The Use and Misuse of the Concept of Affordance

Leonardo Burlamaqui and Andy Dong
University of Sydney, Australia

Given the lack of agreement on the phenomenological elements of affordance, it is difficult to conduct empirical research to test systematic observations across contexts (e.g., industrial design and interaction design). To address this problem, this paper aims to establish a new understanding of the concept of affordance and its key concepts. Through a critical review of influential articles about affordance, the article identifies some uses and misuses of the concept. Then, a definition of affordance is provided, which delineates its foundational elements. Based on the definition, the article proposes a framework to explain how artefacts acquire affordances through the intentional behaviour of designers, certain material features, and contextual constructions. As a result, this research will contribute a new perspective on affordances that may help designers have predictable control over them when designing end-consumer products.

Introduction

Since the 1980s, numerous research and practice-oriented articles have been written about affordance across multiple design domains including industrial design, interaction design, and educational design, to name a few. Its meaning has been changing since Gibson [1, 2] gave birth to this term, sometimes in order to fill theoretical gaps, e.g., [3], and sometimes to shape the concept to fulfill the specific technical needs of a design discipline, e.g., [4]. Norman [5, 6] brought the concept of affordance to the design field, specifically to industrial design and human-computer interaction, and, despite his acknowledged research, focused on perceived affordances only. After that, some frameworks based on affordances have been proposed [3, 4, 7-12], but usually with the lack of pragmatism necessary for designers to design with affordance in mind [12] or with important

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concepts missing, such as the perceivability of the affordance and the influence of context on the recognition of an affordance.

Regardless of efforts to better understand its meaning and implications on designing, there is still no conceptual agreement on the term affordance. Gibson's concept of affordance [1, 2] emphasised the perceiving agent as the source of affordance, and, in particular, the relation between the material properties of an object and the material properties of the perceiver. That is, there is a complementarity between the perceiving agent and the object; an affordance emerges from that complementarity. In contrast, other authors [12] have already described how many other theorists deemphasise the perceptual aspect of affordances due to the theoretical framework that those authors bring to the concept of affordance.

In 1999, Norman [6] acknowledged the need for a clear meaning of affordance in writing that 'sloppy thinking about the concepts and tactics often leads to sloppiness in design. And sloppiness in design translates into confusion for users'. By clarifying the concept of affordance, and pointing out the common foundational elements that underlie it in a practical way, designers can improve the design of products and services, e.g., by eliminating errors, and have an understanding of the way innovation can be introduced from an affordance perspective, e.g., by introducing an affordance that opens up new end-use possibilities. Therefore, this research aims to develop a framework that will give designers a predictable level of control over affordances.

This article presents a critical, chronological literature review of influential articles on affordances. Articles were selected on the basis of their contribution to clarifying, extending, or refuting Gibson's original definition [1, 2]. Some uses and misuses of the concept are pointed out, and common foundational elements – which can be viewed as the necessary elements for a complete understanding of affordance – across those standpoints are provided and explained, one by one. Then, a definition of the concept is presented, which intends to conform as much as possible to Gibson's original definition, accompanied by some relevant considerations. Finally, a new framework is presented, which conveys the relationship between the context of an artefact and the artefact itself, and how these two dimensions influence the perception of affordances.

Origin of the concept

Invented in 1977 by Gibson [1], a perceptual psychologist, the term *affordance* was presented as 'a specific combination of the properties of its

substance and its surfaces taken with reference to an animal'. In 1979, it became part of his book 'Ecological Approach to Visual Perception' [2], which was an attempt to describe an ecological frame of reference for visual perception. Gibson stated that 'affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill...it implies the complementarity of the animal and the environment'.

In his definition, Gibson points to the foundational elements affecting the perception of affordance: (1) *object*; (2) *observer*; (3) *environment*; and (4) *complementary relations between these elements*. Based upon these elements, he postulates several properties of affordances: (1) affordances emerge in perception from the relation between these elements; they are not 'in' any of these elements *per se*; (2) affordances refer to action possibilities, that is, what the perceiver can do with the object; (3) affordances exist independent of the perceiver's ability to perceive it; (4) affordances exist independent of need.

In Gibson's definition of affordance, the most notable element is the relational aspect. Gibson claims that an affordance is not wholly dependent on the observer's perspective nor on the absolute physical properties of an object. By placing affordances in the realm of relations, the concept rejects any dualism of affordance as a property in either the object, observer, or environment. Rather, an affordance is predicated on the complementarity of these elements.

