ON THE IDENTITY OF TECHNOLOGICAL OBJECTS AND USER INNOVATIONS IN FUNCTION

Philip Faulkner
St Catharine's College
University of Cambridge

Jochen Runde
Judge Business School and Girton College
University of Cambridge

To appear in *Academy of Management Review*

Abstract: Recent research on user-innovation has concentrated on changes in the physical form of the objects concerned, to the neglect of changes in their intended use or function. In this paper we advance a theory of the technical identity of a technological object that gives due weight to both its form and its function, and use this theory to categorise different forms of technological change and to unpack some neglected aspects of user-driven innovations in function.

Acknowledgements: we are grateful to Ismael Al-Almoudi, Rick Colbourne, Nathan Crilly, Florian Ellsaesser, Raghu Garud, Mark de Rond, Matthias Holweg, Matthew Jones, Clive Lawson, Paul Lewis, Michael Lounsbury, Kamal Munir, Katharine Norman, Wanda Orlikowski, Adam Power (DJ Rusty), Peter Sklair, Jim Utterback, John Waiting (DJ Ting), Hugh Willmott, participants at the OTREG seminar at Imperial College London, the Workshop on Notions of Practice held at Darwin College Cambridge, November 2007, and the Cambridge Realist Workshop, and to the editor and five anonymous referees for helpful comments on earlier drafts of this paper. Thanks also to Adam Power and Thalia Sklair (DJ Thalia) for their expert demonstrations of some of the techniques of turntablism.

ON THE IDENTITY OF TECHNOLOGICAL OBJECTS AND USER INNOVATIONS IN FUNCTION

Abstract: Recent research on user-innovation has concentrated on changes in the physical form of the objects concerned, to the neglect of changes in their intended use or function. In this paper we advance a theory of the technical identity of a technological object that gives due weight to both its form and its function, and use this theory to categorise different forms of technological change and to unpack some neglected aspects of user-driven innovations in function.

ON THE IDENTITY OF TECHNOLOGICAL OBJECTS AND USER INNOVATIONS IN FUNCTION

One of the most intriguing aspects of recent studies of the pathways and processes by which new technological objects emerge has been the finding that under certain conditions users can play a decisive role in the initial creation of innovative products as well as their subsequent take-up and diffusion (Baldwin, Hienerth & von Hippel, 2006; Franke & Shah, 2003; Franke, von Hippel & Schreier, 2006; Hienerth, 2006; Lüthje, Herstatt & von Hippel, 2005; Morrison, Roberts & Midgley, 2004; Shah, 2006; von Hippel, 1998, 2005). The kinds of issues addressed by these authors – how user innovations arise, why individuals are induced to participate in "innovation communities", the role of "lead users" – have generated a range of important insights into the innovation process and the management of technological change by firms. Yet in one important respect this literature has so far provided only a partial account of the possibilities that exist for user-driven innovation. For in concentrating on "hardware" innovations, that is, on changes in form of the objects concerned, it neglects the importance of innovations in the use to which an existing object is put (e.g. using an electric toothbrush as a shower-head descaler, or a digital camera as a scanner to create documents that can be transported electronically). The present paper is intended to address this gap in the literature.

What follows divides into two halves. The first half develops a theoretical account of the "dual" nature of technological objects building on elements of the theory of social reality set out by the philosopher John Searle (1995, 1999, 2001) and the transformational model of social activity (TMSA) proposed in realist social theory by authors such as Archer (1995), Bhaskar (1979) and Lawson (1997, 2003). We begin by appropriating some of Searle's ideas about assignments of function in Section 1, which we use to arrive at an account of the basic

nature of technological objects and what we will call their technical identity. Section 2 provides an overview of the TMSA, which we develop and present as an abstract representation of the organization of society that captures the structured, processual but nevertheless non-deterministic or "open" aspect of social affairs. The material introduced in Sections 1 and 2 is then combined in Section 3 to arrive at a realist theory of technological objects and how they slot into the social world.

The second half of the paper uses the theory just described to address the question of technological change and user-driven innovations in function in particular. Section 4 presents a case study of a recent episode of technological change, the transformation of the gramophone turntable into a musical instrument in hip-hop music and its subsequent impact on digital players. This account provides the background for Section 5, where we develop a general conception of technological change consistent with our earlier theory of technological objects, and Section 6, where we offer some propositions relating to user-driven innovation in the use to which objects are put. We close with some concluding thoughts in Section 7.

1. FUNCTION, FORM AND TECHNICAL IDENTITY

Given how deeply our taken-for-granted world is impregnated by technological objects, it is easy to assume that there is nothing particularly difficult or mysterious about the nature of their existence.[i] Yet there is more to the ontology of such objects than meets the eye. Consider what is required to make an object a token of some particular type of technological object, such as a 35mm camera. Physical form is clearly important. For something to be a 35mm camera it must generally possess at least a lens, viewfinder, shutter release and film compartment. But the appropriate physical form is not sufficient, and this is because technological objects are also partly constituted by their having a use, or function, of some kind. A 35mm camera, for instance, is an instrument for capturing still images, a telephone

for communicating verbally across distances, a watch for measuring time, and so on. Technological objects therefore have a "dual nature" (Kroes & Meijers, 2006; Meijers, 2000) in being constituted by both physical form and social function.

In order to flesh out these ideas and to develop an account of the dual nature of technological objects, we will borrow some concepts from John Searle's theory of social reality. In describing the ontology of what he calls "institutional facts" Searle attributes a prominent role to our ability to assign functions to objects or other kinds of entities. While Searle focuses on some more complex manifestations of this ability, such as pieces of paper functioning as money or a raised arm counting as a vote, we believe that it is also central to fixing and sustaining the identity of the technological objects that we are surrounded by. Our point of departure, then, is that the function of a technological object flows from an agentive function assigned to objects of that type, where agentive functions are functions that are imposed on entities in pursuit of the practical interests of human beings.[ii]

If the function of a technological object indeed depends on an assignment of agentive function to objects of a certain type, this raises the question of who it is that does the assigning. We will proceed on the basis that agentive functions are generally assigned by social groups whose members' activities contribute – perhaps consciously but more generally as an unintended consequence of those activities – to sustaining the function of the object concerned. For established technologies, those that have achieved stabilization and closure in the sense of the literature on the Social Construction of Technology (SCOT) (Pinch and Bijker 1987), these groups will typically include designers, manufacturers, retailers and users, as well as third parties who might not be directly implicated in the production, sale or use of the object, but who recognise and assign the same function to it. The size of the group concerned will vary. Where the object is one that is used to the same end in many different localities (e.g. spoons, combs and chairs), the group will be large, containing many and

possibly even all members of society. In other cases the group will be far smaller, for example where specialised tools are used in circumstances that touch the lives of only a restricted few.

For new forms of technological object or cases in which existing technological objects are used in a new way, the group assigning the function may initially be very small, including no more than those responsible for the innovations concerned. In many cases the assignments of function involved remain restricted to these groups, perhaps disappearing altogether after a period of time. In other cases, a new assignment of function may spread by being adopted by larger groups, even if often in ways that involve disagreement and conflict, commercial, cultural and other pressures, that lead the eventual form, function and other associated meanings of the object to develop very differently from what the original innovators may have had in mind (Bijker 1995; Bijker; Hughes & Pinch 1987; Kline & Pinch 1996).

As far as the physical form of technological objects is concerned, it is crucial that in order for the functions assigned to them to be sustained, those objects must generally possess the physical characteristics and capabilities required to perform the functions concerned. Of course objects that have a particular function assigned to them often vary considerably in the precise details of their physical characteristics (Mitcham, 1994: 180-181). We accordingly take a "family resemblance" view of technological objects, recognising that many objects have definite common physical features and capabilities on the basis of which they can be grouped as tokens of the same type, even when there may be no single set of physical features that is shared by all of them. In most cases the object concerned will have these features by design. But this is not always so, such as where a naturally occurring object becomes an item of technology or when an object designed with one purpose in mind subsequently becomes used for another. Furthermore, the degree to which different functions require specific physical characteristics of the relevant object may vary considerably. Contrast for example

the constraints imposed on the physical form of an object in order to function as a digital camera as compared with a paperweight.

To capture the coming together of form and function in technological objects we will henceforth speak of particular types of object as possessing a "technical identity" within a social group, something that flows from the combination of their physical form and the use to which they are put within that group. Thus the technical identity of an object such as a 35mm camera, for the social group in which that identity holds currency, is of a portable device possessing a lens, viewfinder etc. that is used to capture still images. Note that it is quite possible for the same physical object to possess more than one technical identity. There are two main possibilities here. The first arises where different social groups, possibly intersecting, assign different functions to the same object, such as the group that use nail files for manicures and the group that uses them to pick locks. The second typically arises within social groups and reflects what we call nested assignments of function, where narrower, more specific assignments of function are assigned to objects that, at a more general level, are also assigned a broader function. An example of nested assignments of function would be the class of objects that serve as off-road racing bicycles being a subset of a wider class of objects that serve as racing bicycles, which is itself a subset of a still wider class of objects that serve as bicycles, and so on.

