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The Identification of Perceived Intended Affordances

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Abstract

An experiment aimed at testing the hypothesis that perceived intended affordances can be affected by two distinct dimensions, classification and framing, was conducted. One hundred and four participants were asked to tell what action they would most likely take upon eight artefacts. Responses were tallied according to whether participants identified the intended affordance. A chi-square test showed that correct responses significantly varied according to the degree of strength of classification and framing. However, a textual analysis of responses to questions asking participants to explain their answers showed that few of the responses exhibited participants' knowledge about affordances. The results suggest that perceived intended affordances have to be learnt or primed to be identified correctly.

Affordance; Affordance dimensions; Design research; Design stance; Perceived intended affordance; Perception

Although affordance remains a key concept in the field of design, typically referring to the possibilities of action that an artefact offers to a user (Gibson, 1977, 1979; McGrenere & Ho, 2000; Norman, 1988, 1999), a significant amount of debate has attempted to clarify aspects of the concept. The most active debates are (1) whether or not affordances are binary, which means that either they exist or they do not (McGrenere & Ho, 2000); (2) whether or not they exist independent of the user's ability to perceive them (Kaptelinin & Nardi, 2012); and, (3) whether or not they rely on the user's past knowledge and experience in order to be perceived (Norman, 1988, 1999). In other words, scholars debate the underlying factors that influence the perception (or not) of an affordance. Lost in this debate, though, are (1) whether users perceive the affordance that was *intended* by the designer; (2) whether it is possible to manipulate it; and, (3) how to do so.

Intentionality is essential in design because designers imbue artefacts with a purpose. The provision of some utility or function is one of the factors that has an evident influence on the artefact's properties and behaviour (Crilly, Moultrie, & Clarkson, 2009, p. 235). Along with its attributes, such as shape, colour and material, an artefact may be designed with one or more affordances intentionally. Thus, among all affordances that a product may have, the ones that need special attention are those that are intended to be perceived. As a way to understand how important intended affordances are, if an affordance is by any chance not perceived as intended, the designer has failed.

Drawing on the common foundational elements of affordance, we have proposed two underlying factors influencing the perception of an intended affordance: classification and framing, also known as *affordance dimensions* (Burlamaqui & Dong, 2015). While 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 user's knowledge and motivations. In other words, classification and framing refer to the extrinsic and intrinsic characteristics of an artefact, respectively.

In sum, the debate around the concept of affordance has missed a key point, whether the perceived affordance is intended or not. What really matters in design is whether or not the user perceives the intended affordance, an argument similarly made in relation to function (Crilly, 2011). Therefore, this paper studies the perceived intended affordances and the effect of the characteristics of the artefact and its environment upon this perception.

Literature Review

According to Norman, Gibson (1977, 1979) coined the term affordance to refer to the "actionable properties between the world and an actor (a person or animal)" (Norman, 1999, p. 39). Later on, Norman (1988, 1999) introduced the concept to the design community and then provided a distinction between real and perceived affordances.

Thanks to Norman, a generally agreeable definition of (perceived) affordance is that it is "the design aspect of an object which suggests how the object should be used" (McGrenere & Ho, 2000, p. 1). This definition implies the existence of five foundational elements (Burlamaqui & Dong, 2015, pp. 302-305). They are:

- Artefact: an object, tangible or not, made or given shape by humans to be acted upon; in other words, it is a designed object;
- User/agent: someone or something capable of perceiving an affordance, and capable of acting upon its corresponding artefact;
- Use: an action that might occur upon the artefact from a user's perspective;
- Perception: sensory experience that involves the use of the five traditionally recognised senses;

- Environment: container of both artefact and user, it is where an affordance is made available and, therefore, the place in which the relationship between user and artefact is established.

A missing aspect of the debates over the concept of affordance, though, is whether the perceived affordance is intended or not. The artefact's purpose may be intended or not, that is, *designed* or *non-designed*, respectively (Burlamaqui & Dong, 2015, pp. 304-306). From a design perspective, however, the relevant type of affordance is the intended or designed one.

The designer's intent has been a crucial part of understanding the meaning of an artefact. For example, if we take into account scholarship from the engineering design, the designed purpose is nothing else but the function of an artefact (Gero, 1990; Gero & Kannengiesser, 2004; Gero, Tham, & Lee, 1992). Although consensus on the meaning of function has yet to be achieved, a function can be defined as *a desired effect by an artefact's behaviour, which can be described in terms of that behaviour (i.e., device-centric viewpoint) or in terms of the elements external to the artefact (i.e., environment-centric viewpoint). This effect refers to the intentions of two types of agents, concurrently: to those responsible for creating the artefact (i.e., designers) and to those who desire the effect (i.e., end-users)*, according to Chandrasekaran and Josephson (2000, p. 170).

Based on the above, there is an underlying element of function that cannot be overlooked: *intentionality*. With this notion in mind, we can divide the affordance domain into two major groups: *intended* and *unintended affordances*. While the latter refers to those affordances that are disconnected to the artefact's function, the former is exactly the opposite. Perceiving an affordance helps the user to enact an intended function, such as swiping a finger (affordance) across a cell phone screen to unlock the interface (function).

