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ORIGINAL ARTICLE

Intuitive interaction with multifunctional mobile interfaces

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Abstract This paper investigates intuitive interaction in the context of mobile phones. The aim is to identify what creates an intuitive interaction with an interface and therefore analyse how features may be designed to maximise the probability of an intuitive interaction. Three experimental studies were conducted. The first study recorded participants' interaction with unmarked mobile phone button schematics with the aim of relating intuitiveness of interaction to the gestalt laws. It was demonstrated that intuitive interaction is facilitated when interfaces have layouts designed using the gestalt laws. The second study compared interactions using touchscreen and button phones to evaluate the significance of the touchscreen. It was found that participants who had never owned a touchscreen handset were still inclined to utilise the experiential knowledge of existing handsets for all of the tasks performed. The final study used the Immersion® CyberGlove® to record participants' interactions with a prop in place of a touchscreen phone when carrying out various tasks. The aim was to determine which image schemata were prevalent in the use of a touchscreen handset. Six image schemata were identified, and it was concluded that these image schemata could improve the efficiency of inclusive design if taken into account. This research suggests that individual image schemata can be related to the continuum of knowledge sources in order to create design solutions that take advantage of the user's basic sensorimotor experience.

1. Introduction

Recently mobile phones have evolved into much more than communication devices, with touchscreen smart phones becoming more affordable and powerful. Consumers are using mobile phones to perform tasks that previously would have required laptop computers. With an ever-growing number of features incorporated into these devices, it is becoming increasingly necessary for designers to consider intuitive interaction when designing new handsets.

'Intuition' is defined as "the power of knowing or understanding something immediately without reasoning or being taught" (Oxford, 2005). In the context of mobile phones, this definition can therefore be interpreted as the ability to attain knowledge about using an interface without intervention of the use of reason. An intuitive decision would therefore consist of the identification of various patterns relating to the dynamics of the present situation. These unconscious decisions could be affected by a person's age, previous technological experiences, and cultural differences. The fact that they could vary

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from person to person so greatly complicates the intuitive design of products. With this in mind, mobile phone designers must engineer every aspect of their products from the size and shape of a device to the positioning of items in menus to meet the criteria necessary to make them intuitive.

Many of the modern phones currently on the market have touchscreen interfaces, all of which have very similar designs. In 2008, 23% of all mobile phone sales were touchscreen smart phones, compared to only 13% in 2007. The figure had risen to above 45% by May 2010 (Mfyall, 2010). There could be any number of reasons for the growing popularity of these devices, including fashion trends, marketing techniques or plummeting device costs; however, it is likely that the touchscreen allows for new ways in which users can interact with handsets intuitively. The increasing market share of touchscreen smart phones makes them an area of interest with regard to intuitive design.

As intuition is not a physical or tangible variable, experimental procedures and technologies from many fields, such as psychology, science and ergonomics may be required to implement a suitable study. Such a study would be continuous as each individual would have different experiences and, hence, a different level of intuition. This is not to suggest that it is impossible to define a set of parameters which would be intuitive to all, but perhaps that this level of intuition would be too basic to be implemented solely into an interface without some level of learning required for a completely effortless interaction. Furthermore, varying patterns of intuition may be exposed between generations and cultures, possibly resulting in different salient directions of intuition between groups or populations.

This paper reports research investigating the impact intuition, as a psychological phenomenon, has on the way consumers interact with mobile phone interfaces. The aim is to identify what creates an intuitive interaction with an interface and thus analyze how features may be designed to maximize the probability of an intuitive interaction. The significance of the touchscreen will be investigated using three experimental studies to determine how people intuitively react when given tasks to perform on mobile phones. Investigations will be made into what makes an intuitive design and how to increase the chances of intuitive interactions between first-time users and complex smartphones. Furthermore, the possibility of improving the design process of mobile phones using cognitive theory will be explored. Comparisons will be made between touchscreen interfaces and more conventional button layouts.

The paper is organized as follows. Section 2 outlines research in design for intuitive use. Section 3 introduces the experimental procedures employed and the main hypotheses tested. Section 4 contains results and a discussion of the findings. Finally, Section 5 concludes the paper.

2. Literature review

2.1. Intuitive interaction

Intuitive interaction is generally understood as an experience wherein a user can immediately use an interface successfully, and furthermore, the interface does what the user expects (Spool, 2005). In a recent comprehensive review of research investigating intuitive interaction, Blackler et al. (2010) define intuition as a type of cognitive processing that utilizes knowledge gained through prior experience. They describe it as a process that is often fast and non-conscious, or at least not recallable or able to be described verbally. In this work, Blackler and her colleagues completed a number of studies with 20 test subjects who were timed while performing tasks on a touch screen television remote. Their device familiarity levels were assessed through surveys. The studies showed a clear correlation between experience level and the time taken to complete the task, indicating that intuition in the context of technological interfaces is closely linked to experience. This result directly contradicts the Oxford English Dictionary's definition of intuition, which insinuates that for a product to be truly intuitive, it must be understood immediately by its user without having ever been taught. For this definition, a truly intuitive product would be operated just as quickly by an inexperienced person as an experienced person. Blackler also concluded that older people used products less intuitively. Intuitive interaction with products therefore involves utilizing knowledge gained through other products or experience(s) to perform a task productively. Intuitive interaction with an interface in this instance is taken by the author to mean an interaction in which proficiency in the interface's key functions is gained with minimal cognitive processing power and is therefore within the smallest possible time frame. An intuitive interface should consist of a number of intuitive applications allowing multiple intuitive interactions to take place when performing a varied array of tasks.