2. THE TRANSFORMATIONAL MODEL OF SOCIAL ACTIVITY

We now turn to locating technological objects, understood in the way just described, as part of social reality more widely. In order to do so, it is necessary first to outline our preferred theory of social reality. The present section is devoted to this task, drawing on recent contributions to realist social theory by Archer (1995), Bhaskar (1979) and Lawson (1997, 2003) among others. One of the principal insights of this literature is that human activities

and social structure are different kinds of thing, however much they may be bound up with and presuppose each other. This insight has a central role to play when we come to incorporate technological objects into our account of social life in the next section, most notably in enabling us to separate the human practices in which these objects are implicated from the social rules that contribute to constituting and sustaining such practices.

Starting at a very abstract level, we take the social realm to be that domain of phenomena whose existence depends on the existence of human beings. We will focus on three key components of this realm: human agency, social structure, and the relationship between the two. Human agency involves the existence of human beings with various capacities and dispositions, and who engage in various forms of activity. By capacities we mean abilities such as our ability to apply reason to our affairs, to learn a new language, and to imagine future states of affairs. Dispositions include such things as our propensities or inclinations to act in certain ways, such as to tell the truth, to work hard, and to avoid pain. Human activities are then the part-product of human capacities and dispositions in operation, and range from deliberate actions based on conscious reasoning through to routine behaviour based on tacit knowledge.

Social structure consists of social rules, relations, positions and the like, which both enable and constrain human activity. Take the case of social positions such as CEO in a public company, airline pilot or school teacher. Each of these positions involves various roles, rights and duties, the performance of which is generally associated with and expected of the people who occupy them. And it is in providing a locus of these roles, rights and duties, both for incumbents and third parties, as well as indicating what kind of behaviour is discouraged or ruled out by them, that such positions inform and govern human activity. Furthermore, and contrary to the image that emerges from rational choice models in which actors are portrayed as at all times engaged in conscious deliberation, we contend that one of

the most striking features of social life is the extent to which human activities take the form of routines that are enacted without much in the way of conscious thought. The pervasiveness of routines is indicative of the "pull" that social structure in general and social rules in particular have on human activities, even where, as we will explain below, the rules in question have not been directly internalised by the actors concerned.

Two key features of the theory we are advocating are that human agency and social structure are recursively organized and that structural reproduction is a generally unintended consequence of human action. The first is captured by what Giddens (1984) calls the duality of structure, that social structure is constantly reproduced as an ongoing consequence of human activities, where those same activities presuppose the very structures that are being reproduced. The second is captured by what Bhaskar (1989: 92-93) calls the duality of praxis, that while human activities are generally consciously directed at intended ends, their contribution to structural reproduction is generally unconscious and unintended. Thus by filling the position of CEO, airline pilot or school teacher, and performing the various roles and duties associated with that position, current incumbents contribute to the reproduction of these positions and their associated practices, and, to the extent that they innovate and depart from existing norms, perhaps also to their transformation over time.

In the next section we will show how the technical identity of the technological objects that surround us depends on the link between certain kinds of social rules and routinized practices or what we will simply call routines. It is therefore necessary to develop in more detail a conception of this link consistent with the broader perspective on social organization provided by the TMSA. By social rules we mean generalized procedures of action that are expressible as injunctions of the form "if X in situation C, do Y", and where "do" is to be interpreted as a placeholder for phrases such as "this counts as", "take this to mean", "refrain from" and so on.[iii] These rules are sustained in virtue of being accepted by,

and implicated in the activities of, members of a social group (where in the limit a group may consist of just one individual), often in ways that require some kind of interdependence between their actions. A notable feature of social rules is their normative force, namely that in the group in which the rule holds, if it is the case that X in situation C then one ought to do Y. An important source of this force is the possibility of sanctions being levied against individuals who fail to conform to the rule, since in breaking a rule an individual can be judged to have acted wrongly or inappropriately.[iv]

Notwithstanding the possibility of individuals acting in contravention to some social rule, the existence of normative procedures of action within groups of individuals implies regularities in the actions of those individuals. Indeed the prevalence of such regularities in human social life is one indicator, as noted earlier, of the "pull" that rules exert on our actions. We will define behavioural regularities as one or a series of actions that are regularly performed by individuals and use the term routines to refer to behavioural regularities that are conditioned by some social rule.[v] Since routines on our definition are a subset of behavioural regularities, our account leaves room for regularities in the behaviour of individuals that do not issue from pre-existing social rules, for example when members of some group simply fall into doing something in a particular way, such as congregating at a particular table at lunch. Here the regularity is not the causal product of any pre-existing rule, at least at first, although a rule may quickly emerge over time and it will be noticed if a group member violates it by sitting at another table, arriving at the "wrong" time, and so on.

In order to understand the relationship between routines and social rules it is useful to distinguish three ways that rules may contribute causally to the determination of behaviour. The first and most obvious is where people follow rules in a deliberate, conscious way, such as the novice attempting to comply with the instructions given by a tennis coach, or when we follow the instructions in a computer manual or a cookbook. This case is perhaps the least

interesting in the present context, since people who are engaging in routine behaviour are typically not following rules in this manner. We generally do not need explicit rules, manuals and so on, once activities have become routine. Indeed, routines are widely regarded as an expression of tacit knowledge, that is, of knowledge or skills that are deployed without much in the way of conscious engagement and which people may not always be able to state in propositional form (Cohen et al., 1996: 658; Cohen & Bacdayan, 1994; Lazaric, 2000).

The second possibility, then, is where people have learned and internalised rules in a way that they are no longer at the forefront of the conscious mind when implicated in action. Rules of this kind are often recoverable by the conscious mind (Lawson, 1997: 178-179). For example, a jazz musician might be able to cast her mind back and recall the rules of particular scale substitutions that she had once learned in a discursive way, but which have since become so ingrained that she can improvise in accordance with them without thinking about it (Sudnow, 2001). The third possibility, emphasised by Searle (1995: 127-147) under the heading "Background causation", is that routines may be a manifestation of people's capacity to behave in ways appropriate to particular rule structures, but where these capacities do not necessarily involve their "knowing" those rules consciously or even subconsciously.[vi] That is to say, there may be cases in which people behave in the appropriate way without drawing on rules that have been internalised in any way. The rules in question nevertheless have a causal role, insofar as they have to have been in situ in order for people to develop the capacities to behave in ways that are appropriate to them. Rules of grammar are a good example here, which many people are able to conform to without their being able to articulate those rules or indeed without their ever having had occasion to reflect on them in a conscious way.

On the conception of social rules and routines that we have set out, social rules are ontologically distinct from the routines they govern. Routines are forms of human activity, whereas social rules reside at the level of shared attitudes and normative commitments, even

where people only become aware of those rules when they have been breached. Our distinction between routines and rules is thus similar in some respects to the distinction between the performative and the ostensive aspect of routines proposed by Feldman & Pentland (2003, 2005). Furthermore, while routines are usefully described as a form of rule-governed behaviour, we cannot attach priority to social rules over the routines that issue from then. The first point to note in this respect is that social rules do not act deterministically, since rules only ever dictate what should, could usefully or ought to, be done in particular circumstances, rather than what will be done. The second point is that not only are routines the product of social rules, even if only indirectly via the route identified by Searle, but that the maintenance of those rules also depends on the routines that may issue from them. That is to say, once established, social rules condition routines, while these same routines contribute to the (unintentional) reproduction and possible transformation of the rules that shape them.

The distinction we drew earlier between routines and other types of behavioural regularities is useful because it allows us to say something about the way in which social rules come about. In many cases of course, rules are the product of deliberate design, such as the button-pushing sequences inscribed into digital equipment that have to be followed closely in order to produce particular results. Yet in other cases social rules emerge spontaneously without being intended by any individual or organization, for instance where a social rule emerges out of what was simply a behavioural regularity as per our earlier lunchtime table example. Once such regularities become accepted as being the appropriate way to act in that sort of situation, they start to engender social rules with normative force, which may then pass on and/or be taught to others. Thus while we have been focusing on the reproduced, and to this extent stabilising, quality of routines, we do not deny that routines may change, be this in response to exogenous or endogenously generated pressures (Feldman, 2000, Feldman & Pentland, 2003, 2005). We will come back to this point below.

3. IMPORTING TECHNOLOGY

We are now in a position to extend the TMSA just described by incorporating into it the conception of technological objects presented in Section 1.[vii] In so doing we will develop an account of the social structure that underpins our relationships with technology and that is reflected in our routinized practices when we interact with it.

Our starting point is the notion of an assignment of agentive function introduced in Section 1, which we argued are partly constitutive of technological objects. From the perspective of the TMSA assignments of function should, we contend, be understood as social rules. Recall that we defined social rules as generalized procedures expressible by suitable transformations of the formula "if X in situation C, do Y", where these rules are sustained in virtue of being accepted by, and implicated in the activities of, members of a social group. In respect of technology, the assignment of function to a certain type of object is one such procedure, expressible as an injunction of the form "objects with such-and-such physical characteristics are for this purpose within such-and-such situation".

