CAPTURING USERS' PERCEPTIONS OF CLICKABILITY

by

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Capturing The Source Of Users' Perception Of Clickability

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Abstract

There are many clickable items on computer screens. Each clickable item is a visual representation of a command indicating its functionality. The problem is that designers have their own conceptual models, which means visual representations of commands are usually very different from one designer to another. In addition, users do not always perceive visual cues the way that designers intended. In fact, two different users may interpret the same visual cue in a completely opposite way. A theory of how users know where to click would ease communication from designers to users.

The theory of affordance, defined differently by Gibson and Norman, offers the possibility of such a theory. Gibson (1977) defined affordance as the possible actions available in the environment to an animal. Norman (1988) defined affordance as appearance suggesting possible uses of the object. While Gibson was referring to the physical environment, Norman was referring to the mental model. Whereas Gibson's affordance is independent of individuals, Norman's affordance may be dependent on an individual's experience.

Designers who are aware of Norman's definition have applied it in their designs. However, this does not guarantee users perceive commands even though they are visible. On the other hand, users may perceive commands even though the design has not met any design guideline. This is because users have some expectations where and how commands should be represented.

To resolve the gap between users and designers, we are looking for a theory of "clickability", which includes but goes beyond the theory of affordance. We first observed users' behaviour performing specified tasks on real applications. These results were ambiguous. Therefore we developed simple abstract screens, apart from any real application. In those abstract screens, cues are tested separately. Based on the current data, intentions and context direct users' responses. In particular, command location is the most powerful factor of all. In conclusion, there are many factors, which are closely interrelated, involved in the design besides affordance. The theory of "clickability" must include all of them.

To Mom and Dad

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Contents

List of Tables

List of Figures

Chapter 1

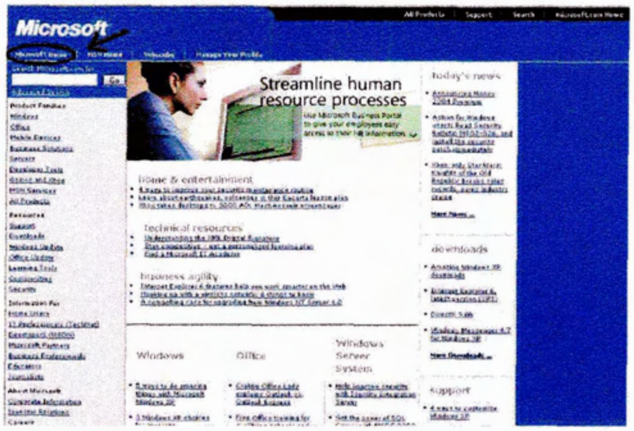
Introduction

When the computer system was first introduced to the public, it used command line interface, which is not easy to learn for novice users. In order to invoke commands, users have to remember exact words. Hence, in the 1960s and 1970s, the graphical user interface was developed [1, pp. 411-419]. In the late 1970s and early 1980s, visual display units and personal workstations were developed. At the same time, word processors were also developed. By the mid 1980s, computing technologies included multimedia [1, pp. 837-839] and information visualization [1, pp. 416-417]. This wave of technologies brought out the opportunities for designing additional applications. With these applications, the computers were available for education and training. One of the biggest challenges is to make computers accessible and usable by others besides engineers. The study of making computers more accessible and usable is called Human-Computer Interaction (HCI). One area of such study is to improve the screen design in a graphical user interface.

Motivation

There are many ways to invoke a command: by keyboard, voice, touch screen, and mouse. Only touch screen and mouse require users to know where the command is located on the screen before invoking the command, which is what we are interested in for this thesis. This is because locations of commands are related to the screen design.

There are many clickable items on the screen along with many possible ways to click on these items: single or double mouse click, and left, middle or right mouse click. To simplify matters, we only consider a single left mouse click. A clickable item on the screen is an enabled control (i.e. it does something after a single left-mouse click). Each clickable item, which represents a command, has some form of visual representation to indicate its functionality. To users, there are two types of visual representations: well-learned and rarely/first time visual cues. We are more interested in first use of visual cues than the well-learned cues. We are not interested in skilled performance, the well-learned cues, because all visual cues can be well-learned given a period of time. However, some cues are easier to learn and some are not. Hence we would like to make the first use of visual cues easier to learn.

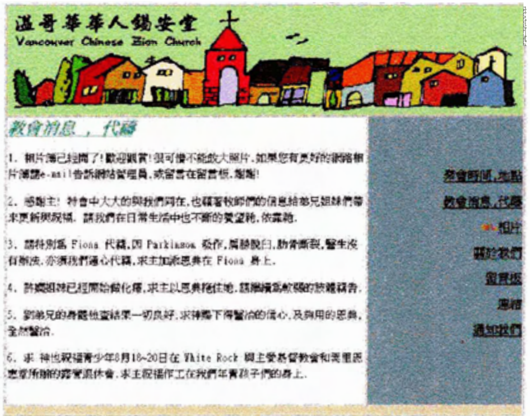


(a) Microsoft Homepage, used by permission [19]

(b) Vancouver Chinese Zion Church Homepage, previous version, used by permission [7]

Figure 1.1: Examples of Web Sites
All screen shots were taken in March, 2003.

Figure 1.1 shows screen shots of three web sites. If I would like to go to their home pages, where should I click? In other words, where is the go-to-home-page control located? The first web site, Figure 1.1(a), has "Microsoft Home" at top of page. The second web



(c) Vancouver Chinese Zion Church Homepage, current version, used by permission [6]

Figure 1.1: Examples of Web Sites (continued)

site, Figure 1.1(b) has an image of house at bottom of the page. The third web site, Figure 1.1(c), has no immediately visible "home" anywhere. However users can see an underlined text "home" at the bottom of page after scrolling down the page. The location of "home" ranges from top to the bottom on the three sites. And in the third web site, it is not even visible without scrolling down the page. Also notice that they all have different visual appearances. One is an image. The other two are just text, one underlined and one not underlined. Yet they are all clickable and have the same function. Some people may argue that some web sites' logos are also links to their home pages. However, we like to point out that not all users know this connection. Taking myself as an example, I did not know the logo is a link to home page until half a year ago. Both locations and visual appearances of this control show us that prior knowledge of what constitutes a clickable item is involved. The knowledge of clickable items helps users to locate items on the screen. Without such knowledge and experience, users do not always know where to click. This is especially true for first use of any visual forms.

Why do users have problems of knowing where to click? The first reason is that objects are designed based on conceptual models, and every designer has his or her own conceptual models. One's conceptual model is usually different from others. Hence, designers may design the same object differently implying that the visual representations of commands, created by designers, are usually very different from one designer to another. The visual representation of "go-to-home" in the Figure 1.1 is an example. The second reason is that users do not always perceive visual cues the way that designers plan. Two different users might interpret the same visual cue differently from the designers' intentions. To illustrate this difference, look at the Figure 1.2 and what do you see?

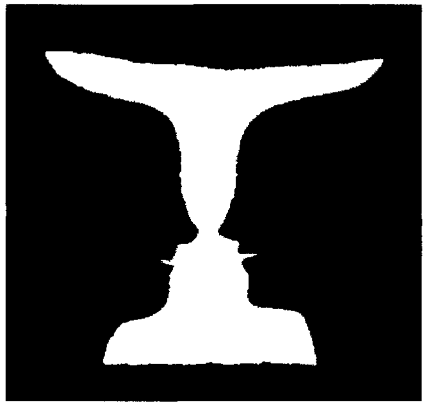


Figure 1.2: A Vase? Two Faces? [25]

Some may see a vase first, and others will see two faces first. This figure is an aspect of human visual organization — figure-ground segregation, part of the visual field becomes figure while the rest of visual field becomes ground [25]. It demonstrates that there is a perception difference between individuals. What can we do to reduce the differences between designers and ease communication from designers to users? One possible solution is to use a visual representation which inherently indicates a control. The implication of this to use the visual representations of screen controls that are independent of context. There is a theory related to context independency — the theory of affordance.

Affordance and Other Candidate Theories for Describing Clickability

There are two main definitions of the word of affordance. Gibson (1977) defined affordance as possible actions available to an individual in the environment. Norman (1988) defined affordance as visual appearance that suggests how the object should be used. In 1999, he made a clarification of affordance. He now terms the affordance he defined in 1988 is a *perceived* affordance [22]. While Gibson was referring to the physical environment, Norman was referring to the mental model. One of the differences is that affordance in Gibson's definition exists whether it is perceived or not while affordance that is perceived, in Norman's definition, may or may not actually exist. Another difference is that Gibson's affordance is independent of the individual's experience, knowledge, culture, or ability of perceiving. Norman's affordance may be dependent on individual experience, knowledge, and culture [18].

There are some designers who are aware of Norman's definition of affordance and they have applied it in their designs. However, following Norman's design guideline does not guarantee users can perceive controls even when the controls are visible. On the other hand, it is possible that users perceive the controls when the design does not follow any design guideline. The reason is that convention is established and users are familiar with the convention. So users have some expectation where and how the controls should appear. There is a third problem: some visual forms do not fall into the theory of affordance. Blue-underlined text is such an example. In the physical world, a button affords push but a blue-underlined text does not afford any action. We first learned that a blue-underlined text on the screen is clickable while using a web browser to enter a link. Then we recognize any blue-underlined text as a clickable item. This is a pattern recognition, a study of how an animal recognize objects and other animals [9]. Therefore we need more than just affordance to understand clickability.

