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Towards a Design Methodology for Applying Intuitive

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1.0 Introduction

The role of intuition in the way that people learn to operate unfamiliar devices, and the importance of this for designers, has been examined by these authors. Intuition is a type of cognitive processing that is often non-conscious and utilises stored experiential knowledge. Intuitive interaction involves the use of knowledge gained from other products and/or experiences (Blackler, Popovic, and Mahar, 2002; Blackler, Popovic, and Mahar, 2003a, b, 2004, 2005). Therefore, products that people use intuitively are those with features they have encountered before.

This position was supported by two initial experimental studies, which found that prior exposure to products employing similar features helped participants to complete set tasks more quickly and intuitively, and that familiar features were intuitively used more often than unfamiliar ones (Blackler et al., 2002; Blackler et al., 2003a, b). The definition of a feature, as the term is used here, is a function of a product that is discrete from others, has its own function, location and appearance and can be designed as a separate entity. A shutter button on a camera, a print icon on software and an earpiece on a personal stereo are all examples of features.

Technology Familiarity was an important variable in this work. It was determined using a questionnaire which asked participants how often they used certain products that had similar features to the product they would use during the experiments, and how much of the functionality of each product they utilised. Participants who had a higher level of Technology Familiarity were able to use significantly more of the features intuitively the first time they encountered them, and were significantly quicker at doing the tasks. Those who were less familiar with relevant technologies required more assistance (Blackler et al., 2003a, b).

A third experiment was designed to test four different interface designs on a universal remote control in order to establish which of two variables – a feature's appearance or its location – was more important in making a design intuitive to use. As with the previous experiments, the findings of this experiment suggested that performance is affected by a person's Technology Familiarity. Also, the results showed that appearance (shape, size and labelling of buttons) seems to be the variable that most affects the variables time on task and intuitive uses. This suggests that the cues that people store in memory about a product's features depend on how the features look, rather than where on the product they are placed (Blackler et al., 2004, 2005). It was also found that older people were significantly slower at completing the tasks and had significantly fewer intuitive uses (Blackler, 2006).

Previously, no-one had empirically tested the nature of intuitive interaction or linked intuitive interaction to the existing theoretical knowledge base. Three principles of intuitive interaction were developed, and a conceptual tool was devised to guide designers in their planning for intuitive interaction. Designers can apply these in order to make interfaces intuitive to use, and thus help users to adapt more easily to new products and product types. The principles and the tool are discussed in detail below.

2.0 Principles of Intuitive Interaction

The following principles were extended from those used as part of the re-design process prior to the third experiment (Blackler et al., 2003a). These principles are the foundation for the methodology reported in this paper. Numerous guidelines for detail design are available; for example, colour, placement of text and so on (for examples, see Wickens et al. 1998), but there are currently no guidelines that are directed explicitly at intuitive interaction. Although application of some existing HCI guidelines may help people to use things intuitively, without guidelines aimed explicitly at intuitive interaction, designers have no way of knowing whether or not they will do so in a particular situation. These principles are developed from empirical research into intuitive interaction and aimed explicitly at increasing its likelihood. They can be recommended as guidelines to help designers make an interface which is intuitive to use.

2.1 Principle 1: Use familiar features from the same domain

Make function, appearance and location familiar for features that are already known. Use familiar symbols and/or words, put them in a familiar or expected position and make the function comparable with similar functions users have seen before. Principle 1 involves employing existing features, labels or icons that users have seen before in similar products that perform the same function. This is the simplest level of applying intuitive interaction and uses features transferred from similar contexts.

2.2 Principle 2: Transfer familiar things from other domains

Make it obvious what less well-known functions will do by using familiar things to demonstrate their function. Again use familiar function, appearance and location. Principle 2 sometimes requires the use of metaphor to make something that is completely new familiar by relating it to something already existing. This principle requires transfer of features from differing domains (either different types of products or technologies or things from the physical world transferred to the virtual world). Emerging technologies like gestural interfaces and ubiquitous computing may require application of this principle as there is nothing similar enough to some of these interfaces to allow application of Principle 1. The desktop metaphor is a good example of this sort of metaphor successfully applied (Perkins, Keller, and Ludolph, 1997; Smith, Irby, Kimball, and Verplank, 1982).

