Intuitive Interaction research – new directions and possible responses.

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Abstract: This paper discusses and compares older and newer approaches to intuitive interaction research over the past fifteen years and asks how we can move forward from here. Outcomes from the different research endeavours are discussed and explained. Existing continua of intuitive interaction are discussed, and a new suggested framework for understanding these various approaches and how the different ideas and findings relate to each other is presented, as a first step to forming a solid platform from which new move forward in various new directions. The framework shows the relationships, differences and commonalities between these ideas and discusses the implications for researchers and designers.

Keywords: intuitive interaction; intuitive use

1. Introduction

This paper is an exploration of emerging ideas and concepts in Intuitive Interaction research. It aims to build on past findings to increase understanding of the potential relationships between various concepts in the domain. Intuitive interaction research has the potential to make a great variety of systems, products and interfaces easier for people to use. The research has covered applications for physical and digital user interfaces, installations, games, NUIs and TUIs, for younger and older adults and even children (Blackler & Popovic, 2015). Researchers have also investigated, tested and provided tools for the most appropriate ways to design more intuitive interfaces (e.g. Blackler, Popovic, & Mahar, 2014; Fischer, Itoh, & Inagaki, 2015; Hurtienne, Klöckner, Diefenbach, Nass, & Maier, 2015).

The paper introduces the earlier concepts and approaches in intuitive interaction research, followed by newer ideas and research in the area. It then presents a framework that shows
the relationships, differences and commonalities between these ideas and discusses the implications for researchers and designers of applying them.

2. Initial concepts and research in Intuitive Interaction

Intuition is the end result of a cognitive process that matches current stimuli with a store of amalgamated experiential knowledge, built up over time in other relevant situations. Over the past fifteen years, various researchers on four different continents using a variety of products, interfaces and experiment designs have all found that prior experience is the leading contributor to intuitive use (Blackler, 2008; Fischer, Itoh, & Inagaki, 2014; Hurtienne, 2009; O’Brien, 2010), and intuitive interaction has become strongly linked with familiarity or prior experience (Blackler, 2008; Blackler, Popovic, & Mahar, 2010; Fischer et al., 2014; Hurtienne & Blessing, 2007; Hurtienne & Israel, 2007; Mohs et al., 2006; O’Brien, Rogers, & Fisk, 2008). Familiar features are used more intuitively, and people with higher Technology Familiarity complete tasks more quickly, with more intuitive uses and less errors (Blackler et al., 2010).

A product can have a high potential for intuitive use if it is designed to take advantage of experiential knowledge that is broadly possessed by its target audience. Two groups of intuitive interaction researchers developed distinct theory about the types of experiential knowledge accessed during intuitive interaction, and how designers could maximise an interface’s potential for intuitive use, yet there is significant overlap between these two models (Blackler & Hurtienne, 2007). The German-based Intuitive Use of User Interfaces (IUUI) Research Group presented a 'continuum of knowledge in intuitive interaction' (Figure 1, top) with types of experiential knowledge accessed during intuitive interaction based on their frequency of cognitive encoding and retrieval (Hurtienne & Israel, 2007). Our intuitive interaction continuum suggested the means by which intuitive use can be supported through design (Blackler, 2008), and is shown in Figure 1 (bottom) as it relates to IUUI’s continuum.

