Popular Culture and New Media

The Politics of Circulation

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palgrave
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Softcover reprint of the hardcover 1st edition 2013 978-1-137-27004-7

First published 2013 by
PALGRAVE MACMILLAN

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Palgrave Macmillan in the US is a division of St Martin's Press LLC, 175 Fifth Avenue, New York, NY 10010.

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ISBN 978-1-349-44421-2 ISBN 978-1-137-27006-1 (eBook)
DOI 10.1057/9781137270061

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A catalogue record for this book is available from the British Library.

A catalog record for this book is available from the Library of Congress.

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Algorithms: Shaping Tastes and Manipulating the Circulations of Popular Culture

Introduction: Measuring and predicting cultural tastes

In 2006 Netflix, a subscription based online film and TV provider, ran a competition inviting people to help to improve their 'most valued . . . assets' their 'recommendation system' (Netflix, 2012). This was described as a 'machine learning and data mining competition for movie rating prediction'. A $1m prize was available to 'whoever improved the accuracy of [the] existing system . . . by 10%' (Netflix, 2012). The aim of this competition they say, in true 'knowing capitalism' (Thrift, 2005) style, was to 'find new ways to improve the recommendations we provide to our members, which is a key part of our business'. The aim then was to find a way of suggesting films to customers that would more closely suit their tastes and to make better predictions about what they were likely to want to watch. The aim was to reduce the error level of such prediction from the root mean squared error of 0.9525 to 0.8572 or less. What is interesting here is not only the systems of prediction that are central to this form of cultural consumption, with films and TV being suggested to us by the devices, but also that the prediction of cultural taste can be metricised. Taste predictions can be turned into a number that represents the accuracy of the prediction. In many ways this example is a microcosm of the processes and underlying cultural infrastructures that are indicative of the arguments of this book. Here data is used to hone the predictive skills of the software and to make ever more powerful recommendations to the users. In other words, this is a kind of enactment through method (Law, 2004). This is predictive software

shaping everyday cultural encounters in ways that are turned into numbers so that they can themselves be measured and altered. The implicit claim in the Netflix competition is that the influence of algorithms on cultural taste is measurable.

In the case of the Netflix competition, a team of developers won the competition with an 8.43 per cent improvement in the accuracy of the predictive recommendation system – we are told that it took 2000 hours of work to put together the combination of 107 algorithms (Netflix, 2012). This material on the Netflix competition reveals how central the accuracy of the recommendation system is to such organisations, with the company working to increase the accuracy of the predictive capacity of their service and to base this around the personalisation of the individual profiles. What this also reveals more broadly, and if we generalise from this one instance, is that contemporary popular culture is being defined and shaped by these underlying collections of algorithms. In short, if we think across all such cultural consumption we can only imagine the density of algorithmic processes and the complex ways that they are now a part of the ordering, structuring and sorting of culture.

The chapter begins with some reflections on what algorithms are and how they have become such powerful social actors. This is then followed with a section that locates the power dynamics of algorithms and how it is that they come to enact parts of the social world. These first sections provide a broad socio-technological backdrop to the study of algorithms; in the following sections the chapter draws upon these founding ideas to move towards the incorporation of algorithms into cultural analysis, first by thinking about algorithms and culture and then by focusing more centrally upon the shaping of cultural encounters and cultural taste. The chapter closes with some conclusions about how this agenda might be developed and how further work might incorporate algorithmic power. This concluding section is also used to think about how the discussion of algorithms might challenge our understanding of how culture works, how it is located and how it circulates through friendship groups and taste communities. One observation is that if cultural taste is central to an understanding of class and social mobility, then we might need to think about how such relations work where algorithms become active in such hierarchies.

Algorithms . . . a return to software sorting

Adrian Mackenzie (2006: 43) notes that '[s]oftware cannot do without, according to computer science, algorithms and data structures'. Algorithms are the organising structures in the software that, we are told, are sinking into everyday life (see Chapter 2). As the computer scientist Herbert S. Wilf describes, an 'algorithm is a method for solving a class of problems on a computer' (Wilf, 2002: 1). Or as Cormen et al. (1990: 1) explain, 'an algorithm is any well-defined computational procedure that takes some value, or set of values, as input and produces some value, or set of values, as output'. Baase and Van Gelder (2000: 2) add that to 'say a problem is algorithmically solvable means, informally, that a computer program can be written that will produce the correct answer for any input . . . Much of the early work in this field, was on describing or characterizing those problems that could be solved algorithmically and on exhibiting some problems that could not be.' The concern for a social scientist might be this notion of a correct outcome and how this might be measured. Alongside this, of course, we might wonder if the output of the algorithm becomes a self-fulfilling outcome, as it comes to act on the world rather than being neutral within it.

So, algorithms are the problem-solving devices in software and code. These types of problems range in form, but many begin with the need to sort data into categories and types. There are many algorithms for this type of classification and sorting work (Cormen et al., 1990: 3–4; and for an overview of types of sorting algorithm see Baase and Van Gelder, 2000: 150–221). In an introductory guide Jeff Edmonds explains the differences, '[a]n *algorithm* is a step-by-step procedure which, starting with an input instance, produces a suitable output . . . In contrast, *code* is an implementation of an algorithm that can be executed by a computer. *Pseudocode* lies between these two' (Edmonds, 2008: 1). Again, algorithms represent the ordering structures in code. Writing in the late 1980s, Robert Sedgewick (1988: 4) warns though that even simple algorithms can lead to 'complicated data structures' (see also Cormen et al., 1990: 6).

In a recently published book titled *9 Algorithms That Changed the Future* (2012) the computer scientist John MacCormick outlines nine types of algorithm that have been most influential, and in the process

he reveals how central algorithms are to contemporary society. In one chapter, for instance, he outlines the algorithms that are used in the compression of files, such as MP3 and the like, which we have heard so much about in music consumption. Similarly JPEG compression algorithms have compressed visual images for circulation. MacCormick also describes the algorithms behind the indexing that allows search engines to work, the ranking system on Google that prioritises the most relevant materials when we are searching, the algorithms that enable content to be communicated securely as well as descriptions of the algorithms used in pattern recognition, for consistency in databases like Facebook and for the correction of errors in everyday internet use. Rather than explore the details of these algorithms, which MacCormick does with some granularity, we can instead reflect upon how the general content of the book intimates towards the vast presence of algorithms in contemporary everyday practices and routines, and how algorithms are now a deeply embedded part of the production, dissemination and consumption of culture. As an example, we might reflect on how powerful something like Google's PageRank is in shaping what we encounter when we search. By making judgements about relevance this algorithm, by prioritising content, is shaping our encounters with information (for a description of how this algorithm makes judgements based on hyperlinks and the perceived authority of these links see MacCormick, 2012: 24–37; see also Mager, 2012).

Before we reflect on this further, we can think for a moment about what these algorithms actually are and how they underpin these processes and systems. MacCormick (2012: 3), attempting to introduce algorithms to a broad non-specialist audience, suggests that 'an algorithm is a precise recipe that specifies the exact sequence of steps required to solve a problem'. Clearly this is a very basic working definition, but it takes the algorithm to the core of its function. MacCormick works with the example of a simple algorithm that we all learn at school, the algorithm for adding together two large numbers. MacCormick (2012: 3) describes this process:

> The algorithm involves a sequence of steps that starts off something like this: 'First, add the final digits of the two numbers together, write down the final digit of the result, and carry any other digits to the next column on the left; second, add the digits

> in the next column together, add on any carried digits from the previous column . . . ' – and so on.