Langdon and Clarkson (2007), like Blackler et al., produced studies that showed intuitive use is significantly affected by age and cognitive ability. This result can be partly attributed to function and partly to design. Langdon and Clarkson stated that design engineers working on these products are for the most part young, technologically experienced males who may neglect older generations.

The methodological tools developed in these investigations include the continuum of prior knowledge (Blackler and Hurtienne, 2007) and the continuum of intuitive interaction (Blackler et al., 2006).

The continuum of prior knowledge (Blackler and Hurtienne, 2007) indicates that prior knowledge acquired before interaction with the new product comes from a variety of sources: knowledge, embodied interaction, culture, expertise, and use of tools. The higher up on the continuum, the smaller the potential number of users possessing this knowledge becomes; while lower level knowledge is more widely available. These lower levels are more likely to be applied unconsciously and therefore intuitively.

The continuum of intuitive interaction (Blackler et al., 2006) outlines three principles for creating an intuitive interface: (i) use familiar features from the same domain, (ii) transfer familiar things from other domains, and (iii) increase redundancy and internal consistency of function, appearance and location within the interface. Furthermore, each principle is linked to a set of terms. The first principle, for example, involves applying existing features, symbols and icons from the same domain and putting them in a familiar position. The second principle relates to the use of metaphors and familiar functions from other domains. The third principle involves using visual and audible feedback, and providing alternative ways of accomplishing a task so that both novices and experts, as well as older and younger users, can use the same interface easily and efficiently. Keeping internal consistency allows users to apply the same knowledge and metaphors throughout the interface.

Similarly, Mohs et al. (2006) have defined a number of principles for designing intuitive interfaces. These include: suitability for the task, compatibility, consistency, gestalt laws (how the mind groups similar elements together based on their shape, color, size and brightness), feedback, self-descriptiveness, and affordances. Some of these principles are related to the use of image schemata.

2.2. Cognitive ergonomics: image schemata and gestalt laws

Johnson (1987) defines an image schema as a mental pattern that recurrently provides a structured understanding of various experiences. He describes it as "a dynamic pattern which functions somewhat like the abstract structure of an image and thereby connects up a vast range of different experiences that manifest this same recurring structure." His list consists of twenty-seven individual schemata, including center-periphery, containment, cycle, path, force, link, part-whole, scale, and up-down schemata. The up-down schema, for instance, was described by Johnson to form the basis of "thousands of experiences and perceptions we experience every day, such as perceiving a tree, our felt sense of standing upright, the activity of climbing stairs, forming the mental image of a flagpole, measuring children's heights and experiencing the level of water rising in the bathtub." Table 1 shows image schemata as further categorized by Langdon and Clarkson (2007).

Much study of image schema stems from research in linguistic expressions (Johnson, 1987; Macaranas et al., 2012). The words used to describe especially metaphorical features act as a gateway to the structure the brain has composed to store the corresponding information. It is important to note that the term 'image' in image schema is not an image that can be drawn or be shaped in a three dimensional world. An image schema does not have the rigidity or specificity of a picture or structure, but consists of parts that can be flexed and sculpted in an infinite number of ways, sometimes interacting with other image schema, to align with perceptions, 'images' and events.

Recently, Hurtienne and Israel (2007) suggested the application of image schemata and their metaphorical extensions to the design of intuitively usable interfaces. Conceptual metaphors extend embodied schemata to structure and organize abstract concepts (Antle et al., 2009). On creating an interface, its perceived structure should try to fit as closely as possible to the mind's image schemata. It would appear that the most relevant schemata for an interface are the cycle schema, path and end of path schema and verticality schema, while the ergonomics of the interface (e.g., buttons, etc.) will apply to link schema, force schema and scale schema (especially with touch sensitive control).

Further studies indicate that configurations and patterns can be applied to image schemata (Hurtienne et al., 2008), thus benefiting from the ability of the mind to group elements when perceiving objects. Theorists reject the assumption that organization is the product of learned relationships, but argue that perception itself is a basic experience. This approach focuses on the idea of the mind 'grouping' elements to perceive objects. The five principles, often called gestalt laws, applied in product design are proximity, similarity, closure, symmetry and common fate. Buttons, for example, grouped together are perceived as having similar functions. These theories indicate that to teach a mind how to use something, it is the information presented to it that will determine its success. As discussed in two previous papers (Marsh and Setchi, 2008; Britton and Setchi, 2010), the success of this information resulting in the 'correct' cognitive response lies in the similarity of the image schema formed while receiving information and the image schema used to implement interaction. Image schemata are flexible structures for the mental organization of experiences and comprehension.

The choice of mobile phones as a platform to study intuitive interaction is motivated by the understanding that interaction with mobile phones is a cognitively demanding task, as evidenced by a recent study which found that cognitively related actions with mobile phones are more difficult to perform than perceptual or motion actions (Langdon et al., 2010).

Table 1 Image schemata (as categorised by Langdon and Clarkson, 2007).

Group	Image schema
Basic	Object, substance
Space	Centre–periphery, contact, front–back, left–right, near–far, path, rotation, scale, up–down
Containment	Container, content, full–empty, in–out, surface
Multiplicity	Collection, count–mass, linkage, matching, merging, part–whole, splitting
Process	Cycle, iteration
Force	Attraction, balance, blockage, compulsion, counterforce, diversion, enablement, momentum, resistance, restraint removal
Attribute	Big–small, dark–bright, heavy–light, straight, strong–weak, warm–cold

3. Experimental procedures and hypotheses

Three experiments are described in this section: a button schematic test, a smartphone comparison test and an image schemata test.