2.3 Principle 3: Redundancy and internal consistency

Redundancy is essential in ensuring that as many users as possible can use an interface intuitively. This involves tactics like using visual and audible feedback, including written labels as well as symbols or icons, and providing different ways of doing things so that both novices and experts, and older and younger users, can use the same interface easily and efficiently. If one user is familiar with a word, another may be familiar with the corresponding symbol; or one user may be used to one way of navigating a device and another may prefer an alternative way. Providing as many options as possible will enable more people to use the interface intuitively. Redundancy is a basic and well known principle of interface design and applying it will help to make an intuitive interface accessible and flexible for more people.

Increase the consistency within the interface so that function, appearance and location of features are consistent between different parts of the design and on every page, screen, part and/or mode. Internal consistency is consistency within a system between its various parts. Keeping internal consistency allows users to apply the same knowledge and metaphors throughout the interface (Kellogg, 1989).

The only author to have offered anything similar to these principles in relation to intuitive interaction is Spool (2005). Spool used the terms *current* and *target* knowledge to refer to the knowledge that users already had and the knowledge they would need in order to use a product respectively. He came up with two principles for intuitive use. Firstly, a designer can design so that both the current knowledge point and the target knowledge point are identical. Here the user already knows everything s/he needs to use the interface because the designer has applied familiar features. This idea is similar to Principle 1. Secondly, the designer can design so that current and target knowledge points are separate, but the user is unaware of this as the design is bridging the gap. The user is being trained in a way that seems natural. This is similar to Principle 2 where metaphor is used to transfer knowledge from one domain or product to another.

However, Spool's (2005) work has not yet been developed any further or tested empirically. He has offered definitions based on his experience with user testing and his categorisations have similarities with those developed here, but his ideas are less rigorously based and do not offer tools by which designers can apply intuitive interaction.

2.4 Continuum of Intuitive Interaction

It seems likely that there is a continuum of intuitive interaction. A continuum was developed based on the principles explained above and related theories. Figure 1 places the various levels of interaction on the continuum in the context of intuitive interaction.

It is suggested that as the newness or unfamiliarity of a product increases, so too does the complexity of the designing required to make the interface intuitive to use. Very innovative products (or those based on very new technologies that have no established conventions) may require the application of features from other domains or metaphors, whereas familiar technologies or features can utilise familiar things from similar products, or even standard stereotypes and body reflectors. These terms are shown at the top of the continuum box. Other theories and terms (shown below) can also be seen as equivalent to the terms used by these authors. All of these terms, and how they link to each other, are discussed in detail below.

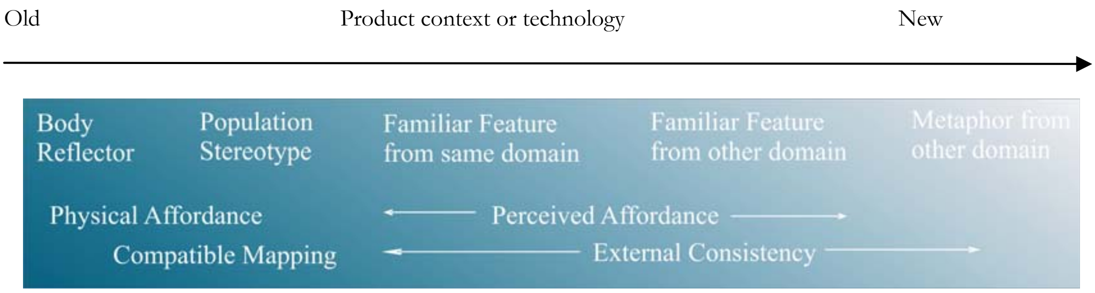

Figure 1. The intuitive interaction continuum including positions of other interaction theories

2.4.1 Body Reflectors

The continuum starts from the simplest form of intuitive interaction; body reflectors (Bush, 1989), which are based on embodied knowledge learned so early that it seems almost innate. Bush (1989) describes body reflectors as products or parts that resemble or mirror the body because they come into close contact with it. Examples include headsets, glasses, shoes, gloves and combs. He claims that humans are pre-disposed to perceive body images for evolutionary reasons. Therefore, designs which use body images should be more readily perceivable. Bush claims that it is not necessary to be familiar with a body reflector in order to ascertain its relation to a person; these forms are self evident in relation to people. Any person would be able to make the association whether familiar with similar things or not. This idea has also been discussed by Norman (2004b) in relation to physical, or real, affordances, which will be discussed further below. The simplest application of Principle 1 would be through real or physical affordances (Norman, 2004b), or body reflectors (Bush, 1989), which people can understand immediately, simply because they reflect their ingrained experience of embodiment in the world (Clark, 1997; Varela, Thompson, and Rosch, 1991).