To address these problems, we also look into other theories such as the traditional approach of visual perception. These theories help us to understand human perception, such as grouping, and how an individual perceives objects and interpret them. The details of these theories are described in Chapter 2.

Methods

There are two study methods: experiment vs. exploratory study. An experiment has a set of independent variables and a set of dependent variables. The experiment tests hypotheses, the relation between independent variables and dependent variables. An exploratory study explores research questions. There are a set of possible variables. The study measures effects of these variables and re-define these variables. We chose the second method, the exploratory study, because we only have research questions and possible variables, not hypotheses and independent/dependent variables.

Organization of the Thesis

As mentioned earlier, users may interpret visual information differently than designers and other users. This is not only because of the individual differences in thinking and background, but also their prior experience. To reduce the gap between users and designers, we need a new theory for "clickability", or one aspect of screen design affordance. This theory will be built on the theory of affordances and have to include other factors that are closely related to the visual design. The first step towards this new theory is to understand users' experience of clickability. What users know about clickability would help us find out what factors we should include in the theory of "clickability".

We first present background theories in Chapter 2. This is followed by studies of naturalistic tasks in Chapter 3 and studies of abstract tasks in Chapter 4. Then we conclude this thesis by a summary and directions of future work in Chapter 5.

Chapter 2

Background Theories

Modern computer systems can support many daily activities such as writing documents, drawing pictures, and information searching. Commands that support these activities are usually presented on the screen in some kind of visual representation. Before users can choose commands, they have to be able to perceive their controls. However, users do not always perceive the controls for the commands. To resolve this, we turned to cognitive psychology for help. Cognitive psychology is the study of human information processing, such as attention, perception, learning and memory [8]. The principles of visual perception help us to understand how humans perceive objects. Thus, it helps us to design perceivable controls for commands, especially for new visual forms of controls.

2.1 Visual Perception – Introduction

Our experiences arise through sensation and perception. Sensation detects the elementary properties of stimuli while perception is our ability to understand the environment. It detects the objects, including their locations, movements and backgrounds. Visual perception has been studied more than other senses such as smell and taste. This process is rapid, automatic, and unconscious and often involves learning [5]. In other words, visual perception is a process of transforming information from the environment, via sense organs, to experience of objects or events [8]. To design a good screen design, we first need to understand how visual information is processed. This is because users do not always perceive the screen controls for the commands.

There are three different approaches to studying visual perception: physiological, traditional, and ecological [4, p. 367]. The physiological approach is centered at the nervous system. It focuses on how the light goes into the eyes and transforms to the electrical activity through the network of nerve cells in the brain. Since the physiological approach cannot explain clickability, we did not pay attention to it. Our attention is on traditional and ecological approaches. Both approaches focus on the light which is reflected from the surface and objects and perceived in the eyes [4].

The traditional approach to visual perception is also known as cue theory. It concerns what processes operate on the retinal image to yield perceptual experience. Cue theory focuses on the process of computation or reconstruction of information obtained from the retinal image. This process requires knowledge of the world. Another way to look at cue theory is the combination of sensory information and cognitive processing. Sensory information is information from the environment and cognitive processing is knowledge and experience. Since cue theory is related to depth, a lot of work is done on depth and size perception. More details are in Section 2.3.

While cue theory involves cognitive processing, the ecological approach to visual perception claims that all information about the object or surface is perceived directly, through the detection of light intensity [4]. Since there is no cognitive processing involved, this approach to perception is also known as direct perception. Direct perception theory was developed by James J. Gibson. The theory originated in the Second World War from his work on improving a pilot's ability to land an aircraft [11]. Gibson's theory was developed with respect to the control of action. Consequently, Gibson's focus was on perception necessary for control of specific kinds of action. Hence this theory is functionally oriented. Here we should point out that his approach to visual perception does not apply well to all aspects of perception such as the distinction between "seeing" and "seeing as" [10]. On the other hand, when Gibson developed this theory of perception, he introduced the concept of affordance [12]. We believe that the concept of affordance is useful to computer interface design. In the next section, we look into the theories of affordance in more detail. Table 2.1 shows the comparison between two approaches to visual perception.

2.2 Theories of Affordance

2.2.1 Gibson's theory of affordances and invariants

Gibson introduced the concept of affordance to explain direct perception. He was interested more in activities of living creatures, such as flying and walking. Hence, affordance is used to describe the relationship of an animal and its environment. Here are some basics

Agreements	
1. Realism: Human is in sensory contact with the world. Perception reveals the world. 2. Mediator: Light is reflected from surfaces and objects. There are a method and a system to perceive lights. 3. Perceptual experience established through learning	
Disagreements	
Traditional Approach	**Ecological Approach**
• Perceive primitive elements, such as edges and blobs, and reconstruct with knowledge of the word. Photo receptors detect the light intensity changes directly. • Depend on internal process • Focus on perception of recognition • Driven by conceptual-driven and data-driven processes	• Perceive information about the objects or surface directly. All properties of the world are perceived by detection of light intensity. • No internal representations involved • Focus on perception of action • Driven by data-driven process

Table 2.1: Comparison Between Traditional and Ecological approaches [4, 8, 9]

about animals and environments defined by Gibson [12]:

- An animal is an organism that perceives and behaves. However, organisms that do not animate because they lack sense organs and muscles are treated as objects.
- An environment is an animal's surroundings. It is not the same as the physical world described by physics. One difference is in the time scale. The duration of processes in the environment is measured in seconds and years only while the duration of processes in the physical world is from millionth of a second to millions of years.
- An animal exists if and only if there is an environment that surrounds it. Gibson called this the mutuality of animal and environment.
- The environment is both permanent and changing. Permanence and changes are relative to the time scale. For example, a room is relatively permanent with respect to the floor, celling and walls. But the arrangement of the furniture in the room changes from time to time.
- The environment of an organism contains level ground, shelters, water, fire, objects, tools, other animals, and human displays.
- The environment of any observer is unique and private under the assumption that no two observers can be at same place at the same time.

A simple definition of affordance is what possible actions in the environment are available to an animal. For example, a horizontal flat solid surface affords support. Objects, such as sticks, which "have opposite surfaces separated by a distance less than the span of the hand" are graspable [12, p. 133]. Direct perception, as mentioned earlier, is functionally oriented. Gibson focused on ground or air locomotion towards a perceived resource such as food or shelter. Thus, affordance is inherently in the object. It is an environmental property that is potentially in the interests of an organism to perceive. Moreover, it is constant. In other words, it does not change over time, nor when an animal moves through environment. Note that affordances could be harmful. For example, a knife offers cutting. At same time, a different handling of a knife could hurt others. Another important aspect of affordance is that its existence is independent to the animal's experience, knowledge, culture and ability of perceiving it.

One important role of the affordances in Gibson's theory is to provide an explanation for the animal's perceptual systems. Gibson claimed that all invariant information is present in the ambient optic arrays and hence affordances are perceived directly and no cognitive process is needed [12]. Also, invariant information is related to the control of actions. One example is what a pilot sees when landing an airplane. As the altitude decreases, the pilot sees progressively finer details of the runway. This change in detail is invariant. However, the rate of increase in resolution is not constant. It increases explosively right before the contact point and indicates when to slow down to ensure a soft landing. Even though Gibson did not directly describe how animals acquire invariant information, it seems reasonable to assume it is by some combination of instinct and learning.

There are three assumptions of Gibson's theory relevant to computer interfaces.

1. Gibson's theory focuses on activities with a low cognitive process, such as locomotion or grasping. Even though he did mention higher-level actions such as mailing a letter, he did not explain how invariant information indicates details of operating the postal service.

2. The physical structure of an object, which makes physical actions possible and desirable, provides the invariant information that indicates the possible actions on the object. For example, the red glow on a stove indicate that there is an element with high heat. Contacting high heat objects is harmful hence we avoid touching the element on the stove. Similarly, the combination of reflection and shading from a coffee mug comes from its physical shape. The physical shape of the coffee mug affords

grasping; hence the coffee mug can be picked up.

3. The physical laws are deeply interconnected and provide convergent cues to the possible action. The physical properties of the coffee mug not only determine the degree of reflection from the mug but also determine the degree of friction, which indicates how much force to be used to grasp the mug.

None of these assumptions holds in computer interfaces. We will elaborate on the implications of this later in this chapter.

2.2.2 Bringing Gibson's theory into HCI

While the definition of affordance given above and its accompanying consequences are known to many in the field of human factors, it is relatively unknown in HCI. The HCI community was introduced to Donald Norman's definition of affordance in his book *The Design Of Everyday Things* [21]. Norman used the term affordance differently from Gibson (Table 2.2). His focus was on some form of conceptual model intermediating perception and action, while Gibson's focus was on available actions in the environment. Based on this frame of reference, Norman defined an affordance as a clue or a suggestion of how the object should be used. Unlike Gibson's definition that affordance is independent of individuals, Norman's affordance may be dependent on individuals' experience, knowledge and culture. Also, perceiving affordances may be influenced by one's prior experience.

Gibson's Affordance DEFINITION: Possible actions available to an individual in the environment	***Norman's Perceived Affordance*** DEFINITION: Suggestions of how the object should be used
• Refers to the physical environment	• Refers to the conceptual model
• The actions capabilities of the individual	• The mental and perceptual capabilities
• Independent of the individual's experience, knowledge, culture, or perception ability	• May be dependent on the individual's experience, knowledge, and culture
• Direct perception	• Perception may be influenced by experiences and knowledge

Table 2.2: Comparison of Two Affordances [18]

On the other hand, there is one similarity between the two definitions we would like to emphasize. Objects such as doors, faucets, and light switches require little high-level reasoning to operate. We are not suggesting that designing these objects is obvious. Norman in his book listed examples of unsuccessful designs to demonstrate the difficulty. He also provided excellent guidelines to improve design. However, we would like to point out that only the most elementary reasoning is required to operate them. Norman also provided some examples of more complex systems in his book. These complex systems, such as projectors and refrigerator thermostats, show that higher level reasoning does play a role in understanding complex systems. But the examples used to explain affordances are always simple objects.

