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Ecologies of creativity: smartphones as a case in point

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Abstract The smartphone can be considered a great example of how technology provides us with information at our fingertips anytime, anywhere. However, we have been operating mostly in the dark without a clear understanding of what our mobile devices have to offer and how people arrive at creative re-use as part of a problem-solving activity. This paper is an attempt to reach a better understanding of the conditions in which creative re-use of smartphones may take place. Our main goal is to theoretically explore the role that the context of one's activity may have in supporting creative re-use. We argue that the smartphone in itself cannot be separated from its cognitive ecology, but it is precisely the way in which it becomes permeable in the context that affords us to potentially come up with new uses and in doing so improve our ability to solve problems.

Keywords Ubiquitous computing · Mobile computing · Affordance · Cognitive ecology · Re-purposive appropriation · Creative re-use

1 Introduction

Creativity is an important aspect of what makes us human. Even though we have developed highly intelligent computers, they still cannot reach our ability of engagement in everyday creative skills (Sawyer 2012). Applying creativity to using a stock of knowledge to facilitate novel problem solving may lead to innovation. Innovation can take many forms, for example product innovation, however design and incremental process innovation are more common (Yusuf 2009). Technology

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can in turn be seen as a means of supporting the realisation of one's creative potential and expressing creativity by providing convenient access to a wide range of information and computational tools (Bonnardel and Zenasni 2010). The smartphone can be considered a great example of technology providing us with information at our fingertips anytime, anywhere (Satyanarayanan 2010). Yet the field of mobile computing has recently experienced a paradigm shift, its significance in enhancing human creativity still has not been entirely clarified.

A paradigm shift occurs when the old way of explaining reality no longer works and we are forced to look for new means to make sense of things (Kuhn 1962; Rosado 1997). This has now occurred in the field of mobile computing with the advent of the smartphone. Our old way of looking at the smartphone as merely a communications device is no longer valid. In this paper we will try to draw a conceptual map, which could help us orient during this moment of friction between the old paradigm and the emergent one.

The current state of things may be considered a critical point. On the one hand, it is apparent that mobile devices have lots of unexplored potential and we are only beginning to scratch the surface of the things these devices will enable us to do. On the other hand, we have been operating mostly in the dark without a clear understanding of what our mobile devices have to offer and how people use them in the real world to support creativity. In this paper, by creativity we refer both to the process *and* the result of creative re-use (or re-purposive appropriation) as part of a problem-solving activity.

The main objective of this paper is to reach a preliminary understanding of how to support the creative re-use of smartphones as an integral part of everyday problem-solving. To this end we claim that a crucial and yet unexplored pathway is to shed light on the role played by the context of one's activity. As we will argue in this paper, the context of one's activity is not just a neutral setting where creativity may emerge.

There is an ongoing paradigm shift, which concerns all the participants—companies, designers, and users. However, at the present stage of our research, we are not yet able to provide guidelines for designers or describe the breadth that such a paradigm shift may have on creativity in other domains, such as the arts and science.

This paper is structured as follows. In the first section we briefly illustrate the main elements of ubiquitous computing as the technological *milieu* for the emergence of smartphones. The most interesting aspect of this new trend is related to the fact that we can no longer regard a piece of technology in isolation, but as something becoming part of one's context.

In the second section we demonstrate how users do not just *use* technological objects, but how they are also more active than ever in trying to creatively exploit latent possibilities—a process we refer to as creative re-use or re-purposive appropriation.

In the third section we introduce the notion of affordance, which is serving the purpose of articulating our notion of a cognitive ecology along with the idea that smartphones are inherently *polysemous*. We then introduce mobile computing as

context-permeable computing. This allows us, in the final part of the paper, to point out several intriguing challenges for design that lie ahead.

2 Ubiquitous computing: a brief introduction

Ubiquitous computing aims to seamlessly integrate computing capabilities into our environments and make technology transparent so we can better focus on our tasks. Ubiquitous computing has the purpose of augmenting and making accessible some experience of the world in terms of sensing, acting, and making decisions. Thus, ubiquitous computing is able to improve people's experience in their environment, for example, by increasing the number and range of tasks, which can potentially be accomplished (Magnani and Bardone 2012).

