From dishwashing to dishwasher cooking: on social positioning and how users are drawn towards alternative uses of existing technology

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This paper is published in the *Cambridge Journal of Economics*, 45(4), 2021, pp. 613-630.

https://doi.org/10.1093/cje/beab026

ABSTRACT

Drawing on social positioning theory and using dishwasher cooking as our running example, we examine how users arrive at alternative uses of already existing technological objects or what we will call "user innovations in function". The first half of the paper provides an abstract account of three forms of structure: social structure, especially as represented by social positions; structures of cognition and action; and the structure of technological objects. The second half theorizes user innovations in function as emerging at the nexus of these different forms of structure, with a view to highlighting (1) the pre-reflective and reflective modes of agency involved; (2) how these relate to what we call "tinkering" and "reflection" in user innovation; and (3) the difference between "local" and "non-local" user innovations in function and their possible roots in tinkering or reflection.

Keywords: User innovation, technology, social positioning, social structure, habitus

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We are grateful to three anonymous reviewers and to Alessandro Freddi, Matthew Jones, Jannis Kallinikos and Roberto Scazzieri for helpful comments on earlier drafts of this paper. Ivano Cardinale would like to acknowledge the research funding provided by the Independent Social Research Foundation's Political Economy Research Fellowship.

1. Introduction

In 2011 Lisa Casali, a well-known Italian blogger and foodie with extensive culinary training, a history of collaborations with top Italian chefs, and a keen interest in sustainability, published her *Cucinare in lavastoviglie* or *Cooking in the Dishwasher* (Casali, 2011). The idea that dishwashers can be used in this way wasn't new, as we know from a 1970 photograph—recently republished in the *Los Angeles Time*s (Harris, 2013)—of an appliance company executive displaying a whole salmon with vegetables, wrapped in aluminum foil, just cooked in a dishwasher (see also Burke, 2013; Dosti, 1986). But the success of Casali's book, now translated into seven languages, marks the transition of this idea from the mere curiosity it was until the mid-2000s into something that many have heard of and even practice.

Dishwasher cooking is an example of user innovation (de Jong, 2016; Gambardella, Raasch & von Hippel, 2016; Shah, 2000), and specifically of what Faulkner and Runde (2009) call user innovation in function where an already-existing device is put to an alternative use that does not involve its being significantly altered in any way. We will pursue this example for the light it throws on the drivers of innovation in function and user innovation more widely. We know from research on technology appropriation (DeSanctis and Poole, 1994; Orlikowski, 1992) and user innovation (Bogers et al., 2010; Faulkner & Runde, 2009) that the intrinsic features of technological objects do not *determine* the ways in which they are used. Yet much of this work tends to stop there, at the *possibility* that users may devise uses of technology beyond those originally intended by their designers. We believe there is scope to go further, to theorize different ways in which users arrive at alternative uses of technology.

We proceed within the general framework of recent theoretical work on social positioning (Faulkner, Pratten & Runde 2020; T. Lawson, 2012, 2015A, 2015B, 2015C, 2016, 2019, 2020) and the social positioning of technological objects in particular (Faulkner & Runde, 2009, 2013, 2019; Heuer & Runde, 2021; C. Lawson, 2017). We extend this work by

outlining a theory of action within social positions that lays bare the roles of the pre-reflective and reflective components of agency (Cardinale, 2018, 2019A, 2019B).[2] Our aim here is to include an element missing in many discussions of human action: that, in many situations, actors are neither forced or structurally determined to act in a given way, nor consciously choose an action from an explicitly formulated alternatives, but are *drawn* towards some actions rather than others. Using the case of dishwasher cooking as leitmotif, we will examine how this element may play out in the case of user innovation and user innovation in function in particular.

The following three sections provide the theoretical groundwork for our argument by distinguishing three different forms of structure: social structure especially as represented by social positions, structures of cognition and action, and the structure of technological objects. We then provide a brief section on broad categories of product-related innovation in the light of the preceding account, followed by a section on agency in user innovation and one in which we distinguish between two forms of agency, project and protention. We go on to deploy this distinction in an analysis of two different sources of user innovation in function, tinkering and reflection, in the context of both what we call "local" and "non-local" innovations in function. The final section brings together the various strands of the argument.

2. Social structure and social positioning

By social structure we mean the emergent realm of social positions, rules and relations. While we touch also on rules and relations in what follows, our primary focus is on social positions. To explain what we mean by social positions, it is useful to begin with the extent to which the social world consists of totalities, that is, relationally organized systems made up of parts that serve as components of those systems in virtue of being so organized. These parts, invariably totalities in their own right, may be animate (e.g., the governing board of a university) or inanimate (e.g., the heating element of a dishwasher). Following Lawson (2015C), we refer to

totalities that include human components as *communities*. Note that references to communities are often meant to include their nonhuman components, e.g., where mention of a university is meant to extend also to its physical infrastructure.

We can then define a social position as a status assigned to an entity by members of a community that confers a social identity to that entity within that community. By social identity we mean simply what that entity is for the community concerned. Employment-related positions within organizations are familiar examples here, such as the positions of student, lecturer or business school dean. In each case the position denotes a particular status within the organization and where it is in virtue of being assigned that status, and so occupying the relevant position, that someone acquires the associated social identity of student, lecturer or dean within the community of the school and the wider communities within which the school is nested.