However, Gibson makes some claims about affordances that are not entirely in accord with his foundational elements. For example, affordances are binary, which means that there are only two existential possibilities: either they exist or they do not, without any middle ground. They simply exist – being perceived or not by the observer – *even if* they are species-specific. In this sense, affordances are functionally generic, applying differently according to the physiological tendencies of an animal. For example, research about mice and their ability to perceive a nest [13] demonstrates his assertion. As a result of the relation between the material properties of the object (nest) and the observer (mouse), the nest affords protection. To the mouse, the affordance of the nest is limited to being a mouse nest, and mice have a very limited conception of what objects could have this affordance. Clearly, for humans, the (mouse) nest affords no protection *if this were the need*. If the need were to hold sundry stationery, then a nest could afford storage. Gibson would claim that the affordance of storage was always present, waiting to be perceived. Our position, though, is that it is the role of the designer to make such affordances perceivable; else, the design is unsuccessful.

Other scholars have also noted this tension between a foundational element of affordances and Gibson's claim on the binary nature of af-

fordances. As stated by Dohn [11], although 'it has often been used as if it were', we do not agree with this idea. To support our position, McGrenere and Ho [3] provide the following explanation: 'Recall the example of a stair being climbable or non-climbable by a particular individual. Reality obviously isn't this black and white; a gray area exists that is meaningful to the stair climber. For a particular individual one stair may be climbable with great difficulty whereas a different stair may be climbable with ease'.

Unfortunately, Gibson leaves the field with a broad explanation of the concept of affordance, which is not sufficient for its application by the design community. His definition of affordance is not immediately useful for the design community as it does not specify how to create the affordance intentionally, which is the role of a designer. Some other researchers have further confounded the definition in ways that hinder the designer from predicting the existence of an affordance. For example, McGrenere and Ho [3] state that an affordance means 'an action possibility available in the environment to an individual, independent of the individual's ability to perceive this possibility'. From a design perspective, this definition is impractical. Designers design distinct intentions into the visual form of an object to control the user's interpretation of the object [14]. If those visual forms are not perceptible, in a sense, the design(er) has failed. Thus, definitions that dissociate the individual from affordances fail to give guidance on *action possibilities to which affordances refer in relation to the user*, *how affordances relate to the user in an environment*, and *how affordances are perceived based on the user's prior knowledge*. In addition, the assertion that affordances are independent of the individual's ability to perceive them is inscrutable and may lead to misconceptions.

Considering that the aim of Gibson's book [2] is to clarify the problems of perception by taking an ecological account, it is justifiable that some of the definitions presented there lack specificity in fields of study other than psychology. As a result, the term *affordance* noticeably evokes different interpretations once inside domains such as interaction design, engineering design, and computer-supported collaborative learning (CSCL). This has led to confounding definitions and the misuse of the concept.

The concept from different standpoints, its use and misuse

In 1988, Norman introduced the term affordance to the design community by applying the concept to ordinary objects in his book 'The Psychology of Everyday Things' [5]. In this book, Norman writes that 'affordances re-

sult from the mental interpretations of things, based on our past knowledge and experience applied to our perception of the things about us'.

Norman deviates from Gibson's concept of affordance by (1) claiming that it relies on the actor's past knowledge and experience, highlighting their mental models and perceptual capabilities over their action capabilities, and (2) making a distinction between *real* and *perceived affordances*. As noted by McGrenere and Ho [3], 'Norman talks of both perceived and actual properties and implies that a perceived property may or may not be an actual property, but regardless, it is an affordance', where perceived affordances are those affordances that exist as a result of the actor's perception and, therefore, may not be what the object is actually for.

Because of the distinction Norman made and the way he referred to affordances throughout his book, it became unclear to which definition of affordance Norman was aiming. So later on, in 1999 [6], he clarified that his book was discussing perceived affordances only, not affordances in a general sense, since 'the designer cares more about what actions the user perceives to be possible than what is true', and reiterates that 'affordances reflect the possible relationships among actors and objects: they are properties of the world'.

Despite the ambiguity created around affordances, Norman's book [5] provided some valuable considerations about the psychological processes needed in operating and comprehending all sorts of devices. Thus, it rapidly became popular among designers, being one of the most important references in design, particularly in human-computer interaction, as it was considered to underpin some fundamental principles of an effective, error-free interface [15]. As a result, the term *affordance* was quickly acknowledged by the HCI community, and started to become adopted with various meanings, as observed by McGrenere and Ho [3]. Once inside the design field, the term *affordance* began to spread – reaching areas such as engineering design and computer-supported collaborative learning – and to acquire new meanings and categorisations, being applied in different ways.