3.1. Experimental design

The experiments included common tasks which were purposefully chosen in order to gain more consistent results. It is likely that if the tasks involved more complex functions, the results would have been more varied making it difficult to draw reliable conclusions. All participants were students at Cardiff University between 18 and 25 years of age. It has previously been proven that intuitive use is significantly affected by age (Langdon and Clarkson, 2007; Blackler et al., 2010). Therefore, the new experiments were designed to compare interaction with devices and identify specific image schemata while controlling for the effect of age on intuitive interaction. The tasks were all performed in the same room with only the participant and the experiment administrator present. A quiet room was used to keep noise distraction to a minimum.

The aim of the first experiment was to determine what keys, or areas of a traditional mobile button phone schematic are most commonly viewed when used for specific tasks, to analyze the basic functions of traditional button layouts, and to determine what aspects of key shape/positioning affect an intuitive interaction.

The aim of the second experiment was to gain an understanding of what aspects of touchscreen smartphones make them more intuitive or more difficult to use. The three tasks chosen were deemed a sufficient gauge of interaction with the fundamental functions of each interface.

The third experiment was designed to analyze which of the image schemata shown in Table 1 are utilized in the cognitive process of performing certain tasks on a touchscreen smartphone. The test was carried out using a right hand glove, introduced later in this paper, as it is assumed that the majority of participants would use their right hand when operating mobile phones and devices. This should increase the likelihood of the unconscious use of image schemata. Left-handed participants were disallowed from the experiment to allow for more uniform results. The subjects were instructed to operate the device solely using their thumbs while the rest of the hand supported the prop. This simplified the experiment, as only the thumb vectors needed to be graphed for each recording.

3.2. Button schematic test

3.2.1. Experimental procedure

The experiments involved a visual test with two schematics of simplified button configurations: one based on a Nokia system, and the other using a *Sony Ericsson* system (Fig. 1), which also holds similarities to Motorola and Samsung systems along with the iPod. Eight subjects took part in this experiment which was recorded with a digital camera. Participants were informed about the scene in front of them: *"You have in front of you a simple schematic of a phone facia. The visuals, key notation and screen interface are entirely that of your choice. You are currently at your 'home' screen with a locked keypad."*

The participants were then asked to perform the tasks listed below, on each configuration one at a time, using the schematics in any way they saw fit.

T1.1. Unlock the key pad.
T1.2. Press the 'menu' button.
T1.3. Open the 'text message' folder and select 'write new message'.
T1.4. Go back to the 'home' screen.

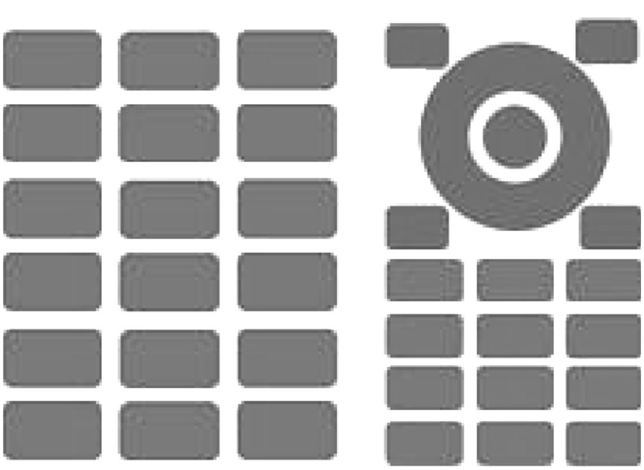

Figure 1 Button schemata test: schematics used in the experiment.

T1.5. Key in the number 07856.
T1.6. Delete the 6 and type a 2.
T1.7. Delete all 5 numbers.
T1.8. (Are you at the 'home' screen?).
T1.9. Find your contacts.
T1.10. Scroll down 5 names.
T1.11. Scroll up 3 names.
T1.12. Call this number.
T1.13. Hang up.
T1.14. Lock the key pad.

The results were used to detect any consistency in the areas used for locking and unlocking the keypad, menu, select, back, number keys, delete and scroll down, scroll up, call and hang up.

3.2.2. Hypotheses

The following hypotheses were tested in this experiment:

H1.1: The Nokia schematic may cause more inconsistencies than the *Sony Ericsson* schematic as the only variable in the former is position, with identically sized and shaped keys, thus removing most of the gestalt laws.
H1.2: The bottom keys will be used only for number typing whereas the top group will be used for interface manipulation, without any cross over. This will be due to the clear divide between the regular shaped keys at the bottom and those above.

The results from this test are expected to indicate broad similarities in desired positions of keys only. The round shape in the top central position of the *Sony Ericsson* schematic bares a far closer resemblance to the items from which this schematic has been derived, and may cause initial recollection of past experiences with such items. If this is the case, it is expected that each test on this schematic will result in similar patterns of interaction.

There is an expectation that some participants may use the circular shape as a 'wheel', in a similar manner to the classic iPod. None of the mobile phones widely available on the market have used this system. However, the iPod has become an iconic example of a portable electronic device, and some subjects may make this link.

3.3. Smartphone comparison test

3.3.1. Experimental procedure

Thirty participants were timed completing various tasks using both a touchscreen smartphone and a conventional button layout smartphone. The phones used were the *Apple iPhone* (touchscreen) and the *Nokia N*95 (button). The phones were unlocked before the tasks took place. The contact and the dates to look for in the calendar were predetermined and remained constant for all tasks on both phones. The participants were timed completing each task and also observed in order to note any of the key problems they faced. None of the participants observed each other partaking in the experiment so that first time users of the phones remained unaware of their functions. A questionnaire was completed by each participant prior to the experiment which highlighted any experience with a smart phone of either brand. Eleven of the participants were experienced *Nokia* users while 5 were experienced *iPhone* users.