2.4.2 Population Stereotypes

At a more complex level, intuitive interaction employs population stereotypes which are engrained from an early age. Humans have assimilated a large number of arbitrary, unnatural mappings from products that were not designed to be usable but that they use easily because they have learned to use them from a young age (Norman 1988, 1993). These population stereotypes derive largely from experience of cultural conventions.

They are just customs, but Smith (1981) claims that "expectations based on customary usage can be strongly compelling" (p306). Strong stereotypes are less vulnerable to stress, change of body position and use of the non-preferred hand (Loveless, 1963). Asfour, Omachonu, Diaz and Abdel-Moty (1991) found that when population stereotypes were conformed to, reaction or decision time was shorter, the first control movement the operator made was more likely to be correct, the operator could use the control faster and with greater precision and learnt to use the control more rapidly.

Population stereotypes have been studied since the 1950s (Smith, 1981). However, Simpson and Chan (1988) claim that many issues remained unresolved, and many recommendations are still based on work done during the 1950s. A lot has changed since then in terms of the population itself and the mediating products that produce the stereotypes, so the existing work is by no means unequivocal (Simpson and Chan, 1988). Some stereotypes may not be transferable to modern digital interfaces, but many others will.

2.4.3 Familiar Features

At the next level again intuitive interaction can work through similar features from the same or differing domains. There is general consensus about the importance of designing artefacts that relate to users' prior knowledge and familiarity, particularly in HCI, but with growing force also in design. The experiments conducted by these authors were based on the differentiation of familiar and unfamiliar features, applied from both similar and differing domains. All these experiments showed that familiarity with a feature will allow a person to use it more quickly and intuitively (Blackler et al., 2002; Blackler et al., 2003a, b, 2004, 2005). This is the foundational conclusion to come from this research and informs the principles and models which have been developed for designing for intuitive interaction. It is envisaged that familiar features from the same and different domains would be the main mechanism for designers to use in order to apply intuitive interaction.

2.4.4 Metaphor

At its most complex, intuitive interaction requires the application of metaphor, used to explain a completely new concept or function. Metaphor involves retrieval of useful analogies from memory and mapping of the elements of a known situation, the source, and a new situation, the target (Holyoak, 1991; Lakoff, 1987). Metaphors are grounded in experience and understood only in relation to experience (Lakoff and Johnson, 1981, p202). Each experience or vicarious experience can serve as a metaphor or analogue (Klein, 1998). Intuition is enabled by this sort of transfer. Using metaphor, a problem is transferred "…to a level where immediate intuition from experience is available" (Rasmussen, 1986, p123). Metaphor allows people to transfer knowledge between domains. When a person has relevant experience in a different domain, metaphors could be used to relate that knowledge to a new situation.

2.4.5 Affordances

Norman (1988) asserts that the thoughtful use of affordances and constraints in designs allows users to determine the proper course of action, even in a novel situation. Affordances have been much popularised and have been used to describe both physical and virtual interface objects (Preece, Rogers, and Sharp, 2002). Norman (2004a) admits that by popularising the use of the term affordance in the design community he deviated from Gibson's (1977) original definition. For example, he has generalised the term to include emotional, social, and cultural affordances.

However, Norman (2004b) has tried to clarify the situation by talking about perceived and real affordances. Physical objects have real affordances, like grasping, that are perceptually obvious and do not have to be learned. A physical object like a door handle affords actions because it uses constraints; its physical properties constrain what can be done with it in relation to the person and the environment. However, a virtual object like an icon button invites pushing or clicking because a user has learned initially that that is what it does. User interfaces that are screen-based do not have real affordances; they have perceived affordances, which are essentially learned conventions. This is a useful distinction – between "real" physical affordances that do not require learning beyond experience of being in the human body, and perceived affordances which are based on prior experience with similar things. Norman's (2004b) perceived affordance has therefore been placed on the continuum as being equivalent to familiar features from the same domain.

It seems likely that physical affordances which are based on basic constraints that are dictated by the human body can indeed be picked up directly by anyone with a normal physique, and could be archetypical. They are related to the body and what can be done with it, and the experience required to use them is limited to experience gained through being embodied in the world; there is no cultural knowledge or even experience with similar things necessarily required here. The physical affordance (Norman, 2004b) is therefore seen as being equivalent to and placed on the continuum below the body reflector (Bush, 1989): a very basic and easy to perceive fit with a part of the body, which people know and understand because of their lifelong experience of embodiment.