Regarding Norman's definition of affordance [5], the HCI community was one of the first to realise that something was missing and started looking for solutions. Authors began to question the distinction between perceptible and imperceptible affordances. In 1991, Gaver [4] revisited Gibson's work [1, 2]. Influenced by the notion of complementarity, Gaver defined affordances as 'properties of the world defined with respect to people's interaction with it'. He wrote that the concept of affordance 'implies that the physical attributes of the thing to be acted upon are compatible with those of the actor, that information about those attributes is available in a form compatible with a perceptual system, and (implicitly) that

these attributes and the action they make possible are relevant to a culture and a perceiver'.

By separating affordances from the information available about the physical attributes of the artefact, e.g., text and labels, Gaver was able to establish a distinction among (1) *correct rejections*, (2) *perceptible*, (3) *hidden*, and (4) *false affordances*. About this categorisation, Gaver explains that 'perceiving that a doorhandle affords pulling does not require a mediating concept because the attributes relevant to pulling are available for perception'. On the other hand, 'knowing that a key should be turned inside a lock does require mediation because the relevant attributes are not available'. Thus, the given examples correspond to perceptible and hidden affordances, respectively. An example of false affordance could be a door handle that (has information that) suggests pulling while it actually affords pushing only. A correct rejection, on the other hand, would be a door handle that neither affords pulling nor (has information that) suggests this kind of action. Therefore, while false affordances deal with misperception, correct rejections deal with the disregard of a certain action, which should not be interpreted as the absence of perception.

Although, from a design practice standpoint, it seems reasonable to distinguish affordances from the information available about the artefact, it is rather difficult to (1) define the conceptual boundaries between the *perceptual information* and the *physical attributes* of the thing to be acted upon, as they seem to be quite intertwined and overlaps between them may exist, (2) put in practice this distinction by successfully identifying affordances and perceptual information, and (3) provide an overarching definition of affordance that is useful to design practice and empirical design research.

Concerned about the issues around the different uses of the concept of affordance within the HCI community, McGrenere and Ho [3], in 2000, revisited Gibson's original definition [1, 2]. According to McGrenere and Ho, and we agree with their analysis to some extent, 'Norman collapsed two very important but different, and perhaps even independent, aspects of design: designing the utility of an object and designing the way in which that utility is conveyed to the user of the object'. Norman [5, 6] favoured the latter over the former due to his emphasis on perceived affordances.

In order to provide clarification, they reviewed the original definition of affordance [1, 2], compared it with Norman's [5, 6], and pointed out an ambiguity – which has already been addressed in this paper – in Norman's definition and use of affordances. Then, they conducted a review of the HCI literature that demonstrated that this ambiguity has led to widely varying uses of the concept of affordance. Lastly, they expand their clarification into a framework for design.

The framework proposed by McGrenere and Ho [3] establishes a relationship between two key elements in the concept of affordance: the ease with which an affordance can be undertaken and the clarity of the information that describes the existing affordance. Based on this relationship, they claimed that improvements in design could be achieved when both elements are maximised.

McGrenere and Ho's contribution [3], in terms of clarification of the original concept of affordance, is undeniable. Their work was indeed very useful, but it stopped short of providing any significant improvement in turning the concept of affordance – which for them meant 'an action possibility or an offering' that includes, but is not limited to, physical interaction – into a concept for the practice of creating design works. They continued with Gaver's line of thinking [4] by highlighting two aspects of design: designing affordances and designing the information that specifies the affordance, and relating them to usefulness and usability, respectively.

In McGrenere and Ho's work [3], one of the claims that sound awkward is when they state that affordances can be undertaken, as they were really actions or tasks, but at the same time they declare that affordances can be designed. Actions cannot be designed, as they are solely undertaken by the user, i.e., the user is the subject within that subject–object relationship. However, affordances can be designed, which leads us to think that, once more, the concept of affordance is still not clear in the design field.

In 2001, Maier and Fadel [7], started to advocate the application of a theory of affordances to engineering design, and, in 2009 [8], they proposed a new design theory based on affordances. Its purpose is made clear when they say that 'affordance based design prescribes that designers analyse the affordances of each embodiment, and attempt to remedy negative affordances during the design process' [8]. Due to their efforts, affordance was no longer viewed as just a useful concept within some technical activity domain, as they advanced it as the foundation of a design strategy.

In their research, Maier and Fadel [7, 8] claimed that affordances may exist between artefacts – which were called *artefact–artefact affordances (AAA)* – and not just between artefacts and users – known as *artefact–user affordances (AUA)* – as posited by the design research community up to that moment. Affordances between artefacts may only be accepted as true if these artefacts are capable of perceiving them, e.g., through a sensor. Otherwise, it would mean that affordances exist regardless of perception, which is implied from the authors' work, as they do not explicitly state the above condition. The idea of affordance as an *aperceptual* concept goes against its very nature [12], given that affordances are established by a complementary relationship between users and the environment through perception.

