# GETTING TO GRIPS WITH TECHNOLOGY

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*Abstract:* This paper advances a general theory of technological objects that attempts to (1) do justice to both their physical and social aspects, and (2) facilitate a realist account of their fit within the social world. The theory is demonstrated by using it to unpack some novel aspects of user-driven product innovation, as illustrated by the appropriation of the gramophone turntable as a musical instrument in hip-hop music and subsequent innovations in digital music players.

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This paper is about the technological objects that populate our day-to-day worlds, from cameras to cars, pushbikes to paperclips, and watches to washing machines. It is widely accepted that such objects have a social as well as a material aspect, and that this social aspect is somehow bound up with what they are used for. But this still leaves the intriguing and rather difficult question of precisely how the social and the material come together in technological objects, and specifically how the myriad diverse physical objects that we use and interact with all the time come to be the readily interpretable things – cameras, pushbikes, watches, and so on – that make up such a large, comparatively stable and apparently highly structured part of the social world. This is the question we will pursue in this paper.

It is important to be clear that when we say "how the social and the material come together" and "come to be" here, we do not mean the pathways and processes that are the usual subject of the literature on innovation and technological change. What we do mean is something rather different, namely the more abstract question of what the conditions are for an object to exist as a particular item of technology in the first place. This question, which concerns the basic nature or ontology of technological objects, is usually taken for granted in the organization literature, be this in contributions from management and economics (e.g. Basalla, 1988; Christensen, 1997; David, 1985; Geroski, 2000; Suarez, 2004; von Hippel, 1988, 2005) or those emanating from sociology, the philosophy of science and social history (e.g. Akrich, 1992; Bijker, Hughes & Pinch, 1987; Bijker, 1995; Hargadon & Douglas, 2001; Oudshoorn & Pinch, 2003). We propose to answer it by way of a realist interpretation of what we will call the technical identity of a technological object. That is to say, we will develop an account of technological objects like cameras, pushbikes and washing machines as real features of the social world, and where what is real is not only their physical/material form but also their actually *being* cameras, pushbikes and washing machines.

We recognise that this is an unusual and rather philosophical-sounding project in the context of organizational research. It is nevertheless a useful one, in our view, because it is to the benefit of any scholar occasionally to take a step back and examine their ontological presuppositions, that is, to ask what they are assuming about the nature of the entities, relations and processes they are investigating. In the first place, such presuppositions have a decisive bearing on how objects of research and areas of enquiry are conceived, the kind of research questions asked, and the appropriateness of particular research methods employed. Since these presuppositions are often vague and tacitly held, bringing them to the surface can be revealing in uncovering contradictions and throwing light on where and why people hold different positions and find it difficult to agree on substantive or methodological issues. In the second place, and this is something we pursue later in the present paper, even abstract ontological investigations can provide fertile ground for the development of theory at a more concrete level. We will illustrate this point by using our theory to derive various implications in respect of user-driven product innovation.

The paper divides into two halves. The first half develops a theoretical framework 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 in Section 1, where we appropriate some of Searle's ideas about assignments of function to arrive at a theory of the dual 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 puts the theory to work by applying it to the subject of user-driven product innovation. 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 the subsequent impact on digital players. This account then provides a setting within which, in Section 5, we develop a general conception of technological change consistent with our earlier theory of technological objects and subsequently, in Section 6, a number of propositions relating to a novel kind of user-driven innovation. We finish 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 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) "for-ness".

In order to flesh out these ideas and to develop an account of the dual nature of technological objects that incorporates both form and "for-ness", 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 a function, or use, 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 sustaining objects as the readily identifiable pieces of technology they are. In particular, we contend that the "for-ness" 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 "for-ness" of a technological object indeed depends on an assignment of agentive function to objects of a certain type, this begs the question of who does the assigning. We will proceed on the basis that such 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 use of the object concerned. For established technologies, 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 such groups varies. 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, such as the case of specialised tools used in circumstances that touch the lives of only a restricted few. And for newly emerging technologies or those that consist of an existing object being used in a novel way by one or a small number of individuals, the group may contain no more than the object's initial innovators.