These data were taken in order to compare experiential knowledge with interaction time.

The participants were asked to complete the following tasks:

T2.1. Contacts task: from the main menu, enter the contacts menu and phone a predetermined contact.
T2.2. Text message task: from the main menu, enter the messages menu, create a new text message addressed to a predetermined contact and write the message 'hello, how are you?'
T2.3. Calendar task: starting at the main menu screen, determine what is scheduled on a specific date via the calendar application.

3.3.2. Hypotheses
The following hypotheses were tested in this experiment:

H2.1. Participants will enter text messages more quickly using the *iPhone* than a button phone due to the presence of a full QWERTY keypad.
H2.2. Participants who own or have owned the *iPhone* will perform the tasks more quickly than participants who own or have owned a *Nokia* due to the assumption that the *iPhone*'s touchscreen allows for a more intuitive interface.
H2.3. It is expected to be a significant gap between experienced users of the *iPhone* and first time users.

The *iPhone* operating system remains a relatively new interface. If this hypothesis is proven to be accurate it will verify previous findings relating experience to intuitive use. This should also mean the longest time recorded for each task is likely to be for the *iPhone*. It is likely most of the users will have had much more relevant experience with phones with interfaces similar to the relatively conventional button layout of *Nokia*.

3.4. Image schemata test

3.4.1. Experimental procedure
A prop of similar weight and size to a touchscreen smartphone was given to the participants. Participants were asked to perform three tasks while wearing the Immersion® CyberGlove®, which recorded the vector movements of their thumbs while performing the tasks. The glove was connected to the computer using a 25 pin parallel port. The data collected from the glove were recorded using Autodesk® MotionBuilder®. An algorithm was written using Matlab™ to provide 3D vector graphs for each recording. The tasks given were as follows:

T3.1. Scroll through the contacts menu
T3.2. Unlock the mobile phone
T3.3. Enter the main menu

For each task, subjects were asked to position their thumbs at the bottom center of the device before the recording began. The participants were told to assume the phone was already unlocked for tasks 1 and 3.

Three of the participants currently owned a touchscreen phone. None of the remaining participants have owned one in the past.

3.4.2. Hypothesis
The aim was to explore if image schemata are formed when performing certain tasks on touchscreen devices. Even in the absence of any buttons or features, people will automatically move their thumbs according to how they would expect to operate existing devices. Participants who own or have owned touchscreen mobile phones are expected to have molded image schemata in their minds, which predetermine how they react when given a task to perform. The following hypotheses were tested:

H3.1: The most common movements performed will emulate the features of the smartphones with highest market share at the time of the experiment.
H3.2: In attempting to access the main menu of a phone, there will be a clear movement to the bottom center of the mobile phone where the menu or home button occurs in the majority of touchscreen mobile phones available at the time of the experiment. An image schema identifiable with this preconception would be the near-far schema.
H3.3: In attempting to unlock the mobile phone, a large proportion of participants will perform a swiping action across the screen. The left–right or up-down schema will be easily identifiable if this is the case.
H3.4: When scrolling through a list, it is expected that participants will swipe up the screen in the positive Y direction. The cognitive processes used are expected to involve the momentum schema when swiping in order to produce a motion and the up-down schema identifiable with lists.

4. Results and discussion

4.1. Button schematic test

Eight subjects took part in the visual experiment. On average, the experiment took a total of 10–15 min for each participant to complete. All subjects carried out the tasks on both schematics.

The hypothesis stated that there would be more inconsistencies for the *Nokia* keypad than for that of the *Sony Ericsson*. As expected, the *Nokia* schematic had a success rate of 50% for the correct interaction being carried out for the respective task while the *Sony Ericsson* scheme achieved 61%. Fig. 2 shows the results for task T1.1 "unlock the keypad" while Fig. 3 shows the execution of task T1.2 "press the menu button". The color scheme and the numbers indicate how many participants used the same pattern.

It was hypothesized that the top group of keys would be used for interface manipulation. It is evident from the results that participants clearly used the top keys for manipulation and the lower keys for number typing. These top buttons are generally used to interact with the software of the phone, while the lower positioned number pad is used almost exclusively for numbers and text when composed of identically sized and shaped keys in a 3×4 arrangement.

4.2. Smartphone comparison test

Table 2 shows the statistics recorded for each task performed on each phone in this experiment. Table 3 shows the average

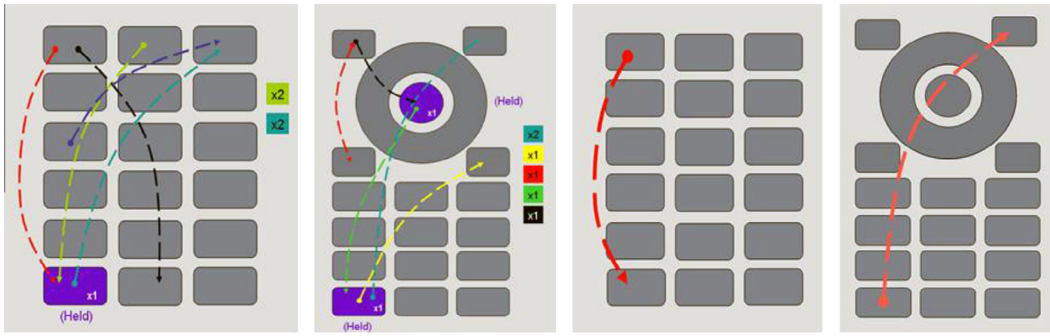

Figure 2 Button schemata test: task T1.1 "Unlock the Keypad".