This, MacCormick points out, is a basic algorithm. A series of steps or points in the 'recipe' that lead directly to the outcome. These basics steps are rigid and prescriptive and lead to an intended output. As he adds:

> One of the key features of an algorithm: each of the steps must be absolutely precise, requiring no human intuition or guesswork. That way, each of the purely mechanical steps can be programmed into a computer. Another important feature of an algorithm is that it always works, no matter what the inputs.
>
> (MacCormick, 2012: 3)

Here MacCormick refers back to the addition algorithm to suggest that whatever numbers you put into the algorithm, it will always work. In very basic terms then an algorithm solves a problem – although some problems fall into the undecidables and cannot be addressed in this way (MacCormick, 2012: 174–198). But the key point for MacCormick (2012: 4), who of course is a computer scientist and is looking at algorithms for their problem solving potential rather than their social and cultural affect, is that 'computers need to be programmed with very precise instructions . . . before we can get a computer to solve a particular problem for us, we need to develop an algorithm for that problem'. This is a very functional vision of algorithms as the underlying sequences or steps of computation that lead to the resolution of specific problems. This is useful in providing a sense of the basic types of functions of algorithms and the hidden depths of algorithmic processes in everyday life (Beer, 2009b). To gain a greater understanding of these in everyday processes, it is worth thinking of these algorithms as an integrated part of the social world. To do this we need not lose sight of the material functioning of algorithms but, as with other technologies, it is helpful to begin to see them as an embedded part of social processes that are enacted in various settings (Hayles, 1999). Adrian Mackenize (2006: 43) points out that algorithms 'carry, fold, frame and redistribute actions into different environments'. Mackenzie's argument is that because of this, and because software is central to the new connectivities that flow into

the environment, so the 'analysis of the mode of existence of algorithms becomes critical' (Mackenzie, 2006: 43). Mackenzie (2006) is arguing here for a social analysis of algorithms that understands how they 'animate', 'order' and 'sequence' the social world. To give an example, in his later collaborative work on code, Mackenzie suggests that crises, be they financial, ecological, cultural or psychological, commonly flow into everyday life through code. This occurs, according to Mackenzie and Vurdubakis (2011: 4), because code is so deeply embedded in the everyday and because these crises are inscribed in the code itself.

Algorithms and the making of the social world . . . or why it is that algorithms matter

So what then might a critical and socially embedded approach to algorithms look like? It is fair to say that outside of a few exceptions, many of which I will discuss in this chapter, there has been very little acknowledgement in the social sciences and humanities of the role of algorithms. As the above indicates, Mackenzie's (2006) provocative study of software is a good place to start. Using examples from 'bioinformatics', Mackenzie begins to set out an agenda for the development of a more social understanding of algorithms and their functions. He suggests the following as a starting point: a 'critical analysis of algorithms would start by recognizing that the expectation that things will be in place is historically and socially specific. Order and sequence are the result of much work' (Mackenzie, 2006: 44). The central issue in the study of algorithms for Mackenzie is the issue of ordering. Algorithms order, he claims, and they have the capacity to make this ordering look natural, unequivocal and definitive. The algorithms here are not necessarily creating a new order, this is not an entirely new 'cyberbole' (Woolgar, 2002) based upon rules made by machines, but may be part of the continuation of historical ordering processes played out through the boundaries they create in the software and its outputs. This, Mackenzie claims, has powerful social implications. As he describes:

> An algorithm selects and reinforces one ordering at the expense of others. Agency, therefore, is by definition contested in and through algorithms. They affect what can be said and done . . . It both naturalizes certain orders and animates certain

> movements. An algorithm naturalizes who does what to whom by subsuming existing patterns and orderings of cognition, communication and movement.
>
> (Mackenzie, 2006: 44)

The scale of the social influence of algorithms, for Mackenzie, starts to become clear here. This is a vision of algorithms as powerful social actors that shape possibilities and limit agency, suggesting the far reaching effects of algorithms in the social world. Algorithms here become a kind of invisible structural force that plays through into everyday life in various ways. This is similar to what Scott Lash (2007; Beer, 2009b) has described elsewhere as 'power through the algorithm'. For Lash these algorithms are creating or reinforcing sets of social rules that may be understood as a new form of power. As Galloway (2011: 95) also adds, 'the point of power today is not in the image', rather he claims that the 'point of power today resides in networks, computers, algorithms, information and data'. With algorithms, Galloway argues, being an 'unrepresentable' force.

Lash, with echoes of Mackenzie's position, says that '[c]omputer scientists understand algorithms in terms of "rules" . . . but these rules are far different from the sorts of rules that human scientists have dealt with over the decades' (Lash, 2007: 70). Lash suggests that what has changed is that where we once might have focused an understanding of power and regulation upon 'constitutive' and 'regulative' rules, now, 'in a society of pervasive media and ubiquitous coding, at stake is a third type of rule, algorithmic, *generative* rules' (Lash, 2007: 71). This is a new form of power, according to Lash, a post-hegemonic power that operates from the inside rather than being about the dominant acting on the dominated through ideology. Lash explains that these:

> Generative rules are, as it were, virtuals, that generate a whole variety of actuals. They are compressed and hidden and we do not encounter them in the way that we encounter constitutive and regulative rules. Yet this third type of generative rule is more and more pervasive in our social and cultural life of post-hegemonic order. They do not merely open up opportunity for invention, however. They are also pathways through which capitalist power works.
>
> (Lash, 2007: 71)

In other words, for Lash, algorithms create realities, they constitute the social world in different ways and they present us with limitations and boundaries that we then live by. We begin to see straight away, however we might feel about Lash and Mackenzie's provocative positions, that algorithms could well be operating to create or maintain rules and orders without really being noticed. They operate, as Thrift (2005) has put it, in the 'technological unconscious' – indeed, the lack of awareness or visibility of these powerful algorithmic processes has been something of an area of consensus (as well as Thrift, 2005; see also Graham, 2005, and Hayles, 2006).

The above suggests that algorithms need to be understood as a part of the social world in order to understand the power they have to shape everyday life. Before moving to look at the implications of algorithms for popular culture, let us turn now to a range of literature that deals with the social implications of the increasing embeddedness of algorithms in social processes. By turning to this literature we can then begin to develop a conceptual vocabulary and approach for thinking in more detail about algorithms in culture.

A common theme, reflected in Mackenzie's central argument, concerns the relations between algorithms and agency, or the contestation of agency, to be more specific, and how these become 'invisible' as they 'increasingly pattern and coordinate everyday life' (Mackenzie, 2006: 45). Mackenzie (2006: 65) concludes that:

> The contestation of agency here concerns how action is both naturalized and animated, made to seem ordinary and extraordinary. Here the contestation of agency pivots on the composite, concatenated patterns and orderings that algorithms condense . . . [no] actual algorithm [is] unattached from the orderings, positionings and sequencings that increasingly weave software into environments.

As software become part of environments so their ordering and sequencing become natural parts of the social world. Thus agency is challenged or contested by these naturalised boundaries, according to Mackenzie, in often unseen and invisible ways. The ordering powers of algorithms are far reaching and are highly prescriptive as they come, via the embedded software, to constitute, shape and order everyday life.

In order to attempt to unpick or understand the ordering power of algorithms and their relations with human agency, Mackenzie, again using bioinformatics as the case study, suggests three 'general implications' that can be explored. It is worth outlining these as a reference point for the discussion of the types of implications and conceptualisations we see emerging in the other writings on algorithms.

First, Mackenzie outlines the abstract nature of algorithms and how their abstractions are translated into sequences, orders and timings. Algorithms may be abstract but they enact material processes. Indeed, what he describes as 'algorithmic time' is an important aspect of this for Mackenzie. He contends that algorithms 'do not simply speed up computation; they institute a composite time and space in which existing orderings and sequences are both preserved and reconfigured' (Mackenzie, 2006: 64). Orders and sequences then, which may be the product of existing tendencies, shift on to the time-scales of the algorithm as it works through its sequences with its allocated computational power. As such the algorithm translates its ordering into the pace or speed of these everyday processes. We come to live, as it were, in 'algorithmic time'.

Second, Mackenzie highlights the 'entwined framings at work in algorithms'. Here the claim is that every 'abstraction is relative to a concrete framing . . . Considerations of computational space and time can be found at each level of abstraction in algorithmic design, ranging from theoretical estimations of algorithmic complexity . . . to optimizations in the flow of code that individual programmers implement in well-known algorithms' (Mackenzie, 2006: 64). For a specific example of this kind of framing Jussi Parikka has described how nature, and particularly insects and swarms, have acted as the model by which software and algorithms have been designed, with the replication of nature's 'perfect machine' being the objective (Parikka, 2010: 145–168; see also Thacker, 2007; and for more on nature, genetics and algorithms see DeLanda, 2011: 48–78). This then is about the social embeddedness of algorithms. It is about seeing algorithms not as abstract lines of code but to see them in their social settings as they become a part of routines and processes. This understanding of the framing of algorithms is concerned with how algorithms allow 'software to flow into everyday life' (Mackenzie, 2006: 64). This framing is both the way in which the software is imagined in the design

stages and how this then feeds into practice. Elsewhere, along similar lines, Kitchin and Dodge say that '[d]evelopers often unconsciously place a particular philosophical frame on the world that renders it amenable to the work of code and algorithms, thus realizing a specific system of thought to address a particular relational problem' (Kitchin and Dodge, 2011: 247). So these social frames are abstractions that enable the software to become part of everyday processes, bringing with them broader social and historical frameworks based upon influences such as nature, biography and even moral frameworks (see Lyon in Kitchin and Dodge, 2011: 104). Algorithms solve problems in particular ways.