As far as the physical form of technological objects is concerned, the key point is 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, routines 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, routines 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 rational choice models in which actors are portrayed as at all times engaged in making choices on the basis of maximising calculations, 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.

A key feature of the theory we are advocating is that human agency and social structure are recursively organized. That is to say, it takes the view that social structure is constantly reproduced as a generally unintended consequence of our activities, where those same activities presuppose the very structures that are being reproduced. Thus by filling the position of a CEO, an 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 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 provide a theoretical account of the rules of particular scale substitutions that she 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 introduced 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 closely followed in order to produce particular results. Yet in other cases social rules emerge spontaneously in social systems 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. 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, in terms of the TMSA, 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".[vii]

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 them 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 identity of technological objects contribute to constituting the activities in which they are implicated.

## 4. PUTTING THE THEORY TO WORK

Although we regard the project of formulating an abstract theory of technological objects as useful in its own right, many readers will rightly be interested in how it bears on more concrete issues in organizational research. Given the very general level at which the theory has been developed the range of potential applications is liable to be extremely broad, ranging from areas such as product design, marketing and the organization of work within management, through to fields as diverse as science and technology studies, culture studies and ethics. Since we cannot hope to address all these possible areas here, we will instead demonstrate our framework by applying it to a particular area that has been receiving increasing attention in the recent literature: technological change issuing specifically from user-driven innovation (Baldwin, Hienerth & von Hippel, 2006; Franke & Shah, 2003; Hienerth 2006; Oudshoorn & Pinch, 2003; Shah, 2006; Ulrich, forthcoming 2007; von Hippel 2005).

To provide us with a site to unpack and illustrate some of the implications of our theory for user-driven innovation, we will begin by relating a recent episode of technological change. The object at the centre of our account is the phonograph turntable, and the story we will relate concerns its transformation from a pure 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 mass appropriation of the phonograph turntable as a musical instrument is often attributed to the influence of a number of prominent DJs associated with the emergence of hip-hop music in the Bronx in New York during the 1970s. However, the idea of using turntables as sound-generating devices in larger musical performances is actually far older than this, having been pioneered by the avant-garde composer John Cage (1939) and, during the 1940s, the father of *musique concrete* Pierre Schaeffer (Hodgkinson, 1987). Groundbreaking as Cage and Schaeffer's innovation was, however, it did not catch on and it was only with the advent of hip-hop DJing 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). The account that follows therefore concentrates on the more recent history of the turntable within the DJ 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 a.k.a. 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 a.k.a. 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 in question would be done using 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 then 13 or 14 year old DJ Theodore Livingston a.k.a. 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 (more on this below). He liked the sound and developed and practiced 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" (for best R&B instrumental performance) from the respected jazz pianist Herbie Hancock's 1983 album *Future Shock*, which featured distinctive contributions from turntablist and DJ Derek Howells a.k.a. 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), many of which have been analysed and codified to facilitate their learning and reproduction by others (e.g. Souvignier, 2003; Webber, 2003). After having been refused twice and having had to negotiate a special study group to assess the pros and cons on turntable instruction, turntables are now taught as an instrument at the Berklee College of Music (Hayes, 2004; Muther, 2004; Small, undated), one of the most prestigious music schools in the U.S.; the musicians union in L.A. now counts turntablists amongst its members (Webber, 2003: 103); and a turntablist has even been a featured instrumentalist in a recent cover story in the respected mainstream jazz magazine *Downbeat* (Jason Kibler, a.k.a. DJ Logic, Murph, 2006). Although there are currently indications that the highwater 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, jazz, pop, nu-metal and even country music bands that include a turntablist in their ranks.


FIGURE 1 - Technics SL-1200 (MK 2)

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 unchanged throughout. 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.[viii] 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).