Social positions locate their occupants as components of larger totalities. There are two points to note here, the first of which concerns the relationality of social positions. This feature is reflected already in social positions always being relative to the social position occupied by the larger totality they form part of as well as those occupied by its other components. It is also reflected more generally in the extent to which social positions are constituted by internal relations, that is, relations in which one or more of the relata are at least partly constituted by that relation. Internal relations are ubiquitous in the social world, including those between the social positions of student and lecturer in the case of our business school example, or between the social positions of business school student or business school lecturer and the larger totality of the business school itself. In each case, the members of each pair depend on, and would not exist without, the other.

The second point is that the social positions occupied by the component entities of a totality entail a general expectation that these entities contribute to the performance of that

totality in certain ways. Following Lawson (2012, 2016), we call this contribution the *system function* or, if there is more than one, the systems functions associated with the social position concerned.[1] Thus, whoever occupies the position of lecturer bears the system functions of providing lectures and conducting research in the larger totality of the business school, just as whoever occupies the position of dean has the system function of leading and helping manage the school. System functions can often be read off the rules expressing the rights and responsibilities associated with a social position, and where these rights and responsibilities interlock reciprocally with those associated with the other social positions to which it is related.

Human actors typically occupy many social positions concurrently and therefore have multiple social identities and system functions. Thus, someone who occupies the position (and therefore is and bears the system functions) of a lecturer in a business school might also occupy the position (and therefore be and bear the system functions) of guitarist in a jazz band, blogger on the Internet, or PTA member at the local school. Of course, human actors enter and leave social positions over time, acquiring or losing the associated social identities and system functions as the case may be.

3. Structures of cognition and action

An important feature of social positioning is that actors develop structures of cognition and action (Bourdieu's *habitus*) that reflect the positions they occupy (see also Searle, 1995, 2011, on the related concept of what he calls the "Background"). Specifically, by acting in accordance with what is generally expected of occupants of the social positions they occupy, actors develop skills and propensities appropriate to those positions (Bourdieu, 1990). This process takes place reflectively—where the actor is conscious of what is expected of them and acts accordingly—and pre-reflectively. The pre-reflective component has two subcases. In the first, new skills

[1] This notion of system function has affinities with Cummins' (1975) understanding of the biological function of a component (such as an organ) as the role it plays within the system to which it belongs. Cummins' view informs Preston's (1998, 2009, 2012) definition of the "system function" of artefacts to which we return below.

initially developed consciously gradually come to be performed pre-reflectively and slip from view into the background. In the second, new skills are developed pre-reflectively from the outset without the actors ever being fully aware of this taking place.

Someone coming into the position of university lecturer, then, would know, discover, or just gradually start acting in ways that conform to, the rights and responsibilities associated with that position, and develop the corresponding skills in preparing and delivering lectures, using PowerPoint, and so on. Over time, some of these rights, responsibilities might begin to fade from the conscious, and the actions that flow from them, to become automatic. In general, actors' structures of cognition and action are imprinted by the particular positions they have occupied over their life history. Since every actor occupies several positions at every moment and over time, each actor's habitus will be a stratification of dispositions attuned to those positions. It follows that while some aspects of habitus are common across occupants of a given position, each actor's habitus will to a greater or lesser extent be different from that of others.

Because the imprinting of habitus through socialization in social positions occurs gradually, and because habitus is to some extent unique to each individual, actors have some degree of autonomy from the immediate pressures they face in the social positions they occupy (Bourdieu, 1990; Lizardo, 2004). This autonomy suggests that social structure and structures of cognition and action are ontologically distinct, and that action can at least be partially explained with reference to the encounter between these two types of structure making some actions possible (enabling), precluding others (constraining), and, as we will go on to argue, encouraging some actions over others (orienting) (Cardinale, 2018, 2019A, 2019B).

4. The structure of technological objects

Thus far we have identified two forms of structure, social structure as represented by social positions on the one hand and structures of cognition and action on the other. We come now to a third, the structure of technological objects.

To say what we mean by technological objects, it is useful to begin with the more general category of objects. We will proceed on the basis that objects have two defining features, that they endure and that they are structured (Faulkner & Runde 2013, 2019). By an object being enduring we mean that it is fully present over the period of its existence, and where the length of this period depends on both the nature of that object and its environment. By an object being structured we mean that it is made up of distinct parts organized or arranged in some way, where those parts are themselves objects.

There are clearly many things in the world that are objects by our definition that we would not class as technological objects, not least the vast number of naturally occurring entities from mountains to meteorites and humans themselves. We define technological objects, typically but not always artifacts, as objects that humans—and indeed some members of the animal kingdom (Chappell & Kacelnik, 2002, 2004)—actively enroll in pursuit of their practical interests. Technological objects may exist as material or nonmaterial things. The material variety have a physical mode of being with spatial attributes such as shape, volume, mass and location, whereas the nonmaterial variety exist without such attributes. Examples of the former include dishwashers and dishwasher heating elements, physical components, suitably arranged. Examples of the latter include text and software, both of them types of syntactic object consisting of symbols forming expressions that adhere to the syntactical and semantic rules of the language in which they are couched. Bitstrings, the ordered sequence of 0's and 1's of the digital world, are themselves syntactic objects (Faulkner & Runde, 2019).