Third, Mackenzie's (2006: 64–65) final implications are based on the 'points of attachment between algorithms and other movements and space'. This is about the ways in which the framing of the software become a part of the context in which they operate. Here the algorithm becomes a part of complex social processes, rather than just having implications for the immediate process of which it is a part. Mackenzie (2006: 65) argues that:

> Algorithms are not neutral formal procedures. In algorithms that predict or correlate sequences of events in living systems, the treatment of living systems as algorithms in process is enmeshed with the broader promises of bioinformatics as source of scientific knowledge and economic value . . . Algorithms themselves are animated: they induce movement between inputs and outputs, and are themselves caught up in diagonal movements between biological knowledge and property value, movements characteristic of the new media biotechnology economy.

Algorithms, in this working, can no longer be seen as neutral problem-solving devices. This final set of implications is concerned with seeing the vast emergence of affect associated with algorithmic processes. As such it is necessary to view algorithms both as a part of the social fabric and as a part of a network of interrelated social processes. Algorithms are both a product and a part of these increasingly software dense environments.

In Mackenzie's writings we have some useful guide points that emerge from this early work on algorithms in the bioinformatics sector. The general guidelines he provides are helpful in shifting

away from a neutral and computer scientific vision of algorithms and towards a vision of algorithms as being deeply embedded in social processes. Of course, the central issue revolves around the relations between algorithms and agency.

Algorithms and agency

As discussed in Chapter 2, Kitchin and Dodge (2011) have influentially argued that software is now central to social functioning (we can locate similar arguments across a range of other articles, most notably Crang and Graham, 2007). What they describe as 'code/space' (see Chapter 2) is riddled with algorithms. Kitchin and Dodge provide a detailed account of how algorithms have become a defining part of various aspects of the social world from air flight to the home. They point out that:

> Software has, at a fundamental level, an ontological power, it is able to realize whole systems of thought (algorithms and capta) with respect to specific domains. For example, consider the influence of formalizing and coding how money is represented and transacted and thus how the banking system is organized and works.
>
> (Kitchin and Dodge, 2011: 26)

The point here is that software algorithms, as has already been suggested, are deeply embedded in a range of social spheres. It should be added that others have acknowledged the power of algorithms in the banking sector (see Gane, 2012b: 66–70). This work has included an account of how algorithmic trading occurs in the financial sector, making trading decisions through the 'Volume Weighted Average Price' or 'VWAP algorithm' (Lenglet, 2011: 49), and the way that codings might end up being 'misaligned' from codes of conduct (Lenglet, 2011: 61). Again, this work describes the way that algorithmic agency intervenes in or bypasses human discretion.

It is notable that Kitchin and Dodge talk here of algorithms as systems of thought. The software, which is becoming incorporated into various spheres, they argue, has ontological powers in that it realises these systems of thought in different social settings. Again, this is a parallel argument to Lash and Mackenzie, in that we see the way

that algorithms have an ordering power that frames the possibilities of action and understanding. The point being that algorithms, as an ordering mechanism of code, are a part of the 'terrain on which decisions concerning chance, pattern, order, values, time, otherness, nature and culture are enacted' (Mackenzie and Vurdubakis, 2011: 4).

By way of illustration of the relations between algorithms, capta – which are selected units of measurement – and 'the world', Kitchin and Dodge turn to weather and climate change modelling. They describe this in the following terms:

> Here, knowledge about the world is translated and formalised into capta structures and algorithms that are then converted into sets of computational instructions that when applied to climate measurements express a particular story. Gramelsberger expresses this as 'Theory = Mathematics = Code = Story.' Our understanding of weather forecasting and climate models are almost entirely driven by these computational models, which have been refined over time in a recursive fashion in response to how these models have performed, and which are used to theorise, simulate and predict weather patterns . . . In turn, the models underpin policy arguments concerning climate change and have real effects concerning individual and institutional responses to measured and predicted change . . . the models analyze the world and the world responds to the models.
>
> (Kitchin and Dodge, 2011: 30)

A similar account then to the opening vignette on the Netflix predictive algorithm. These are recursive processes with algorithms being measured, honed and refined to suit the systems of measurement and the story they fit within – 'the models analyze the world and the world responds to the models'. We can return to the issues of recursivity and ordering in understanding the social power of algorithms, but let us stick for the moment with the issue of agency that still underpins this unfolding power of algorithms in everyday processes. In the above passage from Kitchin and Dodge, we see that knowledge and decision-making in the policy setting is informed by algorithmic processes. As such the agency of the algorithm feeds directly into the agency of 'the committee' – something that would have proven to provide a nice extension to the arguments about the

committee and bureaucratic functioning in the academy made by C. Wright Mills (1959). A clear instance then of data feeding back into decision-making through algorithmic processes.

For Mike Crang and Stephen Graham (2007), we can think of the relations between algorithms and agency in spatial terms as enveloped in the 'sentient city', wrapped up as it is in 'ubiquitous computing' and 'ambient intelligence'. 'Urban ubiquitous computing systems', they argue, 'entwine people, place and software in complex ways. Software algorithms code people, places and their data in interrelated systems that are then used to profile and drive decision making systems. This raises a key question: What happens when the processing and not just the data is embedded in the everyday environment?' (Crang and Graham, 2007: 792). The result is that such processes embed themselves and become a part of the architecture of everyday life. As such a 'wide range of technologies deploying algorithmic calculation, tracking and data mining are being deployed to reconfigure passport systems, borders, even public transport transactions, based on the biometric tracking of identities' (Crang and Graham, 2007: 802). As things stand we can only begin to imagine the power of such processes and the types of consequences they might have. As Jordan Crandall (2010: 69) describes:

> The history of tracking is rooted in the figure of the surveilant – the observational expert, stationed at the monitors of policing, military and intelligence agencies, interpreting movements on images maps or screens. Yet tracking practices have developed in ways that complicate this centralization of human agency. They have come to rely, increasingly, on algorithmic procedures and automated systems, and they have been incorporated into distributed network environments – augmented by new sensing and locationing technologies and embedded into mobile devices, buildings, cars and urban infrastructures.

Again in this account of tracking and surveillance, the expert judgement of the human agent is bypassed by algorithmic systems of judgement. Crandall's account envisions this expert as now being a part of an infrastructure that makes the decisions. This, he claims, complicates the centrality of human agency in such processes of risk assessment. It is not, for Crandall, that human agency is

lost altogether, but rather that it becomes a part of these lively infrastructures.

In order to flesh this vision out we can take the work of Louise Amoore as an example. Her empirical work has shown how in the control of national borders, border guards 'defer security decisions into algorithmic calculation' (Amoore, 2009b: 63). Or, as she describes further elsewhere, the 'data derivative comes into being from an amalgam of disaggregated data – reaggregated via mobile algorithm-based association rules and visualised in "real time" as risk map, score or colour-coded flag' (Amoore, 2011: 27). These, Amoore (2011: 27) argues, 'go on to live and act in the world'. Data derivatives, Amoore notes, become the basis from which predictions are made about potential behaviours or actions – and thus understanding their origins and their part in these systems is crucial in revealing the underlying logics and politics of these decision-making processes. The crucial point here is that such decisions then become the product of algorithmic agency, and various types of data resources, rather than being based upon human discretion. These data resources, as they feed into data derivatives, can be 'fragmented' and are often being used in inferential practices far from their intended uses (Amoore, 2011: 28). As Amoore (2011: 28) adds, 'the data derivative is not centred on who we are, nor even on what our data says about us, but on what can be imagined and inferred about who we might be – on our very proclivities and potentialities'. In this case the decisions about who or what constitutes a risk are made by the processing and sorting powers of algorithms. The data and the means of analysis are inherent in these infrastructures. As Crang and Graham put it, these systems are used 'to call upon memories, via databases recording the history of movements and associations of things, activities and people, and anticipate, so that threatening and "abnormal" behaviours and emergences can be detected and dealt with before the point of terrorist or insurgent attack' (Crang and Graham, 2007: 801–802). These are important politically orientated decisions that are made through the data and analytical functions of the 'sentient city'. As Crandall (2010: 83) notes in an article about tracking and algorithms, such tracking systems:

> can adapt to changes in the observed environment 'on its own', detecting, tracking and classifying abnormal behaviour that was

> not previously defined or anticipated – activity that might be deemed high-risk or potentially violent . . . Since they occur with little or no human involvement, minimizing the need for human intervention or dispensing with it altogether, such activities are often understood to occur 'automatically' or 'autonomously'. In this way the algorithm is dehumanized.