Consider a technological object such as a microwave oven. For something to qualify as such in terms of our earlier account arises from a general association between objects that possess the physical characteristics required to enable people to heat food by microwave radiation, and an assignment to that type of object of the function of enabling people to heat food. We suggest that this assignment of function is a type of social rule, expressible as an injunction of the form "an object comprising a cooking chamber, a revolving tray, a magnetron and a waveguide, has the function of enabling people to cook food".[viii]

Locating our theory of technological objects within the TMSA in this way makes it possible to expand on some aspects of our earlier account. The first point here is that the assignment of some function to an object does not require the members of the group concerned to think of that object explicitly in terms of its components or the function

assigned to it. Typically we just see a microwave oven, rather than a rectangular object made of plastic, glass and metal to which we then consciously attribute the function of allowing us to heat food. This suggests that, in general, we do not actually consciously apply rules to objects in order to recognise and interact with them in the appropriate way, but that we have either internalised the rules as tacit knowledge or else developed capacities or dispositions to act in accordance with the relevant rule structures (the case of "Background Causation" mentioned above). Of course there are exceptions, notably when the assignment of function to an object is new to us or has recently changed. In such cases the conscious mind is likely to have a role to play in our engagement with, or employment of, the object. But as time goes by, the subconscious mind tends to take over, the assignment of function becoming part of our tacit rather than discursive consciousness.

The TMSA also makes clear the recursive nature of the relationship between assignments of function to an object and our use of that object in some activity, that the social rules and the routines they facilitate are at once a condition for and a consequence of the other. Further, as a type of social rule assignments of function exhibit normativity. Once an assignment of function to a certain type of object takes hold and becomes established in a particular group, then it becomes a matter of general policy, a social rule with normative force. Can we be said to break rules when this amounts to no more than our acting contrary to certain Background dispositions? Yes, because there is often a clear sense in which we can be wrong about things, even often where we are unable to articulate the relevant rule (e.g. where we can see clearly that there is something wrong with the grammar of a sentence but can't identify the rule or rules broken). And for most of the technological objects that we encounter during our lives the relevant rules already exist, and we learn to behave in accordance with them, either in the process of growing up or when we encounter new technologies we had not come across before.

This completes our theoretical account of the ontology of technological objects and how such objects come to be the familiar things that make up so much of our taken-for-granted world. We have argued that the identity of technological objects is underdetermined by their physical characteristics, that in addition to their material form there is an inherently social aspect to the identity of such objects that flows from the use to which they are put within a social group. The groups in question vary in size and may be so large as to include almost everyone. We have attempted to demonstrate how the continued maintenance of the technical identity of technological objects depend on the relevant assignments of function being continuously confirmed by, and sustained in, the routinized practices of the members of the group concerned. And as we have just observed, the technical identities of technological objects contribute to constituting the activities in which they are implicated.

4. AN ILLUSTRATIVE CASE

Before we move on to the subject of technological change and user-driven innovation, it will be useful first to break off and provide some background by considering a recent episode of technological change. The object at the centre of this episode is the phonograph turntable, and the story we will relate concerns its transformation from a playback device into a musical instrument in its own right. The story has two parts, the first covering the transition from pure DJing to turntablism in hip-hop music and beyond, and the second covering the subsequent development of digital players specifically designed to allow users to perform various techniques associated with "classical" turntablism. For those unfamiliar with the term, a turntablist, as distinct from someone who uses it strictly in its playback capacity, uses the turntable to create new sounds and music by physically manipulating vinyl records under a turntable stylus, in conjunction with an audio mixer.

A Brief History of Turntablism

The idea of using turntables as sound-generating devices in larger musical performances is not a new one, having been pioneered by the avant-garde composer John Cage (1939) and, during the 1940s, the father of *musique concrète* Pierre Schaeffer (Hodgkinson, 1987) (contemporary exponents of the turntable in the experimental music community include Christian Marclay [see http://www.youtube.com/watch?v=4yqM3dAqTzs] and Martin Tétreault [see http://www.youtube.com/watch?v=D0PeXeNllro]). However, it was only with the activities of DJs associated with the emergence of hip-hop music in the Bronx in New York during the 1970s that the conception of the turntable as a musical instrument in its own right became widespread (Brewster & Broughton, 1999; Demby, 2003; Schloss, 2004; Souvignier, 2003; White, 1996). In the account that follows we will therefore concentrate on the more recent history of the turntable emanating from the hip-hop community (see Newman (2003) and Souvignier (2003) for histories of the turntable *per se*, and Chang (2005), Kitwana (2002) and Rose (1994) for social histories of hip-hop).

A key early innovation on the road to turntablism, attributed to the British dancehall DJ Jimmy Savile in 1946, was the idea of using two turntables at once to reduce the gap between songs while records were changed. This idea reached its full expression – the gap between songs disappearing entirely – with the techniques of slip-cueing and seamless mixing pioneered by Francis Grasso in the late 1960s (Souvignier, 2003: 115-117). Seamless mixing in turn opened the way to the practice of extending the breakbeat, introduced by Clive Campbell (Kool DJ Herc) in the 1970s. The breakbeat is the part of a song, often considered its most danceable part, in which percussion dominates for a few bars. Campbell's innovation was to extend the breakbeat by using two copies of the same record on two turntables, and repeating it by alternating between the turntables, starting the breakbeat section on one record immediately that it had finished on the other (Newman, 2003: 7). This technique was

subsequently refined by Joseph Saddler (Grandmaster Flash), who, with the aid of a home-made mixer and cueing device, perfected what he called the "Quick Mix" (otherwise known as "back cueing" or "breakbeat cutting"), the technique of seamlessly looping the breakbeat part of a song (Chang, 2005: 111-114; Rose, 1994: 53-54).

These innovations, especially the technique of breakbeat cutting, were a defining influence on what became breakdancing and the collage, "cut-and-paste" aesthetic that informed the development of hip-hop music (though by the 1980s most of the cutting and pasting would be done via samplers rather than manipulating turntables, albeit without disturbing the tradition's respect for its DJ/turntablist roots (Schloss, 2004)). Yet the development that, probably more than any other, led to the notion of the turntable as a distinct musical instrument in its own right was the advent of "scratching", a technique discovered by the teenage DJ Theodore Livingston (Grand Wizard Theodore) in 1977. Livingston found that by dragging a record back and forth under the stylus on one turntable, he could generate a rhythmic scratching sound that could be juxtaposed against and used to complement music playing on the second turntable. He liked the sound and developed the technique to the point at which he could incorporate scratching into his public performances.

The scratch caught on and its sonic and rhythmic possibilities rapidly developed to become a defining ingredient in hip-hop and rap music. But it also began to cross over into other forms of music, with turntablists joining bands in other genres and performing a function in many respects similar to a second percussionist/colourist. An early and particularly influential instance of this trend was the Grammy-winning hit single "Rockit" from the respected jazz pianist Herbie Hancock's 1983 album *Future Shock*, which featured distinctive contributions from turntablist and DJ Derek Howells (Grandmixer D.ST). Turntablism continued to grow and develop over the 80s and 90s, to the extent that it now has a firmament of virtuoso stars in its own right, "battling" contests, conventions and dedicated

websites (see for example the links at http://www.hiphop-directory.com and http://www.ukhh.com). A dazzling array of practices and techniques have emerged to become standard parts of the turntablist's skillset (e.g. the "tear", "flare", and the "crab", which are achieved by the technique of "transforming" or chopping up the basic or "baby" scratch sound by manipulating the mixer in a variety of ways).

Of course the move towards using the turntable as a musical instrument was not embraced by all and even actively resisted in some quarters. As Joseph Saddler recounts:

> In 1973, nobody was prepared to put their hand on the turntable and move it in a back and forth motion … DJs hated my guts. I was called everything from an idiot to a ruiner of records (Joseph Sadler, quoted in Faraone, 2007).

There was resistance too, thirty years on, when it was only after being twice rejected and having had to negotiate a special study group set up to consider the matter, that Stephen Webber was allowed to introduce what has since become a highly popular turntable lab at the Berklee College of Music (Hayes, 2004; Muther, 2004; Small, undated). Even then, executive vice-president of Berklee Gary Burton remained unconvinced:

> I wasn't in favor of it, and I'm very skeptical even now … It just seems to lack a lot of the musical elements that are important to me. You know, rich variety and harmony. Varied dynamics and more interesting rhythm combinations. http://www.cbsnews.com/stories/2004/03/25/sunday/main608774.shtml

Nevertheless, the eventual success of Stephen Webber's lab, the publicity it generated (e.g. Demby 2003 and the articles quoted above), as well as the related work by Webber

(2003) and others on codifying the techniques of turntablism (e.g. Souvignier, 2003) have played an important role in bringing turntablism into the mainstream. Thus, and although there are currently indications that the high water mark of turntablism may have been reached and that the guitar is regaining ground as the instrument of choice amongst younger musicians and their returning parents (Sherwin, 2007), there remain all manner of rock, pop, nu-metal and even country music bands that include a turntablist in their ranks, the musicians union in L.A. now counts turntablists among its members (Webber, 2003: 103), and a turntablist, Jason Kibler (DJ Logic), has even been a featured instrumentalist in a recent cover story in the respected and largely mainstream jazz monthly *Downbeat* (Murph, 2006).