An important question for our purposes concerns the identity of (types of) technological objects and how this is achieved and sustained in the communities in which they arise. It is tempting to think that this identity, what an object is in the community in which it arises, is determined by what it is used for, and that this is something that is in turn determined by its structure. But we know already from cases like dishwasher cooking that while the structure of

an object must support its use, it doesn't determine how it is used. The question, then, is how the social identity, use and structure of particular technological objects come to coalesce.

It is at that this point that social structure, structure in our first sense, re-enters. The guiding idea is that the social identity and system function(s) of technological objects flows from their positioning in a way analogous to the case of positioned humans described above (Faulkner & Runde, 2013, 2019; Heuer and Runde, 2021; Lawson, 2012). Thus, the entity that occupies the social position of and therefore is a dishwasher heating element has the system function of heating the water in the larger totality of a dishwasher, just as the entity that occupies the social position and therefore is a dishwasher has the system function of cleaning crockery and cutlery in the larger totality of a system concerned with the production and consumption of food. Further, no less than the social positions occupied by humans, the positions occupied by technological objects are sustained by constantly being reproduced by people using and referencing the object concerned in the "right" way.

Three aspects of the relationship between the intrinsic structure and positioning of technological objects are central to our purposes below. First, and leaving aside possible futures with intelligent machines that are conscious under some description, technological objects are unlike human actors in that they generally don't bear rights and responsibilities in virtue of their social positioning. Nevertheless, the social positions occupied by technological objects form the locus of all kinds of general expectations, rights and responsibilities pertaining to their users and, often, third parties. In the case of the dishwasher, for example, users have the responsibility of ensuring that its installation meets safety regulations and where warranty conditions typically specify that only manufacturer-approved service contractors have the right to repair it. Rights and responsibilities of this kind are reproduced by the object concerned being used and interacted with in the "right" way by human actors, in accordance with its social positioning.

Second, there needs to be a reasonable match between a technological object's intrinsic structure and the social position it occupies for its positioning to be sustained over time. While an object's intrinsic structure may be compatible with it being used in many ways, given human physiology and possible situational constraints that might limit potential users' access to it, if it is inconsistent with performing the system function associated with its positioning, then that object is unlikely to last in that position for very long. Note that objects with different intrinsic structures may occupy the same social position at the same time, so long as these structures are compatible with the associated system function. Even devices as familiar and apparently settled as the dishwasher display significant variation and reflect constant innovation in aspects such as packing arrangements, look, drying technologies, smart capabilities, and so on.

Finally, the intrinsic structure of an object does not determine its positioning and system function(s), and objects with the same intrinsic structure often have one or more current uses as well as other potential uses.[2] In the case of the dishwasher, its generally accepted and most salient system function—which following Preston (2009) we will call its proper function—flows from its social positioning as a dishwasher. But other system functions might flow from its being positioned as a low-temperature cooking device, or a device for warming plates before a meal. And there might yet be others, not all of which can be specified in advance.[3]

5. Product-related innovation

The theory outlined so far suggests three broad categories of product-related innovation. The

[2] Different kinds of technological objects display different degrees of "closure", in the terminology of Kallinikos (2002, 2010), which set different degrees of freedom in their use. For example, nonmaterial digital objects like software applications may be more prone than analogue objects to "evolve once they are designed, often beyond the intent and imagination of the original designers" (Yoo, 2012, p. 135; see also Yoo et al., 2012). However, many technological objects do not permit interference with their internal operations and allow freedom of use only with respect to how they can be integrated within a broader system (Kallinikos et al., 2013).

[3] These observations raise the interesting question of whether a dishwasher used for cooking only becomes a cooker. We suspect that the device would continue to be regarded and referred to as a dishwasher by most people and even the user concerned, since that is its most generally accepted or proper function. However, if we look at what a dishwasher does for a specific user—i.e., if we consider what its use "reveals"—then for someone like Casali the dishwasher is both a washer and a cooker. The generally accepted name of an object is not that important for our purposes, as this would mostly reflect habitual understandings. But if one looks at how the object is used, then an object can "be" different things for different actors.

first and perhaps most familiar is represented by the constant flow of new versions of technological objects already located within already-established social positions, e.g., the emergence of smart dishwashers joining their predecessors in the social position of dishwasher. In this light, pre-existing social positions can be seen as providing the market categories that manufacturers seek to fill with such products. When these efforts are successful, new social positions are created that nest within the larger ones, e.g., the social position of smart dishwasher nested within the more general social position of dishwasher.