Taking a cue from the physical world, a ubiquitous computing environment should include lots of information on the periphery. A ubiquitous computing environment is commonly compared to a walk in the woods, where lots of information is available, yet a person does not feel overwhelmed. Instead they can choose where to focus attention at a particular moment, thus being in control of their experience. This leads to a concept of calm technology, where users sense and control what directly interests them, while retaining awareness of other opportunities to use information and when to focus on it (Roussos et al. 2010). Calm technology engages both the centre and the periphery of a person's attention, but it is the individual, not the environment, who must be in charge of moving things from the centre to the periphery and back (Weiser and Brown 1996). In contrast, currently, rather than being a tool through which people act on the world, our devices too often remain the focus of attention.

Our devices are a means of supplying us with information, which we can choose to move from the periphery to the centre of our attention and back. This information can also be seen as part of a cognitive ecology, which is augmenting our environment and our cognition. However, based on this logic we cannot claim that technology is seamless and transparent. For example Barkhuus and Polichar (2011) note that smartphones are in no way invisible, instead they are always front of stage. Yet they are still considered connected to every realm of people's lives. It is possible that transparency is not something to be sought after and, instead, it is more important for an object to be *ready-to-hand*, meaning that people understand exactly how and why an object can be integrated into their extended cognitive system. This, in contrast to transparency, can be considered a true characteristic of smartphones.

3 Creative re-use and its cognitive ecology

Smartphones have made increasingly visible something that in the past was not as clear as it is now. The incorporation of a piece of technology into one's problem solving activity is not just about using it; it entails a certain active attitude, which may eventually lead the user not just to use pre-existing features, but also to *re-frame* or *re-purpose* them (Dourish 2003). This creative re-use of technology is

called re-purposive appropriation, which is defined as follows: it is the process in which the user makes a certain piece of technology (a smartphone for instance) his own, occasionally coming up with new and unintended purposes beyond those for which it was originally designed (Salovaara 2009; Salovaara et al. 2011; Maestri and Wakkary 2011).

We argue that creativity consists of changing points of reference to develop unplanned links in a meaningful way (Degele 1997). Holding this view on creativity, we posit that creative re-use (or re-purposive appropriation) is an important source of creativity in problem solving for two specific reasons (Salovaara 2012): first of all, creative re-use allows the problem-solver to make use of workarounds, as in some situations re-purposing a device or tool is a way to overcome some intrinsic limitation related to one's equipment. Secondly, creative re-use may also uncover new strategies that help solve problems and facilitate better decisions.

An interesting case that demonstrates this new trend is the embedding of digital cameras in smartphones. Traditionally, digital cameras have been designed and conceived as devices *exclusively* for taking pictures or videos. Although users continue utilising their digital camera embedded in their smartphones for such purposes, they have also started re-purposing them so that their digital cameras can now serve as a scanner, a periscope, a note-taking tool, a lamp, and even a mirror, just to mention a few of them (Salovaara et al. 2009).

These new purposes were often not foreseen by their designers. Conversely, they were unearthed by the users on their own or through social learning, namely, by imitation (Salovaara et al. 2009). Interestingly, this phenomenon is not restricted to a group of technology enthusiasts, who spend their time finding new ways to be creative. According to a recent survey, creative re-use involves half of the users *regardless* of their demographic backgrounds (Salovaara et al. 2011).

This is a trend that does not only concern digital cameras, but also other components that smartphones are now equipped with, for instance a three-axis gyro, accelerometer, proximity sensor, ambient light sensor, GPS receiver, bluetooth, etc. Thus, a potential source of creative re-use is provided by the combination *and* re-combination of these.

A crucial factor enabling and dramatically boosting creative re-use is given by the various App Stores which different vendors are now providing on their devices. Originally introduced by Apple, the App Store is a digital application distribution channel, which allows users to browse and download thousands of applications developed by third-party providers. Given the number and variety of available applications, we may regard the process of browsing and selecting a particular app as being re-purposive, as long as it helps the user to find the best solutions for creative re-use.