Dennett's *design stance* can help us understand the relevance of the aforementioned distinction. The design stance refers to how users reason about the expected behaviour of artefacts. According to Dennett (1987), to predict how artefacts will behave, users may think about what they are designed to do. When presented with artefacts in which they do not have enough knowledge of their physical structure and workings, users adopt a design stance in order to reliably predict how they operate. This standpoint allows users to make predictions based on the assumption that these artefacts will behave as they are designed to behave (Crilly, 2011, p. 19).

Within the scope of the design stance, Crilly pointed out that research has already shown that:

> *"People name and categorize artifacts according to what they believe the designers' intentions were. For example, a collection of things called "clocks" might all be considered to be clocks even if those things take different physical forms (e.g., analogue and digital clocks), and even if they do not all tell the time (e.g., because they are broken or need a new battery). This is because these things were all intended to be clocks, and their form and behavior are just clues to this intention. Conversely, something might very well resemble a clock (perhaps a child's drawing) and something might accidently permit the time to be read (perhaps the moving shadow from a building), but if people don't think those things were intended to be clocks, then those things won't be thought of as being clocks." (Barrett, Laurence & Margolis, 2008; Bloom, 1996; German & Johnson, 2002, cited in Crilly, 2011, pp. 20-21)*

It is essential to highlight that users' beliefs around the designers' intentions, whatever they might be, are based upon what is perceived. In other words, the behaviour of an artefact can be predicted by users based on what they believe to be the designer's intentions, which in turn are based upon the information the artefact gives off. This information includes affordances and, among them, intended affordances. Therefore, it is reasonable to assume that users have to successfully recognise the intended affordances in order to correctly identify what the designers' intentions are.

When it comes to creating artefacts, designers should specifically aim for *perceived intended affordances*. A successful design is the one that conveys to users what they should do to/with the artefact in order to operate it.

In line with the artefact's function, perceived intended affordances refer to *what individuals do to/with the artefact in order to enable its function*. Consequently, we are now able to formalise perceived intended affordance as *the perception of the intended manner by which the function of an artefact is enacted by a user in a given environment*.

Perceived intended affordances are the ones that need to be tackled when creating an artefact as they relate to the way an artefact should be correctly operated. Therefore, our research focuses on perceived intended affordances only, rather than all kinds of affordances.

Hypothesis

We hypothesise that perceived intended affordances can be affected by classification and framing. If confirmed, designers would be able to better predict the extent to which they have control over perceived intended affordances when designing end-consumer products. To test this hypothesis, we conducted a laboratory experiment.

Research Design

The affordance dimensions can be investigated as a 2×2 factorial design. The categorical independent variables, *factor A* and *factor B*, correspond to classification and framing, while the levels, *level 1* and *level 2*, correspond to their respective strengths. These levels imply that the affordance dimensions may be weak(er) or strong(er), accordingly. Hence, the aforementioned hypothesis can be confirmed by testing the correct identification of the perceived intended affordance given these factors (Table 1).

Table 1: Combination of each factor with every level on a 2×2 factorial design

2x2 factorial design		**Factors**	
		Classification (*factor A*)	**Framing** (*factor B*)
Levels	**Weaker** (*level 1*)	Weak(er) classification	Weak(er) framing
	Stronger (*level 2*)	Strong(er) classification	Strong(er) framing

By manipulating one affordance dimension at a time, the experiment will measure the influence of each intervention over an artefact's perceived intended affordance.

Methodology

Participants. A sample of 104 participants took part in the test. The requirements were a minimum age of 18 years and the ability to answer the questions through an Internet-enabled computer or portable device. The sample was randomly split into 2 groups, *group A* and *group B*, with 51 and 53 individuals, respectively.

Apparatus and materials. A total of 12 artefacts of various types were considered in the test. Artefacts were chosen on the basis of being common objects but novel in affordance or appearance. They were divided into 3 equal sets, *set A*, *set B* and *set C*. *Set A* contained an ashtray, a cake server, a calliper, and a clip applier, *set B* contained a corkscrew, an ice hammer, a key ring, and a knife sharpener, and *set C* contained a glass, a paper weight, scissors, and a shovel. For *set A* and *set B*, artefacts provided had an appearance that is different from their standard solutions. *Set A* was manipulated according to an increase or decrease in the level of classification by changing the context in which the artefact was situated; as a result, 2 different states of each artefact were established, *state IC* and *state NC*, where *state IC* refers to the artefact *in* a *context* that is unrelated to its function and *state NC* refers to the artefact with *no context*. *Set B* was manipulated according to an increase or decrease of framing by changing the appearance of the artefact; as a result, 2 different states of each artefact were established, *state WI* and *state WO*, where *state WI* refers to the artefact *with itself* and *state WO* refers to *with other* artefacts of the same semantic category. *Set C* was not subject to manipulation, as its artefacts were intended to be used as warm-up. Therefore, a total of 20 images were generated accordingly, which made up the stimulus set. These images were high-quality full-colour PNG (*Portable Network Graphics*) files, which were manipulated and resized to fit a square of 1000×1000 pixels with a resolution of 72 dpi; they were placed over a white background, and any logos or labels were removed. A visual indication of the scale of the artefact (in relation to a human being) was generated as well. Figure 1 shows a sample of an image.