In IUUI’s continuum the most basic and broadly possessed knowledge identified is innate knowledge, which has genetic origins and manifests in responses such as reflexes. In our continuum the most accessible design strategy is to use physical affordances, which take advantage of embodied knowledge of the world established early in life. Physical objects have real affordances, like grasping, that are perceptually obvious and do not have to be learned. Their physical properties constrain what can be done with them. This fits within IUUI’s sensorimotor level, which also includes knowledge applied during basic analytical processes (such as determining direction or identifying faces). We classed the next level of knowledge as population stereotype, which relates to IUUI’s culture and sensorimotor levels and includes knowledge broadly possessed yet limited by societal bounds (such as different meanings for hand gestures or different directions for electrical switches between cultures). The level with the lowest frequency of encoding and retrieval in IUUI’s continuum is expertise, which is knowledge held only by those adept at a particular speciality (such as the knowledge a “power user” might apply to using a software package such as Excel). To enable
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intuitive interaction in this category, as well as the culture category, we suggested using familiar features from the same domain, but if there are no suitable familiar features, the designer may have to use familiar features from another domain. Familiar features tend to be perceived affordances, virtual objects like an icon button which invites pushing or clicking because a user has learned that that is what it does based on prior experience with similar things. Perceived affordance has therefore been placed on our continuum as being equivalent to familiar features (Figure 2). Finally, if the technology or context of use is completely new then designers can leverage metaphor to communicate the intended interaction. In this way both research groups highlighted how targeting different types of knowledge in the design of an interface might modify the potential for intuitive use.

Figure 1: The Intuitive Interaction Continua compared, adapted from (Blackler & Hurtienne, 2007)

Recently, Still, Still, & Grgic (2015) investigated two methods for eliciting three types of knowledge from users (affordance, convention and bias) for the purposes of designing intuitive interfaces for them. Two of these knowledge types corresponded to those on the continua (affordances = affordances, and conventions = population stereotypes). Through their experiment, they have provided empirical evidence for the existence of a continuum of intuitive interaction.

Hurtienne (2009) conducted a range of studies examining the role of image schemas in intuitive use. Image schemas are abstract representations of recurring dynamic patterns of bodily interactions that structure the way humans understand the world (Johnson, 1987), and thus are important building blocks for thinking. They are based on each individual’s experience of interaction with the physical world, but tend to be largely universal as the physical world operates in the same way for everyone. Because they are based on past experience, and because they are so well known and so universal that they become unconscious, they can be defined as intuitive. Therefore, Hurtienne argued, incorporating image schemas into interfaces can allow intuitive interaction. Through his research, Hurtienne (2009) demonstrated that metaphorical extensions of image schemas can be used in interface design, and that they do result in better performance. The effective use of image schemas and their metaphorical extensions is likely to facilitate intuitive use, because image
schemas are based on prior knowledge that almost every person possesses (sensorimotor knowledge on the continuum). Thus, performance using interfaces based upon image schemas should remain consistent across heterogeneous user groups, making them more ubiquitously applicable than familiar features, which may not be familiar to everyone and generally rely on experience with other products. Hurtienne, Klöckner, Diefenbach, Nass, & Maier (2015) later showed through further empirical work that an interface could also be designed to be innovative, inclusive and intuitive using image schemas.

Strictly speaking, a device or interface is not ‘intuitive’ in and of itself. However, the information processing applied to it can be (Blackler, 2008). Intuitive interactions are generally subjectively the correct action in the situation and can be faster due to the increased speed of subconscious over analytical processing. For these reasons, time on task and accuracy are common experimental measures for intuitive interaction. In the early intuitive interaction research intuitive uses were measured through objective performance metrics such as time to complete tasks and error rates, and researcher coding of intuitive and non-intuitive uses of features. Participants were also asked about what was familiar to them in test interfaces and previously (Blackler et al., 2011). Generally, subjective feedback on what was subjectively “intuitive” was not sought as, due to the non-conscious nature of intuitive interactions, such feedback was thought likely to be unreliable.

3.0 Newer approaches and ideas in Intuitive Interaction

Newer concepts in Intuitive interaction include issues of domain transfer distance and discoverability of underlying working of interfaces and features, as well as the application of intuitive interaction to new environments which include more affective aspects – e.g. toys, video games, public installations and gestural interfaces (Blackler & Popovic, 2015). Work is also ongoing investigating intuitive interaction with tangibles and mixed reality interfaces. Understanding exactly how all of these newer ideas relate to intuitive interaction is important to this field. This will allow designers to use the results of intuitive interaction research with confidence to create better interfaces.