The dominance of the SL-1200 was in part sustained by a process 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 that will be used in performances. Anyone serious about becoming a DJ or turntablist would therefore have to acquire a suitable set of turntables, invariably SL-1200s, for home use. The result was that the nightclubs 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.[ix]

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 part of our story, 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 of 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 beginning of the 1990s. Some DJs quickly followed suit and switched to the new format, taking advantage of the greater portability and durability it offered. But many others, particularly those with an interest and skills 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, much 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, widely regarded as a superior machine and which has become 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.

FIGURE 2 - Technics SL-DZ12000 CDJ player

The 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.

FIGURE 3 - Vestax S1 DJ Turntableguitar

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.


FIGURE 4 - Numark iDJ$^2$

The important point about this second generation of digital players is that the move from audio CD-based to file-based players is a far less dramatic shift for turntablists than the earlier move 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 (a.k.a. DJ Q-bert) and Ronald Keys (a.k.a. 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 described in the preceding section 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, that functions are assigned to objects by social groups of varying sizes, and where the functions assigned to technological objects may be the product of design, adaptation or accident. 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, as the unequivocal air of the words "is" and "has" in the following extracts indicates, perhaps even more widely:

> Today, the turntable is no longer just for playing music, but making music (*CBS News*, 2004).
>
> Since 1977, when a fellow named Grand Wizzard Theodore first pushed and pulled a record back and forth under the needle, the turntable has evolved from a playback device into an indispensable musical instrument – so much so that it now surpasses the guitar in annual sales (Demby 2003, *Washington Post*).

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 the functions users assign to existing technological objects and therefore represents a novel kind of user-driven technological change. We will return to this issue in more depth in the next section. First, however, we need to 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 to which a pre-existing function is assigned, (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.[x] 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. The first round of innovation, 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).

In conceiving of technological change in terms of changes in the form and/or function of a technological object, we are of course not claiming that every instance of technological change will alter the technical identity of the object concerned. Many changes in form, for example, are of a relatively minor, incremental, sort, such as the upgrades to the basic Technics SL-1200 since 1972. These changes alone would not have amounted to the turntable becoming anything other than what it had been up to that point. But changes in form sometimes mark a more fundamental break, such as the shift from piston to jet engines, transistors to integrated circuits, and turntables to CD players. Here it is appropriate to speak of technological changes that changed the technical identity of the engines, components and music players concerned, for there is clearly a sense in which the technical identity of a CD player, say, is a fundamentally different thing from that of a turntable, even if they share the same function at a very abstract level. Much the same kind of point can be made about

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 now turn to technological change issuing specifically from user-innovations in function, a rich and topical site for demonstrating how our approach can be used to inform analysis at a more concrete level. The discussion is arranged in the form of six propositions, in each case illustrated by material drawn from our case study.

**Proposition 1: User-driven innovations in function matter too.**

Recent research into user-driven product innovation (Baldwin et al., 2006; Franke & Shah, 2003; Hienerth, 2006; Oudshoorn & Pinch, 2003; Shah, 2006; von Hippel 2005) has shown that under certain conditions users can play a decisive role in both the generation and subsequent diffusion of an innovation. For the most part, however, this literature has concentrated on "hardware" innovations, that is, on changes in form of the objects concerned, such as hospital surgeons developing or improving pieces of medical equipment in the case of producer products (Lüthje, 2003), 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, in the context of the case considered in this paper, Joseph Saddler jerry-rigging a microphone cue into his mixer setup (Chang, 2005: 112). 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 hardware they may precipitate. Thus the emergence of new techniques associated with the use of a product such as the rodeo kayak (Baldwin et al., 2006) may attract new users and thereby expand the market for that product without any concomitant changes in form. More dramatically, and as we have seen in the case of the turntable, changes in function may even lead to wholesale changes in an object's technical identity, with the possibility of far-reaching and deep-seated effects on previously unconnected firms and markets. The questions addressed by the authors above in relation to changes in hardware – 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 new topics and issues, some of which are addressed in the propositions that follow.