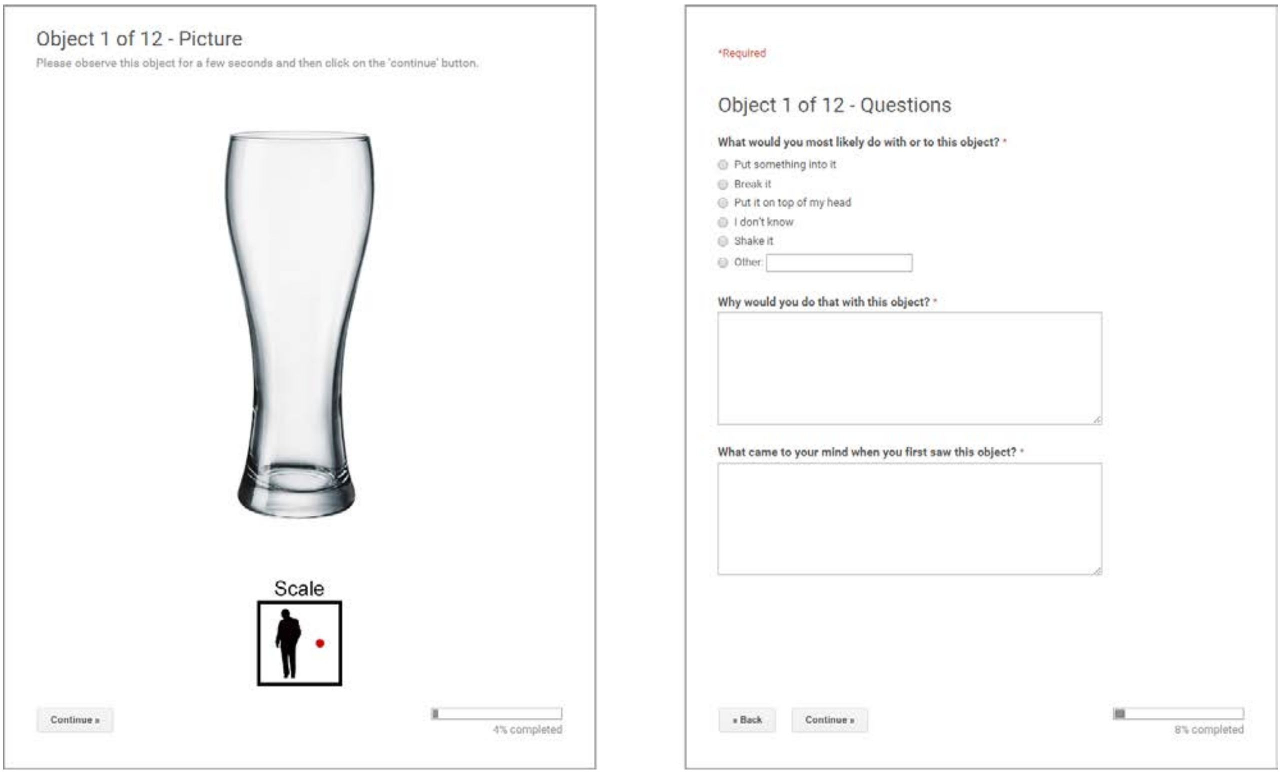

Figure 1: Screenshots of the first trial, where the image of a glass was displayed

Procedure. Participants were given a series of 12 trials. Each trial displayed an image accompanied by a scale indicating the object's size relative to an adult human. On trials 1 to 4, both groups were given *set C*. These trials were used as warm-up so participants would be able to familiarize with the test's structure and have an idea of what to expect. Results from these trials were discarded. Trials 5 to 8 corresponded to *set A*, and thus *group A* was given *state IC* while *group B* was given *state NC*. Trials 9 to 12 corresponded to *set B*, and thus *group A* was given *state WI* while *group B* was given *state WO* (Table 2). In each trial, participants had to answer the following questions after viewing an image for up to 10 seconds: (1) *what would you most likely do with or to this object?*; (2) *why would you do that with this object?*; and (3) *what came to your mind when you first saw this object?*. The first question dealt with the affordance of the artefact. The next two questions sought to identify whether the person thought of its affordance in answering the question. Participants were asked to select from 1 of 6 options. Amongst them, 2 options were always present: *I don't know*, and *other*, the latter requiring an open response. The remaining 4 options were dependent on the artefact depicted by the image, and each one represented a different type of affordance in relation to a human being: (1) small scale (e.g., hand movement is required), (2) medium scale (e.g., arm movement is required), (3) large scale (e.g., full-body movement is required), and (4) complex (e.g., additional artefact is required) actions. There was only one correct option, the perceived intended affordance. Aside from *other*, which was always in the last position, options were randomly arranged. For instance, in the first trial (Figure 1), where the image of a glass was displayed, in addition to *I don't know* and *other*, the options presented in the first question were *shake it*, *break it*, *put it on top of my head*, and *put* *something into it*. The last response is the correct intended affordance. Any mention of difficulties in viewing the image, partially or in full, voided the participant's responses for that particular set.