We need not necessarily assume that this algorithmic agency is accurate, the mere fact that it exists and that it reshapes decision-making is important. Here it is clear that algorithms are having, as Crandall claims, a 'dehumanzing' affect on those being judged and on those making the judgements. There are a set of contrasting norms that individuals are judged against by these systems without human discretion intervening or altering decisions. Crandall argues though that human input into the crafting of algorithms and their decision-making processes complicates matters (the new forms of agency that emerge or are borrowed by algorithms have been discussed in terms of the 'encoding of human' agency by Introna, 2011: 122–130). Crandall contends that the rise of such processes is not a movement into a new machine age but is rather the development of a set of circumstances within which different types of agency combine (Crandall, 2010: 83–84). This is illustrated by the descriptions of the computer scientist Robert Sedgewick (1988: 81), who, from early in the development of computer algorithms, pointed out that algorithms 'rarely exist in a vacuum . . . [p]roper algorithm design involves putting some thought into the potential impact of design decisions on implementations, and proper applications of programming involves putting some thought into performance properties of the basic methods used'. The design of the algorithm then is very much a product of the understanding of the outcomes it is likely to create and is therefore shaped by the judgement of the designer.

This though is not just about the moments in which such big decisions are made, it is also about the way that these decisions are informed by contextualising data of various types. This background information is central in enabling the decision-making processes to occur. As Crang and Graham note, '[c]rucial here is the adaptation of the commercial practices of "data mining" or "predictive analytics" where algorithms are developed to look for patterns in the swathes of captured data, identify or profile behaviours or characteristics

deemed to be "unusual" or "abnormal" ' (Crang and Graham, 2007: 803). And as we now know, the depth of information about us is only growing and spreading across most areas of everyday life, including music and popular culture (Beer, 2010). The result is that there is a plethora of information about us that can be used as a resource to inform algorithmic agency. Stephen Graham, summarising such processes of 'software sorting', directly raises such questions of agency when he points out that 'computer algorithms are being used at the interface of databases and telecommunications networks to allocate different levels of service to different users on an increasingly automated basis' (Graham, 2004c: 325). Indeed, it has been argued that it is the sorting and categorising of things and people that is the real power of algorithms and, in this simple act of 'data differentiation', is where they have the most social consequence (Cheney-Lippold, 2011: 166–172). The point here is that, thanks to some detailed empirical work, some of which I will discuss in more detail below, there are now moments where we might begin to see the agentic power of algorithms as they come to take decisions out of people's hands. The consequence appears to be the meshing of agency in these environments. This work has focused on some key areas, particularly in political geography, but the net can be opened to imagine that the same meshing of agency is emerging, or is even already established, across a range of sectors, with algorithms shaping or making decisions and thus becoming active agents that constitute and shape as well as maintain and facilitate.

Algorithms and recursivity: The iterative dimensions of social life

There are types of algorithms that are specifically designed to facilitate recursive processes. Thus there are engineered forms of recursivity that are part of these software structures. Jeff Edmonds (2008: 2) points out that:

> Most algorithms are best described as being either *iterative* or *recursive*. An iterative algorithm (. . .) takes one step at a time . . . A recursive algorithm (. . .) breaks its instances into smaller instances, which it gets a *friend* to solve, and then combines their solutions into one of its own . . . Recursive backtracking algorithms (. . .) try things and, if they don't work, backtrack and try something else.

These algorithms are either based upon linear stages, or they weave together circulations of algorithmic processes to produce overarching outcomes – and this is before we enter into the functionality of other types of algorithms such as 'greedy algorithms' (Edmonds, 2008: 225–250), 'dynamic programming algorithms' (Edmonds, 2008: 267–292), 'searching algorithms' (Sedgewick, 1988: 193–259), 'sorting algorithms' (Sedgewick, 1988: 93–177), 'graph algorithms' (Cormen et al., 1990: 463–465), 'parallel algorithms' (Baase and Van Gelder, 2000: 612–647) and so on. Underpinning these are a history of algorithm development in mathematics and some well-established 'classic algorithms' (Baase and Van Gelder, 2000: 2). Some algorithms are specifically designed to draw together looped outcomes that bring the decision-making processes back in on themselves to form continual loops. These are self-referential systems.

In a chapter on 'recursive algorithms' Herbert S. Wilf (2002: 49–98) outlines the central features of their functioning. Wilf (2002: 50) points out that the 'hallmark of a recursive procedure is that it *calls itself*'. These algorithms *call themselves*, that is to say that they feed into their own functioning (for more on algorithms calling themselves, see also Sedgewick, 1988: 51). They loop back into themselves in their own processes, thus forming a circular system or looped systems. 'Recursion trees' are then used to analyse the outputs and structures of these recursive algorithms and to measure the 'cost', in terms of 'running time, number of key comparisons and other measures' (Baase and Van Gelder, 2000: 134). Sedgewick (1988: 51) adds that often a 'termination condition' is required to allow the program to stop calling itself when necessary and to prevent it from never stopping. Wilf (2002), writing a decade or so ago, indicates some excitement and awe about the potential of such recursive algorithms. He continues by saying that 'many methods of great power are being formulated recursively, methods which, in many cases, might not have been developed if recursion were not readily available as a practical programming tool' (Wilf, 2002: 50). Wilf appears to be outlining the power of the new potential possibilities of recursive algorithms; we can quickly imagine how such processes have now sunk into the ordinary functioning of software code in the decade or so since his book was published.

Clearly then there are recursive structures built into the infrastructures of new media that have now become mainstream in everyday life. It is worth reflecting back here on how this type

of recursion might have implications for our earlier discussion of agency. There is already some suggestion in this chapter that social models and desired outcomes become a part of algorithmic design and functioning, which suggests that algorithms are by no means free of human agency. This issue resurfaces when considering recursive algorithms. For instance, according to Wilf (2002: 50), 'there is a bit of art involved in choosing the list of variables on which a recursive procedure operates' (Wilf, 2002: 50). The processes of recursivity are not neutral or entirely machinic, rather they are shaped by the choices made and by the 'art' of the designer. Again we find the meshing of forms of agency, not just in the design of the algorithm but also in the types of data resources the algorithm draws from in solving the problem.

We have already seen from Kitchin and Dodge's discussion of weather and climate change prediction that algorithms are not fixed but are part of recursive social modelling – this is also suggested by the Netflix example and in Mackenzie's discussion of framing. Algorithms are themselves folded into circulations of knowledge as they both reflect knowledge about the world and as their performance is measured and refined to designed outcomes. However arbitrary, strange or inaccurate the systems of measurement that define this refining of the algorithm might be, they still have concrete outcomes. The systems for measuring the performance of algorithms and refining their functions are 'virtuals' that become 'actuals' (Lash, 2007) – see again the Netflix example. In these recursive processes we find the agency of algorithms again rubs up against the agency of human actors.

Echoing Mackenzie's accounts of how algorithms are abstracted theories about the world, Kitchin and Dodge (2011: 41) argue that:

> One of the effects of abstracting the world into software algorithms and data models, and rendering aspects of the world as capta, which are then used as the basis for software to do work in the world, is that the world starts to structure itself in the image of the capta and the code – a self-fulfilling, recursive relationship develops.

This is a crucial observation. It is acknowledgement of the way that these algorithms, and the systems of measurement that feed into

them, have the capacity to become active in shaping and constituting social life. If we think of Netflix again, then it is likely that the films that are recommended to you by these algorithmic processes are likely to become the films you watch or that you are likely to want to watch. These are complex social processes that are impossible to unpick and to separate out, but fit more closely with discussions of emergence in complexity theory (Urry, 2003). Whatever the conceptual backdrop used to clarify these processes, it becomes clear that algorithms are an integrated and irretractable part of everyday social processes. They have the potential to become a reality and to reinforce, maintain or even reshape visions of the social world, knowledge and encounters with information. But they do not standalone; they are involved in a complex mix of knowledge and framings of the world. They simultaneously then become actors and shape what that knowledge of the world is. It is for this reason that Kitchin and Dodge (2011: 43) suggest the following formulation:

> Code is an expression of how computation both capture the world within a system of thought (as algorithms and structures of capta) and a set of instructions that tell digital hardware and communication networks how to act in the world. For us, software needs to be theorized as both a contingent product of the world and a relational producer of the world.

This is an important observation about the recursive nature of algorithmic processes. They are formed out of knowledge about the world and measured against that knowledge for their performance, but at the same time they are 'actants' in that world, shaping what it is and how it functions. This is probably one of the must powerful yet under acknowledged points of observation in recent times. Cultural analysis for example, has yet to engage with this observation or with the implications it alludes to for the changing ontology (or doing) of culture.