2.4.6 Compatible Mappings

It has been recommended that designers should exploit natural mappings, which are the basis of stimulus-response compatibility (Norman, 1988; Wickens, 1992; Wickens, Gordon, and Liu, 1998). Stimulus-response compatibility relates to the relationships of controls and the object they are controlling. It is important because a system with a greater degree of compatibility will result in faster learning and response times, fewer errors and a lower mental workload (Wickens, 1987; Wu, 1997). Responses are faster when the structural features of stimulus and response sets correspond and the S-R mappings can be characterised by rules (Proctor, Lu, Wang and Dutta, (1995) Wickens, (1992); Barker and Schaik, (2000) Norman, (1993). These rules (Wickens, 1992) seem to be drawn from population stereotypes to map the set of stimuli to the set of responses. The fewer rules have to be utilised, the faster the response time.

Movement compatibility defines the set of expectancies that an operator has about how a display will respond to a control activity and is largely based on the principle of the moving part (Roscoe, 1968, cited in Wickens et al., 1998), which states that movement should be analogous to the mental model of the displayed variable (Wickens, 1992). Ravden and Johnson (1989) also relate compatibility to similarity of the interface with other familiar systems and with users' expectations and mental models of the system. This highlights the fact that mappings are learned conventions and rely on past experience. Hence compatible mappings have been equated with population stereotypes on the continuum. Population stereotypes and compatible mapping have a similar level of intuitive interaction; they are completely ingrained cultural norms that are widely but fairly unconsciously known by the majority of a particular population.

2.4.7 External Consistency

Consistency is assumed to enhance the possibility that the user can transfer skills from one system to another, which makes new systems easier to use (Nielsen, 1989; Preece et al., 2002; Thimbleby, 1991). It improves users' productivity because they can predict what a system will do in a given situation and can rely on a few rules to govern their use of the system (Nielsen, 1989). Kellogg's (1989) framework distinguishes between internal and external sources of consistency. Internal consistency is consistency within the system. External consistency is the consistency of the system with things outside the system; for example, metaphors, user knowledge, the work domain and other systems (Kellogg, 1987).

Nielsen (1989) argues that the consistency of a device with users' expectations is important, whether those expectations have come from a similar system or something different. Koritzinsky (1989) states that a consistent interface would be predictable, habit-forming, transferable and natural (consistent with the user's understanding). The main point of consistency is to establish a behaviour pattern; similar physical actions in similar situations can establish habits and teach the end user what to expect (Koritzinsky, 1989).Both principles 1 and 2 involve applying external consistency. It can be seen as equivalent to applying familiar features or applying metaphors (Kellogg, 1987).

2.4.8 The Continuum and the Principles

Figure 2 demonstrates how the principles relate to the continuum of intuitive interaction. Principle 1 relates to the simpler end of the continuum, where body reflectors, population stereotypes or familiar things from the same domain are applied. Principles 2 relates to transferring things from other domains, including the use of metaphor. Principle 3, internal consistency and redundancy (represented by the dotted line), needs to be considered at all times and so it surrounds the other principles.