Diefenbach and Ullrich (2015) presented an alternative framework for intuitive interaction, comprised of the four components of gut feeling, verbalisability (one of the commonly used criteria for coding intuitive uses (Blackler et al., 2011), effortlesssness (strongly linked to the kinds of performance measures previously used), and magical experience, and complemented by limiting factors of the product and the user. Although the model is made up differently, none of these potential properties of intuitive use are incompatible with those proposed in earlier work. Instead, they allow for a more subjective view on the part of users. Diefenbach and Ullrich tested the four components of the model and one of their limiting factors (domain transfer distance) through a large survey which presented various scenarios to respondents. Domain transfer distance relates to the distance of a new interface feature from the domain in which a user’s knowledge relevant to that feature is based, i.e. the distance between the domain to which a feature is applied and the domain
from which it originated. Features of an interface may be closer or further from their original source with which participants are familiar. They found that there was a high level of agreement about the four components of their model, and also that participants judged scenarios with a higher transfer distance as more appropriate representations of intuitive interaction. In other words, participants saw magical experience and gut feeling, which are the subjective experiences of high transfer interaction, as more typical of the subjective experience of intuitive interaction than effortlessness and verballisability, which are the kinds of objective experiences generally coded as intuitive in previous research.

Macaranas, Antle, and Riecke (2015) described an experiment in which they tested three different full body gestural interfaces to establish which mappings were more intuitive, one based on image schemas and two on different previously encountered features from other types of interfaces. They found that intuitiveness as measured by performance was not all that users wanted from a system. For example, if participants did not discover the interaction model behind the controls they felt dissatisfied. On the other hand, transparency of the controls also allowed users to engage more with the content presented through the system. Macaranas et. al. (2015) asked their participants about how well they understood both the operation of the system they had used during their experiment and the content presented through that system. The participants’ explanations revealed their conscious and explicit understanding of the controls and content. Macaranas et. al. (2015) therefore suggested that a subconscious understanding of the system (rather than conscious or explicit), enabled participants to focus their conscious attention on completing the tasks, not on learning to use or using the interface. They stated that:

> “Metaphoric mappings [based on image schemas] are perceived by the senses and represent previous knowledge subconsciously used. Conventional mappings [perceived affordances and population stereotypes] on the other hand are acquired through reflection and learning and represent previous knowledge that was consciously used. With metaphoric mappings, many who had high task scores still lacked an explicit understanding of how the system worked” (Macaranas et. al., 2015, p368).

So participants sometimes did not discover the workings of the interface but they still completed the tasks successfully. Presumably they used the image schema mappings intuitively (Macaranas et. al., 2015), but they were often dissatisfied and felt lower competence as they had not consciously discovered the workings of the mappings.

It is interesting that Macaranas et. al.’s findings on discoverability and transparency have some similarities with Diefenbach & Ullrich’s (2015) investigation into the subjective experience of intuitive interaction. The magical or mysterious experiences delivered by more implicit knowledge could be interesting to explore further, but Macaranas et. al.’s (2015) findings suggest that, for some applications, the experiences delivered by the options in the centre of the continua, where users may well have consciously “discovered” their origin by the end of the interaction, are a safer option for providing a usable interface. On the other hand, the ubiquitous and unconscious use of image schemas, physical affordances and population stereotypes may not be consciously noticed by users.
To us, the work of Diefenbach and Ullrich (2015) and Macaranas, at. al. (2015) suggests that where on the continuum the prior knowledge sits affects the subjective experience – e.g. physical affordance (sensorimotor) and even population stereotypes (culture) could be so engrained that they are subconscious, feel automatic and go almost un-noticed by the user, whereas metaphor, if done right, offers a potential route for increasing domain transfer distance and designing more subjectively magical experiences. In between, familiar features may make for a more measureable but more pedestrian experience. A feature with higher transfer distance could appear more mysterious because users may not consciously remember or be able to discover where their knowledge about it came from. Hence, because it is less known and somewhat unexpected in the context, it appears more magical. Therefore, subjective "magical" experiences of intuitive interaction may exist at the opposite end of the continuum than many objectively assessed intuitive uses.