Interestingly, we may view the creation of the App Store itself as the result of creative re-use. When the first iPhone was launched in 2007, users had no permission to install applications. Hackers developed a workaround called jailbreaking to gain administrative permissions to the device and to facilitate the installation of third-party applications. Customers showed great interest in it up to the point that Apple decided to change strategy. One year after introducing the

iPhone, Apple launched its own software development kit and an applications distribution channel called the App Store enabling the installation of third-party applications.

Creative re-use inevitably challenges the way both practitioners and researchers look at design. As anticipated in the introduction, our main objective here is to show the fundamental role that the context of one's activity actually plays. The idea we are going to present in the following section is that the context becomes part of the cognitive process itself, as far as it provides resources for detecting and, upon occasion, even unfolding new and valuable affordances crossing the object's boundaries. Within this *distributed* view, the context cognitively *structures* one's activity and in so doing provides what we will refer to as the *cognitive ecology* for creative re-use.

4 Affordances, cognitive ecology, and polysemy

The notion of affordance is our main theoretical tool for reaching a better understanding of the innovative character of mobile computing and its relation with the context of one's activity. The notion of affordance was introduced by ecological psychologist James J. Gibson to refer to a particular characteristic of human cognition: the perception of an object has almost nothing to do with the abstract features of the object, but it primarily deals with what a person can do with that object, what it allows him to do in his environment. So, a chair affords an opportunity for sitting, air-breathing, water-swimming, stairs-climbing, and so on. As Gibson put it "[…] the perceiving of an affordance is not a process of perceiving a value-free physical object […] it is a process of perceiving a value-rich ecological object" (Gibson 1979, p. 140).

It is important to specify that affordance should not be mistaken for causing. By "causing" we mean the production of a practical effect regardless of the agent's intention (Reed 1996; Withagen et al. 2012). For example, the fact that a chair affords sitting does not mean that a chair *causes* a person to sit. Conversely, an affordance informs a person about an opportunity or a chance to engage with the environment in a certain way (Bardone 2011).

In order to better understand the ecological dimension of affordance it is worth adding that the affordances of one's environment have an important *regulative* function with respect of the user's behaviour (Reed 1996, p. 18). That is, the environment provides the human agent with opportunities for action. What is peculiar to humans, along with our unique evolutionary history, is the ability to intentionally modify the surrounding so as to facilitate or improve the chances for adaptation. The intentional modification of the environment, namely, *cognitive niche construction* (Magnani 2009; Bardone 2011), allows humans to exponentially enrich their cognitive ecology by creating new opportunities for actions, namely, affordances.

Computing represents the most impressive example of cognitive niche construction, as it has reshaped the way of conceiving external objects by unfolding new and unprecedented affordances. Iriki and Sakura (2008) refer to the introduction of

computers as a novel stage in the development of human niche-constructing activities: in their view computing represents a sort of *metaphysical* tool able to extend not only our motor and sensory abilities, but also our abilities of thinking (cognition) and thinking about thinking (meta-cognition).

The notion of affordance may be of help in trying to put a stake in the ground and see how to better assess the recent developments in the field of mobile and ubiquitous computing. What can the concept of affordance really tell us?

Interestingly, Gibson claimed that to perceive an affordance is not to classify an object (Gibson 1979, p. 241). This challenges our object-centred perspective according to which objects are classified based on their function (Withagen and Chemero 2012). For instance, consider an elongated object of moderate size and weight. It affords wielding. Such an object, however, may be used for different purposes. It can be used as a hammer. It may also be used as a rake to gather things that are beyond one's reach, or as a lever. The same holds true for a graspable and rigid object of moderate size and weight. Such an object affords throwing, so it may be used as a missile. But it may also be a ball and so afford playing.

The majority of objects that are not designed are intrinsically *polysemous* (Krippendorff 2009). That is, their meaning and function varies. Unfortunately, Gibson did not provide a clear answer about the polysemy of objects. One possible and quite obvious reason is that the function of an object—how to use it—depends on the context of one's activity. However, that is just a partial answer. We claim that polysemy might be related to the fact that some affordance may cross the object's boundaries. As Bødker (2011) argues, there is nothing like a *one-to-one* relationship between human activity and artifacts. That is, human beings relate not just to one, but to a constellation of artifacts, which arranges the context of one's activity as—we claim—a *cognitive ecology*. A cognitive ecology is a part of the environment characterised by an integrated and structured network of people and various artifacts and objects. In this respect, a cognitive ecology is not just the setting of one's activity, but it describes *the way* people do things (Dourish 2004).