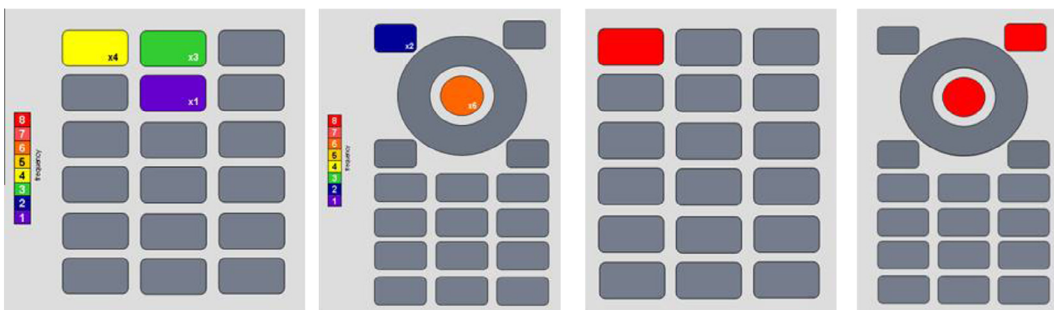

Figure 3 Button schemata test: task T1.2 "Press the Menu Button".

Table 2 Smartphone comparison test: experimental data.

	iPhone			*N95*		
	T2.1	T2.2	T2.3	T2.1	T2.2	T2.3
Average time taken (s)	27.0	70.2	9.8	10.4	41.5	21.9
Minimum time taken (s)	5	13	4	6	7	7
Maximum time taken (s)	84	284	33	21	54	36
Range (s)	78	252	29	15	47	29

Table 3 Smartphone comparison test: data for experienced users.

	iPhone			*N95*		
	T2.1	T2.2	T2.3	T2.1	T2.2	T2.3
Average time taken (s)	12	26	7	7	36	19

time taken to complete each task by experienced users who own or have previously owned either phone.

The most noticeable observation is the difference in the ranges for each task between different users for the *iPhone* and the *Nokia*. For the contacts test, the range was 63 s larger for the *iPhone* than the *Nokia*, and for the messages test, the range was 205 s larger for the *iPhone* than the *Nokia*. The range on the calendar test was the same for both phones.

The exceptionally large range for the messages test on the *iPhone* was due to one individual, as the second longest time taken to perform this test was 122 s quicker. This result was a particularly severe case of a problem that many of the participants had when performing this task. Fig. 4 shows the text message screen of the *iPhone*. The majority entered the contact in the 'To:' bar at the top of the screen. However, many of the participants tried to enter the message in the large space highlighted in the figure. Yet it is the bar below this space where the text should be entered. It is conceivable that participants have associated the full-empty image schema with spaces like this when utilizing other computer interfaces. Furthermore, a circle in Fig. 4 highlights the picture of a camera, which is pressed in order to attach a picture to the message. The placement of this camera image further deterred people from trying to enter text in the bar provided, as many of the participants assumed the text input bar was a feature associated with the camera. It can be concluded that the messaging interface on the *iPhone* is counter-intuitive to new users. It was hypothesized that participants would enter text messages more quickly on the *iPhone*. This hypothesis was made under the assumption that a QWERTY keypad would allow for more efficient typing than a phone keypad. The difference in visual interfaces was not expected to impact the results so acutely.

Participants who have owned an *iPhone* were expected to complete the tasks more quickly than those who have owned a *Nokia* due to the former's touchscreen interface. This was the case for the calendar and messages tests but not the contacts test. This is due to the ability to skip straight through

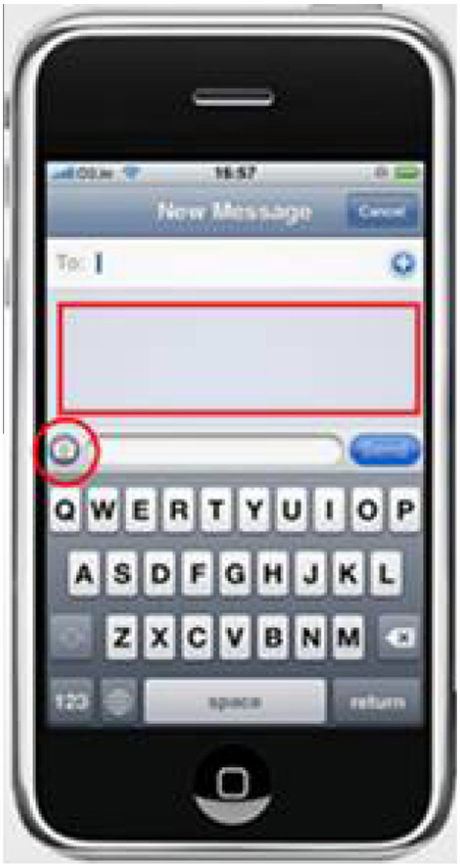

Figure 4 Smartphone comparison test: text message entry.

the contacts list to the alphabetical letter with which the name begins by tapping that letter in on the keypad when searching for a contact. The *iPhone*'s lack of keypad slows people down in this respect.