We now turn to what is perhaps the most striking aspect about the episode we have described so far, namely that the physical form of the technological object centrally implicated in it – the phonograph turntable – remained almost completely unchanged. The turntable of choice in the DJ community is the Technics SL-1200 manufactured by the Matsushita corporation, which was first released as a standard hi fi turntable in October 1972. Its key attribute from a DJing perspective, one that gave it a crucial advantage over most other turntables available at the time, was that it featured a variable pitch control without which beat matching would have been impossible. In addition, its direct-drive (rather than belt-drive) mechanism ensured high torque and thus fast platter acceleration, and its unusual weight made it resistant to feedback and the stylus being disturbed by vibration. While there have been different versions of the SL-1200 since 1972, the successive changes have been relatively minor and did not amount to a fundamental design change.[ix] More than 3 million units of the SL-1200 have been sold since 1972, and the Mark 2 version first introduced in 1978 and shown in Figure 1 enjoys an iconic status amongst turntablists not unlike that associated with early model electric guitars made by companies such as Fender and Gibson during the 1950s and 1960s (http://www.sl-1200.com/top_e.html):

> The Technics SL-1200 was the turntable Grandmaster Flash and practically every other noteworthy DJ relied on. It became the only game in town. Matsushita didn't have to advertise the SL-1200 much, demand from professional DJs was always there. Nor were they under any pressure to improve or alter the design; they just kept on stamping out turntables and selling them. The SL-1200MK2 turntable debuted in 1978, but the SL-1200MK3 didn't arrive until 1989, followed by the SL-1200M3D in 1997. That's roughly one upgrade per decade. Technics continued to tinker slightly with their other turntable models throughout the eighties, but the SL-1200 design was essentially frozen (Souvignier, 2003: 43).

==========

Insert Figure 1 about here

==========

The dominance of the SL-1200 was in part sustained by a form of technological lock-in, a consequence of its adoption by early DJs for the reasons given above, the subsequent adoption by nightclubs who followed the DJs in this respect, and the practice of DJs performing on house turntables rather than their own. DJing and turntabilism are disciplines that require considerable practice, something that is most effectively done on turntables that have the same "feel" as those to be used in performances. Anyone serious about becoming a DJ or turntablist would therefore have to acquire similar turntables, invariably SL-1200s, for home use. Nightclubs consequently had little incentive to move to alternative machines on pain of undermining the performances of DJs who were practicing on SL-1200s. It was clearly also not in the interests of Technics to rock the boat by making any significant changes to the SL-1200. In short, quite apart from being widely recognized as a high-quality

turntable, the SL-1200 acquired the valuable and self-reinforcing attribute of being regarded as the standard turntable among DJs and turntablists.[x]

So much for the first round of innovation in our brief history, a vivid example of user-driven change that led to a radical change in the function of an existing technological object while leaving its physical form almost completely undisturbed. We now turn to the second round, which is in many ways the exact reverse of the one we have just been considering, manufacturer- rather than user-led, and involving significant changes in the form of the technological objects involved. The innovation in question concerns the development of digital music players made specifically for the DJ market, initially in the form of audio CD-based devices and continuing, latterly, with the emergence of audio file-based players.

Audio CDs were first introduced into the US market in 1983 and had almost completely displaced vinyl in the consumer market by the early 1990s. Some DJs quickly switched to the new format, taking advantage of the greater portability and durability it offered. But many others, particularly those with an interest in beat matching, scratching and so on, did not. One reason for this, particularly in the hip-hop community, was the value that many DJs attached to rare recordings that could only be found on vinyl and the "crate-digging" culture that grew around this (Schloss, 2004; Wilder, 2006). But another, more telling, reason, as far as turntablism was concerned, was that these skills were specific to vinyl and could not be replicated on CD players. At first, then, CD players were simply not compatible with the practices and techniques that constituted the turntablist's art.

Over time, however, manufacturers began to introduce "CDJ" players, audio CD players specifically designed for the professional DJ/turntablist. The first professional CDJ scratching deck, American Audio's Pro Scratch, appeared in 2001, quickly followed by a competing product from Pioneer (the CDJ-1000, currently the industry standard), and subsequently by a number of others from companies such as Denon and Numark. The first

Technics CDJ, the SL-DZ1200 shown in Figure 2, was introduced in 2004, and explicitly designed to replicate the look and feel of the classic Technics SL-1200.

==========

Insert Figure 2 about here

==========

A common feature of CDJ machines is a "jog wheel", a platter that facilitates manual control of the CD and allows users to replicate the audio effects associated with traditional turntablism, including scratching (in the case of the SL-DZ1200 this platter is actually motorised and with torque that is a close approximation of the classic SL-1200). The more general advantages of using CDs – size, durability, and more recently CD burning – thus became available to the DJ/turntablist, and then in tandem with various additional digital features not available on standard analogue turntables: the ability to store and instantly access particular loops, delinked pitch and time shifting, cue point setting, and so on, as well as, in some cases, onboard effects such as distortion, wah and panning. Further the CDJ machines do not have to be placed on flat surfaces to function, an advantage that has been taken to the limit in the Vestax turntableguitar, shown in Figure 3, that allows the turntablist to strap on his or her player and roam the stage as an electric guitarist might.

==========

Insert Figure 3 about here

==========

Recent years have witnessed audio data files (such as MP3s) emerge to challenge the audio CD as the dominant digital format in the consumer audio market. With the ability to be stored, copied and transferred in much the same way as any other kind of computer file, audio files further extend the advantages of audio CDs in terms of the storage and portability of music, while also allowing DJs to play samples from a variety of non-music sources (such as

films and television shows) and facilitating music sharing (particularly over long distances via the internet). For DJs this has meant the advent of a second generation of digital players, the form of which has yet to stabilise. Some of these players, such as the latest (Mark 3) model of the CDJ-1000, are little more than a CDJ to which has been added the ability to play audio files stored on data CDs, flash memory cards or USB mass storage devices. Other devices, such as Numark's iDJ^2 shown in Figure 4, involve more radical shifts in form. Although compatible with a variety of storage devices, the iDJ^2 does away with the CD player altogether and is instead designed to act as a DJing console for an iPod digital audio player. A further class of players, such as Stanton's "Final Scratch" system and Native Instrument's "Traktor Scratch" system, consist of vinyl emulation software that runs on a desktop or laptop computer, with manual control of the music provided by a standard turntable on which is played a vinyl record pressed with a digital timecode.

==========

Insert Figure 4 about here

==========

The shift from audio CD-based to file-based players is far less dramatic for turntablists than the earlier shift from vinyl- to CD-based players. For what is at stake here is simply the format in which digital sounds and music are stored, rather than the method of manually controlling them as was the case in the move to CD-based players. While the trend in DJing as a whole has been towards these players, it is perhaps too early to tell how turntablists will be affected. Certainly, while some virtuoso turntablists like Richard Quitevis (DJ Q-bert) and Ronald Keys (DJ Swamp) have embraced electronic tools (e.g. in the use of computers, drum machines, samplers, and so on) they retain their traditional turntable setups.

5. TECHNICAL IDENTITIES AND TECHNOLOGICAL CHANGE

The appropriation of the turntable as a musical instrument provides a dramatic illustration of key aspects of our theory of technological objects: that the technical identity of technological objects is a matter of function as well as form, that form underdetermines function, and that functions are assigned to objects by social groups of varying sizes. Crucially, according to our theory, the technical identities of technological objects are a real feature of the social world, sustained by being reproduced in and through the routinized practices of the groups in which they hold currency. We saw this in how the new technical identity of the gramophone turntable has become institutionalized in the performances and traditions of the hip-hop community and, more formally, in music education, professional associations and specialist publications. That the turntable is a musical instrument is no longer open to question in many parts of the music industry and the wider community.

As our brief history of turntablism also makes clear, however, to say that technical identities are real once they have become established is not to say that they cannot change. More than that, it provides a clear example of how changes in technical identities may emanate purely from changes in function. We will return to this issue in the next section. First, however, we will outline a general conception of technological change consistent with the theoretical framework developed in the first part of the paper.

Conceptualising technological change

We have argued that the technical identity of a technological object flows from that object possessing a particular form and having assigned to it one or more agentive function. The form-function dichotomy suggests that technological change occurs in one of three ways: (1) a change in the form of objects with a pre-existing function, (2) a change in the function assigned to objects with a pre-existing form, or (3) some mixture of (1) and (2). Perfectly pure cases of (1) and (2) are probably quite rare in practice because changes in the form of

technological objects are usually accompanied by (often subtle) shifts in function, and vice versa. Category (3) is therefore likely to be the most common of the three. However, it seems natural to group much of the technological change we experience in category (1), where technological change presents itself as changes in the form of objects that we use to perform already-established functions. Category (2) introduces the possibility of technological change even in the absence of any change in the physical form of the object concerned.