5 Context as the cognitive ecology of one's activity

The characterisation of the context as a cognitive ecology is meant for pointing out that the context is not inert from the cognitive point of view. In this respect we adopt the notion of *wide computationalism* introduced by Wilson (1994). We propose that the context of one's activity is part of a larger computational system, which transcends the boundary of the individual and the device he is using at a particular moment. Building on Wilson's original idea we claim that much of the processing is instantiated within the relationship between the user and the computational artifact. However, not all computational processes are so instantiated. That is, the context as one's cognitive ecology is not just a place where we interact with various artifacts, but it is part of the interaction itself, encoding and then delivering part of the computational resources that we have at our disposal.

Going back to the example of the digital camera embedded in a smartphone, let us analyse the case in which we decide to use the device as a note-taking tool.

Suppose we have an animated discussion with a colleague using a big blackboard in the room. In this particular case, the digital camera turns into a note-taking tool if all the following conditions are met: (1) the camera can take a photo of the blackboard and what is written on it; (2) we want to keep track of our drawings and schemas on the blackboard; (3) we lack any other tool for keeping track of our drawings and schemas on the blackboard. Thus, the first condition regards the object, the second the subject, and the third the context.

We argue that the third condition regards the context as it shows that the availability of an affordance is given by the presence or absence of other devices. In our very trivial example, the affordance of the digital camera would have not been visible if we had used a sheet of paper or a tablet computer. In the former case, we would have gone for the photocopy machine, in the latter case we would have sent the document by email. With this example we claim that it is this ecological dimension that is usually overlooked or—even worse—simply ignored. This might be due to the fact that we mostly focus attention on the most proximal part of our cognitive ecology, which is the one related to the interaction between the user and the artifact.

If we adopt such a perspective, then the context is not a cognitively inert setting of the interaction, but part of the interaction itself, which therefore should be addressed as such. That is to say interaction should not be confined only within the user-device relationship. This allows us to come to a better understanding of the context in which creative re-use may take place.

Currently the central issue of making computation sensitive and responsive to its context (Dourish 2004) is biased towards the idea that ultimately context provides valuable information, but only about the setting of the user-device relationship. That is, the way it is conceived does not imply that information acquired about context shapes the relationship itself. It can only help to dynamically tailor the behaviour of the device. We argue that this approach is characterised by what we may call a *representational bias*. In order for the device to be context-sensitive, it should somehow represent context. To put it another way, the device is supposed to have a flexible model of the world in order to act in it.

Our approach is meant to put the device in the world without putting the world in the device (Leahu et al. 2008). In order to do that we should move the boundaries of technological artifacts *outward*. That is, we should explicitly address how a certain device can be integrated into the cognitive ecology of one's activity. More specifically, what we are proposing is the idea that a device can become part of the context and so help us not just accomplish a particular task, but enhance our chances for creative re-use and in so doing improve our ability to solve problems. The challenge laying ahead is more about how to design devices that are not simply context-sensitive, but also and foremost context-*permeable*, so as not to impair creative re-use.

6 Mobile computing as context-permeable computing

It is interesting to note that technology is limited and nearly always fails in some way. In the case of mobile devices this is especially true as, for example,

smartphone usage becomes a practice of overcoming limitations. Yet people may find creative ways to mix and match functionalities and applications to reach their goals, because the necessary affordances are there (Barkhuus and Polichar 2011). People will often find ways of using technology and its affordances that are unexpected and unanticipated. Thus, the meaning of technology depends on how its general features are used for solving specific problems in specific cognitive ecologies, which, therefore, start to play a crucial role.