**Proposition 2: User innovations in function arise by design, or by accident in the course of human activities directed at other ends.**

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

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.

With respect to user-innovations in function, these variations may arise either as the intended outcome of user activities consciously directed at changing the way an object is used, or as the unintended outcome of chance discoveries in the course of using an object in activities directed at some other end. Purposefully intended variations in function typically occur where (1) conventional ways of using an existing object are perceived as ineffective or improvable and alternatives are sought, (2) where a need arises for an item that does not yet exist or, if it does, is unknown to the user, or (3) where the item that would normally be used for some purpose is unavailable. The initial appropriation of the turntable in hip-hop music arguably falls most squarely into category (3), coinciding as it did 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). 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 (consciously) searching for an alternative:

> 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 (Joseph Saddler, undated).

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.

Theodore Livingston's accidental discovery of the "scratch" typifies the second kind of innovation in function that arise as a result of a chance discovery. Here in his own words is how it was made:

> 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 Livingstone 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, namely that he happened to have been playing the music too loud, that this happened to have irritated his mother, and that, in his agitation at having her berate him, he happened to be subconsciously manipulating a

turntable in a rhythmic way. All this would have counted for nothing, however, had the necessary background conditions not been in place, namely that this was someone concentrating on enhancing his already considerable DJ skills, using a two-turntable set up complete with faders. As is revealed in a subsequent interview, a key element in his discovery was that he could hear both turntables at once and was therefore in a position to notice the juxtaposition of his rudimentary scratching against the sound of the other record playing normally:

> … I had one record playing on my right hand side and I was holding the record on my left hand side and back then we didn't have no cross faders … so I had all the up and down faders all the way up and whiles she was screaming at me in the doorway I was rubbing the record back and forth, so when she left the room I realised what I was doing and practiced and perfected it … (Theodore Livingstone quoted in Molly Malone, 2005).

Again, the discovery of the scratch marked only the beginning of the innovation, the bulk of which consisted of its subsequent refinement and diffusion.

**Proposition 3: 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 range of activities ranging from design and manufacture through to marketing and distribution. Users, in contrast, typically have a much narrower and relatively more intimate engagement with such objects in connection with their use as a means of achieving certain ends. If so, users as a group 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. The scope for the emergence of new uses for existing technological objects, be these the result of deliberate search or chance discovery, is thus likely to be far greater amongst users than manufacturers of these objects.

The economics of innovation also has an important role to play here. Making a commercial success of a new assignment of function to an existing object with an established technical identity is something that is likely to require significant investment on the part of manufacturers. However, once this investment is made 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 and Gilmore, 1999)). Thus investment in novel use by firms is likely to be discouraged. 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.

On the user side, conversely, the incentives tend to favour innovations in function over innovations in form. The key point here lies in the ability of the average user to innovate, since 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 time and, often, the passion to develop and perfect the skills and techniques

involved. These are resources that youthful turntablist innovators, much like the kind of 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 4. The diffusion of user-innovations in function depends on salience.**

By the salience of user innovations we mean their capacity to capture the attention of potential adopters. Salience depends on (1) various features of the innovation itself (how striking or dramatic it is in the context in which it emerges, its perceived 'fit' with the activities and self-image of potential adopters, its perceived scope for development, and so on), (2) the social status/visibility of the innovator, and (3) geographical, technological or institutional factors that influence the ease with which it can be communicated to potential adopters.

The innovation in use in the case of the transmuting gramophone enjoyed a high level of salience from all three of these sources. In the first place, it was highly attention grabbing in that it contradicted just about everything people had been taught about playing records. As anyone who lived through the vinyl record era before the advent of turntablism will recall, scratching a record was synonymous with damaging it, and deliberately pulling a record back or slowing it down under the stylus – if it had occurred to anybody to do this at all – would have been thought likely to damage both the record itself and the turntable motor and/or drive system. Indeed, it bordered on sacrilege even to touch a record on its playing surface. It is thus with some insight and a keen sense of history that Joseph Saddler, one of the fathers of turntablism, summarizes his contribution as one of violating this last taboo:

> The big DJs of the 70s would *never* touch the grooves of the record, just the edge … By using a turntable, a handmade mixer, and *placing my fingers on the vinyl*, I never really realized that I would be changing the way DJs would play music forever (Joseph Saddler, undated, emphasis in the videotape original).