Table 2: Relation between trials and groups of participants, according to the manipulation of the affordance dimensions, where *N* is the number of participants in each condition.

Relation between trials and groups of participants		**Trials**	
		5 to 8 (*set A*) Manipulation of classification	**9 to 12 (*set B*)** Manipulation of framing
Participants	***Group A***	*State IC (N=51)*	*State WI (N=51)*
	Group B	*State NC (N=53)*	*State WO (N=53)*

Measurement. Unsuccessful and successful perceived intended affordances were measured by counting the number of unexpected and expected answers obtained, respectively. If responses given through the open-ended option *other* were similar to the expected answer, they were considered correct. For example, in the first trial, where the image of a glass was displayed, *pour a beer* would be considered as an expected answer. Furthermore, depending on the information provided in the open-ended questions, responses could be considered expected answers, as explained below. The influence of each intervention over an artefact's perceived intended affordance was measured by comparing the answers from *group A* with the ones from *group B*.

Data analysis. To analyse the open responses regarding the reasons for the participants' answers, responses were organised into three categories: (1) affordance, (2) function, or (3) semantic category. The criterion to determine which category applies to a response was:

- Affordance: what a user can do to/with an artefact in a given environment;
- Function: what an artefact is capable of being used for, which instead refers to the artefact's purpose (Gero, 1990);
- Semantic category: what an artefact is.

Based on the above, if a semantic category was identified, and it matched – or it was similar to – the one related to the artefact in question, the response was considered an expected answer. Back to the first trial, *cup* or *vase*, for instance, would be considered expected answers, as they are similar to the semantic category *glass*. A similar approach was applied to responses in which the function of the artefact has been mentioned, such as *drink*.

Results

From a total of 832 responses, 2 were invalid due to the participant not being able to view the image properly. A 2×2 contingency analysis using chi-square test (Table 3) indicated that correct responses significantly varied according to the degree of strength of the affordance dimensions. Intervention in classification resulted in 82 correct answers from *group A* against 117 from *group B*, which corresponds to a 17.59% increase in correct responses from *state IC* to *state NC* ($\chi^2(1) = 17.59, p=.0022$). Similarly, intervention in framing resulted in 65 correct answers from *group A* against 104 from *group B*, which corresponds to a 23.08% increase in correct responses from *state WI* to *state WO* ($\chi^2(1) = 23.08, p=.0003$). Overall, the manipulation of classification and framing was capable of increasing by 20.11% the likelihood that the intended affordances will be perceived.

Table 3: 2×2 contingency tables by affordance dimension using chi-square test

Contingency analysis of classification	Classification		Total
	Group A	Group B	
Correct answer	82	117	199
Wrong answer	122	95	217
Total	204	212	416

Contingency analysis of framing	Framing		Total
	Group A	Group B	
Correct answer	65	104	169
Wrong answer	139	106	245
Total	204	210	414

That said, when results related to each artefact were tallied individually, they suggested that individuals could not necessarily identify the intended affordances. In other words, on a per artefact basis, the manipulation of the affordance dimensions could not cause a significant impact on perceived intended affordances. After running a separate chi-square test for every artefact, it was verified that only 3 of 8 artefacts had significant results ($p < .05$): the ashtray, the corkscrew and the ice hammer, the first one from the classification set and the other two from the framing set (Figure 2).