The hypothesis also stated that it is likely there will be a large discrepancy in times between experienced *iPhone* users and inexperienced *iPhone* users, and the longest times recorded for each task would have been for the *iPhone*. For the first two tests, the hypotheses were true for both the ranges and the longest recorded times. The calendar test, however, showed very similar average time recordings for both phones.

The calendar function on the *Nokia* required the users to enter an applications menu first, while the *iPhone* presents the calendar at the top of its primary menu screen. The quickest *iPhone* result was, therefore, much quicker than the fastest *Nokia* recording in this test, which can be credited to an experienced *iPhone* user. However, it should be noted that the task involved more steps on the *Nokia*, yet it still yielded similar overall results to the *iPhone*, demonstrating the relationship between experience and intuitive use.

This test showed that while the *iPhone* had a very efficient interface for users with experience, some of the features proved to be counter-intuitive initially, whereas the *Nokia* in general was interacted with very intuitively and quickly. The clear difference in average time taken between users who had prior experience with each brand and those who had not is shown between Tables 2 and 3. The correlation between intuitive interaction and experiential knowledge is apparent. It was perhaps not the aim of *Apple* to create an interface which participants learned quickly and intuitively, but rather to reinvent the way people interacted with these devices. Designs like this may in turn leave people associating entirely new image schemata with various tasks in the same way companies like *Nokia* did at the turn of the century. However, the creation of interfaces that force the formation of new schemata is potentially alienating to older users. This represents a potential opportunity of competitors in the marketplace to increase their competitiveness through inclusive design that is familiar to older users, rather than remaining focused on younger generations and competing in a more saturated market.

4.3. Image schemata test

The vector graphs for thumb movement were produced in Matlab™ for each subject and each task performed (see Fig. 5). The *x*, *y* and *z* axes represent direction of thumb movement, with the *x* axis being the horizontal axis of the screen, the *y* axis the vertical, and the *z* axis showing thumb movement towards and away from the screen. The units for each graph are in millimeters.

Fig. 5 shows two of the vector graphs produced; the left showing a participant trying to unlock the phone by sliding their thumb across the horizontal axis of the screen and the right shows a participant trying to scroll through the contacts menu in the horizontal axis of the screen.

It was hypothesized that participants conducting the first task, scrolling through the contacts list, would perform an upwards swiping motion on the screen. Six of the ten participants performed a swiping motion, four of which were in the positive *y* direction as hypothesized. The remaining four participants pressed down in one place rather than swiping it. One participant showed a very steep approach angle in the negative *y* direction possibly implicating a ‘striking’ action in order to create a downwards momentum. The hypothesis was not fully supported, even though all of the individuals who own a touchscreen phone performed the expected positive *y* axis motion. The results indicate that it is common for individuals who do not own a touchscreen mobile to still utilize schemata associated with their button phones despite the knowledge that the device they are interacting with has a touchscreen.

In the second task, unlocking the mobile phone, six of the ten participants performed the swiping action as hypothesized, four in the *x* axis and two in the *y* axis. All of the participants who owned a touchscreen phone performed a swiping action, one in the vertical *y* axis and two in the horizontal *x* axis. One participant clearly demonstrated an expectation of unlocking a touchscreen phone by pressing two on-screen buttons consecutively, imitating a method used with many existing button phones. This behavior is linked to the path schema. This particular participant indicated the application of existing experience in interaction very clearly.

The six participants who performed a swiping action were expected to have created image schemata through experiential use of existing touchscreen phones. The four participants who performed a horizontal swipe across the screen may have used image schemata associated with the *Apple iPhone*. This would coincide with the hypothesis that participants will emulate actions required to unlock the market-leading phones as *Apple* currently holds the leading market share for touchscreen handsets.

The Google Android operating system held the fifth largest share of the smartphone operating system market in 2009

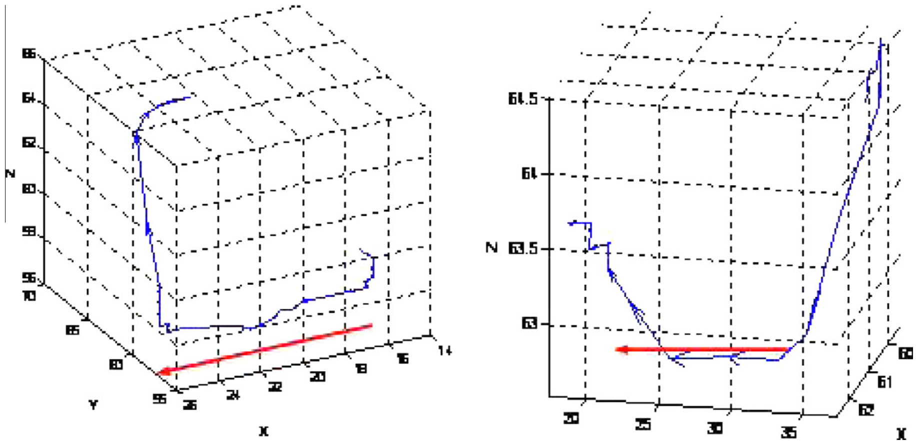

Figure 5 Image schemata test: examples of vector graphs produced.

when the study was conducted (Mfyall, 2010). The technique to unlock it is to slide a central bar on the screen upward. The two individuals who slid their thumbs across the screen in the y direction may have had some experience with this operating system.