This changing ontology, as Scott Lash (2006 and 2007) has also described, is defined by the increasing possibilities for data to 'find us'. This is where data folds back into the social world and begins to not just capture it but also to 'constitute it' (Lash, 2007). They make the world. We do not need necessarily to search for things, because they come to us. Here algorithms are involved in recursive processes

as they shape what data flows where and to whom. Algorithms define what 'finds us', and so have a powerful place in the circulations of data and how these are filtered and directed. This is a key new form of power, according to Lash (2007), which he describes as being post-hegemonic. By post-hegemonic he means that it is a form of power that does not act on someone from above, through ideology, but rather it is an immanent form of power that acts within lives by shaping and constituting lifeworlds (for an overview of this argument, see Beer 2009b). For Adrian Mackenzie these processes of data finding-us are part of what he calls the 'performativity' of code and the 'performativity of circulation'. Mackenzie notes, for example, that:

> As culture becomes 'operational', or as information technologies become more cultural, that is, as they merge into wider circulatory practices of ordering and coding, of representing and regulating differences in some ways and not others, erstwhile infrastructural things like operating systems, protocols, algorithms and code figure as singularities.
>
> (Mackenzie, 2005: 74)

Again we see here that the performance of circulation that occurs, the circulations that define what 'finds us', are the product of such systems. Mackenzie's point is that such systems have merged into wider cultural process and have become a part of how culture is ordered and organised. These infrastructures, for Mackenzie and Lash, have become part of the everyday, they have become cultural themselves as well as becoming a part of how culture is organised and consumed. This incorporation into the everyday combines with the ability to shape the things that find us and to constitute space and cultural experience. For Lash and Mackenzie these algorithms are powerful devices. This power comes from the way that they are implicit in the recursive and iterative processes that define everyday life.

Finally, to add an additional layer to these recursive and iterative processes we might also imagine that these algorithms are powerful not just in shaping encounters but also in shaping behaviour. If data are able to find us, then we might imagine that behaviours might be shaped by these data. Here behaviours and action might become a product of attempts to play with outcomes, to predict algorithmic processes and to try to shape the way that these algorithmic

circulations occur. In a piece on what she describes as the ideology of algorithms Astrid Mager talks of the way that 'website providers not only provide content and links to search engines use to index the web, but also deliberately please search engines by designing their sites according to search algorithms' (Mager, 2012: 777). These she describes as being examples of how algorithmic processes also become a part of social action, based that is not just upon what they do but on how individuals and organisations respond to what they do – or to what they think they might do. But the iteration does not end there. Rather, in response, these 'marketing strategies alter search algorithms by forcing engineers to "tweak" the algorithm to maintain the quality of search results' (Mager, 2012: 777). The algorithms are then shaped and reshaped in response to these games and to try to prevent certain forms of behaviours, or to guide the processes towards more specified desired outcomes. Here we see that the algorithms themselves, which are affording these recursive cultural processes of data circulation, are a part of these iterative processes as they are redesigned and rewritten in response to these feedback loops. As Mager claims, there is an 'engineering-driven logic underlying the construction of search algorithms' (Mager, 2012: 775). They are far from fixed properties, but in defining what finds us, they are in turn rewritten, as we saw with the Netflix example, in response to the way that the circulations play out. Here then we have complex layers of recursive and iterative processes each implicating the other in various ways. This we can begin to imagine sits quite nicely with accounts of emergence, chaos and social complexity (Urry, 2003).

Algorithms, ordering and control

The above sections have briefly discussed how algorithms have come to have implications for agency and for defining recursive cultural flows and circulations. With this as a background we are able to think about the general ways in which algorithms are complicit in processes of social ordering and control. Cheney-Lippold (2011: 166), for instance, directly connects issues of ordering and control to the categorisations that are made by sorting algorithms. The power here is in defining and differentiating us through data, which, in turn, creates normalising behaviours and identities (Cheney-Lippold, 2011: 177). Indeed, there are a number of arguments being made about the

new forms of power that emerge in software dense infrastructures and algorithmically defined information flows. As might be expected, the ways that these new forms of social power operate fits into the questions about agency and iteration that we have already discussed. For example, a common power associated with algorithms and software concerns the ability of companies and organisations to track and trace individuals and groups. The result is the often discussed ability of companies to harvest data and to make predictions about people. For instance, Crang and Graham (2007: 811–812) say that:

> Consumer technologies are also clearly designed to make our preferences for, uses of, and indeed thoughts about, products traceable. In the newly visible field of practices they, too, can then deploy algorithmic agency to target the most appropriate or profitable consumer.
>
> (Crang and Graham, 2007: 811–812)

Again we find the constitutive power of these systems outlined. Here these systems make preferences visible to organisations so that they can then act on these newly visible consumer patterns. The result is that capitalists can target consumers by using the predictive capacities of the new digital architectures of consumption. The form of social power operating here is about selection, about who gets targeted, who gets preferential treatment and who is looked upon favourably (Graham, 2004c). This might seem minor, and indeed the attention of being targeted might be unwelcome, but in some instance being targeted and viewed preferentially might actually play closely with life opportunities, comfort and even social mobility, if, for example, the products are financial services, healthcare services, or insurance (Burrows and Ellison, 2004).

Indeed, there seems a general consensus that 'code is altering the nature of consumption' (Kitchin and Dodge, 2011: 210). In fact there is a good deal of literature now emerging about new forms of consumer capitalism in an age of predictive algorithms and software-centred consumption practices (Thrift, 2005; Turow 2006). This change in the nature of consumer capitalism is illustrative of the almost unimaginable power of algorithms in the global economy. For example, Kitchin and Dodge (2011: 210) have observed that:

> Software has led to the virtual abstraction of money, enabling finance to circulate through dense, interconnected and interdependent network of companies, products, and property, and creating new, fictitious, and speculative capital which is highly mobile. As a consequence, capta and software algorithms are at the heart of the global financial system, underpinning how monies were and continue to be, monitored, transferred, tracked, repackaged, sold, and leveraged

Kitchin and Dodge's position is that software, code and algorithms are at the centre of the functioning of consumer capitalism. Indeed, the economy couldn't actually function without them. This begins to give us a sense of the scale of the social ordering powers of algorithms, their reach into everyday processes and their embedded functioning in everyday life. Kitchin and Dodge take such observations far beyond this more abstract account of the flow of finance and the large-scale circuits of consumer capitalism to embed such ideas in the mundane environment of the home. They argue that: 'Every home is a node in multiple consumer and government networks relating to utilities, entertainment, communications, finance, taxation, health, and security, some of which work in real time, others asynchronously, all using electronic captabases structured and worked upon by software algorithms' (Kitchin and Dodge, 2011: 169).

In short, such large-scale functioning is networked into homespace (Dodge and Kitchin, 2009; see also McKelvey, 2010). These homes are also judged and defined by the algorithmic processes of which they are a part. This can relate to the way that the home is monitored for utilities and the like, but there is also a software density within the home that they have described, populated as they often are by various devices that require software and algorithms in order to function (see Chapter 2). What Kitchin and Dodge do here is to show the various scales of analysis that are required in understanding software and algorithmic processes, and how these different scales indicate the large-scale and small-scale power of algorithms in everyday life.

We might wonder though why this type of vast embeddedness of algorithms is actually also about new forms of social ordering and control. I've provided some outlines of this already in the chapter, and we will turn to culture in a moment for some specific examples.

If, for the moment, we stick with these broader themes, then Kitchin and Dodge provide us with some analytical pointers for unpicking algorithmic social ordering. They claim that there are 'grammars of action' within software code, and these have various outcomes that implicitly intervene in social ordering and control. Kitchin and Dodge (2011: 109) argue that the 'grammars of action of code increases the power of traditional . . . surveillance and also actively reshapes behavior, creating automated capture systems in which software algorithms work automatically and autonomously'. Here we see multiple types of levels of social ordering occurring through software algorithms. They note that these algorithms help to increase visibility and thus expand the possibilities of traditional forms of surveillance. These algorithms are actively reshaping behaviour, as we have already seen in the above sections on agency and recursivity. And finally, importantly, algorithms work to capture and respond to social behaviours and actions in automated and unseen ways. This final issue means that algorithms, as has been shown elsewhere (Lash, 2007; Thrift, 2005; Hayles, 2006), order the world in ways that are often not even visible.