We argue that computers are fundamentally different from these simple systems. This is because the control of computers is inherently indirect and the relationship between human movement and machine outcome is mediated by complex software. The operation of a computer requires complex reasoning about the link between the controls and the internal system state. This is not like operating an apple or a light switch. "Operating" an apple, such as plucking or biting it, is done by directly coordinating physical movement with the visual field. Even though light switch is also an indirect interface and there exist variations of light switches through different circuits, operating a light switch requires only a simple cognitive link between the change in control and the change of ambient light.

2.2.3 The levels of computer affordances

The indirect nature of controlling computer systems forces us to make new choices in our definition of affordance. Recall that in Gibson's theory, the relation between perception and action was direct. The outcome of action was directly related to the physical actions performed and the visual appearance of the action. In Norman's slightly more complex examples, the relation between the physical appearance of the control and the physical action required to operate it is also direct. But there is an indirect link to the controlled item. For example, a well-designed door handle should suggest which way the door will open as well as how to operate it — push, pull or turn. Norman points out that different design processes, such as labelling and convention, indicate what is indirectly controlled by that movement [22].

However, in window-icon-menu-pointer (WIMP) interfaces, there is absolutely no inherent connection between the appearance of a control, the physical operations required to operate it, and its effect upon the system. This simple difference has a profound implication for the definition of affordance. We must now choose the level of actions at which affordance is defined. The physical directness in Gibson's definition implicitly defined the level of analysis. An affordance is an action that can be directly applied to an object. But in the WIMP realm, no action is direct.

What is an "action" in the WIMP environment? We suggest there are three possible definitions in the WIMP environment, listed in increasing level of semantic content:

1. The physical level: The physical movement of the user and movement feedback. At this level, a movement feedback such as cursor motion indicates progress of the interaction technique.

2. The interaction technique level (IT level): The physical movement of the user and the interaction technique feedback indicating the invocation of the command. The feedback at this level, such as a colour change on a button, indicates that the interaction technique is complete and a command has been carried out, but not necessarily the outcome of that command.

3. The semantic level: A change to the state of the program's conceptual model. This change may or may not be indicated by feedback.

Norman in his most recent discussion of affordances has adopted the physical level [22]. This has the merit of corresponding most closely of the three to the direct physicality of Gibson's environments. However, it makes affordances useless for screen interface design because it ignores the possible operations of the program. The screen affords clicking at any point. As the result, the affordance of clicking offers no guidance whatsoever to the user on what can be done with the program.

McGrenere and Ho in their commentary and refinement of affordance definitions [18] argue for the semantic level. This has the merit of corresponding most closely to the abstract definition of affordance, provided by Gibson. It also suggests elegant connections between usefulness and actual affordance, usability and perceived affordance. However, we argue that this level is too abstract. Even though Gibson's definition was abstract, his focus on physical environments grounded his discussions in short, physical actions sequences. Such actions can arguably be performed without a mediating mental representation. If we adopt the semantic definition of affordance, we expand it to include long, abstract action sequences such as writing a conference paper on a word processor. This kind of action is almost certainly guided more by some sort of conceptual model of the program than by simple mappings of visual appearance to possible action.

The ultimate goal of Gibson's notion of affordance was to determine what an organism had to perceive to thrive (or at least survive) in an environment. He created the concept as a foil for his notion of perceptual invariants. To be fit for an environment an organism should perceive the invariants that indicate affordances, basic actions it can undertake. His theory explicitly disallowed complex reasoning about the environment. We argue that the interaction technique (IT) level is the best approximation of his ideas in the environment of screen interfaces, as well as the most useful definition for both users and designers of such interfaces. To support effective behaviour, the screen design should provide simple visual indications of basic actions. Defining affordances at the physical level prevents this because it ignores the visual display. Defining affordances at the semantic level prevents this because it includes abstract actions that require complex reasoning and cannot be simply perceived.

Norman argues for a strong distinction between affordances and perceived affordances [22]. Affordances are actual possibilities in the environment that may or may not be perceived, while perceived affordances may or may not actually exist. McGrenere and Ho continue this distinction [18]. We agree with previous authors that affordances exist independently of an organism's ability to perceive them. However, we do not agree that this decouples affordances from perceptiblity. For the concept to be useful, affordances should be defined at a level corresponding to simple percepts, such as Gibson's invariants, without appeal to complex reasoning. "Writing a technical paper" is not usefully defined as a software affordance because it cannot be perceived from a glance at the screen. It can only be drawn from previous experience or implied from a conceptual model of the software.

There are several advantages of defining affordances at the IT level. First, it is useful for designers because it works at the lowest level of software design. Second, it keeps affordances clearly distinct from the conceptual model, providing two distinct layers to design from. Third, it is useful for users because they can learn to recognize screen controls by learning to recognize the visual representations of their affordances.

According to our definition, screen affordances are fundamental to clicking. We argue that when attempting to perform an unfamiliar task, users scan the screen looking for possible operations. Affordances indicate that a given screen region is available as a control, and in particular that it is clickable.

2.3 Traditional Approach To Visual Perception

There are some visual forms of screen controls related to affordance directly. One example is $2\frac{1}{2}$ D buttons, or protrusion. Protrusion looks like a pushable object on the screen. Hence protrusion affords "pushing". However, there are some visual forms that the theory of affordance cannot explain. An example is a blue underlined word on a web site. We learn a blue underlined word is clickable. It does not afford clicking in the physical world. Since the theory of affordance cannot explain this type of visual form, we need other theories to support clickability. One of the theories is the traditional approach to visual perception.

As mentioned in Section 2.1, the traditional approach to visual perception is also known as cue theory. It focuses on the process of computation or reconstruction of information obtained from the retinal image, which is correlated to the depth of the world. Cue theory is related to the depth and size. There are several groups of cues:

- Physiological cues: also known as oculomotor cues. This type of cues depends on our ability to sense the position of our eyes and tension in our eye muscles.
- Pictorial cues: also known as monocular cues. These are cues that can be depicted in a still picture. They include linear perspective, overlap, size, and shading.
- Binocular cues: comparison of information between the eyes caused by the horizontal, angular, or uncrossed/crossed disparity.
- Motion-produced cues: depend on the movement of the observer or object in the environment.

However, these cues are not our focus. It is true that there is perceived depth on the computer screen. We can include some depth cues; however, they have little to do with clickability.

In the above example, a blue underlined word, is considered as a clickable item on the screen because we learned in the past that clicking a blue underlined word or text will generally take us to a web page. Whenever we see a blue underlined word or text, we consider it to be a link to a web page. Therefore it is clickable. Another example is Figure 2.1. A on-line weather information web site uses a Canadian map as one of navigation methods. Each province on the map is a control, which takes users to a list of cities in that province. Users recognize they are possible screen controls after they learn that these areas are clickable, either from this web site or other similar web pages. In other words, what we learned in the past regarding clickability is carrying forward to the present. This is directly related to object and pattern recognition.[12]

So what is object and pattern recognition? A simple mechanism is that animals recognize objects or other animals by their key stimuli. A key stimulus of an object or animal is a feature of that object or animal, which evoke a response from the animal. Bruce, Green, and Georgeson in their book *Visual Perception* described a more complex mechanism — a

Figure 2.1: Example of Pattern Recognition

theory of object recognition [4, pp. 216-225]. In 1978, Marr and Nishihara in 1978 created a scheme for object-centered representations, an axis-based structural description. It is built from images and accessible through a stored catalog system for recognition. Later in 1987, Biederman developed his theory of human object recognition based on Marr and Nishihara's work. His theory is dividing object into small parts and then matching parts against geometric ions ("geons"). Another mechanism is template matching scheme. The process of template matching includes rotating, scaling, and finding the major axis of the target to match an object in the template. The template is located in long term memory. Its limitation is that it fails to account for individual discrimination, i.e., individuals categorize patterns differently. The details of those mechanisms and its implications can be found in perception literature.

2.4 Related Theories

There are other aspects of clickability that do not fit into theories of affordance and object/pattern recognition. An example is the flashing blue button used by Mac OS to indicate the default screen control. Another example is the layout of screen controls. Screen controls with similar functionalities are usually near each other. Flashing blue buttons is related to visual attention and layout is related to Gestalt principles. We look into details of both theories below. At the end, we also take a brief review of colour and culture.

Visual Attention

In web sites, there are many flashing objects or objects that move around, which also are clickable. Visual attention offers us some explanation of why this type of objects are used on web sites.

Attention is crucial for selecting visual information over space and time [14]. This is because what we perceive is driven by what we intend to do. We select information that is relevant to our actions from the environment, which presents far more information to us than needed at any given time. We may or may not ignore other information which is also presented to us at the same time. Take driving as an example. Driving safely depends on the drivers' abilities to detect and monitor stop signs, traffic lights and other cars. It is necessary for drivers to pay less attention to other things such as flying birds or cell phones ringing. Therefore, a reliable and efficient attentional selection is crucial [14].

Visual attention has several points that may be useful to interface design:

- If the distractors are located closely to the target, then these distractors can not be singled out. In other words, distractors cause attention split from the attention of the target. This is important for layout of controls on the screen. A sufficient space between commands would help users focus on the target command.