Tangible User Interfaces (TUIs) and Natural User Interfaces (NUIs) have long been claimed to be more intuitive than other types of interfaces. They involve more everyday movements and gestures than many more traditional interfaces, which theoretically should place them at the lower end of the continuia (Figure 1). For example, they use physical affordances such as touching and grasping, innate responses such as turning towards a stimulus, population stereotypes such as shaking the head, and sensorimotor actions such as moving up and down. However, this assumed increased intuitiveness of TUIs had not previously been empirically shown.

Recently, we have shown that a tangible toy is indeed more intuitive than an intangible equivalent, as well as leading to more successful game play (Desai, Blackler, & Popovic, 2015). Intuitive uses were facilitated by high reliance of the tangible toy on physical affordances, as opposed to the intangible toy’s reliance on perceived affordances. We have found similar results when looking at a “mixed reality” (mixed tangible and intangible) toy, whereby the physical affordances of the toy were more intuitive to use than intangible aspects such as perceived affordances (Desai, Blackler, & Popovic, in press). This lends support to the claims that TUIs and NUIs have the potential to be more intuitive, but suggests that we need to design mixed reality systems carefully if we are to keep those benefits when entering the digital realm.

All these new ideas and approaches have exciting potential to grow the field of intuitive interaction and to inform designers of a variety of systems about how to make interfaces both engaging and intuitive. However, we need to understand how they relate to each other if we are to have a coherent understanding of how to apply intuitive interaction going forward.

4. Putting it all together

The implications of these exciting new directions are only now emerging and it can appear difficult to see exactly how all these ideas relate and so forge a way forward. However, one
response from those who developed initial theories could be to adapt and evolve the continua to include and explain these new ideas and approaches. Building on work done in the past which compared and contrasted the two separate continua of intuitive interaction (Blackler & Hurtienne, 2007) (Figure 1), an initial attempt to explore how these newer ideas relate to older ones is shown in Figure 2. Here, the continuum previously developed by us (Blackler, 2008) is shown alongside some of the new concepts that are currently being explored.

Thus, tangible interfaces mostly rely on physical affordances, whereas intangibles rely on the other aspects of the continuum, depending on the system and its design. Mixed reality systems could access all parts of the continuum, although it is perhaps unlikely that one single system will relate to all of them. Magical experiences appear to relate to increased transfer distance, and so are most likely to be induced by metaphors. At the other end, physical affordances appear to facilitate unconscious, transparent interactions which could be delivered with or without application of image schemas. Discoverable experiences would seem to be likely in the centre part of the continuum, where users are most likely to recognise the previous knowledge they are applying. Very simple and engrained knowledge such as physical affordances could pass unnoticed as it is so well used and so expected. A metaphor may be undiscoverable for a different reason – users may be able to apply the metaphor but unable to recall the source of their knowledge, which likely offers the highest potential for facilitating magical experiences. Metaphor has also been slightly distanced from the other parts of our original continuum. This is because it has become clear that it is not always a simple continuation from the other concepts and in fact could be applied in other ways than we originally assumed.

Finally, ubiquity of previous experience and potential for more people to be able to intuitively use a feature is highest at the lower end of the continuum and decreases from left to right. Metaphor is again a potential exception here as a very universal metaphor could be applied in some cases.

It should be noted that there will be exceptions to these examples, and this exercise is intended only as an aid to understanding at this point and does not present hard and fast rules. For example, we did find some use of perceived affordances with the tangible toy, but most of the overall uses and intuitive uses were facilitated by physical affordances. Similarly, physical affordances and metaphors could both be discoverable – we are simply speculating that, based on the evidence so far, they may be less discoverable than perceived affordances.
Figure 2: The Intuitive Interaction Continuum as it relates to new ideas in Intuitive Interaction

This work is intended to offer a starting point for more exploration of how all these factors interact and affect each other. It is not intended as a new continuum, but rather as an aid in understanding how newer concepts may relate to ideas in the existing continua. For example, “magical” is not necessarily opposed to “image schemas”, and although it may be non-compatible with “transparent” and “unconscious” we do not yet know if it is the actual opposite of one or both of them. As more research is done this framework may evolve further into a new continuum, or some other format. In the meantime it can aid understanding for researchers in the field as well as designers who want to make interfaces more intuitive.