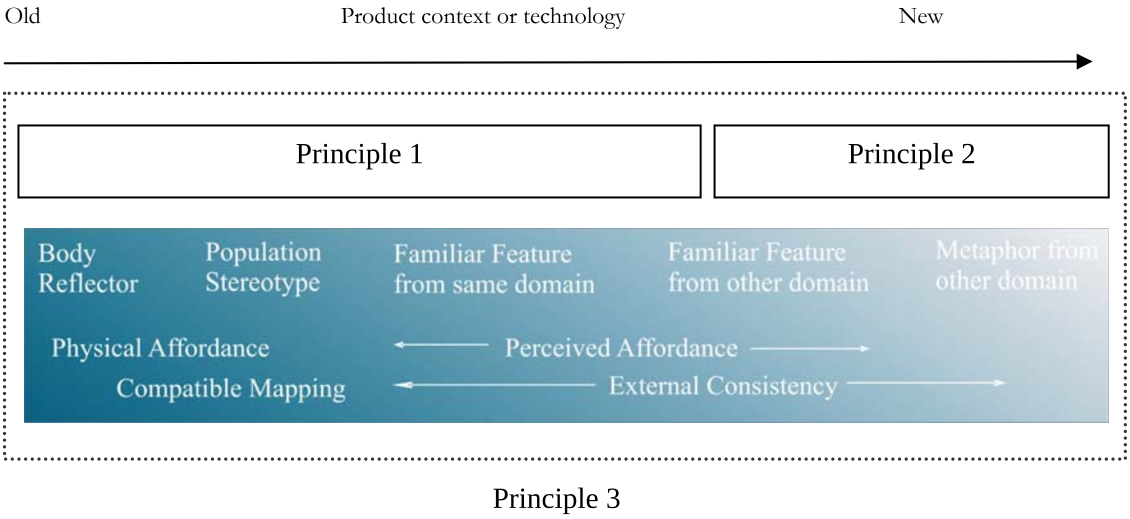

Figure 2. The intuitive interaction continuum as it relates to the principles

2.4.9 The Continuum and Technology Familiarity

Looking at this continuum, it may seem to make sense to say that as one moves along to the right, more Technology Familiarity would be required to use the interface. However, if the principles and tool suggested here are used, it should be possible to design an interface at any of these levels which people with differing levels of Technology Familiarity could use intuitively. For example, a metaphor or familiar feature from another domain may be more familiar to some than a feature from the same domain – depending on their experience with the various domains. Therefore, the continuum represents the complexity or recency of the product or technology but not the level of technology familiarity required to use it.

3.0 Conceptual Tool for Applying Intuitive Interaction

Figure 3 shows how the principles can be applied during the design process. The continuum (in a vertical orientation) is juxtaposed with an iterative spiral, which represents a design process with a variety of entry and exit points. The spiral is based around the three "factors" of function, appearance and location (Figure 4).

Consistency and redundancy are represented as a dotted line surrounding the spiral, as also shown in Figure 2. They should be considered at all times during the design process in order for design for intuitive interaction to be effective. Applying a similar type of familiarity to each factor of each feature is part of remaining consistent. This could mean, for example, that if the function of the feature requires a metaphor, that metaphor is also applied to the appearance and location of that feature, so that the metaphor remains consistent.

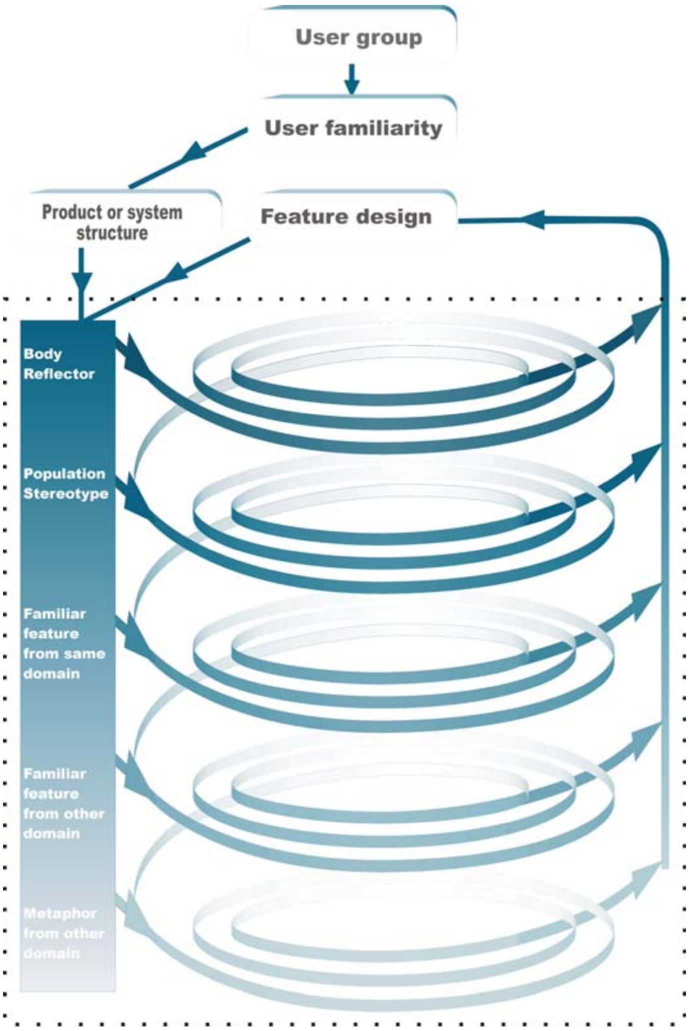

Figure 3. Conceptual tool for applying intuitive interaction during the design process

As indicated at the top of the diagram, before starting design, the designers need to establish who the users are and what they are already familiar with so that they know what stereotypes, features or metaphors would be suitable to apply. This task will be discussed in depth in Section 4.1.