Meanwhile, in 2004, Kirschner, Martens and Strijbos [9] developed a model for the design of CSCL environments, based on three distinct types of affordances: *technological*, *educational*, and *social affordances*, to claim that affordances could have some kind of purpose or meaning other than the actual use of the artefacts they embody. In 2006, Suthers [10], in turn, proposed the study of what he called *technology affordances* for intersubjective meaning making as an integrating research agenda for the CSCL field. In this work, Suthers used the concept of affordance as defined by Norman [5, 6], i.e., perceived affordances, and explained that 'understanding the affordances technology offers for intersubjective meaning making is as foundational to CSCL as understanding learning'.

Similar to the HCI field, the CSCL community embraced the concept of affordance, and equally with various interpretations. So, as a response for the way the concept of affordance has been used in the CSCL field, in 2009, Dohn [11] was responsible for providing a renewed look at this theme by proposing a Merleau-Pontian account of affordances. In this work, she made use of the concept of *body schema*, which is complementary to the concept of affordance. She postulated that '*affordance* signifies that meaning is in the world, not in the head, and *body schema* signifies that the world is meaningful because of what we can do in it'.

Although the body is an important component in any action the agent undertakes, as well as in the way an agent perceives and experiences the environment, when it comes to perception, the mind is paramount. Compared to the mind, the body plays a small role in perceiving affordances, though, as it works merely as a vessel, as a variable whose influence on perception is quite limited. The mind, on the other hand, is where cognitive processes take place, from perception to meaning making. While the body matters when it comes to its relation to the artefact, remembering that affordance is a relational concept between the material properties of the artefact and the perceiver, the (human) mind gives us additional capacity to discover the affordances of artefacts through prior knowledge. The mind gives meaning to what the body can do to the artefact.

To sum up, despite the new interpretations of the term *affordance*, it is important to note that Gibson's original definition [1, 2] is still the most often referenced meaning, suggesting that the foundational elements of Gibson's concept of affordance are generally accepted, though what these elements 'claim' about the properties of affordances remain debated. However, some of the authors previously cited here may have provided confounding definitions of affordance, which has led to its misuse by the design community [6, 12]. Furthermore, while Norman [6] believes that the designer cares more about perceived affordances, this judgment should be made by the designers themselves. The judgment is supposed to be con-

cerned with both aspects – whether or not affordances are considered to be separate from the information available about them – as subjectivity and objectivity are part of the cognitive process, being equally important for perceiving affordances, regardless of the cognitive load they exert. Within this context, real and perceived affordances are a matter of taxonomy.

In a design context, the important issues about affordances are the strategies designers could employ to make affordances more evident and understanding how the user's prior knowledge and the environment in which the user and artefact exist can shape affordances despite the intentions of the designer. It is to these ends that we review the common foundational elements of affordances as a base for a framework to address these issues.

The common foundational elements

Based on the aforementioned definitions of affordance, here we provide what we believe to be a common set of themes across all these standpoints. Despite modifying the definition and use of affordance in discipline-specific ways, each of the standpoints described previously share the following common foundational elements, which should be regarded as the variables that affect the perception of affordances:

Artefact

For the purpose of this study, an artefact refers to an object, tangible or not, made or given shape by humans to be used or to be acted upon. In general, designers have a particular interest in objects, which depending on how they relate to each other, as well as their circumstances, may constitute a single artefact. Nevertheless, it is important to note that affordances are precisely elicited from the *properties* and the *behaviour* of an artefact. While the properties are the (physical) attributes of an artefact – such as size, volume, proportion, weight, color, and texture – the behaviour refers to the particular ways by which an artefact exists and, therefore, interacts with the environment (its immediate context).

For understanding what behaviour means, it is essential to consider that it *happens in time*. The behaviour forces us to view artefacts as dynamic entities in the environment that are subject to change. The distinction between properties and behaviour does not mean that the former is the static feature of an artefact, while the latter is its dynamic counterpart. Far from that, the properties of an artefact *exist in time*, and are subject to change. Behaviour refers to how an artefact responds to the environment; it is the result of a cause-effect relationship with the latter. For example, a swing-

ing pendulum has *swinging* as one of its behaviours due to the way its properties, e.g., structure, material, and mass, respond to the environment. A melting ice cube, on the other hand, has *melting* as one of its behaviours, while some of its properties, e.g., volume, proportion, and mass, change considerably as a result of this behaviour. These behaviours can also influence affordances, such as melting ice affording friction reduction.

It is worth mentioning that the definition of behaviour provided here is quite similar to the concept of *actual behaviour* from Gero's *Function–Behaviour–Structure (FBS)* model [16], specifically in relation to its clarified definition [17], which was paraphrased by Vermaas and Dorst [18] as 'the artefact's actions or processes in given circumstances of the natural environment'.