- Larger differences between the target and distractors increase search efficiency. It is easier to identify the target when distractors look distinctly different from the target. The difference could be in colour, shape, orientation, size, and other properties. This is useful for designing controls on the screen. The more differences between visual representation of commands, the easier users would be able to locate the target command.

- Memory also affects our attention. Memory traces of previous perceptual interactions. Items that appear in the memory get faster attention. This suggests that familiar design of controls is likely to draw users' attention more quickly.

There are also some other points of visual attention which help us understand users:

- When our attention shifts from one location to another, our focus of attention moves instantly without a cost for the amount of distant traveled. However, it is not clear whether attention has impact on intermediate loci as it moves.

- Attention can be splitted. Studies showed that one can track typically 4-5 objects at same time.

- In one theory, there are two types of attention: endogenous and exogenous attention. Endogenous attention, also known as top-down or goal-driven attention, is effortful, voluntary and clearly under the control of the individual. Exogenous attention, also known as bottom-up or stimulus-driven attention, draws attention automatically to a particular location. The control systems of these two types of attention interact with each other. Therefore, in visual search, attention is guided by interactions between the exogenous input and endogenous perceptual set.

- When users are in a goal-driven state, other information in the environment is ignored or inhibit. However, this does not means that those information are unseen, rather they may be implicitly registered. In other words, users may remember some irrelevant information regarding the environment even though it is not their focus at that point of time.

Gestalt Principles

One of the questions raised during our abstract screen studies (Chapter 4) was how layout affects users' responses. Existing applications and web sites today generally have different ways of placing screen controls. Applications have controls on top or bottom of the screen while web sites have controls on top or on the sides. Gestalt theory seems to provide us some answers of different layouts.

Gestalt theory was founded by Max Wertheimer, Wolfgang Köhler and Kurt Koffka in early 20th century. The word gestalt originated from Gemany. It literally means shape or form. In psychology, it means the whole. Gestalt psychology is a study of perception and behaviour from the standpoint of an individual's responses to configurational wholes. It shows the importance of organizations of visual perception. One important, also well-known, finding is "the laws of grouping", first noted by Werthemier. Werthemier (1912) was interested in "what goes with what" in visual perception [8, p. 154]. He constructed visual arrays of simple geometrical elements and varied one single factor to determine its effects on perceived grouping.

Here are some examples of "the laws of grouping" [24, 8]:

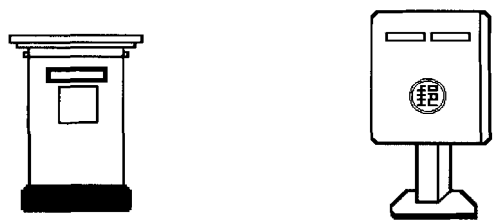
Therefore, it is not surprising to find examples that used these laws in interface design.

Colour and Culture

The language of colour and culture also has some influences on users' perception. Colour helps to separate objects from their background. It helps us to make fine discriminations between objects. In real life, we also use colours many other ways. For example, traffic systems worldwide use colour red as stop or hazard. Therefore, a red item on the screen

THE LAWS	ITS EXPLANATION	EXAMPLE IN INTERFACE DESIGN
Proximity:	items seen as a group if they are close to each other	words on a menu bar
Similarity:	items seen as a group if they share visual characters such as color or size, a special case is "common fate" which refers to motion	Toolbar icons
Closure:	group elements into complete, closed figures	Overlapping windows
Symmetry:	symmetric elements seen as a group	Window manipulation controls, e.g. scroll bar
Continuity:	group elements into continuous contours or repeating patterns	a page of paragraphs

may tell users to stop the action. However, colour red may have other meanings in different context. In Chinese culture, the red also implies something good or joyful. So when we use red colour in the design, it may indicate a warning or not, depending on how users interpret it. In addition to individual difference, designers also bring in their culture differences. Similar objects may have different appearances in different culture. Mail box is an example. The mail box in UK is different from the one in Taiwan (see Figure 2.2). Therefore, the design of a mailbox control on the screen may not be the same. However, due to their complexity, we do not consider colour and culture effects here.



(a) Mailbox in UK

(b) Mailbox in Taiwan

Figure 2.2: Examples of Different Style Mailboxes

2.5 Visual Indicators – What's on the Screen

Before defining a theory of "clickability" from the theories of affordances and visual perception, it is necessary to understand how visual representations are used currently on the computer screen. Therefore, the first step we took is to find out what we already have on the screen. There is a huge amount of the information that is presented to us by a typical desktop screen. We focus on how the commands are presented to users to catch their attention. Most of the commands are represented by some visual vocabulary. We collected some visual indicators of commands from Mac OS X, Microsoft Windows, and Unix. The criteria includes operations can be done on the screen, anything that invokes or contains an action and its appearance, and anything that brings out other commands. They are:

1. click
2. drag
3. operations: close, minimize, enlarge, open windows
4. click to pop up a window
5. click to bring window to front
6. text
7. image
8. image and text
9. button
10. scroll bar
11. menu bar
12. menu entry with icon
13. 3D projection
14. ▶ symbol
15. round edges
16. square edges
17. plain, looks like a picture
18. 3D projection that is <u>not</u> clickable
19. enabled v.s. disabled
20. navigate scroll bar by dragging thumb or clicking on the buttons or empty scroll space
21. empty (in Mac OS) or full (in Microsoft Windows) scroll region to indicate full document in view
22. mouse-over gives more description in lower text box
23. click some places changes menu bar
24. click on menu and drag continues to drop down menu, also highlights current menu
25. combo boxes: look like a button but act like a menu, two arrows indicate a combo box
26. similar functions grouped together
27. gives text when cursor on image
28. cursor changes to indicate enable, <u>does not</u> change over disabled
29. cursor <u>does not</u> change to indicate enabled
30. Mac OS X: window buttons look disabled but are enabled (and light up when cursor over)
31. (flashing) blue for defaults
32. image changes when cursor on top
33. "..." in menu indicating a dialog box
34. click at an item on menu bar and get a drop down sub-menu
35. Microsoft Windows: underscored character indicates command key

36. resize region in Mac OS X does not look like click-and-drag

37. radio buttons: only one of the group can be active

38. faded or gray indicates "disabled"

We also grouped them by their similarity in functions or types. Figure 2.3 shows the result of categorization. There are three major groups: Type of visual indicators, Functions of mouse, and Visual cues. Types of visual indicators are the basic forms which are used to present commands. They include image, text, scroll bar, menu bar and buttons, as well as their styles. Mouse has three functions: click, drag and mouse/cursor over effects. Visual cues are anything that attempts to catch users' attention, such as enable versus disabled icons and symbols.

While we collected these visual indicators, we noticed that not all commands are represented by one visual indicator. Some commands, especially in some applications and web sites, are indicated by mixing 2 or more visual indicators. This is because some visual indicators do not express their functions well when they stand alone. One example is buttons with images only in Microsoft Word 2002. Users might not recall or understand the images hence they usually have a mouse-over effect. The function of a button is displayed after the mouse cursor positions at the button location for a few seconds. We also found that there is no consistency. Some commands have different visual indicators in different operating systems. For example, item number 21 — whole document has empty scroll region in Mac OS and full scroll region in Microsoft Windows. This inconsistency also occurs within Microsoft Windows applications — application Notepad has empty scroll region as full document. Do users understand the visual language presented to them on the screen? Is this understanding the source of the problems which users experience? We tried to answer these questions in the next chapter.

2.6 Summary

Our goal is to provide better design guidelines for screen controls. In other words, we would like to define a theory of "clickability", which is based on affordances and other relevant theories. This theory of "clickability" should reduce the difference between users and designers and make any new visual feature of screen controls easier to use. In this chapter, we presented several theories that would help us to achieve this goal. These theories help us to understand how users perceive screen controls. They are:

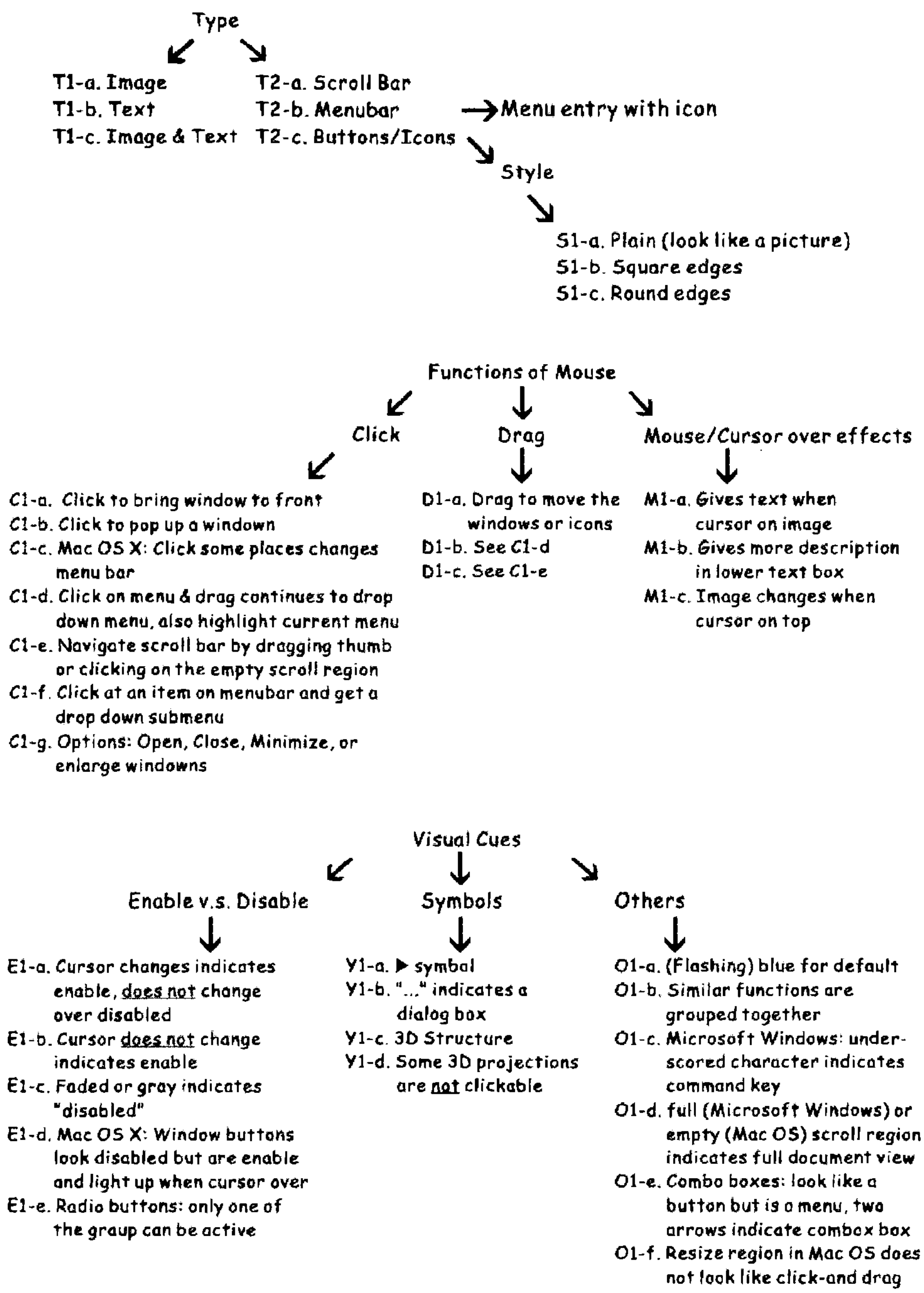


Figure 2.3: Visual Indicators of Commands

- Theory of affordances: This theory offers us the idea of creating screen controls independent of the context.
- Traditional approach to visual perception, in particular, object and pattern recognition: Users recognize screen controls from previous learning.
- Visual attention: What users perceive is driven by what users intend to do.
- Gestalt principle: Users group similar visual representations of screen controls together. Similarly, designers place similar screen controls near each other.
- Colour and culture: Users may perceive screen controls based on their understanding of colour and their background.

With the understanding of these theories, we can create a better design for screen controls. However, conventions have been developed over the years. It is easier to improve the current convention than create a new design. Understanding what users learned about clickability would help us to know which visual cues are more effective and which are not. Hence, we present our studies of understanding users in the next two chapters.

Chapter 3

Studies of Naturalistic Tasks

3.1 Motivation and Overview

In the last chapter, we mentioned that users may not know all the available screen controls and may interpret screen controls differently from other users, which motivate us to provide better design guidelines for screen controls. In order to achieve this goal, we first studied the theory of affordances and other theories regarding visual perception. These theories help us to understand the relationship between human behaviours and visual perception. With the understanding of visual perception, we can create a better design of screen representations of commands, which improves users' interaction with computer systems. On the other hand, conventions of screen design have been established. Instead of creating a new design of visual cues, it is easier to adopt it from current convention. Hence it is important to understand what users have learned about clickability. It helps us to understand which visual cues are more effective and which are not.

At the end of last chapter, we listed 38 visual indicators of commands on the screen, collected from various desktop/operating systems. We also grouped these indicators based on their functionalities and types (see Figure 2.3). We noticed that many controls on the screen consist of two or more visual indicators. We also found some inconsistency of cue usages between applications. So, how many visual indicators do users recognize? And which cues are recognized? To answer these questions, we conducted a survey, in which users were asked to recall and highlight what they remember as clickable on the screen. The result of the survey raised another question — how and why do users know these cues indicate the clickability? Hence, we conducted an observation study of users with computing applications. We hoped observing on individuals' working with computer systems would help us to understand how and why know visual cues indicate the clickability. These studies are described in this chapter.

3.2 Survey

This section gives the details of how the survey was designed and held, as well as the result. Here is how this section is organized: We first describe the design of the survey and how the survey was held. The analyses and results are presented next, followed by summary of this study.

3.2.1 Study Design

Overall Design

As mentioned in the last section, we were interested in how many visual indicators users recognize, as well as which visual indicators they recognize. Since we would like users to recall them, there was no need for users to interact with a computer system. Hence we chose to do a survey on a computer screen shot.

In Figure 2.3, we know clickability and draggability are two major functions of the mouse pointer/cursor. Therefore, what is clickable and what is draggable were the two parts of the survey. We were also interested in whether users could predict what would happen after clicking. Hence we selected three locations (see Figure 3.1(b)) on the screen shot and ask them to tell us what would be the results of clicks at these locations.

Stimuli

We captured two screen shots, one from Microsoft Windows and one from Mac OS X, and ran a pilot study. Pilot studies indicated that participants were unfamiliar with Mac OS and so the main study used only the Windows screen shot.

Figure 3.1 shows the Microsoft Windows screen shots we used in the study. The screen shot was the Windows desktop and contained some opened applications. The desktop was partially visible. Participants were able to see some items that were on the desktop. The opened applications were Internet Explorer Browser, SSH Secure File Transfer Client, SSH Secure Shell Client, and Microsoft PowerPoint. The screen shot was printed on paper. There were three tasks:

1. Highlight anything that is clickable (Figure 3.1(a))

2. Highlight anything that is draggable (Figure 3.1(a))

3. Describe the outcomes of clicking at three different locations (Figure 3.1(b))

Clickable, Draggable and Outcomes are used to refer these three tasks later in this chapter. Note that the original screen shot was coloured. However, we presented to user the black and white photocopy version as in Figure 3.1.

3.2.2 Study Task

This survey was done on paper. Each participant received three pages. Each page contained one task described above. A highlighter and a pen were provided during the survey. Participants were told to use the highlighter in the first two tasks. They also had the option to write rather than to highlight.

3.2.3 Participants and Sample Size

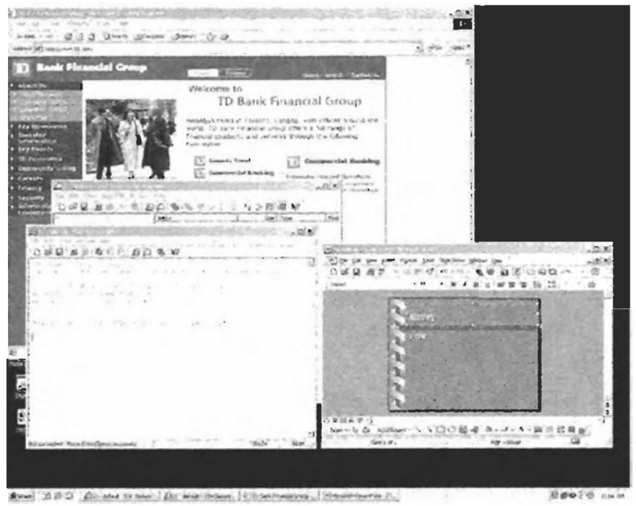
There were eleven participants, six males and five females, seven computing/engineering (CE) and four non-computing/engineering (Non-CE) students. Participants ranged from 19 to 29 years old. Computing science/engineering participants were older than non-computing science/engineering participants. This is because majority of them were graduate students whereas non-computing science/engineering participants were mostly undergraduate students. The hours spent using a computer ranged from 4.5 to 60 per week. Computing science/engineering participants spent an average of 40 hours per week on computers while non-computing science/engineering participants spent an average of 9 hours on computers each week[1].

Here are participants' experience on applications and websites:

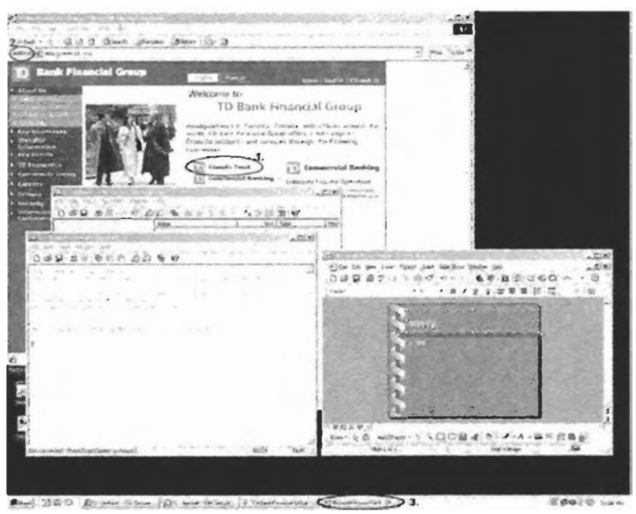
- Desktop

  Participants were all familiar with at least one version of Microsoft Windows. However, five out of eleven participants, all CE participants, knew Mac OS and three participants, all CE participants, knew another desktop. The most well-known desktop, besides Microsoft Windows and Mac OS, was Linux. Other known desktops were Unix and FreeBSD.

[1] The complete statistics of participants' background can be found in Appendix F.