The second category comprises novel technological objects introduced in the absence, other than in very broad terms, of well-established social positions for them to fall into. There are three subcases here, the first of which is where the object comes to be adopted and used in broad accordance with what its designers intended, e.g., the foil surfboard, the harpejji and, going back a bit, the pocket calculator. The second and third subcases are ones in which the new objects fail to be taken up and disappear, or where manufactures discover successful alternative uses for them not originally intended or even imagined by their designers. Famous examples of the former include Google Glass, Nintendo's Virtual Boy and Twitter Peek. Famous examples of the latter include 3M's Post-it Notes, originally designed for use in an industrial application but which became ubiquitous in offices throughout the world (and now have a Stickies digital equivalent), and sildenafil citrate, originally developed and still used to treat pulmonary arterial hypertension, but now more famous and considerably more lucrative as Viagra.

The third of our categories comprises the innovations that emanate from users and involve objects with a history of being positioned and used in some way(s) coming to be positioned and used in other ways. Dishwasher cooking is one example, but there are many others. Some owe much to serendipity, as with the gramophone turntable, firmly positioned as a playback device until the accidental discovery of the "scratch" that paved the way to its

repositioning as a musical instrument (Faulkner & Runde, 2009). But many derive from deliberate attempts to solve a problem. A good example here is frugal or Jugaad innovation that often involves putting familiar objects to new uses (Radjou et al., 2012, p. 4), such as using top-loading washing machines to mix yoghurt-based drinks as featured in a 2010 HSBC TV commercial (https://www.youtube.com/watch?v=blc0uYrhjTw).

6. User innovation and agency

Understanding how users arrive at uses of technological objects other than what their designers intended requires thinking about the agency of users. By agency we simply mean actors' capacity to act in ways not fully determined by their circumstances.

There are various views in the literature on how much agency users enjoy in how they use and interact with technological objects. At one end of the spectrum is work that suggests that users are highly limited in this regard. Prominent here is the classical experiments on "functional fixedness" emanating from Gestalt theory (Duncker, 1945) and the applications to technological innovation these inspired (Allen & Marquis, 1964). Functional fixedness is typically understood as a psychological bias that prevents users from using objects in a non-standard way that may be required to solve a problem.

However, we know from cases like dishwasher cooking that functional fixedness may be absent or overcome. There is research also at this end of the spectrum, where technological objects are used in nonstandard ways or ways that deviate from what their designers intended. A prominent example here is the "enactment approach", an offshoot of an influential stream of the organizational literature on technology (Orlikowski, 1992; Orlikowski & Robey, 1991; and DeSanctis & Poole, 1994) rooted in Giddens's (1984) theory of structuration (Jones and Karsten, 2008; Leonardi & Barley, 2010). On this approach, technology is seen as at once enabling and constraining action—much as Giddens depicts social structure as doing—and where structures are "patterned streams of action and interaction" (Leonardi and Barley, 2010,

p. 22), not embedded in technology and appropriated as much as "(re)constituted in people's ongoing interactions with the technologies at hand" (Feldman & Orlikowski, 2011, p. 8). Technology use thus becomes "a recursive process of constitution" of structures (Orlikowski, 2000, p. 409) or "technologies-in-practice", where such structures in turn shape action via actors drawing on them (Feldman & Orlikowski, 2011).

The enactment view follows Giddens in attributing a high degree of agency to actors, depicting users of technology as always being able to "choose to do otherwise" (Giddens, 1993 in Orlikowski, 2000, p. 412), use only some of its features, or perhaps even reject it altogether. While it is recognized that "the physical properties of artifacts ensure that there are always boundary conditions on how we use them" (Orlikowski, 2000, p. 409), it is emphasized that the set of possible uses of any artifact is never intrinsic to it but an "open-ended set of emergent structures that may be enacted through recurrent use of a technology" (Orlikowski, 2000, p. 412). However, the enactment view has little to say about why some uses and ways of interacting with a particular artifact are more likely to be adopted and sustained over time than others, or about how people come to converge on particular uses and modes of interaction when there are usually many others available to them. Much the same could be said of sister studies that do not explicitly invoke Giddens's version of structuration (e.g., Hutchby, 2001; Leonardi, 2011; Zammuto et al., 2007).

Other approaches focus on means-ends reasoning guiding user innovation, and the costs and benefits that might provide users with incentives to innovate and possible advantages over third-party producers in doing so. Particular emphasis is placed on the costs associated with transferring knowledge from users to third-party producers, where users may know relatively more about their own needs and sometimes even about how to meet them (von Hippel, 1994; Lüthje et al., 2005) and may have the knowledge and expertise to develop tailored solutions at a lower cost than producers could manage (Franke and Shah, 2003; Lakhani and von Hippel,

2003). Benefits may derive from various sources: users being able to appropriate the innovation, especially where the innovative product has been tailored to their specific needs (von Hippel, 1988, 2005; Lüthje, 2004); users being able to sell the innovation (Shah & Tripsas, 2007); or the simple enjoyment of the process of innovating in its own right (von Hippel, 2005, 2017; Lüthje, 2004).

A characteristic feature of these approaches is that they assume the set of innovations (or at least their broad contours) is known in advance. For example, this assumption is apparent in the suggestion that producers might try to predict which users are likely to develop a certain kind of innovation. Thus Lüthje et al. (2005) suggest that, to develop safer mountain bikes, producers might identify users who are at once particularly exposed to risk (e.g., extreme bikers) and likely to have the capability to find solutions (e.g., if they are doctors) (see also Shah, 2000, on the role of "lead users"). However, while there are cases in which possible innovations can be broadly anticipated by producers, this is rather less likely in the case of innovations in function. A dishwasher manufacturer would need already to have conceived of the possibility of dishwasher cooking, for example, to be able to identify someone like Lisa Casali as a lead user on the basis of her knowledge of cuisine and interest in sustainability. The innovation in function would then in effect already have occurred.