It will be evident that the two rounds of innovation described in our brief history of the turntable are paradigm cases of our two limiting categories.[xi] The first round, in which the turntable was transformed from music playback device to musical instrument, is a clear case of the same-form-different-function variety of technological change (2). The innovations in the second round, particularly the CDJ players designed specifically to facilitate turntablists' existing techniques, are an instance of the same-function-different-form variety of technological change (1). Here manufacturers took as given the new function assigned to the turntable and sought to modify existing digital playback devices to accommodate the practices associated with it.

In conceiving of technological change in terms of changes in the form and/or function of a technological object, we are not suggesting that every instance of technological change will alter the technical identity of the object concerned. Whether it does so or not will be specific to the social group in which the object is used and depend on the (usually implicit) judgements of sameness or difference made by its members. This means, of course, that there is a degree of arbitrariness in whether or not a new technical identity emerges after one or more technological changes and, if it does, exactly where the line is drawn between the "old" and the "new" technical identity. Indeed the line may not be completely clear even within a particular community of users. For example, a subset of users who are more technically literate and understand the extent of certain underlying changes in form in a same-function-

different-form case of technological change may be relatively more inclined to treat the object in its new form as a new kind than would lay users who do not have the same degree of technical understanding.

Nevertheless, experience seems to show that there is often considerable agreement on whether or not technical identities have changed in the wake of technological change. In the first place, much of technological change is incremental and usually appears to leave established technical identities undisturbed. For example, we found nothing to suggest that any of the various changes to the form of the motorised turntable since it first became established as a music playback device led users, be they members of the traditional record-playing or DJ communities, to regard it as a different kind of thing. However in other cases of same-function-different-form technological change in which the changes in form are more thoroughgoing, users are often led quite naturally to treat the old and the new forms of the technological objects as different kinds of things, e.g. in the cases of the shift from piston to jet engines, transistors to integrated circuits, and turntables to CD players. The same point applies to variations in function. Although an important advance in the art of DJing, taking the turntable out of the parlour and into the dancehall as part of a twin turntable setup did not itself alter the technical identity of the turntable as a music playback device. Only with the more radical innovations of breakbeat cutting, scratching and the like, did the idea of the turntable as a musical instrument take hold.

6. USER-DRIVEN INNOVATIONS IN FUNCTION

Having set out a conception of technological change consistent with our earlier theory of technological objects we can now address the question of user-driven innovation. As we argued at the start of the paper, research on this topic has concentrated on “hardware” innovations, that is, changes in form of the objects concerned: kite-surfers building their own

harnesses and safety systems as alternatives to commercially-produced products in the case of consumer products (Tietz, Morrison, Lüthje & Herstatt, 2005), or hospital surgeons developing or improving pieces of medical equipment (Lüthje, 2003) and, in the DJ community, Joseph Saddler jerry-rigging a microphone cue into his mixer setup (Chang, 2005: 112), in the case of producer products. To the extent that user innovations in function are mentioned at all this has tended to be with respect to changes in "technique" (Baldwin et al., 2006: 1294-1296), that is, changes in the way that an object with a given technical identity is used, e.g. surgeons developing new procedures or kite-surfers performing new tricks. Even here, however, such innovations are typically mentioned only insofar as they are associated with innovations in form.

From the viewpoint of our own theory, changes in function are as much an instance of technological change as changes in form. If so, user-led innovations in function constitute an important line of research in their own right with organizational implications over and above those connected with changes in form they may precipitate. Thus the emergence of new techniques associated with the use of an object such as the rodeo kayak (Baldwin et al., 2006) may attract new users and thereby expand the market for that object without any concomitant changes in form. More dramatically, and as we have seen in the case of the turntable, changes in function may lead to wholesale changes in an object's technical identity, including the same object having multiple identities, with possibly far-reaching and deep-seated effects on previously unconnected firms and markets. The questions addressed in the existing literature on user innovation – how user innovations arise, why individuals are induced to participate in community-based innovation, the role of lead users – remain relevant here too, but the focus on innovations in function also opens up a variety of new topics and issues, some of which are highlighted in the remainder of this section. We have distilled four propositions, each illustrated by material drawn from our earlier case study.

Proposition 1: User innovations in function are advantageous to incumbent producers.

For manufacturers, user innovations in function that catch on represent the spontaneous emergence of new markets for objects of an existing form. Provided there exist set-up costs of some kind to potential new producers, the likely beneficiaries of this additional demand, at least in the short-run, are incumbents who gain what is effectively a windfall having invested nothing in generating these new markets. In the case of the turntable, existing manufacturers, particularly Technics which also enjoyed the lock-in effects described above, were able to profit from selling an essentially unchanged product to a completely new market.

The scale of the benefits that accrue to manufacturers as a result of user innovations in function depends on the extent to which the new function sustains a group of users that is (1) sizeable, (2) enduring and (3) unable to appropriate existing instances of the object for use in its new function. The importance of the first two factors is straightforward. While alarm clocks are sometimes used to trigger bombs, and strapped-down MIG jet fighters to extinguish oil fires (Oudshoorn & Pinch, 2003: 1), the additional demand such uses generate is unlikely to have a significant impact on the overall size of the markets concerned. And the more enduring the group that assigns the new function the longer that manufacturers will be able to benefit from it, especially if it affords them the time to respond to the innovation, for instance by offering slightly updated and improved versions of the product tailored to its new function and which may persuade existing owners to upgrade (e.g. changing the rotary pitch control on the original SL-1200 with an easier-to-use and more accurate slider control). Of course, there may also come a point at which manufacturers start producing new kinds of technical objects to perform the new function, and which may eventually displace the original repurposed object. We saw something of this with the emergence of the various digital

players which have made inroads into the turntable market, and to which Technics took some time to respond with its own CDJ player.

Although both the size and longevity of the group using an object in a novel way are important determinants of the potential benefits to manufacturers from user innovation in function, so too is the extent to which users already have access to the object and are able to use it in its new function. Two points stand out here. First, the greater the overlap between the group assigning the new function to the object and the object's original group of users, the smaller the likely impact on demand since users already own, or can otherwise access, the object concerned. Thus although spoons and combs have long been used as instruments in musical performances, this is unlikely to have significantly increased demand for these objects as most users already own the objects concerned. Second, the greater the durability of the object the smaller the likely effect on demand, since durability implies an object that is not rapidly consumed in use and that users therefore have no immediate need to purchase additional units for use in its new function. Thus even if the two groups of users are near identical, a new assignment of function to an object may significantly increase demand provided the object concerned is relatively non-durable.

In light of the above, the striking thing about the turntable episode is that the new assignment of function generated a sizeable new market for turntables just when its traditional market was beginning to disappear with the emergence of digital musical players. The challenge to incumbent manufacturers was then to sustain and promote their dominant position in this new market. In the case of Technics this was achieved by marketing activities such as sponsoring the DMC world championship, while at the same time keeping changes to the SL-1200 to a minimum, making only minor modifications to a design that is now over thirty years old. Given that this same period coincided with an era of rapid technological development in the electronic music equipment industry, it would be easy to dismiss the

relatively minor changes to the SL-1200 as a symptom of inertia on the part of a complacent dominant manufacturer. From the point of view of retaining its status as the industry standard, however, the ploy was a rational one. As we have already argued, any attempt to change its design in any significant way would likely have been self-defeating.

Of course cases as extreme as the turntable, where a long-established technological object undergoes a spontaneous change in function radical enough to change its identity with little or no change in form, are rare. The more usual case is where (often unexpected) changes in function are precipitated by prior changes in the form of technological objects, or in subsidiary objects complementary to them. Recent examples here include SMS messaging becoming a major use of mobile phones, the PC becoming the gateway to a vast communication and information-retrieval network rather than being used primarily as local repository for information, a word-processing tool, and so on, and the camera becoming more heavily associated with communication through the immediate sharing of electronically-transported and often disposable images with the advent of digital imaging, rather than the archiving of "kodak moments" associated with pre-digital photography (Runde et al., 2008). In such cases the impact on established manufacturers, even in the short-run, is far less certain, for the preceding changes in form suggest a more disruptive market environment, with greater opportunities for those outside to enter with innovative products.

Proposition 2: Users dominate manufacturers as sources of innovations in function

Although manufacturers have close and lengthy engagements with the technological objects they produce, this is typically spread over a diverse set of activities ranging from design and manufacture through to marketing and distribution. Users, in contrast, typically have a narrower and relatively more intimate engagement with such objects in connection with their use as a means of achieving particular ends. If so, users are likely to have a comparative

advantage over manufacturers as a source of innovations in use (thus Baldwin et al. (2006) report that all of the innovations in technique in rodeo kayaking over the period of their study came from users). Of course many manufacturers seek to explore how users use and interact with their products by exposing them to focus groups, testing them in different settings, and so on. Nevertheless, sheer weight of numbers ensures that there is likely to be wider variation among users and the contexts in which they operate, than manufacturers can achieve artificially. To this extent, the scope for the emergence of new uses for existing technological objects is likely to be far greater amongst users than manufacturers of these objects.