Designers then need to go through the spiral twice. Firstly the structure or form of the system or product needs to be established. This would involve primarily establishing the various functions that need to be included in the interface or product, as until the functions are established nothing else can be done. Following that, overall appearance (look and feel or form) can be established, and finally, location of global features within the structure. Once this first stage is completed the spiral is entered a second time for the detailed design of each feature.

Each loop of the spiral has three layers. These layers represent the factors function, appearance and location (Figure 4). They are placed like this so that function is tackled first, then appearance and finally location. The factors are addressed in this order as that is the order of priority that has been established through this research. Appearance had more effect on intuitive interaction than location (Blackler et al., 2005), so appearance needs to be addressed before location. However, appearance and location cannot be determined for a feature that has no associated function, so function needs to be determined first.

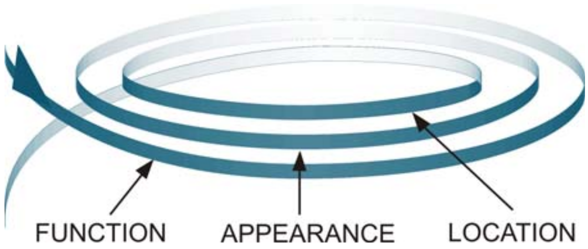

Figure 4. Detail of the three loops within each spiral.

The conceptual tool has been designed so that one can enter the spiral at a suitable point and leave it when necessary. As designers work down the spiral, they can establish the earliest point at which a familiar thing can be applied to that feature. For a simple interface, this may be a body reflector for a handle or a population stereotype for direction of a scale. For more complex interfaces, it would involve applying familiar features from similar or extra-domain products. For very new technology which has none of its own conventions, a metaphor which relates to something that is familiar to the users would need to be applied. The spiral should be exited at the point at which a suitable level is found.

However, it is also possible to enter the spiral further down if appropriate, especially after designers have worked through the first few features and have established where on the continuum they are working. Figure 5 shows an example of a designer entering and working on the continuum near the top (applying population stereotype). Figure 6 shows an example of a designer entering at the halfway point but then not finding suitable familiar features to apply, and needing to progress to the metaphor level.

Once the entire form or structure of the product and the design of all the features has been taken through this process, an appropriate level of familiarity based on things that target users already know will have been applied consistently throughout the design. According to all the conclusions reached though this research, working through this process should mean that the resulting product is intuitive to use.