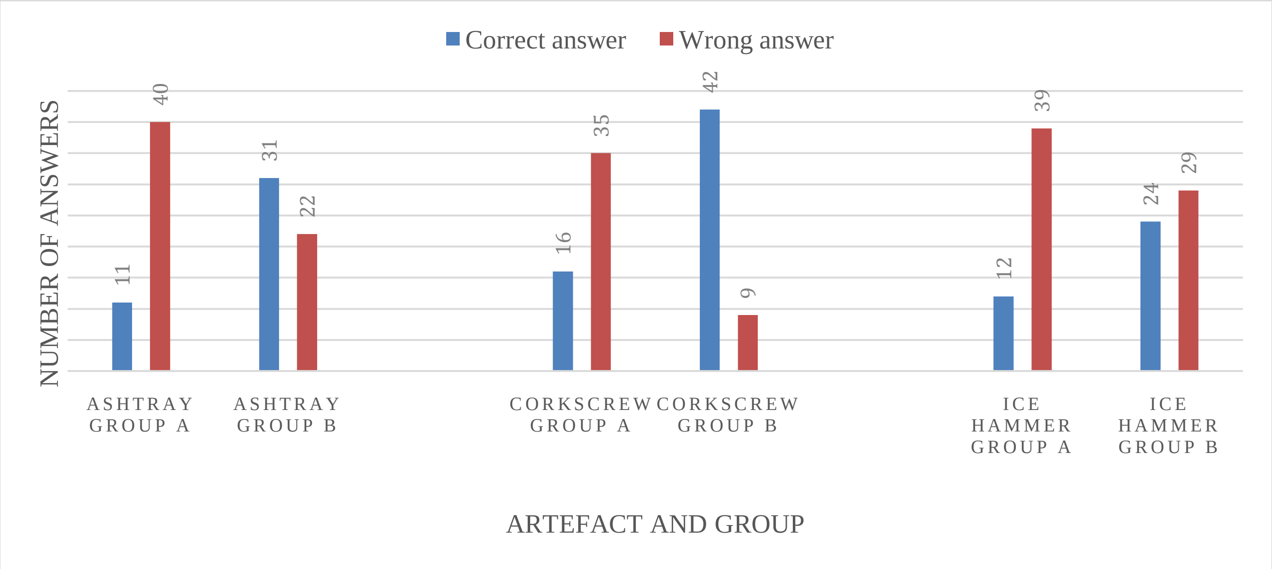

Figure 2: Chart of a 2×2 chi-square test for ashtray, corkscrew and ice hammer

On the ashtray (Figure 3), intervention in classification resulted in 11 correct answers from *group A* against 31 from *group B*, which corresponds to a 36.92% increase in correct responses from *state IC* to *state NC* ($\chi^2(1) = 36.92, p = .0001$). On the corkscrew (Figure 4), intervention in framing resulted in 16 correct answers from *group A* against 42 from *group B*, which corresponds to a 50.98% increase in correct responses from *state WI* to *state WO* ($\chi^2(1) = 50.98, p < .0001$). On the ice hammer, intervention in framing resulted in 12 correct answers from *group A* against 24 from *group B*, which corresponds to a 21.75% increase in correct responses from *state WI* to *state WO* ($\chi^2(1) = 21.75, p = .0197$).

Figure 3: Significant manipulation of classification, from *state IC* (on the left) to *state NC* (on the right), on an ashtray

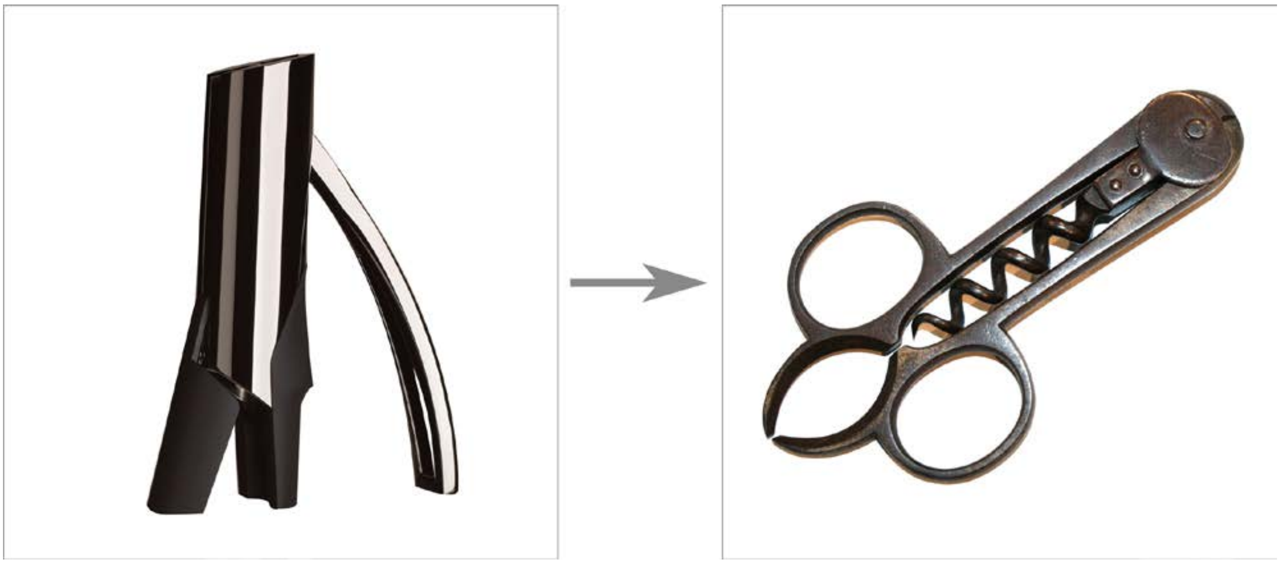

Figure 4: Significant manipulation of framing, from *state WI* (on the left) to *state WO* (on the right), on a corkscrew

Among the artefacts whose results did not reach statistical significance, the calliper was the one with the lowest score from the classification set, while the key ring had the lowest score from the framing set (Figure 5).