Agent

An agent refers to someone or something capable of perceiving an affordance, and capable of acting upon its corresponding artefact. Thus, it can be defined as a potential perceiver and actor. Having said that, machines can be equipped and programmed in such a way that they can be treated as agents.

Agents are driven by *motivations*, which refer to the true reasons of their intended actions. Alternatively, when aimed at humans, which are the agents of greatest interest here, this definition may be interpreted as needs and desires, while it can be viewed as results and outcomes for machines and, finally, just as needs for nonhuman animals. About this subject, Gibson [1, 2] states that 'the affordance of something does not change as the need of the observer changes'. However, this need is capable of sharpening the perception of a specific affordance, standing out from the others.

In addition, agents are provided with what we call here as *knowledge*, which is the sum of what has been perceived, discovered, and learned. With regard to humans, however, this definition encompasses experience, culture, and beliefs.

Environment

Environment is the container of both artefact and agent. Due to its characteristics and its content, it is naturally active and dynamic. It is where the potential use of an artefact is made available and, therefore, the place in which the relationship between agent and artefact, i.e., interaction process, is established.

Since an artefact is available in the environment, the latter takes on a decisive role on how an agent perceives the affordances of the former, being capable of influencing perception. The result of this relationship (be-

tween an artefact and the environment) is a concept that is not only strongly related to the environment, but is also likewise dynamic in nature: the *context* within which the artefact lives.

Although it is only implied in each of the previous definitions, the context turns out to be a concept of utmost importance for the correct understanding of affordances, as it permeates all its common foundational elements. Just as the environment, the context gives off information, and this information, in turn, influences how affordances are perceived.

Perception

Perception is the sensory experience that involves the use of the five traditionally recognised senses, i.e., sight, smell, taste, touch, and hearing. Additionally, it can be viewed as the primary link between an agent and an artefact, from an intended action perspective. An intended action always requires an agent, as well as perception, while an unintended action does not. Unintended actions result from an agent's false perception or from the absence of perception. Returning to our previous example, if an agent accidentally falls inside an open manhole, we can infer that it has occurred due to misperception, e.g., the manhole appeared to be closed, or to the lack of perception, e.g., the agent was distracted. Therefore, in affordance, perception can be viewed as a moderating variable because it affects misperception of the potential action.

Potential use

Potential use is an element that encompasses Gibson's complementarity concept [1, 2]. It refers to an action that might occur upon the artefact from an agent's perspective. This action always needs an agent, i.e., the actor, and an artefact to be acted upon. It is thus based on the relation between the physical capabilities of the agent and the material properties of the artefact.

Actions can be intended or not, and although the understanding of an intended action is clear, which is when an action actually matches what an agent previously had in mind, i.e., a purpose, an unintended action might not be. Whenever the action does not match what an agent had in mind, this can be considered an unintended action, even if the agent did not mean to act upon an artefact. For example, the action of an agent accidentally falling into an open manhole can be classified as an unintended action.

While the term *action* usually implies a subject, the term *use* implies a subject and an object, which is one of the reasons why *potential use* has been chosen to the detriment of *action possibility*. In addition, *use* means *to apply for a purpose* – that is, doing *a* for achieving *p*, where *a* means

one or more actions, and *p* means purpose – which fits well into an affordance account, due to the fact that only actions that have intention, i.e., intended actions, are of interest. Thus, the concept of potential use has to be viewed as the necessary actions for achieving a purpose that, by any chance, can be assigned to an artefact by an agent. In other words, to put an artefact into use is to set the purpose one assigns to it, which we call *assigned purpose*, in motion.

According to Gero [16], 'design is purposeful, and the activity of designing is goal oriented'. Thus, designing an artefact means creating something capable to meet specific needs and desires, i.e., purposes. Put it that way, design is a process in which an artefact is built to achieve a purpose, its purpose, which we call *designed purpose*. However, whatever the purpose of an artefact might be, designed or not, it can only be achieved when an artefact is put into use by an agent, which is a consequence of the process of assigning purposes, as previously explained. Given this, the designer has to be aware that an assigned purpose might differ from the designed one, resulting in what we call *non-designed purpose*, so the outcome can be quite different from what was originally expected. In this context, it is clear that the agent's motivations are key, as they might promote, for example, a purpose that actually puts people's lives at risk.

From a design perspective, the operation of an artefact can be considered correct or not, which refers to the way an artefact should be manipulated to achieve its designed purposes. In this case, a comparison between the actual operation of the artefact by an agent, which we call *actual use*, and its expected operation, i.e., the use planned by the designer, that we call *expected use*, takes place. If they match each other, one can infer that the agent correctly manipulated the artefact.