Let us again take a single dimension of the hardware—the camera— that may support a number of use cases, which are impossible to predict beforehand. As noted before, a camera can be used to make pictures, but also to scan a product's barcode, a book's ISBN number, or a document. Here we have a potential source for different and quite heterogeneous affordances, which are brought out by integrating a device's feature—a camera, for instance—into the cognitive ecology of one's activity. So, a camera at a stunning sunset is a means for making a memory permanent, in a supermarket—a barcode scanner for comparing prices of products, in a library—external storage to get more information about a book, and so on. In this respect, a smartphone comes with a limited set of functionalities out of the box, yet through the App Store it is possible to expand the functionality of the device by effectively adding affordances to it increasing creativity and innovation.

This combinatorial power is nothing new and has been present in desktop computers for some time, but it seems to be significantly more apparent and useful in smartphones, where the hardware fades into the background and the activity tends to take centre stage, making context integration possible or, at least, much easier.

Most objects we use tend to be designed for a specific purpose. However, it appears that the smartphone breaks this rule due to its inherent *context permeability*, which, we claim, has a specific role here. It might be helpful to think of a smartphone as a *placeholder*, which can drastically affect our ability to solve a problem, as far as it affords creative re-use. This means that the smartphone is not limited to helping us solve a particular task, but has a broader purpose in helping us creatively adapt to our environment as a whole.

This is due to the fact that the smartphone, given its context-permeability, can be highly integrated into a specific cognitive ecology—better than any other device, and so affords creative re-use. Thus, the smartphone can be seen as having several distinct properties:

- The task for using the device does not need to be strictly defined beforehand, which means that its usage can be *opportunistic*;
- It engages the context as the cognitive ecology of a user's activity;
- It dynamically collects feedback in order to modify its behaviour based on a particular context, which means that it is context-permeable;
- It enables the user to act on his environment in order to increase the chances of successfully adapting to it.

These properties challenge the way we think of design. Usually when an object is designed, it is because the designer expects people to do something specific with it. So, the design (D) of a device can be considered functional (f) for a purpose (P) the designer has in mind. Thus,

$$D = f(P)$$

This means that design is driven by the purpose the designer has in mind. But in reality defining a specific purpose might prove to be difficult, because the purpose of using an object might change depending on the user's context. A potential solution would be to design an object, which serves multiple purposes (mP). So,

$$D = f(mP)$$

The next step would be an attempt to design objects that are sensitive or even permeable to context (C), which leads us to

$$P = f(D, C)$$

Such a shift might lead to a different conception of design, which would not aim to support or facilitate a specific task, but the very activity of *tinkering*. Tinkering is the process in which the outcome of one's activity is not the result of a plan as in the case of engineering. Conversely, it is something that mostly relies on contextual and therefore partly accidental and/or unpredicted elements. As Jacob put it, a tinkerer is a person "who uses everything at his disposal to produce some kind of workable object" (Jacob 1977, p. 1163). In our case, the very idea of tinkering encourages leaving room for *chance-seeking* activity (Bardone 2012), which is not to be considered here as blind guessing, but as an activity controlled by a sophisticated feedback system. This is coherent with the idea of a "bag of tricks" approach defined as the "right combination of available tools to fit the situation rather than seeking the perfect package" (Barkhuus and Polichar 2011).

7 Conclusion and future trends

In this paper we have illustrated the role played by context to account for the increasing complexity characterising recent development in the field of mobile computing. The main idea we put forward is that smartphones can be seen displaying a high level of context-permeability as soon as context, as the cognitive ecology of one's activity, enters the scene, and thus favours creative re-use. That is, the affordances of a smartphone cannot be predicted, and thus designed beforehand, because its affordances partly emerge as a result of the integration into the user's cognitive ecology. We have referred to the notion of polysemy in order to grasp this particular aspect. We have argued that smartphones are inherently polysemous, because their usage tends to cross the device's borders and in so doing new functionalities are unpredictably unfolded.

At the present stage of our research, we are not able to provide guidelines informing the actual design of smartphones to support creative reuse. However, we pointed out that polysemy and creative re-use are sources of major challenges for designers as well as cognitive scientists interested in how the ecological dimension of one's activity has an impact on creativity. In this paper we attempted to provide a partial answer about where polysemy may come from. However, several related questions still need to be answered. For instance, is it possible to deliberately design a polysemous device? What would that imply for the arduous task of designing

devices affording creativity as such? What kind of consequences would that have for the very idea of cognition?

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