However, none of the approaches discussed above say much about how users come to converge on specific solutions where many may be possible, except as the result of conscious choice. To be sure, the literature on user innovation does touch on issues related to the pre-reflective in the places it emphasizes the importance of tacit knowledge (e.g., von Hippel, 1994; Lüthje et al., 2005). But this emphasis is usually connected with the problem of tacit knowledge being costly to transfer, not with the question that we address in the present paper: how the pre-reflective and the reflective play into how users uncover alternative uses of pre-existing objects, or how they settle on specific uses over and above what is suggested by means-ends calculation.

We now consider these last effects and explain how social structure may *actively orient* as well as enable and constrain what people do (Cardinale, 2018). To do so we need to introduce the distinction between action by *project* and action by *protention*.

7. Project and protention

The distinction originates in Husserl's (1991) analysis of time consciousness (Cardinale, 2018; 2019B) where he contrasts "expectation" with "protention." Expectation, which corresponds to the usual way in which our perception of the future is conceptualized, refers to a conscious representation of what are taken to be distinct possible future eventualities. Protention, in contrast, refers to an anticipation of a forthcoming perception of something that lies in the future but is experienced as emanating from the present—such as when we are able to anticipate the melodic phrase that follows the one just heard. Drawing on Husserl, Bourdieu (2000) uses the term "project" (rather than "expectation") for the kind of representation of the future that is typical of reflective action, and "protention" for the pre-reflective anticipation of the future that characterizes habitual action. In what follows, we use "project" to refer to the explicit positing of possibilities as one of a set of distinct alternatives, and "protention" to refer to the pre-reflective anticipation of something that offers itself as self-evident without being explicitly posited as one of a set of distinct alternatives.

Action by project is the mode of action assumed in rational choice theory, where actors are treated as consciously appraising possible actions and their consequences (Samuelson, 1947; Savage, 1954; Sugden, 1991). It is also the mode of action assumed in theories of bounded rationality, where actors are treated as "intendedly rational but only boundedly so" (Simon, 1997, p. 88). While actors are regarded as unable to think of all possible actions and consequences on this approach, those they do consider are posited as distinct alternatives that can be consciously appraised.

Much of the literature on user innovation assumes bounded rationality in Simon's sense

(Bogers et al., 2010) and consequently also assumes action by project. While users and producers are depicted as being limited in their ability to verbalize their knowledge and absorb knowledge they don't have, they are nevertheless still seen as making choices based on an evaluation of costs and benefits, and hence within a means-ends framework.

The enactment approach, in its emphasis on the agency of users, also appears to assume action by project:

> [People] are purposive, knowledgeable, adaptive, and inventive agents who engage with technology in a multiplicity of ways to accomplish various and dynamic ends. When the technology does not help them achieve those ends, they abandon it, or work around it, or change it, or think about changing their ends. A practice lens thus recognizes that users may always choose to do otherwise (Orlikowski, 2000, p. 423).

While Orlikowski probably doesn't mean that users *always* act by project, i.e., monitor their action on an ongoing basis, the alternative mode of action isn't explicitly theorized. The same goes for other approaches that take the view of social structure as enabling and constraining action: while they do not necessarily reduce action to project, they seldom theorize alternative modes of action (DeSanctis & Poole, 1994; Giddens, 1984; Orlikowski, 1992).

Reducing agency to project leaves a crucial component of agency out of the picture. The missing element is that, in many situations, actors are neither forced or structurally determined to take a given course of action, nor consciously choose one from a set of explicitly formulated alternatives. The concept of protention captures this case, where the actor is *drawn* towards a course of action that isn't "chosen" from a set of alternatives posited as such, but pre-reflectively anticipated as something forthcoming that appears so "real" that it seems already there, emanating from the present (Bourdieu, 2000, p. 207). Action by protention is neither fully conscious in the sense of project (visualization and evaluation) nor merely

automatic and unreflective. Rather, it is a form of inclination or propensity towards some courses of action rather than others.

This kind of propensity is sometimes hinted at in the organizational literature on technology. For example, Zuboff (1988) emphasizes the framing effects of the technological rendition of work tasks, which encourages action along lines compatible with that framing. She also calls attention to the fact that, while technology opens up spaces of possibilities for action, it also has the potential to modify power relations within organizations in ways that make some courses of action more likely to be pursued than others. In a similar vein, Kallinikos (2002, 2010) suggests that the influence of technology on action is expressed by "the distinctive ways by which a technology invites people to frame a delimited domain of tasks or activities and organize their execution" (2002, p. 290). Further, there are places in which means for theorizing this phenomenon are already present in the literature on technology and organizations. For example, Faulkner and Runde (2013) emphasize that an important component of the use of technological objects has to do with people's dispositions to act pre-reflectively in ways that are attuned to the social positions they occupy, and invoke Searle's (1995) concept of "Background causation" to explain this component of action (see also Runde, 2002).