The three participants who pressed down in a single place on the screen may or may not have drawn upon previous experience when performing the test. The Samsung S8000 is an example of an interface which requires this motion. However, the Samsung interface had not previously held a large share of the worldwide touchscreen operating system market (Mfyall, 2010), making it unlikely all three participants have had experience with this particular phone. It may be that one or more of these three participants simply pressed down in one place as a conscious guess, implying the touchscreen was too unfamiliar to draw upon any existing unconscious cognitive thought processes.

Analyzing the results for the third task, entering the main menu, it is apparent that two participants appeared to show thumb movement away from the screen rather than towards it, with no negative z direction movement. The assumed reason for this was that the participants had begun the movement before the recording had officially taken place.

Out of the eight participants with coherent results, five pressed directly down on the screen from the primary position and three pressed down after movement to the right. None of the participants showed any notable movement in the y direction, indicating that all of them expected the menu to be at the bottom of the screen. This corresponds with the hypothesis that the near-far schema will be associated with the menu button in most users' cognitive thought processes due to its importance. The button is never assumed to be far away from the natural thumb position.

The three dominant smartphone manufacturers of 2009 were *Nokia*, RIM *Blackberry*, and *Apple* (Mfyall, 2010). All of the touchscreen handsets manufactured by these companies at the time positioned their main menu buttons at the bottom center of the screen. The evidence that participants have emulated this in the experiment further implicates the use of existing experience in intuitive interaction. These findings also correspond to the hypothesis that participants' actions would imitate the existing interfaces currently holding highest market share. A popular main menu button position on conventional button mobile phones was under the bottom right of the screen. This is the positioning of the main menu button on the *Nokia N*95.

Table 4 Image schemata test: total uses of image schema.

Tests	Left–right	Up–down	Momentum	Counterforce	Near–far	Path
Scrolling	–	6	6	1	–	–
Unlock	4	2	–	–	–	1
Main menu	3	–	–	–	8	–
Total	7	8	6	1	8	1

Table 4 shows the total number of uses of each image schema clearly identified in the test. The assumed uses of the up-down schema in the contacts task for people who indicated to simply press down in one place were not included. The most frequent were the near-far and up-down schema, followed closely by the left–right and momentum schema. The recognition of individual image schemata relating to specific tasks may in this context agree with claims that intuitive decision making is a heuristic process that utilizes clear identifiable 'rule of thumb' concepts gained through trial and error.

Listed below are four schemata identified as specifically relating to three particular touchscreen phone functions:

Scrolling – up–down, momentum
Unlocking – left–right
Main menu – near–far

4.4. Recommendations

The following suggestions were made after studying the interaction with the button schematic keypads and the smart phones.

Unlocking and locking a button schematic keypad should involve two keys at opposite ends of the keypad adapted from the Nokia system and menu should be located top left or top center. This key should also double as the select key when in a menu context. There is no preferred side to locate a back button, but it should not be placed in a central position. The function of the delete key should be clearly marked as there is no preferred choice of position for this function. Scrolling should be given a top central position, with a vertical alignment. Call should always be on the left hand side and hang up on the right.

It is suggested that designers produce studies like the CyberGlove® experiment in order to identify schemata in relation to each function performed by individuals using a device. When implementing a function into the interface, designers can use these studies to ensure that they implement a method that utilizes the schemata identified in the study. For example, when adding a scroll function to the interface, the use of the up–down and momentum schemata could be included as a minimum requirement. Identification and implementation of schemata in the design process provides a clear cut and quantifiable way of improving intuitiveness of individual functions. Inclusive design is one of the main areas of design where a process like this would be applicable. The use of the CyberGlove® to record these motions rather than simply taking a video recording for observation demonstrates a method of graphing the results and analyzing them in more detail, making the observations less ambiguous.

Image schemata can be used in design solutions to help identify each cognitive process drawn upon by the user in completing a task. An interface can then be designed that provides a solution designed to trigger individual image schemata and tap into the user's unconscious sensorimotor knowledge.

It would conceivably be beneficial to incorporate the analysis of image schemata into inclusive design of mobile phones. If each individual image schema involved in performing each function on an interface is identified, the opportunity to maximize the number of processes that only draw upon sensorimotor sources of knowledge arises. The use of these techniques in engineering design could potentially widen the target customer base of multifunctional smartphones, directing more attention to less technologically experienced users who would otherwise be alienated.

Although it is possible to maximize the use of sensorimotor knowledge this way, many of the complex technological functions featured in modern day mobile phones will certainly require some use of image schemata only obtained from prior experience to be used intuitively. It is evident that many mobile phone interfaces have attempted to visually represent their functions in a way that could make them obvious to users such as a picture of an address book representing the contacts list or an envelope representing the text messages menu. It is highly improbable, however, that a user with no experience with mobile phones would draw upon existing image schema and intuitively know what these functions are.

From these results, it can be concluded that the holistic definitions of intuition are not directly relevant to intuitive interaction with technological products. Age and cognitive ability have a large influence on intuitive use, necessitating the development of inclusive design. It is evident that experience must be taken into account when defining intuitive use. The theory regarding the continuum of knowledge sources demonstrates that user interfaces which tap into sensorimotor knowledge are more intuitive to use. The use of image schemata in the design process can aid designers in tapping into the user's sensorimotor knowledge, and could therefore prove very helpful in the field of inclusive design.

5. Conclusions

The research reported in this paper confirmed that intuitive interaction only occurs between a first time user and a complex artifact if proficiency in its key functions is gained with minimal cognitive processing power. An intuitive interaction requires some unconscious use of existing experiential knowledge.