The economics of innovation also plays an important role here. Although incumbent manufacturers stand to benefit from the discovery of new uses for their products (Proposition 1), promoting a new assignment of function in respect of an existing object with an established technical identity is something that is likely to require significant investment on the part of manufacturers. Once this investment is made, however, the barriers to entry to rival producers are likely to be relatively low, since it is harder to protect a novel use of an object than it is a novel form (unless the object benefits from the kind of lock-in effects that benefited the Technics SL-1200, or already has a brand that can be transposed as in the case of new uses for existing brands of packaged goods (Wansink & Gilmore, 1999)). Further, it may be difficult for manufacturers to promote innovative uses of an object to a new market segment without disturbing that object's original market. Thus while incumbent manufacturers are likely to profit from new assignments of function that emerge spontaneously among users, investment in novel use by firms is likely to be discouraged.

On the user side, conversely, the incentives tend to favour innovations in function over innovations in form, even given the inertial pull of what is sometimes called 'functional fixity' in the psychological literature (Adamson, 1952; German & Barrett, 2005). The reason for this is that user-innovations in function require none of the financial capital and

production know-how required for the modifications in form that are studied elsewhere in the innovation literature. Rather, the most important input for users wanting to innovate in function is ingenuity and, in the cases in which there is a need to develop and perfect the associated skills and techniques, the time and passion to do so. These are all resources that the youthful turntablist innovators, much like the sports enthusiasts studied by Hienerth (2006) and Baldwin et al. (2006), the analogue to 'lead users' in the user-innovation literature, had available in abundance.

Proposition 3: Users are likely to seek new functions for existing objects when (1) an object is considered ineffective or is superseded in its current use and an alternative use for it is sought; (2) an object that would normally be used for some task is rendered ineffective or regarded as inappropriate for some reason, and alternative objects are sought that could perform the same or similar function; (3) a need arises for an object that does not yet exist; or (4) the object normally used for some purpose is unavailable.

Recall that, on our account, assignments of function are no more than social rules and that social rules do not determine human activities as much as facilitate and constrain them. It follows that human activities that draw on, and are conditioned by, existing assignments of function are likely to reflect, not only continuities with former performances, but also purposely intended or accidental variations (Feldman, 2000; Feldman & Pentland, 2003, 2005; Orlikowski, 2000) that, if they catch on, may erode what is sometimes called functional fixity in the psychological literature (Adamson, 1952; German & Barrett, 2005) and lead to the transformation or extension of those same assignments of function.

Where variations in the functions assigned to existing objects are purposely intended, they are likely to arise in the four types of scenario enumerated in the proposition above. The initial appropriation of the turntable in hip-hop music, for example, arguably falls most

squarely into categories (2) and (4). With respect to (2), the innovation emerged within a culture that celebrated the rebelliousness and bricolage that would go on to define the hip-hop movement. As expressed by Joseph Sadler:

> An instrument is defined as a device with which to produce a musical sound. I always wanted to create music. Traditional instruments was not what I wanted to use. So growing up in the 'hood I simply chose my own (Saddler, undated).

But the emergence of hip-hop and turntablism also coincided with a period in which the city of New York was close to bankruptcy and budget cuts in school music programmes drastically reduced access to traditional instruments (Rose 1994: 34). With respect to (4), then, the household gramophone was often the closest thing to a musical instrument available to young people in the communities concerned and so became an obvious outlet for those with musical inclinations searching for an alternative.

The development of purposely-intended innovations in function follows a logic that is broadly similar to the trial-and-error problem-solving process described by von Hippel (2005) in the context of hardware innovations. In response to the perception of a new problem or need, an innovator hypothesises that the problem may be overcome by using an existing object in a new way. The innovator then tests the proposed solution, amending it in light of the results and iterating the process until a satisfactory solution is found. Joseph Saddler's development of the Quick Mix, which as we have already noted was a carefully worked out refinement of the needle-dropping technique first performed by Clive Campbell (Chang, 2005, pp. 112-113), is a good example of this process, as are many of the various subsequent innovations in turntablist techniques.

While we have focused on users deliberately searching for new functions, this is not to deny that chance may also play an important role in the emergence of new uses for existing

objects. A good example here is Theodore Livingston's accidental discovery of the "scratch". Here in his own words is what happened:

> I can thank my mother for that. I was in my room playing music too loud. My mother banged on the door, and when she opened the door she was pointing her finger at me, telling me I had to turn the music down, or turn it off. While she was in the doorway screaming at me, I had one record playing, and was moving the other record back and forth. In a rhythmic motion. And didn't realize what I was doing until she left the room. Once I realized what I was doing, I experimented with different records. It became the scratch and the rest is history (Theodore Livingston quoted in an interview with Todd Souvignier (Souvignier, 2003: 48); see also the interview with Billy Jam, undated).

This is a fascinating snippet for its emphasis on serendipity. That said, the elements of chance involved would have been of little consequence had Livingston not been someone able to recognise the possibilities thrown up by them. And this is something that likely depended very heavily on his already having considerable skills as a DJ, and his practicing on a two-turntable setup complete with faders and so able to notice the juxtaposition of his rudimentary scratching against the sound of the other record playing normally (Malone, 2005).

Proposition 4: User-innovations in function provide scripts for manufacturer-led changes in form.

An intriguing aspect of the turntable episode is that it illustrates a departure from the conventional story of designers setting the pace in "configuring" users of new kinds of technological objects (Woolgar, 1991). In a suggestive paper, Akrich (1992) compares designers to film scriptwriters attributing specific activities and responsibilities to the

intended users of technology who then attempt to "inscribe" these into the objects concerned. In terms of our theoretical framework this portrayal of designers is an appealing one, particularly where the technological object concerned is intended to serve a new or largely unfamiliar function and for which a market has yet to be created. Where an existing technological object is subject to a user innovation in function, however, it is often users who provide designers with scripts with which to work from. This is exactly what has been happening in the second round of innovation described in our case, where, faced with a range of by now established practices and techniques associated with classical vinyl turntablism, designers in companies such as American Audio, Pioneer and Technics have responded by developing digital audio players designed to facilitate the performance of versions of those same "scripts". Indeed this is exactly how the new Technics CDJ is presented in the company's own marketing material:

> The Technics SL-DZ1200, the world's first Direct-Drive Digital Turntable, looks – and more importantly feels – like spinning wax on a classic 1200. The distinctive slip surface on the 10" platter lets you spin, scratch, break, and otherwise work a track in a number of formats, including CD, MP3 and AAC. Along with its realistic vinyl feel and classic direct drive, the SL-DZ1200 also lets you store, playback, scratch and loop sampled media from a removable SD memory card. About the size of a postage stamp, these cards store all your favorite samples, songs – even whole albums. And although they won't ever be able to replace vinyl, they're a whole heck of a lot easier to carry around than a crate of records. It looks like Technics is about to kick off a whole new era for the DJ – again.
>
> (www.panasonic.com/consmer_electronics/technics_dj/prod_intro_sldz1200.asp)

In reversing the conventional story in this way, with users coming up with scripts that designers then read, our account again underlines that social structure – particularly existing assignments of function and the social rules that underpin practices in which technology is implicated – is an important element of the context in which the innovation and subsequent adoption of new technological objects takes place. As the passage above makes clear, existing social rules influence both the form and function of new products, with manufacturers of digital DJ equipment going to great lengths to preserve existing associations with turntablism, both in terms of how the equipment looks and feels (the jog wheel taking the form of a mini-turntable) and how they are presented and spoken about (e.g. "scratching" when there is in fact nothing of the kind in a literal sense going on in a digital environment). As Hargadon & Douglas (2001) argue in theorising the notion of "robust design", the challenge for designers and manufacturers of new products is to decide which details of an innovation to present as new, which to present as old, and which to suppress altogether. These challenges are likely to be particularly severe when a product designed to serve an established function differs radically in form to existing devices. Thus in its description of the SL-DZ1200, Technics downplays the possibly disruptive effects of CDJ players' more novel features, to the point of reassuring DJs, particularly vinyl "purists", that new media such as memory cards "won't ever be able to replace vinyl". For Technics, a manufacturer simultaneously supplying both analogue turntables and digital players, the difficulties are of course multiplied, as witnessed by its demonstrating the SL-DZ1200 player at the very DMC championship in which contestants are explicitly barred from using machines of this type.

7. CONCLUSION

Our aim in this paper has been to contribute to the literature on user innovation by advancing the idea of user innovations in function. To this end we developed a theory of the technical

identity of a technological object as something flowing from its function as well as its physical form, and proposed a corresponding conception of technological change as something that may emanate from, and be reflected in, changes in function as well as changes in form. We highlighted the possibility of such innovations being sufficiently dramatic, where they catch on, to alter or augment the established identities of technological objects.

There are many ways in which the account we have put forward might be developed further. At the more concrete level, and staying on the subject of user innovation, it would be useful to examine technological change that involves contemporaneous changes in form and function rather than the limiting cases of "same-form-different-function" and "same-function-different-form" that we saw in our illustrative case. As we noted, shifts in form and function are more likely to proceed in tandem and in an interconnected way, and there is therefore a need for detailed study of the links between user innovations in form and user innovations in function. Second, there is considerable scope for investigating more deeply the impact of power on the emergence, coalescing and possible transformation and dissolution of technical identities. Finally, and while we have said a fair amount about the meaning of technical objects insofar as this relates to assignments of function, there are various other ways in which meaning – relating to normative, political, ethical and aesthetic considerations, for example – may enter and influence the trajectory and speed of technological change and its diffusion. Again, while we touched on these additional avenues of meaning in our case study, there is considerable scope for further investigation here.