Issues still to be explored and investigated include understanding more about how discoverability interacts with level of consciousness – there is presumably a relationship. Those functions which are “undiscoverable” may never become conscious. Finding the right balance between discoverability, intuitive use and subjective feelings of competence and satisfaction is a challenge which needs meeting. Could reducing the transfer distance increase intuitive interaction but also reduce satisfaction? Knowledge of some features could be so engrained they are not consciously noticed (they are transparent, like many physical affordances at the bottom end of the continuum), or the metaphor is so smooth it is not consciously noticed (at the top end of the continuum). What about metaphor which is not so well executed? Is that more discoverable and less transparent? Is that then more or less “magical”? Not every feature will have a perfect metaphor as not every function has a
very applicable source and/or target for metaphor, so those metaphors may be less smooth and more likely to be brought to a users’ consciousness.

Ideally, we would like to develop ways in which designers can provide both magical (subjectively intuitive) and unconscious (objectively intuitive) types of experiences for ultimate ease of use and engagement. To do this we would need to compare subjective "magical feeling" intuitive uses with unconscious and automatic intuitive uses. We could do this by manipulating the "transfer distance" for these features. Then we will be able to discover whether the feature uses we code as intuitive are the same or different to the ones the participants report as "intuitive" or magical. This would combine two distinct yet complimentary approaches to intuitive interaction research. While earlier approaches mainly focussed on how quantifiable prior knowledge contributes to intuitive interaction, performance parameters and related design principles, Diefenbach’s approach puts a bigger emphasis on the subjective experience of intuitive interaction and its different facets. An understanding of the differences these two types of “intuitive” uses (subjective and objective) would allow us to develop ways in which designers can create experiences which are subjectively engaging ("magical" as assessed by participants) as well as objectively simple and easy to understand ("intuitive" as coded by us) by using the right combination of features in an interface.

We also still need to explore how tangibility affects consciousness and “magical experiences” – and how it interacts with transfer distance. Tangibles are associated with low domain transfer distance as the origin of prior knowledge and the application of knowledge both relate to the same physical domain with spatial and material characteristics. Low transfer distance results in less verbalisation and effortless use of the interface (Diefenbach & Ullrich, 2015), which in turn is evident in intuitive use of tangibles. The result of low domain transfer distance in tangibles is that the spatial and material features are easily discoverable, which explains the high scores for intuitive use of tangibles in our tangibles study (Desai et al., 2015). Intuitive use of intangibles is associated with higher domain transfer distance as the prior knowledge is often acquired from the physical domain and transferred to the digital. In intangibles, then, the origin of prior knowledge and the application of that knowledge relate to different product domains with different technologies and different materials. However, does this mean that because physical affordances often have a very short transfer distance, they are lacking in “magical experiences”? Can the magic only happen when they are transferred to the virtual, when they are no longer physical affordances anyway but perceived affordances? Or is there a way to allow the “magical experience” with tangibles?

5. Conclusion

This paper has provided an overview of concepts in intuitive interaction research old and new, and made a start at bringing together the disparate ideas in order to foster better understanding of the various concepts. The framework presented is intended as a discussion point and a step towards further theory building in this domain, and brings together all of
the newer ideas within the context of the established work to help clarify understanding about what intuitive interaction is in all its incarnations, how and when it happens and how it can be facilitated. This will allow designers to apply the ideas with more confidence and better clarity, and researchers to build on the extant work in the field to develop it further and offer more comprehensive tools and recommendations to designers.

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