Suggestive as these contributions may be, however, they leave considerable scope for further work on the subject. We now attempt a step in this direction by delving deeper into the paths user innovations in function may take.

8. Paths to alternative uses

Any technological object will have an associated set of possible uses, many of which may never be mobilized or even identified. We will call the subset of possible uses of an object that have been mobilized in one or more communities (via being positioned as a component of a larger totality in the manner described in section 4 above) the *current system functions* of that object. What we earlier defined as the proper function of an object—its most widely accepted system

function, usually that intended by its designers and manufacturers—is then also a current system function.[4] Washing dishes and low-temperature cooking are thus both current system functions of the dishwasher, but only the former is a proper function.

Relative to this proper function, dishwasher cooking is an innovation in function. However, innovations in function don't have to be relative to proper functions since, as we will see below, any current system function may provide a point of departure for subsequent innovations in function. It is useful here to distinguish between "local" and "non-local" innovations in function. Local innovations in function are ones that rely on the same principles of functioning as the current function they depart from. The many examples of the dishwasher being "hacked" to wash things not normally associated with it—golf balls, keys, wheel rims, shoes, tooth- and hairbrushes, computer keyboards, mop heads

[4] Our definitions diverge from other theories of artefact creation that distinguish between "the standard functions of artefacts and alternative, occasional functions" (Preston, 2009, p. 225-226; see also Preston 1998, 2012; Scheele, 2006; Houkes &Vermaas, 2004, 2010; Houkes et al., 2011). Preston calls the former proper functions and the latter system functions. We make a similar distinction but differ in our aims and definitions. Preston developed his distinction for the purpose of explaining why a given artefact has a certain function—selectively appropriating Cummins' (1975) criticism of functional explanation as understood in the tradition started by Hempel (1959) and Nagel (1961). To this end, Preston defines proper functions as those which artefacts "have historically been reproduced to serve" (Preston, 2009, p. 226); they are accordingly "associated with explanations taking the form of causal-historical accounts of why a thing is there in the first place" (Preston, 2012, p. 144). System functions, in contrast, are those which artefacts "were *not* reproduced to serve but are capable of serving—e.g., spoons can serve as musical instruments" (Preston 2009, p. 226, emphasis added), and are "associated with explanations taking the form of compositional analyses of the capacities of containing systems in terms of their component parts" (Preston, 2012, p.144). On this view, system and proper functions are not reducible to each other because '"[each] of these notions of function has associated with it a proprietary mode of explanation" (Preston, 2012, p. 144).

Our own focus is on the kinds of agency involved in users uncovering alternative uses of an already-existing technological object, and how this depends on the positioning of the user and object. What matters for our purposes, then, is the system function(s) currently assigned to an object, which we call its *current* system function(s), in parallel to the system functions of positioned humans. On our account, *all* uses of an object that have been mobilized and are enacted are current system functions. Proper functions are then a subset of the set of current system functions, rather than being distinct from them.

Our position is consistent with that often expressed in the literature (Preston, 1998; 2009; 2012; Houkes & Vermaas, 2010; Houkes et al., 2011) that functions must have a normative aspect to distinguish between an object that malfunctions and one that has no function. While in Preston's terminology system (as opposed to proper) functions are non-normative, in our terminology all current system functions have a normative component insofar as they reflect general expectations about how the relevant object should perform in the capacity concerned. In our terminology, therefore, an object that malfunctions and cannot perform the system function associated with its social positioning nevertheless retains its identity and system function so long as it retains that positioning. Note, finally, that this case is distinct from the one in which an object is unsuited *in general terms* to performing the system function(s) associated with its social positioning, in which case this positioning will be unlikely to last for very long.

(https://www.bigglobaltravel.com/trends/dishwasher-hacks-tb/), medical equipment in small surgeries (Ebner, Eitel, Scherrer & Daschner, 2000) and, even if contrary to the advice of O'Connor and Armstrong (2014), dental equipment in dental practices—are all innovations of this sort. Each derives in a relatively straightforward way from a current, and in this case also the proper, function of the dishwasher.

"Non-local" innovations in function are then those that are oblique or even orthogonal to the current function they depart from. Dishwasher cooking is a good example here, as is the turntable being used to perform music rather than play back recorded music. In both cases the innovations concerned involve the respective devices in sets of activities unconnected with their proper functions, as signaled by the change in the verb from "wash" to "cook", and from "play back" to "perform".

Starting from a current system function of an object—and leaving aside the important category of purely accidental discoveries—there appear to be two main avenues for user innovations in function. The first and likely more common is tinkering, a trial-and-error approach to the exploration of alternative uses of a technological object that are largely consistent with taken-for-granted assumptions about what will usually be its proper function. These assumptions accordingly play an important role in channeling the direction in which tinkering takes place, especially where the relationship between an object's structure and its use is a "black-boxed" (Roozenburg, 2002) and actively inhibits the explicit visualization of a broader range of possibilities. The dishwasher hacks mentioned above, in our view, are likely to be the product of tinkering: what is being washed varies, but the dishwasher is consistently seen as a washing device.