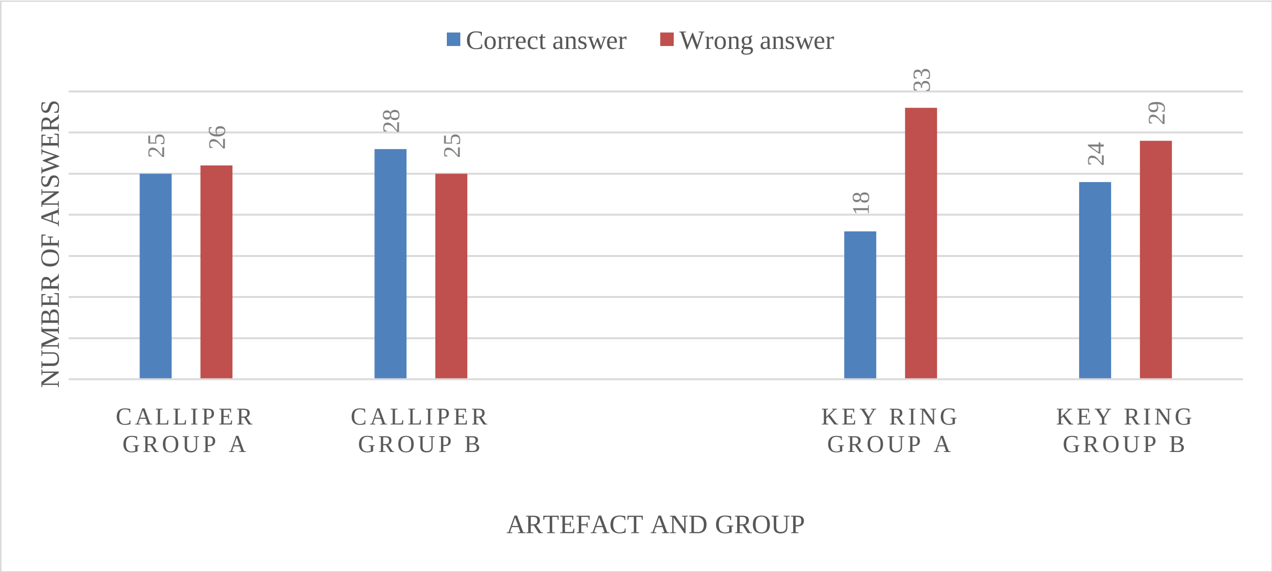

Figure 5: Chart of a 2×2 chi-square test for calliper and key ring

On the calliper (Figure 6), intervention in classification resulted in 25 correct answers from group A against 28 from group B, which corresponds to a 3.81% increase in correct responses from *state IC* to *state NC* ($\chi2(1) = 3.81, p = .6976$). On the key ring (Figure 7), intervention in framing resulted in 18 correct answers from group A against 24 from *group B*, which corresponds to a 9.99% increase in correct responses from *state WI* to *state WO* ($\chi^2(1) = 9.99, p = .2993$).

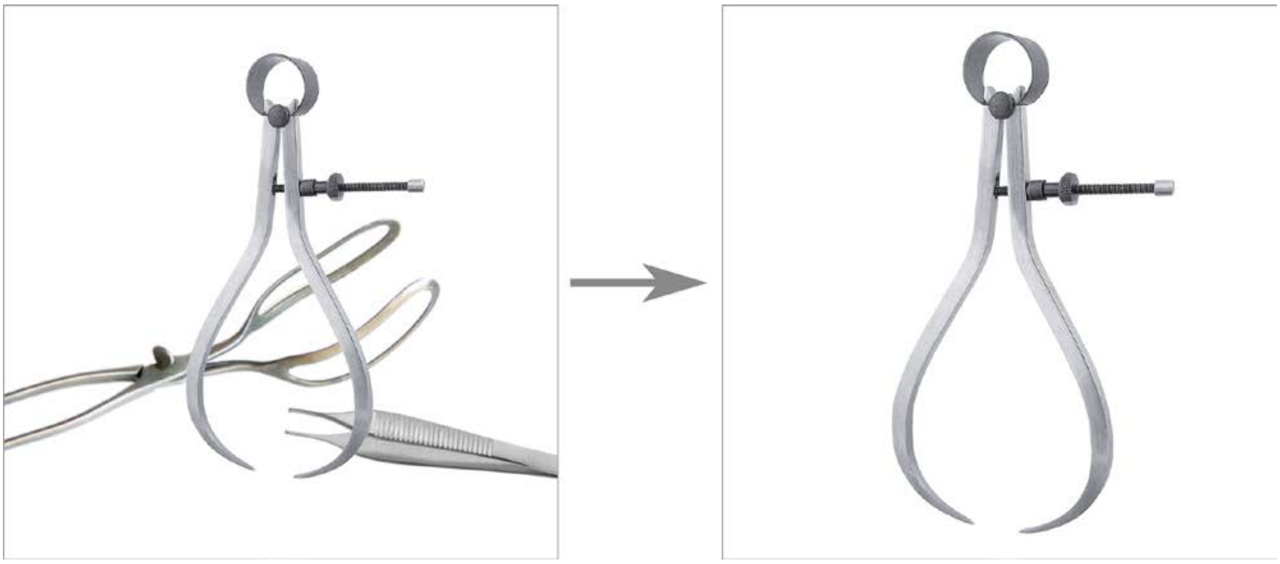

Figure 6: Non-significant manipulation of classification, from *state IC* (on the left) to *state NC* (on the right), on a calliper