Although this is not the aim of this paper, we acknowledge that the expected use of an artefact is defined in accordance with its designed purposes and, therefore, is based upon its functions, which fits well into the FBS model and its conceptualisations around function [16, 17]. Alternatively, by taking into account Vermaas and Dorst's considerations [18] on the FBS model, we could say that, while the designed purposes are the reason for which an artefact exists, i.e., they are the originally designated goals of an artefact, and functions are 'physical dispositions of an artefact that contribute to the purposes for which the artefact is designed', the expected use refers to a process in which functions are manipulated as a means for achieving the purposes of an artefact. Consequently, the expected use of an artefact may be interpreted as a *use plan*, which, according to Vermaas and Dorst [18], is 'a plan for achieving the purpose associated with the artefact that contains at least one considered action that involves the manipulation of the artefact'.

Definition of the concept

Now that the five common foundational elements that underlie the meaning of affordance across all the provided standpoints have been described, we are finally capable to postulate that the concept of affordance refers to *cues of the potential uses of an artefact by an agent in a given environment*.

Based on the above definition, the only uncontroversial claim about affordances is that they are about action possibilities relative to the agent. To properly understand what affordance is about, first and foremost, it is essential to consider that affordances are not the use itself, but the call for it. They are cues that *invite* an agent to act upon the artefact. Gibson [19] describes a car as providing to the driver 'a sort of field which yields a variety of perceptual cues and which invites and supports specific actions. The impressions constituting it are kinesthetic, tactual, and auditory, as well as visual, and they interact with the impressions from the terrain to produce the totality of cues on which the driving-process is based'. In other words, affordances are the means by which an artefact conveys the ways by which to be operated. Its operation, in turn, implies a purpose, which may be different from the designed ones. Affordances are, thus, strongly related not only to the designed purposes of an artefact, but also to the latent ones, i.e., assigned purposes. So, if we put the agent aside, when an artefact is used differently from its expected use, this is because of what it affords, as affordances are indicative of its latent purposes. Yet affordances alone are not the only reason why an artefact may be used differently from the way it was supposed to, since context has been disregarded, as well as the agent's knowledge and motivations. It is obvious that those elements play a role in the process of perceiving affordances, as it will be shown later.

In addition, it is important to note that every affordance needs an agent to exist. If there is no agent capable of perceiving something regarded as an affordance, its existence turns out to be a philosophical question.

Although, in the literature, it appears that artefacts have just a few affordances, if we consider that they are cues to the necessary actions for achieving purposes that can be assigned – whatever the odds might be – to an artefact by an agent, this scenario would probably change. Based on that assumption, it could be inferred that every artefact has an uncountable number of affordances, which is in fact what we and others [12] postulate. In addition, we have to be reminded that affordances are not binary, like being turned on or off. To be perceived, they are subject to a few variables, which will be addressed soon.

Considering that perception is a rather complex process, a clarification around the conditions an affordance is perceived seems to be necessary. However, before stepping in this matter, it is important to note that, although affordances do not always depend on perception to exist *per se*, from the design point of view, perception is paramount and, thus, has to be included for a complete understanding of affordance. If affordance is treated as an *aperceptual* concept, it would be rather difficult to evaluate its effectiveness for a given artefact, as well as the design of the artefact itself. If the designer, for example, does not understand what is happening with the affordance, given the fact that the agent, i.e., the end-user, is not able to perceive it, the designer might not know how to design the artefact, which will eventually result in failure. So, there is no point in conceptualising something that does not involve the process by which an agent detects stimuli from an artefact.

Once realising that affordances are indicative of the latent purposes of an artefact, they should be thought of not as phenomena that are attached to it, but as a dimension in which the whole artefact provides cues of how to make use of it. Therefore, affordances are perceived by taking into account the whole artefact – including all the parts that are needed for achieving its purposes and made available for perception, attached to it or not – even if its operation is limited to just a small part of it. To illustrate this point, consider the power button of a TV's remote control: alone, it affords just *pressing*, which is actually the button's behaviour from the agent standpoint, but if we think about both TV and remote control as a single artefact, it could be said that the button affords *pressing for turning the TV on/off*, which is indeed an affordance, as it is related to a purpose, in this case the designed one; to fulfill the affordance means producing an outcome that depends on the artefact as a whole, which would not occur otherwise, i.e., the remote control alone.

An affordance is correctly perceived when, to accomplish a specific task, an agent recognises the corresponding use an artefact has to offer, that is, the necessary actions for achieving its assigned purpose. To understand the feasible use of an artefact, some cognitive effort is needed, even if it involves a *direct perception* [1, 2] or an *automatic process* [12]. Regardless of the complexity of an affordance, the process of perceiving it always exerts some cognitive effort from agents. This match between perception and the potential use of an artefact is based on knowledge, or in specific cases, on primitive instincts.