The theory of technological objects we have put forward is not restricted to the subject of user innovation and might also be fruitfully employed in other areas of organizational research. For example, the theory is likely to be useful in applied work in which questions of (changes in) the identity of technological objects come to the fore: e.g. in areas of marketing, product design and development (consider the case of the conception and

presentation of hybrid objects such as the iPhone), and the conduct and organisation of work (remember that the new use of the turntable and the practices associated with turntablism are mutually constitutive). There are also connections to be made with existing theoretical approaches. For example, there are important links between our theory of technical identity and the literature on the social construction of technology (SCOT) (Bijker, Hughes & Pinch, 1987; Bijker, 1995; Pinch and Trocco, 2002), particularly in respect of our emphasis on the interpretation of technological objects within social groups. Here we regard our theory as generally complementary with SCOT, albeit as doing something rather different: whereas SCOT tends to focus on the historical processes through which technological objects emerge, their 'comings into being' as Hacking (2002: 4) puts it, we have focused on some general properties of such objects – the 'beings that become' (Hacking, 2002: 5) – and the conditions of their existence. To some extent, then, we hope that our theory might serve as a contribution to the theoretical grounding of the kind of studies of the emergence of technological artefacts conducted by representatives of SCOT. Further, to the extent that assignments of function and the technical identities they support form part of social structure, we believe our theory may contribute to deflecting some of the criticism that SCOT has received for underestimating the influence of social structure (Russell, 1986) and especially the conditioning effect of social rules (Klein & Kleinman, 2002).

To close, we would briefly like to draw attention to the particular theoretical orientation adopted in this paper, an approach that goes under the general banner of social ontology. Ontology is the study of the kinds of things that exist in the world and their possible modes of existence, and social ontology is that part of ontology concerned with the social realm. After a long period in the shadows of positivism ontology is currently experiencing something of a resurgence,[xii] and involves, as we have here, taking a step back and reflecting on the properties and conditions of existence of the entities under investigation.

There are many reasons why such stepping back may be useful, some of which we hope are reflected in the paper. Chief amongst these are gaining clarity about the object under investigation, generating categories for theory development, and, given that not all objects of research are equally amenable to the same analytical tools, providing a basis for making informed choices about appropriate research methods. The present paper has been a preliminary ontological investigation of just one particular kind of social entity, namely technological objects. We suggest that the same sort of approach might usefully be applied to the many other kinds of objects posited in organization research, such as "institutional fields", "social networks" and "organizational routines" to name just three.

FOOTNOTES

[i] We use the term "technological objects" rather than the more common "technological artefacts" to accommodate the possibility that the objects in question may be naturally occurring as well as man made, such as when a stray and hollow reed is used as a straw.

[ii] Nonagentive functions, as distinct from agentive functions, are functions that we assign in our theoretical descriptions of naturally occurring phenomena, such as when we say that the function of the heart is to pump blood through the body.

[iii] The "if X" and "in situation C" parts of the injunction are of course sometimes suppressed in ordinary language, as in statements such as "publish or perish" or "keep left".

[iv] The self-imposed rules followed by singleton groups containing just one individual also bear normative force, although here the sanction will necessarily be some form of self-imposed punishment, or more commonly, the unease, remorse or guilt felt when these rules are violated.

[v] Note that on our definition routines are a manifestation of human activity, rather than being a potentiality or a capacity. On this point we part company with commentators such as Hodgson (2005), who regard routines as "stored behavioural capacities or capabilities" which, as such, many never be exercised. Further, on our definition routines involve not one but two kinds of regularity, namely the regularity captured by the "if X do Y" part of the rule being enacted, and the regularity that arises from the repeated enaction of the rule.

[vi] Searle defines the Background as the set of non-intentional or pre-intentional capacities that allow intentional mental states to function. We will not attempt to justify our adoption of Searle's thesis of the Background here, save to say that it and similar ideas have wider currency in philosophy, e.g. in the work of the later Wittgenstein, in Bourdieu's notion of the

"habitus", and in Hume's work on human cognition. See also Searle (2001 chapter 2), Fotion (2000), Nightingale (2003) and Runde (2002).

[vii] Lawson (2007) offers an alternative route to incorporating technology within the TMSA.

[viii] We suppress the qualifier about the context in which the rule applies. It has been suggested to us that the assignment of function here might be characterised as a convention as much as a social rule. Our response to this is that conventions are rules too, but a special kind in which the rule is sustained in virtue of everyone expecting everyone else to conform to it, everyone expecting everyone else to expect everyone else to conform to it and so on.

[ix] The SL-1200 Mark 2 introduced in 1978, the version most widely used in the DJ community, differs from the Mark I version in featuring an improved motor and shock resistance, redesigned casing, the addition of a ground wire, and in that the original rotary knob pitch control has been replaced with a slide control. The improved platter torque and redesigned casing (which brought the weight of the turntable up to 27 pounds and thereby made it considerably less susceptible to vibration than its forerunners and many of its competitors) were probably the most significant enhancement from a DJing perspective.

[x] We are grateful to Adam Power (DJ Rusty) for alerting us to this point. The situation we have just described is a convention in the co-ordination game sense of Schelling (1960) and Lewis (1969), and similar to the well-known lock-in story told by David (1985).

[xi] We will not consider in any detail the third, mixed category of technological change involving both changes in function and form here, both because of limitations in space and because this would involve repeating many of the same points we raise below. However, the digital video ("VDJ") players that have appeared with the recent emergence of "video turntablism" (turntablism augmented with synchronised and unsynchronised visual imagery

using “visual scratching”, “visual beat juggling”, and so on) would likely be a good candidate for a study of this sort.

[xii] For examples see the projects described at the following websites:
http://socialontology.berkeley.edu/
http://www.formalontology.it/
http://ontology.buffalo.edu/
http://www.jfsowa.com/ontology/
http://www.csog.group.cam.ac.uk/

REFERENCES

Adamson, R. 1952. Functional fixedness as related to problem solving: A repetition of three experiments. ***Journal of Experiment Psychology***, 44: 288-291.

Akrich, M. 1992. The de-scription of technological objects. In W.E. Bijker & J. Law (Eds.) ***Shaping technology/building society: Studies in Sociotechnical Change***: 205-224. Cambridge Mass.: MIT Press.

Archer, M. 1995. ***Realist social theory: The morphogenetic approach***. Cambridge, UK: Cambridge University Press.

Baldwin, C., Hienerth, C., & von Hippel, E. 2006. How user innovations become commercial products: A theoretical investigation and case study. ***Research Policy***, 35: 1291-1313.

Bhaskar, R. 1979. ***The possibility of naturalism***. Hemel Hempstead, UK: Harvester Press.

Bhaskar, R. 1989. *Reclaiming reality:* ***Critical introduction to contemporary philosophy***. London: Verso.

Bijker, W.E. 1995. ***Of bicycles, bakelite, and bulbs: Toward a theory of sociotechnical change***. Cambridge, MA: MIT Press.

Bijker, W.E., Hughes, T.P., & Pinch, T. (Eds.). 1987. ***The social construction of technological systems***. Cambridge, MA: MIT Press.

Brewster, B., & Broughton, F. 1999. ***Last night a DJ saved my life: The history of the disc jockey***. London: Headline Book Publishing.

Cage, J. 1939. ***Imaginary landscape no. 1 (musical composition for two variable-speed phono turntables, frequency recordings, muted piano and cymbal)***. Edition Peters 6716@1960. New York: Henmar Press.

CBS News. 2004. Turntablism 101: The turntable as an instrument. http://www.cbsnews.com/stories/2004/03/25/sunday/main608774.shtml, March 28.

Chang, J. 2005. ***Can't stop won't stop: A history of the hip-hop generation***. London: Edbury Press.

Cohen, M.D., & Bacdayan, P. 1994. Organizational routines are stored as procedural memory: Evidence from a laboratory study. ***Organization Science***, 5: 554-568.

Cohen, M. D., Burkhart, R., Dosi, G., Egidi, M., Marengo, L., Warglien, M. & Winter, S. 1996. Routines and other recurring action patterns of organizations: Contemporary research issues. ***Industrial and Corporate Change***, 5: 653-698.

David, P. 1985. Clio and the economics of QWERTY. ***American Economic Review***, 75: 332-337.

Demby, E. 2003. Learn to Turntable. ***Washingtonpost.com***, Sunday, July 13, p. M09, http://www.washingtonpost.com/ac2/wp-dyn/A40878-2003Jul10?

Faraone, C. 2007. Grandmaster Class. http://www.berklee.edu/news/2007/11/grandmaster_flash.html

Feldman, M.S. 2000. Organizational routines as a source of continuous change. ***Organization Science***, 11: 611-629.