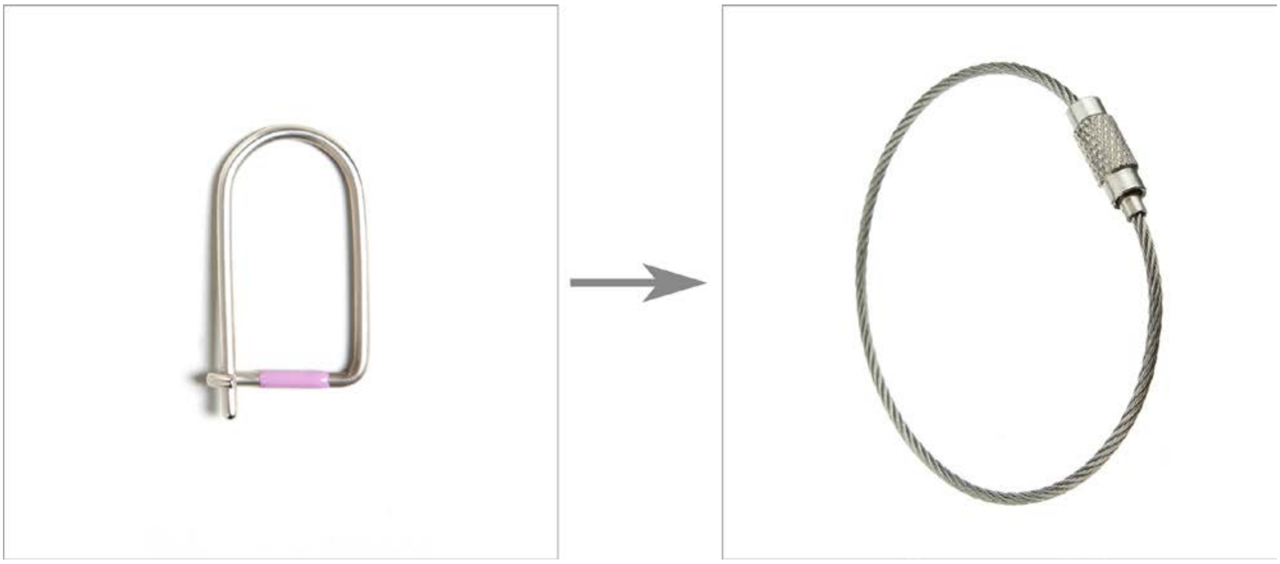

Figure 7: Non-significant manipulation of framing, from *state WI* (on the left) to *state WO* (on the right), on a key ring

An analysis of textual responses in which individuals explained their answers, 204 of them (24.6% of all valid responses) included expressions such as *it looks like*, *it reminds me*, *it resembles*, and *it is similar to*. To some extent, this externalisation indicates that participants were comparing the artefacts they saw with those that are part of their repertoire. If we take into account the novel appearance of the artefacts used in the experiment, this behaviour also suggests that participants were neither familiar with the purpose of these artefacts nor how to activate the function. Moreover, 80.72% of the participants' responses did not discuss the action that the artefact presented to the participant. Even physical properties strongly related to intended affordances, such as properties of the artefact (e.g., shape and size of an obvious handle), were often unmentioned by participants. When asked why they would take the action they have pointed out, individuals usually provided elements that were function-related. For example, there were answers such *to open a bottle of wine* for the corkscrew and *to measure something* for the calliper.

When asked about what came to their minds when they first saw those artefacts, individuals generally provided responses that were category-related. For instance, there were answers such as *medical instrument* for the ashtray and *bracelet* for the key ring.

That said, it is important to notice that participants were sometimes able to identify the intended affordance without successfully recognising neither the function nor the semantic category of the artefact. For example, on the ashtray, from a total of 42 correct answers, 16 of them, which correspond to 38.09%, did not mention anything related to an ashtray. In most of these cases, individuals thought that the artefact was meant to hold something, such as a pen, or to roll or slide something over its surface, such as a ball.

Conclusion

The experiment demonstrated that the manipulation of the affordance dimensions influence the perception of intended affordances. An increasing strength of the affordance dimension increases the likelihood that perceived intended affordances will be successfully identified.

However, the results suggest that the manipulation may not have a considerable impact on perceived intended affordances if the user is not familiar with how the artefact is used or has not seen anything similar before.

Overall, the results show that there are situations in which the context, or the artefact itself, constrain the user's perception of an intended affordance strongly. And, then, there are other situations in which their knowledge and motivations constrain the perception of intended affordances.

On the one hand, in a strong classification the artefact's perceived intended affordance remains intact, regardless of how the context presents itself; in a weak classification the user may assign new functions to the artefact, depending on the context. On the other hand, in a strong framing the artefact itself brings the frame, due to the strength of its properties and behaviour to the detriment of the user's knowledge and motivations; in a weak framing it is the user who brings the frame instead.

Discussion

Based on the results, we conjecture that individuals require prior exposure to *intended* affordances to perceive them as there is no evidence that the participants see intended affordances as being intrinsic to the artefact.