(a) Screen shot of Microsoft Windows



(b) Screen shot of Microsoft Windows with 3 marked locations

Figure 3.1: Screen shot used in Survey
(a) was used in the task Clickable and Draggble;
(b) was used in the task Outcome.

- Applications

  CE participants used more Microsoft applications — Word, Excel, and PowerPoint — than Non-CE participants. In fact, Non-CE participants used mostly Word only. Among CE participants, the most frequently used application was Word, followed by PowerPoint, then Excel.

- Web Browsers

  All of them used a lot of Internet Explorer (embedded in the Windows system). The second popular browser was Mozilla or Netscape, which were used by computing science participants only. Only a few participants used other browsers.

- Web Sites

  All participants used the Google search engine often but not necessarily other web sites. Amazon represents shopping web sites. We chose it because it is a popular and well known shopping web site. Yahoo maps represents information web sites. Participants did not use web sites such as Amazon and Yahoo maps frequently at all.

- Hot Keys (Short-cut Keys)

  CE participants knew more hot keys and used them more frequently hot keys than Non-CE participants.

In summary, CE participants had more experience on different applications and web sites than Non-CE participants[2].

3.2.4 Schedule and Setting

The duration of this survey was about 15 minutes. Participants were scheduled based on their preferences. This survey was held either at the room ASB 9834 in Simon Fraser University Burnaby Campus or at the locations of participants' choices.

3.2.5 Analyses and Results

The results were divided into three parts, based on the tasks: Clickable, Draggable, and Outcomes. For each part, we first introduced the correct responses of that task, followed by users' responses, then analysis and some discussion.

[2] The complete statistics of participants' computer usage can be found in Appendix F.

Task 1 – Clickable

First, we defined a clickable item on the screen as an item for which a single left-mouse click changes the internal program state and perhaps the screen state. Therefore, the correct response for this task is the entire screen except a small area on the Task Bar where there are no icons or buttons. Two participants, both CE, highlighted the entire screen. Other participants highlighted some parts of the screen shot, such as icons and buttons. Notice that some of the clickable items like icons appear in more than on location. However, not all participants highlighted all of them. Here is the list of items in the order of most frequent choice to the least:

Number of Responses (*Max.* = 11)	Items on the screen
11	Icons, Buttons[3], Menu Bar
10	Web Text Link
8	Text Area[4]
5	Title Bar of File Display, Images/Pictures in the web site
4	Title Bar of Windows[5]
3	Scroll Bar, Windows Task Bar[6]
2	Desktop Space, Tool Bars, Text in the web site[7]

Analysis and Discussion: Icons, buttons, menu bars and web text links are the most popular answers. This is not a surprise since users encounter these items every time they use applications or web sites. The reason that web text links only had 10 responses instead of 11 was due to the fact that one participant thought the active window was Microsoft PowerPoint. All his responses were within that window frame. He believed that all the clickable items were in the active window only. Text Area was the next most frequent answer since participants use Microsoft applications and web browsers frequently. The rest of the answers had less than 50% of responses for several reasons. First, recall that participants did not highlight all the related items. One example of that was text area. There were two locations related to text area: address box in the web browser and PowerPoint slide. Most of participants only chose one of them, not both. This implied that there was a great chance that participants knew what objects were clickable but fail to recognize them. Second, some

[3]Including the ones in tool bars

[4]Located in PowerPoint slide and web browser address section

[5]Excluding any icons and buttons

[6]Scroll bar: only the space, arrows counted as buttons, Windows task bar: excluding icons and buttons

[7]Tool bar: right-mouse click, Text in the web site: excluding text links

functions were not often used by participants. For example, clicking on one item of the title bar of the file display would sort the files based on that item. This was not a frequently used function. It was easily missed when the window was behind another window and no file listed. Lastly, the survey was given in black and white, so some details were smoothed out by the gray scale and photocopy machine. In summary, there were only a few items on the screen that participants consistently recognized: icons, buttons, menu bars, web text links, and text areas. And the visual indicators that are associated with these items are not many either. There were 9 out of 38 of the list in Section 2.5:

4. click to pop up a window
5. click to bring window to front
6. text
9. button
11. menubar
14. ▶ symbol
15. round edges
16. square edges

Task 2 – Draggable

There are 13 draggable items on the screen shot:

1. Individual Windows (by dragging title bars of the windows)
2. Borders of the Windows
3. Corners of the Windows
4. Icons on the desktop or Windwos Task Bar
5. Text boxes (in PowerPoint only)
6. Tool bars
7. Scroll bar
8. Width of the title bar of file display
9. Windows task bar
10. Separate bar between window functions and web page space in the Internet Explorer browser
11. Image/picture in the web site
12. Text in the web site
13. Icon in the web address box

The first 10 items appear on applications or the desktop and the last 3 items are related to web sites. And participants' responses were

Number of Responses ($Max. = 11$)	Items on the screen
9	Windows[8]
5	Icons on the desktop or Windwos Task Bar
4	Text Boxes[9], Tool Bars
3	Borders and Corners of the windows, Scroll Bar
2	Widths of Title bar for file display, Windows Task Bar
1	Text and Images/Pictures in the web site, Icon at the web address box, Separate Bar[10]

It is interesting to note that one participant did not highlight any item. And like Clickable, not all participants highlighted all related items.

Analysis and Discussion: There was only one item which had over 50% of responses – Windows. Perhaps re-positioning windows is a frequently used function. There were two possible explanations. First, recall that participants did not highlight all the related items. One example of that was icons. There were several icons on the Windows task bar and two on the desktop. Some participants highlighted the icons on the Windows task bar but not the ones on the desktop. This implied that there was a great chance that participants knew what items were draggable but failed to recognize them. Second, the survey was given in black and white, so some details were smoothed out by the gray scale and photocopy machine. Overall, participants did not recall many items that are draggable.

Task 3 – Outcomes

In this task, we asked participants to report what would happen after clicking at appointed locations (see Figure 3.1(b)). The correct answers are:

Location 1: Go to Canada Trust Home Page

Location 2: Nothing

Location 3: Activate PowerPoint Window

Recall that we only considered a single left-mouse click. Here are participants' responses:

[8] Drag window title bar

[9] Only in PowerPoint

[10] between window functions and web site space in Internet Explorer Browser

	Number of Responses (*Max.* = 11)	
Location 1	3	Go to Canada Trust Home Page[a]
	1	Go to Canada Trust Home Page, possibly with new window
	4	Another web page replaced current one
	1	Option of Canada Trust pop-up
	1	Nothing
	1	Close other windows
Location 2	8	Nothing[a]
	2	Highlight web address
	1	Open previous addresses menu
Location 3	7	Activate PowerPoint Window[a,b]
	2	Pop-up PowerPoint Window
	1	Open PowerPoint Window
	1	New options of PowerPoint pop out

[a]Correct response

[b]Including answers such as bringing PowerPoint Windows in focus or on top

The first entry of each location is the correct answer. During the survey, some participants expressed verbally that they guessed some of these answers.

Analysis and Discussion: The majority of participants understood the outcomes of the clicking. At location 1, most participants considered it to be a link and responded that another web page would appear, even though they might not know which web page. Similarly, most participants knew nothing would happen when clicking at location 2 and knew the PowerPoint window would be active when clicking at location 3. However, as mentioned earlier, some answers were guessed. Our observer noted that at least two participants said they did know the answer but wrote down "Nothing" at location 2. We also received some unexpected answers. For example, clicking at location 1 will "close other windows" or "New options of PowerPoint pop out" after clicking at location 3. Now, a question was raised: how do users know the outcome of clicking? Not all participants who had correct or close to correct responses used these applications before. There is something about visual appearances of these items that indicates their functions.

3.2.6 Summary

We learned several human behaviours from this survey. First, most participants were aware of the most frequently used items only. As a result, only a few items on the screen were recognized by more than half of the participants. This answered our question of how many visual indicators users recognize. Second, not all participants recognized all related items at the same time. Third, users do not always know every single outcome of clicking. This also shows that not all visual representations of screen controls gives users good indications of what the commands are and how they work. This implies that the perceptions of designers and users may not be the same. Is there a better visual representation of screen controls for which users and designers would have similar perception?

However, this survey has a limitation. We only have access to what users recognized on the screen shot. When we asked them to perform task 3, we found that participants knew the answers even though they never used these feature. However, in this survey, we were unable to gather information on which visual cues indicate the possible results of actions. We could not draw any conclusion about how users know the outcomes. We believe that some visual features of the screen controls indicate clickability and their functions. Hence, we turned our focus to find out what visual features communicate with users effectively.

3.3 Real Application Observations

The result of our Survey, which were described in the last section, showed that users did not recognize much on the screen shot. However, we believe that there is something about visual appearance of screen controls they recognized that indicate their functions. Hence, in this section, we present results of our attempt to find the visual features of screen controls which effectively communicate to users. We studied this by observing users' interaction with a computer system. We first describe the design process of this study, including two pilot studies. Then the analyses and results are presented next, followed by the summary.

3.3.1 Study Design

Overall Design

In the last study, we found that survey did not give us any information regarding how users recognize where to click and know its outcome. The survey was based on users' previous experience. There was no information of how they knew. We could ask users how. However, the moment users start thinking how, they might invent reasons. One possible solution is to observe their interaction with computer system. There was not much to observe in the Survey because there was no interaction with real computer systems. But when users interact with the system, we can observe the positions of the mouse pointer/cursor and users' gestures. The positions of the mouse pointer indirectly suggests users' thinking paths. Users' gestures show their attitudes and reactions, which also indirectly suggest their thinking paths. Therefore, observations of users' interactions with real applications or web sites were our first attempt to find visual features that communicate to the users effectively.