The second approach, which we call "reflection", involves more in the way of standing back, discursive reasoning and an explicit visualization of possible alternative uses consistent with the structure of the object concerned. Reflection in this sense often arises from a need to

satisfy some end in a context in which dedicated tools to do so are unavailable or simply don't exist. For example, someone out of gas for their oven and stove might be looking for alternative ways to cook a meal. If some of the more obvious options such as cooking on the wood grill or in the kettle (https://www.scouts.org.uk/activities/kettle-cooking/) are ruled out or rejected for some reason, we can imagine that person making the conceptual leap in recognizing that the dishwasher might do the trick too. In cases of this kind, reasoning moves from an abstract function to finding an already existing device, perhaps with an entirely different proper function, to do the job. The alternatives contemplated in this case are different objects, which are compared in terms of how well they might perform the required function.

Reflection might also work in the opposite direction, beginning with an existing object and then moving to alternative ways in which it might be used. In this case the alternatives visualized are the potential uses of a given object with certain intrinsic properties and capacities. In our example, this kind of visualization might follow from reflecting on the dishwasher's capacity to generate hot water, create steam, generate ambient heat, and so on. Processes of this kind might draw attention to alternative uses in both directions: hot water and steam being put to other uses (e.g., low-temperature cooking) and dishes being cleaned using other means (e.g., a hand shower in the bathroom).

Both forms of reflection involve opening the "black box" of the relationship between the structure of an object and its use, which is less likely to occur in the case of tinkering. To the extent that they involve leveraging explicit technological knowledge or even scientific principles, they correspond to what Simon (1996, p. 113) calls "design" in the context of the creation of objects: attaining goals by creating or appropriating artifacts that derive from knowledge of the principles governing their working and of the environment in which they are deployed (Kallinikos, 2012; Roozenburg, 2002). An interesting current non-culinary example is the use of electric vehicles (EVs) to support microgeneration, with power companies trialing

vehicle-to-grid charging specifically to help smooth the peaks and troughs of renewable energy, and potentially contribute to phasing out high-carbon conventional power stations (https://www.edfenergy.com/electric-cars/microgeneration). It is hard to imagine this kind of idea arising without opening the "black box": the structure of EV batteries, and especially their high capacity required to serve their proper function of providing EVs with a sufficient range, which can be harnessed to perform the (non-local) function of storage of energy when the EV is not attached to the grid.

All innovations in function arrived at by reflection are by definition a form of action by project, even if they involve elements of trial and error or tinkering. In contrast, we suggest that tinkering is often rooted in protention in the first instance. While we don't know the history of the various dishwasher hacks listed above, for example, it seems to us likely that in at least some of the cases, the users involved were drawn to using the dishwasher without much explicit thought about its intrinsic properties or alternative ways of washing the item concerned.[5]

The question whether there is a specific relationship between project and protention on the one hand, and local and non-local innovations in function on the other, is an interesting one. It is tempting to associate protention-driven tinkering especially with local innovations in function, on the grounds that trial and error guided by taken-for-granted assumptions about proper functions is more likely to produce incremental rather than radical changes. But it is difficult to make hard and fast claims here, especially once the effects of chance and serendipity are allowed for, and the different directions in which these may drive the user. The precise way in which project and protention play into local or non-local innovations in functions in any

[5] Note that we are talking about the relative importance of project and protention in any particular case and over its various stages here, as every instance of user innovation will involve elements of both forms of agency. At some point, even reflection must bottom out in taken-for-granted assumptions about elements of the situation, implicit expectations that things that have worked in the past will continue to do so in future, and so on. And even in situations in which protention is dominant, there will be overarching goals that are conscious (e.g., wanting to clean the wheel rims or mop head in the case of our earlier example). Distinguishing between project and protention in principle is nevertheless useful when thinking about the kinds of agency that may be in play, which of the two may be dominant, and how they relate to whether innovations in function are local or non-local.

specific case, in our view, has to be treated as an empirical question.

Going back to our running example, it seems unlikely that, accidents aside, dishwasher cooking emerged from tinkering in the vicinity of its proper function of washing crockery and cutlery. Of course, accidents do happen. For example, it is conceivable that someone using a dishwasher to rinse vegetables[6] might run a high temperature rather than rinse setting by mistake, only to discover their vegetables cooked and thereby, the possibility of dishwasher cooking. However, it seems to us more likely that coming up with something like this idea requires explicit knowledge of technical features of the device and the possible uses they may afford.

For Lisa Casali, a dishwasher is for washing dishes no less than it is for anyone else. However, as someone with extensive culinary training and a history of devising techniques for environmentally friendly cooking, her habitus includes looking for new cooking techniques, putting ingredients to different uses, etc. The temperature ranges 50-55°C, 60-65°C and 70-75°C—standardly (though subliminally for most of us) associated with the Eco, Normal and Intensive washing cycles in many dishwashers—were accordingly salient and meaningful to her as being within the range used in sous vide water baths: "I had a eureka moment when I realized that dishwasher cooking is just an instance of low-temperature cooking, which has been extensively codified and has a dedicated literature" (Casali, 2015, personal communication translated by the first author). Via reflection, she was able to disentangle a form-function relationship normally black-boxed when the dishwasher is used in an unreflective way—a device harnessing hot water and steam to wash dishes—and arrive at a new one—a device harnessing hot water and steam to perform low-temperature cooking without the need to buy the expensive equipment that restaurants use for this purpose. She went

[6] Detergent should be avoided for this purpose and some practitioners recommend the use of vinegar (https://www.dailymail.co.uk/femail/article-8500817/Woman-stuns-internet-cleaning-fruit-vegetables-vinegar-dishwasher.html).

on to experiment with different washing cycles, ingredients and recipes, now guided by explicit knowledge of the principles of low-temperature cooking.