It has been shown that Nokia has set a very high standard of 'intuitive use' for button layout mobile phones that other manufacturers have since tried to match. Even with an unmarked, limited gestalt arrangement of keys, half of all interactions asked to be carried out on the schema were successful. *Sony Ericsson*, with a starkly different scheme, where gestalt laws are far more eminent, produced an even higher score. This is a clear illustration that previous experience plays a key factor in intuitive interaction, with a further increase in success rate where interfaces have a layout which improves a participant's cognitive reasoning through use of the gestalt laws. Furthermore, the use of the gestalt laws may enhance the intuitiveness of simpler functions on smartphones that still utilize a more traditional button layout.

The image schemata test demonstrate that users 'mold' image schemata in their cognitive thought processes when interacting with new devices in order to better understand them next time around. The study identified new image schemata associated with the use of a touchscreen device. The experiments confirmed that experience was a key factor in intuitive interaction. It was shown that a touchscreen interface is more difficult to grasp among new users than a conventional keypad interface, although for experienced users the touchscreen was more efficient. The results strongly suggest that it is experience with market-leading mobile phones that influence people's interactions with new interfaces.

Identifying image schemata which draw from sensorimotor knowledge on the continuum of knowledge sources is a quantifiable way of designing interfaces for intuitive use. Identifying image schemata used to interact with previous successful handsets can also greatly improve the intuitiveness of a new design. These methods can aid engineers in the process of inclusive design. Unfortunately, the use of image schemata in the design process is not a widely covered topic of study. However, the possibility that this integration of cognitive theory and engineering design could further progress the concept of inclusive design should be assessed in full.

Further work should involve the identification of image schemata for a wider variety of tasks performed on touchscreen phones. If a particular available handset was determined to embody a large proportion of these image schemata into its interface, it should be possible to compare its level of intuitive interaction with other existing handsets that do not embody as many image schemata into their functions. A comparison like this could validate the theory that image schemata can indeed be used in the design of handsets that are intuitive to a large number of users. Studies could also be carried out regarding the relation between effective touchscreen user feedback and intuitive interaction, which is a topic of particular interest because touchscreen devices rely on visual and other forms of feedback due to the lack of physical buttons. Without feedback users may be unsure of whether they have performed the correct action.

The use of the Immersion® CyberGlove® and a prop in place of a touchscreen handset was an effective way of graphing interactions so that they could be quantitatively analyzed and displayed in the form of a technical report. Further work could include developing techniques to identify image schemata in a measurable way in order to efficiently improve the design process and further understand the relevance of cognitive psychology in the field of design for intuitive use.

References

Antle, A.N., Corness, G., Droumeva, M., 2009. Human-computer-intuition? Exploring the cognitive basis for intuition in embodied interaction. International Journal of Arts and Technology 2 (3), 235–254.

Blackler, A.L., Hurtienne, J., 2007. Towards a unified view of intuitive interaction: definitions, models and tools across the world. MMI-Interaktiv 13, 37–55.

Blackler, A.L., Popovic, V., Mahar, D.P., 2006. Towards a design methodology for applying intuitive interaction, In: Friedman, K., Love, T., Côrte-Real, E., Rust, C. (Eds.) Proceedings Wonder-Ground Design Research Society Int. Conference, Lisbon.

Blackler, A.L., Popovic, V., Mahar, D.P., 2010. Investigating users' intuitive interaction with complex artifacts. Applied Ergonomics 41, 72–92.

Britton, A., Setchi, R., 2010. Intuitive Interaction with Multifunctional Smartphone Interfaces, I*PROMS'10. Cardiff, UK, 15–26 November 2010.

Hurtienne, J., Israel, J.H., 2007. Image schemas and their metaphorical extensions intuitive patterns for tangible interaction. In: 1st International Conference on Tangible and Embedded Interaction (TEI'07). ACM Press, Baton Rouge, pp. 127–134.

Hurtienne, J., Weber, K., Blessing, L., 2008. Prior experience and intuitive use: image schemas in user centred design. In: Designing Inclusive Futures. Springer, London, pp. 107–116.

Johnson, M., 1987. The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason. University of Chicago Press, Chicago.

Langdon, P., Clarkson, J., 2007. The effects of prior experience on the use of consumer products. Universal Access in the Information Society 6 (2), 179–191.

Langdon, P., Persad, U., Clarkson, P.J., 2010. Developing a model of cognitive interaction for analytical inclusive design evaluation. Interacting with Computers 22, 510–529.

Macaranas, A., Antle, A.N. Riecke, B.E., 2012. Bridging the gap: attribute and spatial metaphors for tangible interface design, In: 6th International Conference on Tangible, Embedded and Embodied Interaction (TEI2012). Kingston, Canada, 19–22 Feb 2012.

Marsh, A., Setchi, R., 2008. Design for intuitive use: a study of mobile phones. I*PROMS' 08, 1–14 July 2008, Cardiff, UK.

Mfyall, M., 2010. AdMob mobile metrics report, Available at: <http://metrics.admob.com/page/3/> (accessed 14.09.10).

Mohs, C., Hurtienne, J., Israel, J.H., Naumann, A., Kindsmüller, M.C., Meyer, H.A., Pohlmeyer, A., 2006. IUUI - intuitive use of user interfaces. In: Bosenick, T., Hassenzahl, M., Müller-Prove, M., Peissner, M. (Eds.), Usability Professionals 2006. German Chapter of Usability Professionals' Association, Stuttgart, pp. 130–133.

Oxford, 2005. Oxford English Dictionary. Oxford University Press.

Spool, J., 2005. What makes a design seem intuitive? User Interface Engineering, <http://uie.com/articles/design_intuitive/> (accessed 30.10.12).