We had two choices of observation: on an application or web browsing. Before we designed this study, we ran one pilot study on an application and one on web browsing. These pilot studies helped to design the final version of the study. The details are next.

Stimuli – Pilot studies

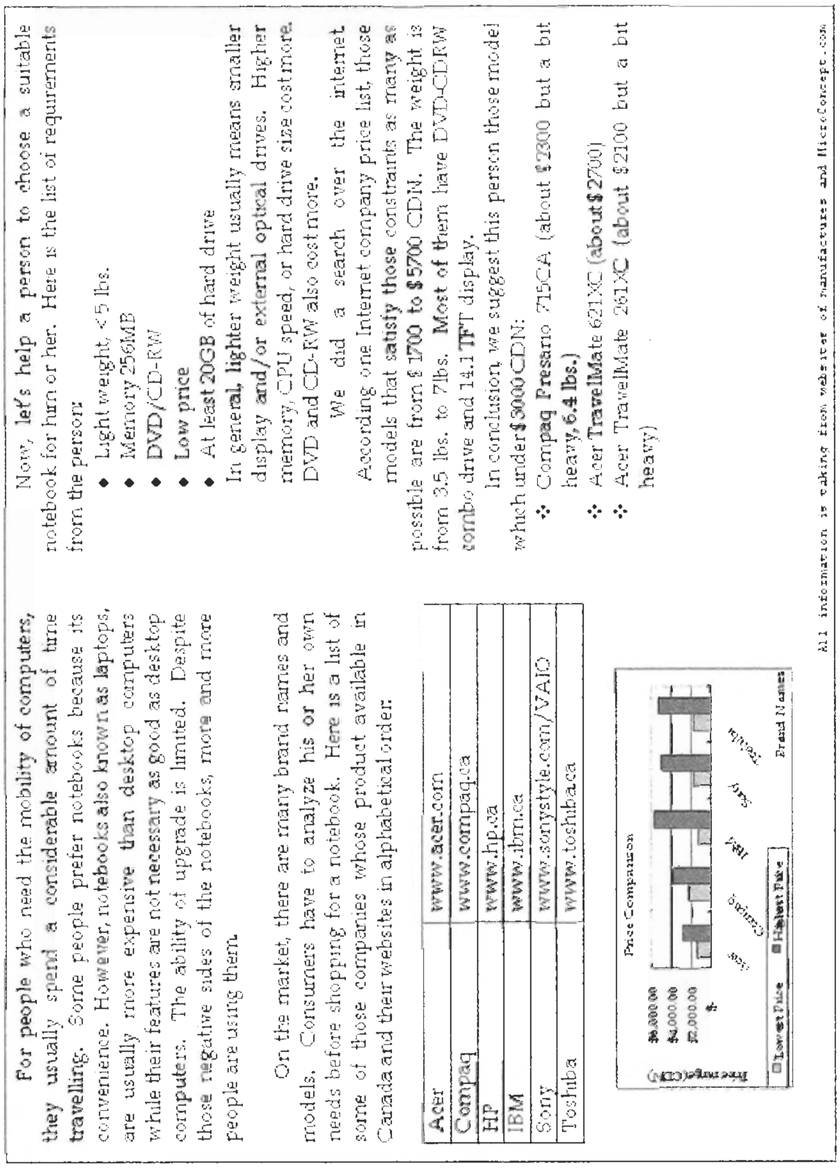
There were two pilot studies. The first pilot study was an observation of an application. The second was on web sites. There were two participants in the first pilot study and four participants in the second pilot study.

Application Observation: We chose Microsoft Word for two reasons. First, word processing is one of the common uses of computer. Second, Microsoft Word is one of the most used word processing applications. This pilot study consisted two parts: first, a brief demonstration of participants' typical usage of the application and second, duplicating a one page document as closely as possible. This document (see Figure 3.2) contained 2 columns of text in landscape, two types of bullets, a table, a graph and an image. Another table[11] was also given, which was the information to create the graph.

The typical usage of Microsoft Word that participants showed the observer involved saving files and formatting text font, size and face. It was simple and straightforward word processing. Since participants knew where the functions were located and performed them without any delay, this did not give us any information of how they knew where to click.

When recreating the document, participants only used certain functions which they had used frequently, such as the "undo" button. We also found that the science student had more experience using different functions in this application than the interior design student. The science student, who studied Biochemistry, had created graphs and tables for lab reports before and knew where to click to change text into two columns and how to create the table and the graph with given information. The science student spent some time thinking about which function she could use to create a graph and two columns. This was probably due to the fact that someone was watching and she was a bit nervous. It was interesting that even though the interior student did not know how to create a table or graph, she found a way to achieve the goal. Instead of looking up help on the features, she spent quite a

[11] This table is in Section C.1



For people who need the mobility of computers, they usually spend a considerable amount of time travelling. Some people prefer notebooks because its convenience. However, notebooks also known as laptops, are usually more expensive than desktop computers while their features are not necessary as good as desktop computers. The ability of upgrade is limited. Despite those negative sides of the notebooks, more and more people are using them.

On the market, there are many brand names and models. Consumers have to analyze his or her own needs before shopping for a notebook. Here is a list of some of those companies whose product available in Canada and their websites in alphabetical order:

Acer	www.acer.com
Compaq	www.compaq.ca
HP	www.hp.ca
IBM	www.ibm.ca
Sony	www.sonystyle.com/VAIO
Toshiba	www.toshiba.ca

Now, let's help a person to choose a suitable notebook for him or her. Here is the list of requirements from the person:

- Light weight, <5 lbs.
- Memory 256MB
- DVD/CD-RW
- Low price
- At least 20GB of hard drive

In general, lighter weight usually means smaller display and/or external optical drives. Higher memory, CPU speed, or hard drive size cost more. DVD and CD-RW also cost more.

We did a search over the internet. According one Internet company price list, those models that satisfy those constraints as many as possible are from $ 1700 to $ 5700 CDN. The weight is from 3.5 lbs. to 7lbs. Most of them have DVD-CDRW combo drive and 14.1 TFT display.

In conclusion, we suggest this person those model which under $3000 CDN:

- Compaq Presario 715CA (about $2300 but a bit heavy, 6.4 lbs.)
- Acer TravelMate 621XC (about $ 2700)
- Acer TravelMate 261XC (about $2100 but a bit heavy)

All information is taking from websites of manufactures and MicroConcept.com

Figure 3.2: Sample Document in the First Pilot Study

bit of time clicking on different functions which were displayed by default. She explored all kinds of buttons displayed on the screen by default. In particular, she explored drawing functions and table functions. She kept clicking on these functions to understand what they do. Towards the end of study, she figured out how to create a very simple table. She decided to duplicate the graph by using the drawing tools. The graph was a bar graph. So she used rectangular drawing function to create the graph box and bars, and add the labels by using a text box function. Even though she did not fully finish the whole document, she manage to create the graph fairly close to the original. Note that both participants were unable to finish the document within an hour.

Since participants did not finish recreating the document, we realized this document was either too long or too complicated. On the other hand, how the interior design student achieved creating table and graph showed us there is a problem. All the functions that were displayed by default had the same look — a small icon image. Since she knew some of these display functions such as save, she recognized that they were all clickable. However, she had no clue what the functions did even though she knew what she was looking for – icons to indicate to generate tables and graphs. It also seems like she was unaware that explanations of buttons appear with mouse-over effect. This raised the question of how users interpret these icon images. In other words, how labels suggest clickability by suggesting functionality, which refers to the functional relationship discussed in Chapter 4, Study 2. We were looking for the answer throughout the rest of our studies. In summary, we were unable to gather any information of how users know the images displayed as application functions are clickable. This is because users know some functions displayed as clickable images and treat other displayed images as unknown functions, which are also clickable. This is human nature of treating similar objects as a group (Gestalt Principles), which was described in Chapter 2.

Web Site Observation: While we were running the pilot study on Microsoft Word, we also ran a similar pilot study on websites as well. We asked participants to choose one or two web sites that they visited frequently. Their choices of web sites ranged from reading news, wallpaper download, e-mail, university student service, to search engine. Participants then visited these web sites while we observed their behaviour.

There were four participants in this pilot study. The first participant, who had the shortest observation time, visited only two pages of news website. She quickly scanned the first page using the scroll bar and clicked a link on the top of page to jump to a page containing a list of news videos. She then selected a news video to watch. The second participant chose the search engine. While she was doing her research on a specific topic, she also used an on-line e-mail system to forward information to her friends and used Microsoft Works to save some of information she found on the web sites. She clicked mostly on "back" button to go back to the search result page. The next participant chose a wallpaper download website. He mostly used a menu on the left of the web page to browse selections and clicked on images to download. The last participant used a web-based e-mail service and university student service, provided by her school. She clicked on the menu on the side bar to access her personal student records.

Since the web sites they browsed are their frequently visited pages, participants did not have any difficulties to browse web sites. In addition, they went directly to their targeted links on the pages. We were unable to gather any information that would tell us how users know what visual features of the screen controls indicate the clickability. Therefore, we needed another method beside just observation. We chose a think-aloud protocol.

We had two of the four participants re-run this pilot study with a think-aloud protocol. Unfortunately, this was not very effective. One participant did not say much. The other participant said a lot but not much related to the clickability we were looking for. Even though think aloud is a good method for tracking users' thinking paths, very little information participants said was useful to us.