Aside the most basic and primitive affordances, which we could call *instinctive affordances*, such as the artefacts that afford nesting for mice [13] – as they are successfully perceived without any previous experience, i.e., knowledge, because the meaning of such an artefact appears to exist in

their brains from birth. The cognitive effort relies on memory, which is the result of knowledge. In other words, without knowledge, an agent cannot perceive affordances other than the instinctive ones.

In the example provided earlier, the affordance that exists in the power button of a TV's remote control would probably never be perceived if, before anything else, an agent does not know what a button is. In this case, the only way to overcome this obstacle is by analogy, which depends on the agent's knowledge of artefacts whose properties and behaviour may be similar to the button. Else, the affordance could be guessed at some point. It is worth mentioning that this process in which an agent tries to make use of an artefact by analogy refers to what the HCI field calls *familiarity* [15] or *guessability* [20]. Hinze-Hoare [20] defines it as the 'degree to which the user's own real world personal experience and knowledge can be drawn upon to provide an insight into the workings of the new system'.

With regard to the process in which affordances are perceived and, then, purposes are assigned, the agent's motivations are central and should not be overlooked. But, together with the agent's knowledge, these are not the only elements at play. Context, which was the missing part in this consideration, provides relevant information about an artefact and influences how affordances are perceived. Depending on the artefact, the context is responsible for strengthening and weakening certain affordances, as it will soon be shown.

Therefore, for the purposes of empirical design research, the concept of affordance should be viewed as a problem of transmission of cues from the artefact and the environment to the perceiver. It is a problem about the way the information of an artefact is made available to the agent, and the way this information is captured by this same agent.

The framework

The purpose of this framework is to provide the necessary knowledge to assist designers in creating new artefacts, or introducing new features and functionalities, within an affordance perspective. The framework has to consider that the problem for the designer is to strengthen or weaken the perception of the affordance, that is, impose control over the perception of an affordance. By embracing the aforementioned elements, the framework should be viewed as an outcome of our considerations around the concept of affordance.

During the process of building the framework, Bernstein's notions of *classification* and *framing* [21] emerged as an interesting way for convey-

ing the groundwork in which the elements that have been selected earlier should be built upon. For Bernstein, education is about the transmission of knowledge, which is governed by the regulation over what knowledge can be transmitted and its relation to other knowledge (classification) and how the knowledge is transmitted and acquired (framing). Therefore, based on the similarities that have been found, we decided to adopt Bernstein's terminology and framework, by applying some necessary changes and making them suit the elements that have been previously selected, so that the resulting framework would meet the purpose.

In affordance, classification refers to the degree to which the artefact is perceived as it was meant to be, i.e., its designed purposes, in relation to the context. Framing refers to the degree to which the artefact is perceived in relation to its own constraints, i.e., the artefact's properties and behaviour, to the detriment of the agent's knowledge and motivations.

On the one hand, when an artefact has a strong classification it means that, regardless of how the context presents itself, the understanding of the artefact's affordance remains intact; and, when it has a weak classification, it means that non-designed purposes may be assigned to the artefact, depending on the context. On the other hand, in a strong framing the artefact itself brings the frame, i.e., the affordance is tightly bound to the artefact, due to the strength of its properties and behaviour to the detriment of the agent's knowledge and motivations. As Gibson [2] wrote, 'the object does what it does because it is what it is'. In a weak framing the agent brings the frame, i.e., the affordance is not so tightly bound to the artefact, due to the strength of the agent's knowledge and motivations to the detriment of the artefact's properties and behaviour. Our knowledge about artefacts is not generated strictly through the act of perception; prior knowledge will shape the perception of suggested possibilities. The predictive brain hypothesis [22] suggests that even prior to our perception of the artefact, the brain has already activated analogical references of *what this artefact is most like* based upon other artefacts in our field of view.