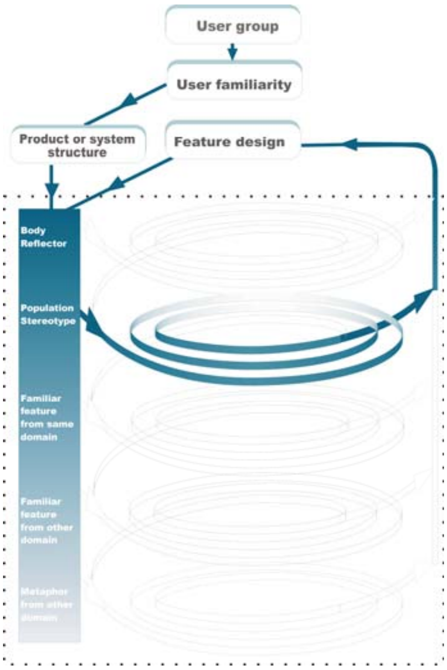

Figure 5. Working at the second level on the continuum

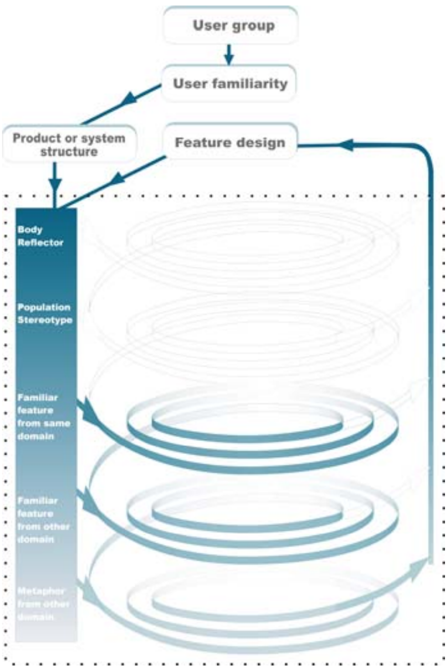

Figure 6. Working from the halfway point to the bottom of the continuum

4.0 Conceptual Tool Trial

This conceptual tool was trialled by asking an undergraduate industrial designer to apply it while designing a consumer product over a 10 week period. This project was undertaken as part of a vacation research scholarship scheme designed to encourage promising students to consider research degrees. He was asked to use the conceptual tool to design a digital camera, designing the form and the interaction of the camera, including menu functions, and using the model to look at function, appearance and location of each aspect in detail. He was also asked to evaluate the tool at the end of the exercise. He kept a log book during the design process and produced a report at the end detailing his experiences with using the tool and his evaluation of it.

The designer found that the tool forced him to spend a great deal more time researching and analysing the intended users than he would otherwise. He found this frustrating at first, but with some persistence began to see its benefits. He stated that usually he would have gone straight to researching the field of information based on the product he was designing but the model encouraged him to gain an understanding of information related to other products that the user group would already be experienced with.

The designer searched the literature for current trends in digital cameras and their users and buyers. He found that many digital camera buyers already had experience with camera phones. Many new digital camera users are first becoming used to the idea of digital photography through using camera phones, and then buying digital cameras because they desire better picture resolution (PC_Magazine, 2005). He then used a detailed product review to investigate existing digital cameras and mobile phones in order to establish the function, location and appearance of each feature relevant to digital camera design. The results from this product review were used to decide which features should be transferred to the new camera from existing cameras and camera phones.

The designer believed that this adjustment to his research method allowed a minor breakthrough to be achieved for digital camera design. By looking at the other products that the intended user group interacted with, he was able to include key aspects of products they would already be familiar with (for example, the use of soft keys transferred from mobile phones), and include them in the design to enable it to be used more intuitively. This is something that he did not believe he could have done if he had followed his usual design process.

However, the designer felt that the significance of the research component was not conveyed by the tool in its current form. The research component takes up only a very small portion of the page when viewed in comparison with the five levels for feature design, which does not accurately portray the importance of these two initial steps. He suggested that these two steps be adjusted so that they have greater presence on the page, and perhaps even extrapolated so that they give a more detailed description of what processes may be involved. The literature relating to this stage is reviewed below.

4.1 Establishing Familiarity for Various User Groups

As the trial demonstrated, "…making design decisions about familiarity is not always simple" (Rosson and Carroll, 2002, p121). Familiar terms can have multiple meanings. Also, familiarity to one user is not familiarity to others. Even translation may not achieve the same level of familiarity in another language. In order to design a product to facilitate intuitive interaction, designers need to carefully identify the target market for the product and establish what features target users would be familiar with. Metaphors should be selected for their appropriateness to the target market and should be matched to the experiences and capabilities of typical users (Smith, 1998). Many designers believe icons have more universal familiarity than labels as all users live in the same visual world, but even then items can look different. For example, mailbox icons commonly used for email were based on US rural mailbox designs which are not seen in many parts of Europe. It takes some careful research to make sure the familiar features chosen are going to be understood by all users. A localisation process may also be necessary for products released internationally.

Spool (2005) favours field studies for identifying the user's current knowledge. Watching potential users in their own environment and working with their normal tools and tasks reveals their knowledge and the upper bounds of it. For identifying target knowledge he recommends usability testing. After a test it is possible to list all the knowledge the user needed to acquire during the test. Spool found during his user testing that groups of users form clusters around the various current knowledge points. This could lead to a way of better defining target users and what they know, but he does not explain exactly how it is done. He does say that design teams can work with users in the middle of the important clusters and this helps them to define personas. Personas were often linked to lifestyle in the past, but here is real and useful link to prior experience that could be used to allow intuitive interaction.

Margolin (1997) also discusses how designers can gain more knowledge about users. He suggests that designers gain such knowledge from their own experiences as users, from communities or subcultures of users (e.g. Internet forums or clubs), and from market research. However, none of these are really enough as they stand at present, and designers do not currently have enough information about people and products to create products that better represent the desire for a satisfying world (Margolin, 1997). Designers do not have enough information to go on when developing new products, and Margolin sees a need for large scale research on the subject of product use.