Again Louise Amoore's work is instructive in revealing exactly how these invisible processes work on the ground. Her suggestion is that algorithms work by focusing attention on specific things. The power of the algorithm is to draw attention to a desired focal point, thus obscuring the other possibilities. This is about the way that algorithms direct and guide encounters and decision-making. To be more exact, Amoore (2009a: 22) argues that:

> In effect, algorithms precisely function as a means of directing and disciplining attention, focusing on specific points and cancelling out all other data, appearing to make it possible to translate *probable* associations between people or objects into *actionable* security decisions

Selectivity and direction are the domain of algorithms. Algorithms highlight one point and in so doing mask others. And then on top of this, algorithmic systems make predictions and probable associations seem concrete, real and inevitable. This is to make a reality out of a set of predictions which then become the basis of decision-making. This might be decision-making about a myriad of things, including music

choices and the like. Fans of cricket at this point, for example, might be thinking about the way that a simulation is used to predict the trajectory a cricket ball would have taken after hitting the batter's leg. Here a probable outcome is used to make a decision about whether the batter should be out leg-before-wicket or not (i.e. would the ball have carried on and hit the stumps). Here a prediction created by software algorithms becomes the basis of an actionable decision.

Indeed, for Amoore one of the key powers of algorithms is in the predictions of the future that they are used to make. These predictions, as we have suggested, become realities from which decisions are made. Thus the algorithm shapes decision-making processes with very real implications for individuals and how they are treated. Amoore (2009a: 22) explains that '[b]y connecting the dots of probabilistic associations, the algorithm becomes a means of foreseeing or anticipating a course of events yet to take place'. These 'lines of sight' are powerful in shaping all sorts of decisions. Again, in the security setting they are a way of predicting levels of risk and acting on such predictions. For Amoore, this signals an important change in decision-making processes and in the types of resources used to make judgements about people, with new types of data fusing with new algorithmic decision-making processes. As Amoore (2009b: 53) puts it:

> The deployment of algorithmic calculations in this context signals an important move – from the effort to predict future trends on the basis of fixed statistical data to a means of pre-empting the future, drawing probable futures into imminent and immediate commercial decision.

Amoore's point is that such processes need to be understood in order to understand the implications they have for decision-making. Clearly there is a widespread and significant presence of algorithms shaping such judgements. In turn these have material outcomes for those who are making and those who are on the receiving end of such decisions. This 'anticipatory knowledge' (Kinsley, 2012: 1562–1564) has come to be very powerful in the security sector. Kinsley (2012) argues that a critical response to the use of such knowledge is crucial (see also Knox and Harvey, 2011). The algorithms here are powerful in making predictions that then classify and order people, and then

ultimately shape how they are treated and what type of response they receive. Undoubtedly then there is a politics of algorithms on display in Amoore's work. For Amoore (2009a: 22) these represent a 'mode of calculation' based upon the sharing of data between agencies, with the algorithm producing a 'visualization of suspicion' that then feeds into judgements about how other people are judged. The roots of these systems return us back to consumer capitalism, as the 'origins of algorithmic techniques for visualizing people lie, perhaps not surprisingly, in commercial techniques for imagining the consumer' (Amoore, 2009a: 22). We are seeing then the same types of algorithmically defined decision-making and prediction about individuals across various sectors.

We can only then, based on Amoore's work, begin to imagine how we, as consumers, are being analysed (for example see Beer, 2010). As well as thinking through the issues associated with the highlighting of certain possibilities and the power of prediction in shaping decisions, Amoore also describes how algorithms become powerful in making and shaping social norms and perceptions of appropriate or ordinary behaviours. Amoore argues that '[m]odes of attentiveness in contemporary homeland security practice ... are particularly dependent on algorithmic logics that designate anomaly on the basis of a screening of the norm' (Amoore, 2009a: 25). The algorithms use the data to make judgements against such social norms. Those who do not display such norms are highlighted as holding abnormal properties. We can imagine, when we think of how these systems are being used across sectors, how powerful these embedded norms might be. Jordan Crandall similarly claims (2010: 71) that algorithms are powerful, often through the analysis of risk in surveillance, in that they 'construct the norm'.

So on the surface algorithms might appear to be neutral decision-makers. It would seem though that this is far from being the case. Rather they are active in normalising behaviour patterns and in making predictions about the perceived adherence to norms based upon certain data sets. Finally, Amoore points out that '[w]hile they appear to visualize a picture of a person that is culturally nuanced – every minute and prosaic "behaviour", every aspect of a way of life potentially becoming a part of the classification – they actually efface difference in their drive for identification' (Amoore, 2009a: 24). So whilst we might think of algorithms, in the security and border

services as well as in consumer culture, as providing tailored and individual responses, they are in fact often making judgements about groups and the norms of those groups. They are judging not that individual but making deductions based upon the data about other groups of individuals.

Some of the decisions that shape everyday lives need not be as obviously significant as those taken by border guards. Even, according to Kitchin and Dodge (2011), familiar and routine software 'applications like Microsoft Word or Adobe Photoshop are flexible and open-ended tools, but they come loaded up with structures, templates, default settings, algorithmic normalities and path dependencies that often subtly but necessarily direct users to certain solutions' (Kitchin and Dodge, 2011: 122). Perhaps we can add other familiar software applications such as PowerPoint, Google Scholar, Atlas.ti, NVivo, LexisNexis, SPAD and SPSS (on the latter see Uprichard et al., 2009). We can imagine that these all come with such algorithmic normalities that frame the outputs of academics and direct us to certain solutions. There is some scope here for thinking of the power of algorithms in academic research, with these underpinning software gently shaping what it is that academics produce, what they find out, what they see in their data and how they perform their work. The central point though is that even these fundamentally ordinary software applications are subtly framing everyday practices. The outcome is that we can begin to see the scale of algorithmic sorting not just in cultural consumption, but also in the making and finishing of cultural products.

I have already described briefly how Mager's work explores the algorithmic shaping of behaviour. But when considering how algorithms play a part in social ordering processes it is perhaps important to reiterate how 'capitalist ideology gets inscribed in search algorithms by way of social practices' (Mager, 2012: 770). This is to think of algorithms not as neutral mathematical forces that simply do a job but to return again to the earlier point about the social models that are used to design algorithms. It is to presume that dominant capitalist ideologies become a part of how algorithms themselves are designed and the functions they perform. This, for Mager, is about how capitalism 'gets aligned with and woven into the mathematics of search algorithms and how website providers and users comply with and stabilize this dynamic' (Mager, 2012: 770). Capitalist spirit,

she argues, gets 'inscribed in the fabric of search algorithms by way of social practices' (Mager, 2012: 782). Galloway (2011: 100) indirectly draws a similar conclusion by noting that there 'is one game in town: a positivistic dominant of reductive, systemic efficiency and expediency'. The values of capitalism, famously described by Lyotard (1979) as the minimum input maximum output performativity equation, are inscribed on to the design and functioning of the algorithm. The pursuit of the increasingly perfect predictive algorithm in the Netflix competition with which I opened this chapter, serves as an illustrative example here. It is helpful to return to Adrian Mackenzie's (2006) work here to think of this ideology of capitalism as being a part of the models that frame and instruct algorithmic design. In this parallel work Mackenzie and Vurdubakis (2011: 4) also suggest that code and algorithms need to be understood 'not only in terms of software but also in terms of cultural, moral, ethical and legal codes of conduct'.

As this all indicates, there are also some very mundane and everyday ways in which algorithms perform an ordering function. Here the power of algorithms is in shaping what or who is visible. Again, the issue of the type of material we encounter is important. Taina Bucher (2012) has argued that social networking sites like Facebook are the site of algorithmic power where the threat of invisibility leads to certain types of activities and behaviours. It is of course the algorithmic processes that define visibility in these spaces. As with Amoore's work, the algorithms in social networking sites are intended to make behaviours visible, but in this instance the outcomes are more publicly visible and desired. People want to be visible and so they play to the 'algorithmic architectures'. Bucher's study shows how the 'news feed' on Facebook, which is a stream of information about the things your social network of 'friends' are up to, is an algorithmic sorting process that makes decisions about what and who should grab the headlines and thus be more visible. In this instance the EdgeRank algorithm uses various features to filter the news alerts. These include the level of interaction between the two friends, the type of interaction, how important that type of interaction is deemed to be and the 'time decay' or how fresh the news is (Bucher, 2012: 4). One of Bucher's claims is that the power of this algorithm to make things visible is at the same time a powerful force in promoting the threat of invisibility in these spaces, with visibility being a kind of reward for being active and interacting frequently. Bucher's work shows

then how algorithms are central to the operation and behaviours we might find on Facebook, which, given its population, reveals just how deeply embedded algorithms are in everyday cultural practices and interactions.

