stimuli and displaces existing diversity with superlative efficiency. We may in the process be condemning those who come after to lives of robotic absurdity, making them martyrs to our vainglorious and infinite conception of our very finite selves.

Acknowledgments

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References

Allenby, G. M., & Rossi, P. E. (1998). Marketing models of consumer heterogeneity. *Journal of econometrics, 89*(1-2), 57-78.

Baudrillard, J. (1994). *Simulacra and simulation*. Trans. S. Glaser. Original work published 1981. Ann Arbor, MI: University of Michigan Press.

Baronchelli, A., Ferrer-i-Cancho, R., Pastor-Satorras, R., Chater, N., & Christiansen, M. H. (2013). Networks in Cognitive Science. *Trends in Cognitive Sciences, 17*(7), 348-360. doi:https://doi.org/10.1016/j.tics.2013.04.010

Boden, M. (1990). *The creative mind : myths and mechanisms*. London: Weidenfeld and Nicolson.

Dewey, J. (2012). *Democracy and Education*. Original work published 1916. Newburyport, MA: Dover Publications.

James, W. (2012). *The Principles of Psychology, Vol. 1*. Original work published 1890. Newburyport: Dover Publications.

Quine, W. V. O. (1951). Two dogmas of empiricism. *The philosophical review*, *60*(1), 20-43.

Quine, W. V. O. (1990). *Pursuit of truth*. Cambridge, MA: Harvard University Press.

Shackell, C. (2018). Finite cognition and finite semiosis: a new perspective on semiotics for the information age. *Semiotica*, 2018(222), 225-240 doi: https://doi.org/10.1515/sem-2018-0020

Shackell, C. (2019). Finite semiotics: recovery functions, semioformation and the hyperreal. *Semiotica*, 2019(227), 211–226. doi:10.1515/sem-2016-0153

Shackell, C. (in press). Finite semiotics: cognitive sets, semiotic vectors, and semiosic oscillation. *Semiotica*.

Stiegler, B. (1998). *Technics and time: The fault of Epimetheus* (Vol. 1). Trans. R. Bearsworth and G. Collins. Original work published 1994. Stanford, CA: Stanford University Press.

Thaler, R. (2009). *Nudge : improving decisions about health, wealth, and happiness*. New York: Penguin Books.