At the same time, the innovation was a perfect fit with the spirit of rebelliousness and celebration of bricolage of what became hip-hop, and subsequently sustained by a strong sense of its cultural roots in the DJ culture and associated aesthetic and normative commitments (Schloss, 2004). Moreover, the innovation quickly came to be seen as an outlet for the creativity of DJs, ripe for further development by figures like Theodore Livingston and the legions of turntablists that followed him. Further, and this speaks to the point about the social status of the innovators, many of the early DJ innovators were prominent and influential members of their communities, 'titans in the streets backed up by a major crew' (Chang, 2005: 111; see also Perkins, 1996: 5-9), who provided powerful role models for their followers to emulate and, where possible, to go beyond.

Perhaps the most important change influencing the salience and thus the diffusion of user innovations over the last ten years has been the development of ICT media - email, the web, chat rooms, search-engine facilities and so on - that provide powerful tools for people with niche interests to find each other and to form innovation communities within which to communicate and share their ideas (von Hippel 2005). While the growth of turntablism has benefited from these media too over the last decade, it had already emerged and spread twenty years before these media had developed. Nevertheless, it did benefit from a closely-knit innovation community of its own, something that was greatly facilitated by hip-hop first emerging and developing in a small and highly-concentrated geographical location, namely the 'seven mile world' (Chang, 2005; Rose 1994, p. 53) of the Bronx in New York. This was a tightly-knit community in which participants knew what was happening, and closely observed each other.

An important institutional stimulus to turntablism was the DJ 'battling' contests synonymous with hip-hop:

> Conflict is an ever-present element in any life, including that of DJs, and it's expressed in the hip-hop practices of battling. Sound systems compete on the basis of volume and selection, just like the Jamaican ancestors. DJs compete through musical knowledge, turntable and mixer skills, showmanship and crowd pleasing. MCs rank each other on lyrical ability, flow, attitude, looks, stage moves, and audience response. MC battling has special roots in the African-American oral tradition of competitive insults known as "the dozens". Battling is an outlet for competitiveness, a venue for skill building, and establishes a peer-status hierarchy within this scene. Battling inspires technique advancement and innovation, and is part of the engine that keeps both hip-hop and turntablism exciting (Souvignier, 2003:123-124; see also Katz, 2004).

Battling is thus the turntablist equivalent of the 'cutting contests' that were so instrumental to the shaping of bebop jazz, a key and deliberately organized element in the development of the genre.

The effect of competition on the diffusion of innovations is something that has been widely studied in the literature on user innovations in form (Franke & Shah, 2003; Ulrich, forthcoming 2007; von Hippel 2005) where there is evidence that competition may limit the proclivity towards free sharing of ideas and resources often observed in innovation communities, thus hindering the spread of product innovations within, for example, sports enthusiast communities. Just the same kind of thing occurred amongst the early DJs at the start of hip-hop, who actively guarded the tricks of wiring they used to achieve maximum volume from their P.A. systems (Chang, 2005, pp. 69-70). Yet to the extent that innovation among DJs is also concerned with technique (and in competitions such as the prestigious DMC "world championship" of DJing and turntablism the use of a standard Technics turntable setup means that there is no scope for users making hardware innovations) competition tends to promote rather than discourage sharing and the diffusion of new ideas, since the gains to innovation – impressing one's peers, winning competitions, being recognised as the inventor of a technique that has become a standard part of the turntablist's armoury, etc. – only accrue from being put on public display. In this respect the development of turnablism represents a mix of both community- and proprietary-innovation, with the cooperation and enjoyment associated with such a highly social, and performance-based, activity coexisting with the high degree of rivalry and structured competition found in the DJ community.