Algorithms, cultural encounters and the shaping of taste

There has been a good deal of talk in the social sciences about the importance of cultural tastes and preferences. This literature outlines the part that tastes and preferences in culture play in fostering social connections and divisions, in making social class, in building and maintaining social hierarchies and networks, in catalysing group formation and friendships, in defining positions in fields, in affording or denying social mobility and the like (see for example Bennett et al., 2009). These types of debates have re-emerged recently with some strength through the rejuvenation of the analysis of the class/culture nexus and the renewed interest in the application of Pierre Bourdieu's analytical frameworks (Bennett et al., 2009). Despite this interest, virtually no attention has been given to how cultural infrastructures and emergent media forms might be shaping, guiding and reshaping these apparently important cultural tastes and preferences. As a result we might be missing an important dimension from such analyses of the social ordering powers of culture. Indeed, it might even be the case that some of the discussions about cultural omnivorousness (Savage and Gayo, 2011) and the like are missing out on one of the crucial dimensions that is now responsible for the formation of taste. This is not to say that social class and personal networks do not shape taste anymore, but that ultimately we may find in new media infrastructures powerful forces that implicate the direction of cultural tastes. For example, and to foreground the argument, it might be that tastes amongst a group are eclectic or, to use the post-bourdieusian language, omnivorous, because algorithms guide them towards such taste formations. As such, the following argument might ask questions about our understanding of the causality of culture. Reflecting on the previous discussions of algorithmic agency, recursivity and power, the chapter now attempts to open up this issue for further elaboration.

Of course, one of the most visible forms of algorithmic recommendation comes from the highly popular online retailer Amazon.

Amazon is now highly familiar and has been widely commented on. Amazon, as we know, recommends book, music and film purchases based on purchasing profiles. As Kitchin and Dodge (2011:205) describe:

> Amazon's 'personalized recommendations' works on . . . tracking the browsing history, keyword searches, and purchases of individual customers to build a multi-dimensional profile of taste in reading or music or other consumer items, to then make recommendations for other purchases based on what other people with similar profiles have bought.

Amazon does not just have these automated recommendations, it also guides by showing what other people who viewed the item also purchased, by showing what percentage of people who bought the viewed item then went on to purchase, the list goes on. These all use data to algorithmically guide choice.

Back in the early 2000s Robert Spector (2002) wrote a short account of the early development of Amazon. This now provides a useful historical document of the approach that made Amazon a distinctive presence at the time of its publication. The book is obviously now out of date in terms of the technical aspects of the site, but it remains revealing in terms of the ethos underpinning the individual tailoring of the site for visitors, the strategies of predicting tastes and the making visible of other people's purchasing – thus building a number of feedback loops into the consumer experience. In particular, Spector's history outlines the attempt to hone customer experience around personalisation. The aims were to make the site increasingly efficient, rapid and functional (Spector, 2002: 126–157). Spector reflects on the early stages of the recommendation system, saying that as 'the site became more sophisticated, the service has become more personalized . . . The personalization is part of Amazon's philosophy of "mass customization" ' (Spector, 2002: 142). Again we see this use of aggregate level knowledge of consumer patterns being used to indicate a personalisation, or mass personalisation, of the consumer experience. These, as Nigel Thrift (2005) has described, are classic rhetorics of 'knowing capitalism'.

Spector continues by describing the various developments in the recommendation of products to users of Amazon, and how these

were honed in the early stages. Despite these developments being at a nascent stage, they highlight the centrality of personalisation and notions of shared taste in the processes from the outset. Apart from anything else, this shows the length of time that recommendation systems and the visibility of purchasing patterns of other people have now been enmeshed in consumption practices. Indeed we find that this type of 'knowing' ethos is built into the structures and cultures of this type of organisation. This is revealed by Spector (2002: 142) in a quote from an interview with Jeff Bezos, the founder of Amazon: 'I want to transport online bookselling . . . back to the days of the small bookseller, who got to know you very well and would say things like, "I know you like John Irving, and guess what, here's this new author, I think he's a lot like John Irving" '. The suggestion in this interview with Bezos is that Amazon effectively aimed to replace this type of 'knowing' form of consumer interaction, with human agency and knowledge central to the connections required for the personal recommendation to be made in the small shop, with the agency of algorithms and the knowledge extracted from large-scale data about consumption. Here algorithmic agency replaces human judgement and databases replace the accumulated tacit knowledge of an individual at work for years in a bookshop. Although we might of course question the rather quaint image that Bezos conjures in order to do this, we can still see the early direction and rhetorical construction of algorithmic systems.

To bring this story up to date, as I was compiling this chapter Amazon launched a new service which it called Amazon Cloud Player. In line with other forms of cloud computing, the idea is that music collections are no longer stored on a single device, but rather they exist in 'the cloud' and can therefore be accessed from any web enabled device – a classic Web 2.0 approach towards storage (see Beer and Burrows, 2007). This service enables all music purchased on Amazon, as well as other imported music from iTunes and the like, to be securely stored on Amazon. The pitch that accompanies this development suggests that the user need no longer worry about storing their music, nor need they worry about their music collection being a 'bit messy'. The new facility is presented as a solution to such problems, as it allows a consolidation of music into one accessible space. We can imagine though that what we also get here is a space that has a very comprehensive ability to capture music listening

practices. The result of which is that Amazon will in turn be honing the data resources that then feed back into their predictive analytics and recommendation system. It is at this point that the capabilities and functioning, presented through capitalist rhetoric, begin to mesh with design futurism to 'make' particular futures (Kinsley, 2012). This example illustrates how such 'circuits of capitalism' (Thrift, 2005) are central to the generation of value in these media forms. Again, expanding the ability to extract by-product data becomes a part of the development of the site.

The inclusion of personalised processes in consumer capitalism has received quite a bit of attention over recent years, but the ways in which this now familiar recommendation system might be intervening in the formation of taste and preferences has received much less attention. Returning to Amoore's work, the power of algorithms is in focusing the attention and in highlighting particular focal points. As with decision-making about risk factors, here recommendations present actionable decisions based on probable associations, as Amoore put it. The recommendation algorithms draw the attention towards particular cultural products and thus exercise the power to shape cultural encounters that then feed into taste. This has not really seeped over into work on cultural taste, although it is undoubtedly now a prominent part of consumer culture. As things stand the exact part that something like the Amazon recommendation system plays in taste formation is unclear.

Such cultural algorithmic processes reach far beyond these more visible recommendation systems. When searching on Google we see what other people with similar search terms searched for, we get pingbacks showing us who is talking about our blog entries, we can see what is trending on Twitter, we can even get academic articles recommended to us on Google Scholar. Each of these processes uses the feedback of data and algorithmic selection and visibility processes to order culture, drawing attention to certain things and away from others, and often providing real-time accounts of what is hot (see Chapter 5). It is now common to find that even broadcast media, such as TV shows, are commented upon via Twitter, with presenters sometimes even revealing in real-time how their show is being received by Twitter users. The list of such algorithmically refined feedbacks of data into culture are massive once we look across the different circulations of data that inform us of what is going on around us or that enable the culture to 'find us'.

The recommendation systems of prediction, as with Amazon and Netflix, are, despite being familiar and automated, in some ways the most visible aspects of 'knowing capitalism' (Thrift, 2005) in culture. To take another example, Genius is the predictive arm of Apple's ubiquitous iTunes software (Beer, 2010). Genius allows users to find music that they might like on iTunes, based not just upon their purchasing profile but also on the basis of the music they have actually listened to (which is captured by the devices and software). Here the predictions make connections based upon iTune's vast accumulated data about its millions of users worldwide. A similar application of this type of predictive algorithm can be found on the music site Last.fm. This site uses the data 'scrobbled' – which is the data harvested from devices – to build up a profile and make selections of music to listen to based upon the profile. As with Amoore's observations about such processes appearing to be individually tailored but actually being about the aggregate level analysis, such processes are described as being about helping us to find music that suits us. Genius and Last.fm both use algorithmic predictive processes to highlight music and to guide users towards particular songs. Thus these algorithms have a significant power in shaping cultural encounters, in making cultural connections and in highlighting some music and thus relegating other music. The influence that this has on the cultural landscape of individuals can only be significant when we imagine the scale of the use of such systems, and when we begin to add together some of the most prominent means of cultural consumption in iTunes, Amazon and the like. There are also now numerous 'apps' emerging that use algorithms to help the music to 'find us'. Some use purchasing or listening profiles, others find similarities in the structures or sounds of the songs themselves to make these connections.