Preece et al. (2002) argue that it is imperative that representative users from the real target group be consulted, and recommend that designers start with an understanding of how people use similar products, even if the product they are designing has no exact equivalents. When introducing a new product type (their example is the introduction of the mobile phone), it may not be possible to study people using them; but there are predecessor products (e.g. standard phones) that can help to inform designers about users' behaviour with similar products. Preece at al. (2002) mention the need to find out about the tasks users currently perform, their associated goals and the context in which they are performed. They recommend a combination of naturalistic observations of users' existing tasks, questionnaires, interviews, focus groups, user participatory design workshops and studying documentation in order to find out about users' behaviour with similar products and their aspirations for the new one. Of these, observation seems to be the method they most favour; this, they say, gives insights that other techniques cannot, and they emphasise that the day-to-day use of products will differ from the procedures set out in the documentation.

Legacy systems have some advantages here as they may provide some features to draw on. For new-generation product design, it is helpful to understand the typical tasks performed with several of the antecedent products (Smith, 1998). There may be more than one of these if a new device merges tasks previously done with different products. Rohlfs (1998) describes re-design of legacy software applications. He uses current and new users' experience with an existing application (or similar products and/or applications), and also their familiarity with the task to be performed, to inform a new design. He converts this sort of information into a current task definition which describes how users currently perform the tasks. Understanding how the tasks are currently performed provides an important foundation for the design process. It allows designers to maintain the aspects of current tasks that work well, and to identify which features are well-used and would be suitable to transfer to new interfaces.

There is certainly an opportunity for further research to establish which user groups have familiarity with which types of features. Whatever tools are used, it is clear that establishing the knowledge that users already have is an important step in selecting familiar features to design into a product.

5.0 Conclusion

This paper has provided an overview of the extensive research into intuitive interaction, presented conclusions and recommendations from the research. Further, it has showcased a proposed tool for applying intuitive interaction to the design process and also revealed some early results from the trialling of that tool. Intuitive interaction has been shown to be based on familiarity with similar features in an interface, and the tool developed has been used in a trial situation to facilitate the design of product features which are intuitive in their function, appearance and location. This work is moving towards a more fully developed design methodology for intuitive interaction. With this aim, future work will concentrate on a range of areas, as discussed below.

The tool is proving useful in a pedagogical setting but more research needs to be done in order to establish reliable ways of discovering what types of features are likely to be familiar to particular market segments. The top section of the model then needs to be adapted accordingly. Currently work is underway on further extrapolating the "user group" and "user familiarity" boxes and undertaking further testing of the tool with a group of postgraduate designers. The technology familiarity questionnaire developed as part of this research has also been applied and adapted by the students to the purpose of discovering more about what the users groups are familiar with. This seems to have been a successful exercise but the project is still ongoing. User testing of the students' designs will be used to establish the effectiveness of the tool in this case. The tool will then be further refined and finally it will be tested with designers in industry to establish its applicability in the real world.

Detailed methods to establish which features are familiar to particular user groups need to be developed so that these principles can be applied successfully to all types of artefacts for many groups of users. There is also a dearth of research into stereotypes for new and digital products, and this research has highlighted the need for that to be addressed.

Age and its relationship with intuitive use is an area that warrants further study. It would be helpful to see how this relationship can be explained and to establish what designers can do to help older people to use things more intuitively.

The location of features was shown to be much less important than appearance (Blackler, 2006; Blackler et al., 2004), and the way in which appearance and location of features are varied to different extents in existing interfaces would seem to explain this. However, qualitative data and work on response times (e.g. Pearson and van Schaik, 2003) would suggest that location does make some difference to the speed of sub-tasks. Eye tracking studies may reveal more about intuitive search behaviour of users.

It was not possible to investigate the effect of colour and the stereotypes related to it as part of this research due to the limitations of the products used. Software or reconfigurable colour touch-screen-based devices could be used to mediate this kind of investigation.

The application of these principles to other areas of design, such as software, would be a useful contribution. There are many overlaps and shared metaphors between digital devices and computer software so similar principles should be applicable.

As has been demonstrated, there is potential for further work in this area. However, this research has put in place a set of principles and conceptual tools and has established a foundation for the study of intuitive interaction, and gives future researchers in this area a solid basis from which to work.

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