**Proposition 5: User innovations in function are apt to be advantageous to incumbent producers.**

For the manufacturers of technological objects, 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 incumbent manufacturers who gain what is effectively a windfall having invested nothing in generating these new markets. In the case of the transmuting turntable, existing turntable manufacturers, particularly Technics who 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 assignment of 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 as bomb triggers, and strapped-down MIG jet fighters used 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).

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 in particular 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, their use 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 worn out, or used up, in use, meaning users have no need to purchase additional instances of the object 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 amongst turntablists just at the start of a prolonged period of contraction of its original market. 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, as a word-processing tool, and so on, and the camera becoming more heavily associated with communication through the sharing of electronically-transported and relatively disposable images with the advent of digital imaging, rather than the archiving of "kodak moments" associated with the pre-digital era of photography. 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 6: User-innovations in function provide scripts for manufacturer-led changes in form.**

An intriguing aspect of the turntable episode is that it constitutes a departure from the conventional story of designers setting the pace in "configuring" users of new kinds of technological objects (Woolgar, 1991). In a highly suggestive paper, Akrich (1992) compares designers to film scriptwriters attributing specific activities and responsibilities to the intended users of technology that are then "inscribed" 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 to work with. 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 turntablism, designers in companies such as American Audio, Pioneer and Technics responded by developing digital audio players designed to facilitate the performance of those "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 user-innovators in function 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 their 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 initially suppress altogether. And 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 digital players' more novel features, to the point of reassuring DJs, particularly those

regarded as 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

We said in the introduction that it is useful for scholars sometimes to take a step back from the specific focus of their research and to reflect on the general nature of whatever it is they are investigating. This paper has been an exercise in stepping back on these lines, an ontological investigation of the nature of technological objects. Of course, as with any investigation, we cannot claim truth for our theory, only that it is the best picture that we have been able to come up with. That said, we do believe that it is a compelling picture and one that encourages fresh ways of thinking about technological objects and technological change.

The primary theoretical contribution of the paper was to combine ideas from John Searle’s theory of institutional facts and wider realist social theory, to arrive at an account of the technical identity of technological objects as something that issues from both their physical structure and the agentive functions that groups within society assign to them. We argued that these identities are real, despite their depending in part on how those objects are “constructed” by the community in which they hold currency. So while there is a clear sense in which what technological objects are depends in part on what the community believe them to be, on our account, this is not to say that the technical identities can be anything individuals would like them to be. Assignments of agentive function and the technical identities they underpin are as much part of social structure as the rules of the road and the rights and responsibilities of CEOs of public companies. As long as assignments of function prevail, moreover, they both facilitate and constrain activities in a way that is as real and as tangible as the physical form of the objects to which they are assigned. This was clearly illustrated by the case of the transmuting turntable, where the emergence of a new technical identity that arose almost exclusively from a new assignment of function, had very real effects on the success of a product that was nearing the end of its life in its prior function, on its successor technologies and even on the development of musical and wider cultural genres.

Given the very general nature of our theoretical framework, there are many ways in which it could be used to inform further research in areas of interest to organizational researchers. In the present paper we concentrated on the topic of technological change, focusing particularly on change that issues from user-driven innovation in function, illustrating this with the case of the transmuting turntable. The six propositions developed in the preceding section provide only an initial exploration of this intriguing aspect of user innovation. Yet in setting out these points we hope at least to have shown how by re-examining a basic social category such as “technological object” it is possible both to provide a new perspective on existing areas of research as well as to open up entirely new ones. We hope others might be encouraged to explore further the potential applications of our theoretical framework, as well as to pursue ontological enquiry into the many other important social entities and processes that are ripe for such study.

[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 willwill 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) and Nightingale (2003).

[vii] 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.

[viii] 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.

[ix] We are grateful to Adam Power (a.k.a. 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).

[x] 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.

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