In other words, these systems are now a routine part of consumer culture. In some ways their influence is now so deeply embedded and often unseen that it is increasingly hard to imagine or describe the impact that algorithms might be having on cultural encounters, tastes, preferences and subsequently on communities, groups, networks and movements. They are already almost too numerous to describe or list. If cultural encounters are shaped by culture finding-us, then we might imagine that this will complicate any kind of reductive vision of how cultural capital might be accumulated. If this cultural knowledge now finds-us, then cultural know-how

might be decoupled from the types of socialisation processes that are more dependent on friendship groups and the consumption of the right type of broadcast media outputs. We might wonder where this might leave something like Sarah Thornton's (1995) notion of 'subcultural capital', if these forms of knowledge can now circulate outside of subcultural groups and as they find a new audience through algorithmic processes.

We now need some more comprehensive studies that make some attempt to understand how these algorithmic new media infrastructures are coming to shape tastes and preferences. These would need to explore how these systems intervene in some of the social connections and divisions that we have long understood to be linked into expressions of taste. I have mentioned two examples from music in iTunes and Last.fm. Amazon deals with a more wide ranging scope of consumer purchases from DVDs, to music, to film, games and games consoles and even clothing. Then we can add the types of networked hard-drive based smart television systems and watch on demand services provided by many channels. I also mentioned the Netflix example; other on demand web-based services are taking on a new presence even in mainstream and public broadcasting. Similarly in literature, iTunes and Amazon are influential, particularly with Amazon's Kindle e-readers, but also stretching into academia we can consider how other digital literature is finding its audience through news feeds on academia.edu and the developments that are occurring around Google Scholar and what look to be new 'apps' that mean that academic articles will now begin to find researchers based upon their reading and/or publishing profiles. As Kitchin and Dodge (2011: 205) argue, this 'kind of analysis is only feasible with the scalability and automation offered by coded, algorithmic processing'.

Of course, as a rejoinder, we might wonder if and how people respond to the recommendations they are presented with. Do they take them up? Do they see them as being relevant and helpful? Do they respond critically? This is the point when human agency rubs up against algorithmic agency. The important point though is that it is the algorithmic agency that is deciding what it is that the individual encounters, and what it is that they are making a decision about. Their interaction with that capitalist organisation is algorithmically defined and so is the cultural opportunity it affords. This is where we might return to the points raised earlier about the power of

algorithms in making certain objects more visible, as with Bucher's work on Facebook and Amoore's and Crandall's on tracking and risk assessment. Here it is about the visibility of culture, and of particular forms of culture that algorithmically finds its audience. These systems shape cultural encounters and cultural landscapes. They also often act to make taste visible. The question this creates is about the power of algorithms in culture and, more specifically, the power of algorithms in the formation of tastes and preferences. When we look, as we increasingly do in the analysis of culture, to work exploring taste, we often see taste expressed in acts of consumption. But these expressions in acts of consumption might not be originating from the same pathways and resources that we might imagine. At least the origins of taste formation may now be, at least in part, algorithmically shaped by these new media infrastructures as they come to dominate popular culture. To take an example, behind every multiple correspondence analysis diagram depicting taste clusterings (see for example Le Roux et al., 2008) there could be algorithmic processes lurking in the shadows, shaping those clusters by influencing cultural knowledge, tastes and preferences. Perhaps this is not just about cultural know-how and social capital, perhaps it is something much more material that is now a structural part of how culture is encountered, consumed and disseminated. There are a new set of agencies mixing in these processes that are actively having a say in the formation of cultural know-how. Algorithms are also drawing cultural boundaries and influencing where these boundaries are placed and where divisions occur. The observation we are led towards, by looking across at work in bioinformatics, border control and computer science, is that in the case of culture, as it follows the types of processes prevalent in other spheres, we need now to pay attention to what might be thought of as *the infrastructures of taste formation* and to a potential shift in the ontology of taste formation.

Conclusion: opening up the missing dimensions and dynamics of cultural taste

Given the above discussions it is perhaps not surprising that software algorithms have been described as 'a vital source of social power' (Kitchin and Dodge, 2011: 246). The obvious outcome of this observation is a call for us to 'to prise open the black boxes

of algorithms . . . to understand software as a new media that augments and automates society' (Kitchin and Dodge, 2011: 246). This is required, so the argument goes, in order for us to understand this concealed social power in operation. As Steve Graham has recognised, 'the algorithms that support . . . choices, simulations, orderings, and classifications . . . remain completely and utterly unscrutinized' (Graham, 2005: 10). Things have shifted in the last seven or eight years, and as a result Graham's claim that they are 'utterly unscrutinized' no longer entirely pertains, indeed I have shown a range of work here in which algorithms and software are at the forefront of the analysis. There still remains though a need for us to get to the 'very guts' (Graham, 2005: 10) of these systems. In culture, for instance, there is very little work on the social and sorting power of algorithms. This needs to be addressed, and opening this project up has been the main objective of this chapter.

Developing their broader project, Kitchin and Dodge have argued that '[t]here is also a need to develop a sub-area of software studies – algorithm studies – that carefully unpicks the ways in which algorithms are products of knowledge about the world and how they produce knowledge that then is applied, altering the world in a recursive fashion' (Kitchin and Dodge, 2011: 248). This chapter has hoped to demonstrate that this vision for algorithmic studies is needed in the study of culture and particularly popular culture. This is no easy task, because, as Graham points out, 'the worlds of software-sorting tend not to be amenable in any meaningful way to traditional geographical or social scientific research techniques or conceptualizations' (Graham, 2005: 15). The same applies to the study of culture; we have few methodological or conceptual points of reference for such a development of the study of algorithms in culture. I hope that the exploration of conceptual ideas around algorithms in this chapter, as applied to culture, offers a vocabulary and framework for developing such a set of analytical approaches.

As part of this set of developments, and to locate a way to continue with such a project, we can turn again to Kitchin and Dodge's (2011: 255) important book. They conclude that what is needed is a 'genealogy of algorithms'. As they add:

> We believe it would be instructive to conduct a detailed archeology of how algorithms come to be constructed – to excavate the social

> lives of ideas into code – and how an algorithm then translates and mutates across projects to be reemployed in diverse ways.
>
> (Kitchin and Dodge, 2011: 255)

It is such a vision of an archaeology or genealogy of algorithms that needs to be developed in cultural analysis in order for a more complete vision of contemporary culture and contemporary popular culture to be developed. This is not something that can simply be developed in one book chapter, rather this is an ongoing task that will need resources and time. If algorithmic systems are ignored we may come to know very little about the actual functioning of culture in the everyday setting, particularly as software and algorithms come to define more and more aspects of how culture is made, disseminated and consumed. Popular culture, to use Kitchin and Dodge's (2011) terminology, is 'code/space', it relies on software and algorithms to function, and therefore this functioning needs to be part of the analysis. The issues of agency, visibility and prediction have been discussed here as key problems within this project.

Perhaps the most important observation to take away into an understanding of culture is that algorithms do not just predict. Algorithms have the capacity and potential to *make taste* by shaping cultural encounters and crafting our cultural landscapes. They are, as Morris (2012) put it, prescriptive as well as descriptive. As such there is some suggestion that the very ontology of taste formation may be altering. These recommendations and encounters will inevitably become self-fulfilling prophecies as they continue to shape our cultural landscapes and the things we come across. This then, as Sterne (2012) notes in his detailed account of the culturally defining MP3 format, is an 'algorithmic culture'. If this is the case then it is crucial that we begin to see how algorithms implicate culture. This potentially requires us to revisit some of our understandings of the ways that culture is organised and how it feeds into social relations. In this chapter, using a range of literature from various disciplines, I hope I have shown that there are various social dimensions to algorithms that are now likely, given the prominence of new media infrastructures in cultural production and consumption, to be altering aspects of cultural engagement and circulation. There is something of a changing ontology of taste formation being intimated here. Not least we are forced to wonder what this means for our

understandings of the role of cultural tastes and preferences in social divisions and social ordering. What, for example, do predictive algorithms mean for a concept like cultural capital if we are now able to experience cultural encounters algorithmically rather than as a preformed path of socialisation? Also, we might wonder what predictive algorithms might mean for social network analysis if they intervene in the foci that facilitate social connections? The list continues, what this chapter has sought to do is to raise such questions for further consideration, and in so doing lay out a set of conceptual touchstones for developing just such an agenda in the study of culture. However these technologies develop, algorithms are already deeply implicated in the manipulation of the circulations of data within and through popular culture.

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