Feldman, M.S., & Pentland, B. T. 2003. Reconceptualising organizational routines as a source of flexibility and change. ***Administrative Science Quarterly***, 48: 94-118.

Feldman, M.S., & Pentland, B. T. 2005. Organizational routines as a unit of analysis. ***Industrial and Corporate Change***, 14: 793-815.

Fotion, N. 2000. ***John Searle***. London: Acumen Press.

Franke, N., & Shah, S. 2003. How communities support innovative activities: An exploration of assistance and sharing among end users. ***Research Policy***, 32: 157-178.

Franke, N., von Hippel, E., & Schreier, M. 2006. Finding commercially attractive user innovations: A test of lead-user theory. ***The Journal of Product Innovation Management***, 23: 301-315.

German, T., & Barrett, H. 2005. Functional fixedness in a technologically sparse culture. ***Psychological Science***, 16(1): 1-5.

Giddens, A. 1984. ***The Constitution of Society***, Cambridge: Polity Press.

Hacking, I. 2002. ***Historical Ontology***, Cambridge, Mass.: Harvard University Press.

Hargadon, A.B., & Douglas, Y. 2001. When innovations meet institutions: Edison and the design of the electric light. ***Administrative Science Quarterly***, 46: 475-501.

Hayes, R. 2004. Berklee turns tables on music education. http://www.berklee.edu/opi/2004/0217.html

Hienerth, C. 2006. The commercialization of user-innovations: The development of the rodeo kayak industry. ***R&D Management***, 36, 273-294.

Hodgkinson, T. 1987. Pierre Schaeffer: an interview with the pioneer of musique concrète . ***Recommended Records Quarterly Magazine***, 2 (1).

Hodgson, G.M. 2005. ***The nature and replication of routines***. Unpublished manuscript, University of Hertford.

Jam, B. undated. Creator of the scratch: Grand Wizard Theodore. ***Hip Hop Slam***. http://www.hiphopslam.com/articles/int_grandwizardtheo.html

Kitwana, B. 2002. ***The hip hop generation: young blacks and the crisis in African-American culture***. New York: BasicCivitas Books.

Klein, H.K., & Kleinman, D.L. 2002. The social construction of technology: Structural considerations. ***Science, Technology and Human Values***, 27: 28-52.

Kline, R. & Pinch, T. 1996. Users as agents of technological change: The social construction of the automobile in the rural United States. ***Technology and Culture***, 37: 763-795.

Kroes, P., & Meijers, A. 2006. The dual nature of technical artefacts. ***Studies in History and Philosophy of Science***, 37:1-4.

Lawson, T. 1997. ***Economics and Reality***. London: Routledge.

Lawson, T. 2003. ***Reorienting Economics***. London: Routledge.

Lawson, C. 2007. An Ontology of Technology: artefacts, relations and functions. ***Techné: Research in Philosophy and Technology***. 11, forthcoming.

Lazaric, N. 2000. The role of routines, rules and habits in collective learning: Some epistemological and ontological considerations. ***European Journal of Economic and Social Systems***, 14: 157-171.

Lewis, D. 1969. ***Convention: A philosophical study***. Cambridge, Mass.: Harvard University Press.

Lüthje, C. 2003. ***Customers as co-inventors: An empirical analysis of the antecedents of customer-driven innovations in the field of medical equipment***. Proceedings of the 32nd EMAC Conference, Glasgow 2003.

Lüthje, C., Herstatt, C. & von Hippel, E., 2005. User-innovators and "local" information: The case of mountain biking. ***Research Policy***, 34: 951-965.

Malone, M. 2005. DJ Grand Wizard Theodore Interview. http://www.*ukhh.com*.

Meijers, A. 2000. The relational ontology of technical artifacts. In Kroes, P. & A. Meijers (Eds). ***The empirical turn in the philosophy of technology***: 81-96. Oxford: Elsevier Science.

Mitcham, C. 1994. ***Thinking through technology: The path between engineering and philosophy***. Chicago: University of Chicago Press.

Morrison, P., Roberts, J., & Midgley, D., 2004. The nature of lead users and measurement of leading edge status. ***Research Policy***, 33: 351-362.

Murph, J. 2006. Spinning a new song: DJ Logic Goes Legit with the Turntables. ***Downbeat***, Nov 2006: 38-40.

Muther, C. 2004. Berklee professor takes DJ class out for a spin. ***Boston Globe***, February 17.

Newman, M. 2003. ***Pedestrian history of turntablism***. http://www.pedestrian.info/PedestrianHistoryofTurntablism.pdf.

Nightingale, P. 2003. If Nelson and Winter are only half right about tacit knowledge, which half? A Searlean critique of "codification". ***Industrial and Corporate Change***, 12: 149-183.

Orlikowski, W.J. 2000. Using technology and constituting structures: A practice lens for studying technology in organizations. ***Organization Science***, 11: 404-428.

Oudshoorn, N. & Pinch, T. 2003. ***How users matter: The co-construction of users and technology***. Cambridge MA, MIT Press.

Pinch, T. & Bijker, W.E. 1987. The social construction of facts and artifacts: Or how the sociology of science and the sociology of technology might benefit each other. In Bijker, W.E., Hughes, T.P., & Pinch, T. (Eds.). 1987. ***The social construction of technological systems***. Cambridge, MA: MIT Press.

Pinch, T. & Trocco, F. 2002. ***Analog days: The invention and impact of the Moog synthesizer***. Boston Mass.: Harvard University Press.

Rose, T. 1994. ***Black music: Rap music and black culture in contemporary America***. Middletown: Wesleyan University Press.

Runde, J. 2002. Filling in the Background, *Journal of Economic Methodology*, 9: 11-30.

Runde, J. Jones, M., Munir, K., and Nikolychuk, L. 2008. On rules, routines and the adoption of technological product innovations: the case of the transition from analogue photography to digital imaging. *Cambridge Journal of Economics*, forthcoming.

Russell, S. 1986. The social construction of artefacts: A response to Pinch and Bijker. ***Social Studies of Science***, 16: 331-346.

Saddler, J. undated. ***Videoclip declaration prior to entering website***. http://www.grandmasterflash.com/

Schelling, T.C. 1960. ***The strategy of conflict***. Cambridge, Mass.: Harvard University Press.

Schloss, J.G. 2004. ***Making beats: The art of sample-based hip-hop***. Middletown: Wesleyan University Press.

Searle, J.R. 1995. ***The construction of social reality***. Middlesex: Allen Lane, The Penguin Press.

Searle, J.R. 1999. ***Mind, language and society***. London: Weidenfeld & Nicolson.

Searle, J.R. 2001. ***Rationality in action***. Cambridge, MA: MIT Press.

Shah, S.K. 2006. Motivation, governance, and the viability of hybrid forms in open source software development. ***Management Science***, 52: 1000-1014.

Sherwin, A. 2007. Guitar sales boom means hip-hop has had its day. ***Times Online***, http://www.timesonline.co.uk/article/0,,2-2547585.html.

Small, M. undated. Faculty profile: Stephen Webber's long and winding road, http://www.berklee.edu/bt/153/bb_faculty_profile.html**.**

Souvignier, T. 2003. ***The world of DJs and the turntable culture***. Milwaukee: Hal Leonard Corporation.

Sudnow, D. 2001. ***Ways of the hand: A rewritten account***. Cambridge MA: MIT Press.

Tietz, R., Morrison, P. D., Lüthje, C. and Herstatt, C. 2005. The process of user-innovation: A case study on user innovation in a consumer goods setting. ***International Journal of Product Development***, 2: 321-338.

Von Hippel, E. 1988. ***The sources of innovation***. New York: OUP.

Von Hippel, E. 2005. ***Democratizing Innovation***. Cambridge MA: MIT Press.

Wansink, B. & Gilmore, J. 1999. New uses that revitalize old brands. ***Journal of Advertising Research***, 39: 2 90-98.

Webber, S. 2003. ***Turntable technique: The art of the DJ***. Boston: Berklee Press Publications.

White, M. 1996. The phonograph turntable and performance practice in hip hop music. ***Ethnomusicology OnLine***, 2, http://www.research.umbc.edu/eol/2/white/index.html.

Wilder, E. 2006. ***Endtroducing…***New York: Continuum International Publishing Group.

Woolgar, S. 1991. Configuring the user: The case of usability trials. In J. Law (Ed.) ***A Sociology of Monsters***: 57-99. London: Routledge.

FIGURE 1

Technics SL-1200 (MK 2)

FIGURE 2

Technics SL-DZ12000 CDJ player

FIGURE 3

Vestax S1 DJ Turntableguitar

FIGURE 4

Numark iDJ[2]

Phil Faulkner (pbf1000@cam.ac.uk) is

Jochen Runde (j.runde@jbs.cam.ac.uk) is Reader in Economics and Director of Programmes at Judge Business School, University of Cambridge, and Fellow and Director of Studies in Management Studies at Girton College, University of Cambridge. He received his Ph.D. in Economics from the University of Cambridge. His research interests include social ontology and the ontology of technology in particular, explanation in the social sciences, decision-making under uncertainty, and the development and commercialization of digital technologies.