Once a new use has been uncovered and become a current system function it provides a point of departure for further innovations in function. Some of these might be via tinkering, but now in ways that are local to the new system function. A good example here, a transposition of the idea that the dishwasher can be used to cook food, is using the machine's ambient heat to help the dough rise when preparing homemade bread: "I sometimes use the dishwasher […] to facilitate the first phase of the rise of bread dough, taking advantage of the first half an hour of the drying cycle, or even after the drying cycle, using the residual heat" (Casali, 2015, personal communication translated by the first author). Other examples include using the dishwasher to soften unripe avocadoes or to warm serving plates using the dry/heat cycle (https://www.bigglobaltravel.com/trends/dishwasher-hacks-tb/). The set of nonlocal system functions may be widened too, e.g., using the dishwasher to rinse vegetables (thereby returning to a use more local to its proper system function), or transposing from using its ambient heat to help the dough to rise to using it for a tropical plant that would benefit from a few hours at a higher temperature every day (non-local to its system function of helping dough rise because it uses the heat not to cook but to create a different microclimate outside the dishwasher).

The preceding examples show how innovations in function can lead to further innovations in different dimensions. We mention two more in closing. The first is follow-on innovations in function in complementary items, e.g., where a dishwasher cooking enthusiast uncovers a new system function for clingfilm on finding that, for certain dishes, it is superior to sous-vide bags or screw-tight glass jars. The second is that innovations in function are often followed by innovations in form, e.g., the flow of digital devices such as the CDJ player and all manner of virtual DJ gear that followed the repositioning of the gramophone turntable as

musical instrument (Faulkner & Runde 2009).[7]

9. Conclusion

We are now ready to formulate explicitly our theory of how user innovations in function arise, by way of reflective and pre-reflective forms of agency, at the nexus of the social position(s) occupied by the user, their structures of cognition and action or habitus, and the intrinsic structure and social positioning of the technological object concerned.

The theory may be summarized as follows. The intrinsic structure of any technological object defines its possible uses, given human physiology and possible situational constraints that might limit potential users' access to it. The habitus of a user then serves to structure some subset of these uses into current system functions and, by extension, potential local and non-local alternatives to those system functions. This structuring depends in turn on the social positioning of the user and the objects that surround them, since the habitus of the user is shaped by their experiences within the social positions they occupy over time, as well as by the social positionings and attendant social identities and system functions of the other humans and nonhumans in the communities of which they are members. Thus, in terms of our running example, the dishwasher is unequivocally positioned as a low-temperature cooker by Lisa Casali and others positioned as practitioners of the art of dishwasher cooking, while remaining positioned as a dishwashing device both for this group and its lay users. Low-temperature cooking has therefore become a current system function of the dishwasher for the former group, although the structuring of associated alternative uses into local and non-local potential system functions will differ according to the individual habitus of each user.

We have distinguished between innovations in function predominantly rooted in

[7] There is also the converse case in which innovations in form involve innovations in function in their components. A graphic example here again is the incubator made of car parts in which headlights serve as sources of heat (https://blogs.scientificamerican.com/news-blog/babys-hot-wheels-an-incubator-made-2008-12-16/).

tinkering and those rooted in reflection. In both cases, an actor with a particular habitus and practical needs confronts some already existing technological object in a way that suggests uses that might become system functions over and above those conventionally associated with it. But the mechanisms involved are different. We have argued that user innovations in function rooted in reflection are an expression of action by project, and this is so even if they involve elements of trial and error or tinkering. We have also suggested that user innovations in function rooted in tinkering are often the product of what is action by protention in the first instance. But in both cases, users are oriented towards some uses over others in ways that are not reducible to conscious choice between alternatives posited as such, and which therefore cannot be explained by theories committed to understanding how users uncover alternative uses of technological objects purely in terms of project.

We hope that the categories developed in this paper, especially the distinctions between action by project and action by protention and between local and non-local innovations in function, might assist future work on user innovation in function and, more generally, situations in which users differ in how they deploy specific items of technology. Given the rate at which the world's population of technological objects keeps expanding, and then especially in the digital realm and in a climate in which re-use and versatility of use look likely to receive increasing attention on sustainability grounds, the scope for such innovations and the incentives to make them will surely only increase. While there is now a nascent literature on cases in which current system functions vary across users (Bogers et al., 2010; Faulkner & Runde, 2009; von Hippel, 1988), therefore, there should be considerable opportunities for further research on user innovation in function and, especially, on the fascinating question of how different technology users departing from the same current system functions might nevertheless arrive at very different local or non-local innovations in function.

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