In addition, based on the textual responses exhibiting participants' lack of explicit knowledge about affordances, there is reason to believe that the concept of affordance is a tacit or implicit knowledge. Generally, affordances appear to be implicit in the artefact's function or in its semantic category. That said, when users do not know what the artefact is or what it is for, intended affordances might be a means by which users can predict what the objected is designed for (design stance).

It is reasonable to hypothesize that when users successfully identify a perceived intended affordance, it is because they were primed by prior experience. Hence, in a situation where users are exposed to potentially new or unexpected intended affordances, it would make sense to prime these affordances in order to make them more explicit to users. To do that, *signifiers* (Norman, 2008) may have an important role. As defined by Norman, a signifier is "some sort of indicator, some signal in the physical or social world that can be interpreted meaningfully" (Norman, 2008, p. 18), which, from an intended affordance perspective, can be interpreted as *the information available about the intended affordance of an artefact* (Kaptelinin, 2014, p. 64). So, for instance, if a button has a label next to it, the latter functions as a signifier that may help users to understand that the former is actually clickable, which corresponds to the intended affordance.

Although we disagree with Norman on his claim that signifiers replace affordances (Norman, 2008, p. 19), as there is no evidence that this is true, the concept of signifier is strongly connected to affordance. Signifiers may play a supporting role in making intended affordances more obvious to users. Therefore, the idea of primed recognition of intended affordances via signifiers presents itself as a viable and useful design principle.

Implications

The manipulation of the affordance dimensions might be viewed as novel strategies for designing end-consumer products. Affordance-wise, it would be possible to design towards these conditions:

- Weak(er) classification, where affordances are perceived in such a way that the operation of the artefact is intentionally dependent on the context and, thus, open to the user's interpretation;
- Strong(er) classification, where perceived intended affordance are successfully identified, regardless of the context of the artefact;
- Weak(er) framing, where affordances are perceived in such a way that the operation of the artefact is intentionally open to the user's interpretation;
- Strong(er) framing, where perceived intended affordance are successfully identified, regardless of the user's knowledge and motivations.

In short, the strategies provided can be divided into flexible uses (i.e., weak classification or framing) and rigid uses (i.e., strong classification or framing). While the former is related to functions assigned by the user, which can be viewed as a process of user empowerment, the latter refers to designed functions, which can be viewed as a process of controlling the way an artefact is used.

According to the *Function–Behaviour–Structure (FBS)* model (Gero, 1990), the aforementioned strategies can be applied when conceptualising the artefact's behaviour. That said, given that affordances are part of a dynamic interactive process in which the user is at its very centre, the user's situation has to be taken into account. Thus, the situated FBS model (Gero & Kannengiesser, 2004) provides a better view of the points in the process where these strategies may be put in place (Kannengiesser & Gero, 2011).

The effectiveness of the proposed strategies can be measured by conducting usability tests throughout the design process. In this case, each condition should be regarded as a heuristic that determines how successful the user interaction with the artefact is. The more the process is recursive, the more the output may influence the outcome. Overall, these strategies may generate opportunities for introducing new features of a design, so as to better convey how the artefact should be used.

Additionally, if we take into account that affordances are tacit or implicit knowledge, and that intended affordances have to be learnt or primed in order to be perceived, it becomes clear that designers do not have much room for inventing new affordances, at least not without the aid of signifiers. In this case, users should be primed so as to ensure that they are able to successfully identify the perceived intended affordances within a specific context.

Although more research is needed to back some of the claims made in this article, the findings presented here may help designers understand and better predict the extent to which they have control over perceived intended affordances when designing end-consumer products. Finally, the research questions the design principle that designers can design an arbitrary affordance into an artefact, expecting that the affordance is 'natural' and therefore both perceivable and knowable (knows what the intended affordance permits the user to do to the artefact). Rather, our research suggests that affordances may be perceived, but intended affordances may remain unknown.

Acknowledgments

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Leonardo Burlamaqui is a UX (User Experience) designer from Brazil with over 15 years of experience. He is currently undertaking a PhD in the School of Civil Engineering at the University of Sydney. Under Professor Andy Dong’s supervision, his research focuses on the perception of intended affordances. He holds an MSc degree in Design from ESDI - UERJ (2010-2012), a Postgraduate degree in e-Business from EPGE - FGV (2000-2001), and a BA degree in Industrial Design from ESDI - UERJ (1995-1999) with majors on both Industrial Design and Graphic Design.

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Professor Andy Dong’s research addresses the central activity of engineering: the design of new products and services. He joined the University of Sydney in 2003 after completing his PhD and postdoctoral training in mechanical engineering at the University of California, Berkeley. He started in the Faculty of Architecture, Design and Planning, as a Lecturer and eventually became the Head of Discipline for the Design Lab. In 2010, he was awarded an Australian Research Council Future Fellowship. He was appointed the Warren Centre Chair for Engineering Innovation in 2012 and joined the Faculty of Engineering & Information Technologies. He is on the Editorial Board of the key journals in design research including Design Studies, Journal of Engineering Design, and Research in Engineering Design.