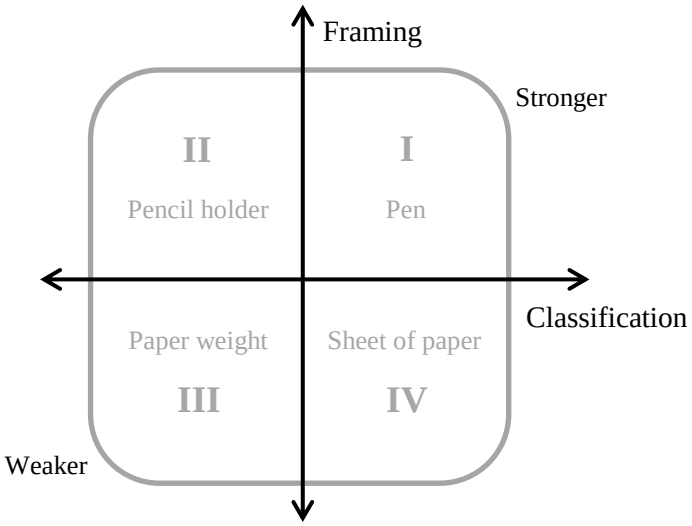

Fig1. Visual representation of the proposed framework on affordances

To allow some form of measurement, the framework is represented as a Cartesian graph (see Figure 1) where the ordered pairs (*x*, *y*) relate classification, on the *x*-axis, to framing, on the *y*-axis. To facilitate its understanding and implementation, the graph is divided into four quadrants and an artefact is pointed out as an example for each one. Thus, *quadrant I* refers to stronger classification and framing, e.g., a pen, *quadrant II* refers to weaker classification and stronger framing, e.g., a pencil holder, *quadrant III* refers to weaker classification and framing, e.g., a paper weight, and *quadrant IV* refers to stronger classification and weaker framing, e.g., a sheet of paper.

Classification and framing are referred to as *affordance dimensions*, because they not only relate to each other, but also represent quantitative values, which are derived from the aforementioned elements. Note that classification and framing are *stronger* or *weaker* to rebut the *exists*/*does not exist* dualism of affordances in favour of attention towards the degree to which an affordance is perceived.

With regard to the examples provided and the way they relate to the affordance dimensions, an ordinary pen is supposed to be in quadrant I because, regardless of the context (stronger classification), its own constraints, to some extent, do not allow different uses other than its expected use (stronger framing), which is *writing/drawing on a surface*; a pencil holder is supposed to be in quadrant II because it may afford something different from its expected use, if it is found next to a sink or on a kitchen

bench (weaker classification), although being constrained by its own properties and behaviour (stronger framing); a paper weight is supposed to be in quadrant III because it can be interpreted as many things, such as a door holder or a decorative object, depending on the context (weaker classification), and on the agent's knowledge and motivations (weaker framing); a sheet of paper is supposed to be in quadrant IV because its designed purpose is still clear in different contexts (stronger classification), although it is open to a plethora of different uses, e.g., origami, due to its weak intrinsic constraints (weaker framing).

Generally speaking, the resulting framework shows that there are situations in which the contexts, or the artefact itself, i.e., its properties and behaviour, constrain the agent's perception of an affordance strongly. As such, the framework suits cultural paradigms of affordance. Changing the environment of an executive chair from a boardroom to a waiting room weakens the classification by removing the cultural rule that the chair affords sitting for the senior executive. And, then, there are other situations in which the agent's knowledge and motivations constrain affordances. So, the context, or the artefact itself, intrinsically tells the agent much more about what the artefact is capable of *doing*.

Final considerations

Although we recognise that the proposed framework has not yet been empirically tested yet, which is the next step of our research, in this paper we provided enough arguments, i.e., a dialectical approach, capable of supporting its underlying mechanisms. Although one could argue that without further proof our framework is just a guess, lacking empirical evidence, the framework generates testable hypotheses. One such hypothesis is that strengthening the framing of artefacts reduces the variety of uses to which a human agent associates to an artefact. According to the framework, depending on the situation, when the designer has considerable control over the artefact being designed, i.e., its properties and behaviour, as well as its context, then is more likely that it will evoke fewer non-designed purposes, because of how the agent, i.e., the end-user, perceives its affordances; otherwise, we predict that the artefact is more likely to produce exactly the opposite effect.

Designing artefacts from an affordance perspective is not a matter of making certain affordances perceivable, e.g., visible, to the detriment of others, as being turned on or off; rather, it is about making them more or less obvious. As previously stated, affordances are not binary; they can be

strengthened or weakened, as if they were connected to a 'slider'. Once affordance perception is treated as a problem of information transmission, it is reasonable to consider the importance played by context or the agent's knowledge and motivations; both of them act as a force in favour of, or against, the artefact's designed purpose. Therefore, the proposed framework not only provides some awareness about this subject, but may also help designers to create end-user products that are less error-prone or more open to different assigned purposes.

Given the degree to which potential non-designed purposes may be assigned to an artefact, this paper might serve as a reference for designing towards (1) strong framing, i.e., rigid uses, in which case it has to be ensured that the constraints are perceivable enough, so the agent's understanding over the artefact is not affected, whatever the context or the knowledge and motivations of the agent; or (2) weak framing, i.e., more flexible uses, where affordances are perceived in such a way that the operation and/or the purpose of an artefact are intentionally open to the agent's interpretation, which can be viewed as a process of empowerment of the end-user.

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