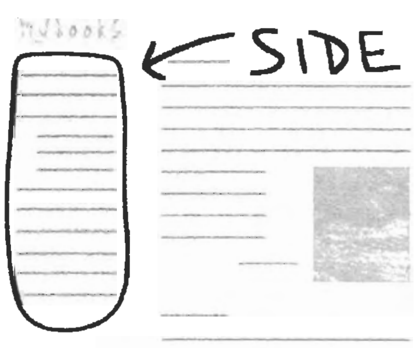
Summary of Pilot Studies: The pilot studies had several limitations. First, there was too much going on. In the application observation, there were too many actions involved. It was hard to distinguish what cues involved in which action. Second, there were many paths to achieve actions. One example was that participants could generate a graph by using drawing functions in the application, instead of using table and graph functions. This was a problem because it did not help us to find out which visual cues indicate clickability. Recall that most of the screen controls are made of two or more visual cues. When participants chose a familiar path to achieve actions, we can only conclude that the combinations of visual cues indicated clickability, not the individual visual cues. Third, participants performed familiar actions automatically. For example, they clicked on "undo" or "back" button without extra thinking or searching when they would like to go back to a previous state.

Recall that our goal was to find visual features of screen controls that indicate clickability and their functions. The limitations made it hard to gather information that would help us to understand which visual cues communicate to users effectively. When the intended action goals were familiar to users, they responded automatically without any delay. We noticed that users recognized unfamiliar screen controls as clickable items when these unfamiliar screen controls have similar appearance of the familiar screen controls. We were interested in the situation when users encounter a screen control that was not like any screen controls they had seen before. This would give us information of how users know where to click. In other words, stimuli with unfamiliar visual representation of screen controls or locations might help us to gather information. In addition, we were looking for answers of how labels suggest clickability, by suggesting functionality.

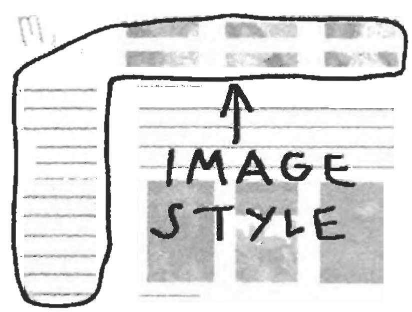
3.3.1.3 Stimuli

We chose to use web sites. This is because we were unable to gather any information of how users know where to click when the screen controls and their locations are familiar to users. Users act automatically with well-known screen controls. Different visual forms of screen controls or locations might help us to capture how users know where to click. After years of development, applications all have similar locations and visual forms for the screen controls. On the other hand, web sites change constantly. Moreover, visual representations of screen controls in web sites are not uniformally designed. One such example is the function of "go to home page", described in Chapter 1.

The task we considered was book search. By giving participants a book description, we tried to force users to go through a sequence of links to reach the book itself. During the search, we hoped to capture visual features of screen controls that indicate clickability and their functions.



(a) Side Design



(b) Gamma Design, Image style

Figure 3.3: Two Major Layouts of Bookstore Web Sites

We collected a list of bookstore web sites and categorized them by their layouts and graphical languages. There are two major layouts: the book categories appear either at the side of the page (Figure 3.3(a)) or at the top and the left of the page (Figure 3.3(b)). We called the second a Γ design. Most of the web sites we found have Γ design but a few have the side layout. There are two major graphical representations of links: test style or image style. Figure 3.4 is an example of a web site that only uses text style. We selected five web sites of this style. We also selected one web site with image style (Figure 3.3(b)).

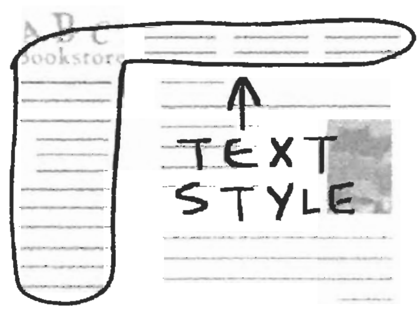


Figure 3.4: Γ Layout of Bookstore Web Site, Text style

For each web site, we found a book that existed in the web site database and its description. They were all different. If they had been the same book, then after knowing the book title from the first web site, users could have used a search function to find the book in other bookstores. Each book could be found by going through book categories. In addition to the book description, we also gave some book categories, publishers, or authors' first or last names. We asked participants to find the matching book title, its ISBN and the current price. Here is one example of a book description we gave:

2. www.chapters.indigo.ca

"The women had no chance. The men were nothing but one of six teams capable of winning. So said the critics and naysayers. But on February 21st and 24th, 2002, the women and men of Canada's ___ teams completed an historic double, a perfect sweep of ___ gold at Salt Lake 2002. ... For the men, it represented the end of a fifty-year drought that went back to the '52 Edmonton Mercurys. For the women, the win was sweet revenge for an unexpected loss at Nagano in 1998. For all of Canada, the wins not only satisfied a nation infatuated with ___—it helped define and re-affirm the country's identity."

Category: Sports
Author(s): First name is Andrew
Publisher: Fenn Publishing Company Ltd

Book Title: ______________________________

Book ISBN: ______________________________

This study consisted of six book searches on six different web sites. We had two versions:

Version 1		Version 2	
Γ, text web site 1	Book 1	Γ, text web site 1	Book 1
Γ, text web site 2	Book 2	Γ, text web site 2	Book 2
Γ, text web site 3	Book 3	Γ, text web site 3	Book 3
Γ, text web site 4	Book 4	Γ, text web site 4	Book 4
Γ, text web site 5	Book 5	Γ, text web site 5	Book 5
Side, text web site 6	**Book 6**	**Γ, image web site 7**	**Book 7**

The difference between the two versions is the sixth web site. The first five web site had Γ design and text style on the top menu selection. The sixth web site of version 1 had different layout, the side design. The version 2 had different style of menu selection, image style. The idea was to let users get familiar with one particular layout and graphical language. Then we would like to see how they changed their behaviours by giving them a different style of web site at the end. We hoped the change of behaviours would reveal users' thoughts, from mouse movement and users' gestures, and help us to understand users. Also note that the books for the two final web sites were different. This was due to the fact that we had hard time to find one book that existed in both web sites.

3.3.2 Study Task

In this study, participants were asked to browse six different online bookstore web sites. A list of book descriptions was given, one for each website. Participants were asked to find the latest available version of the book title, its ISBN and current price that match the book description.

3.3.3 Participants and Sample Size

We were more interested in non-technical users. The reason was that their understanding of computer systems was likely to differ from technical users such as engineers or programmers. Technical users have more experience on visual language of commands. It would be harder to observe how they solve the difficulties.

There were two university level students in this study, one from each gender. Neither participants was a computing science or engineering student. One participant is a music student and the other studies home economics. The average time they spend on computers was 14 hours per week. In fact, they indicated all the time they spent on computers was web browsing. Both participants currently used Microsoft Windows before 2000 version, Internet Explorer browser and Google search engine. Only one participants currently used Microsoft Word, the other used it a lot before. One participants used to browse Amazon website, the other hardly use it. Participants hardly or never used any other applications or web sites we listed. The most frequently performed activity on the web sites was e-mailing, at least once every day. The other activities they performed on the web sites were reading news, articles or magazines and browsing online. These activities were either at least once every month or every week. Participants used web search engine at least once every week and library catalog system at least once every month.

3.3.4 Schedule and Setting

The duration of this study was one hour. Participants were scheduled based on their preferences. The study was held at the locations of participants' choices.

3.3.5 Software and Hardware Systems

The study used participants' personal computers. All computers had Internet connections. The operating systems were Microsoft Windows. All participants used Internet Explorer to complete this study.

Web Site	Correct Answer	Participant 1	Participant 2
1	The Complete Chronicles of Narnia 0066238501	*Chronicles of Narnia* *0064409392*	*The Chronicles of Narnia Box set* *0064409392*
2	Canadian Gold 2002: Making Hockey History 1551682680	Canadian Gold 2002: Making Hockey History 1551682680	Canadian Gold 2002: Making Hockey History 1551682680
3	Tips for Good Living with Arthritis 0912423277	Tips for Good Living with Arthritis 0912423277	Tips for Good Living with Arthritis 0912423277
4	Catch Me If You Can 0767905385	Catch Me If You Can 0767905385	Catch Me If You Can 0767905385
5	Busted! 0740726757	Busted! 0740726757	*The Humongous Zits* *0740700138*
6	Quest: A Guide for Creating Your Own Vision Quest 0345409035	N/A	Give up, can't find it
6	Emma 0451523067	Emma *055321019X*	N/A

Table 3.1: Observation Result
NB. Incorrect selections are in italics.

3.3.6 Results and Discussion

Even though we did not specify a duration should be done, participants automatically did their best to finish up as soon as possible. However, the answers were not all correct. Table 3.1 shows both the correct answers and the answers from participants. We saw that first book, fifth book and one of the sixth book were not the same. The first book has many different editions. This was the reason we asked participants to write the book ISBN. Both participants found the correct book title but different edition. One possible reason was that they did not check the book publication date to confirm. Another reason could be that they simply forgot the instruction we gave — find the latest version of the book. One participant got the wrong book to the fifth title. This might be because the book is about "Zits" but the actual book title did not contain "Zits". Hence it was easy to miss. One participants found the sixth book but a different edition again. The web site for this book is selling mostly used books. So it was possible that the book we requested was sold and no longer available. The web site has the book description for all books with that title, regardless its version. Hence the participant picked any one that listed. The other participant had a hard time finding the last book and finally gave up due to time for her another appointment. We did not pay close attention to the correctness of the prices. This is because prices change from time to time.

During the observation, we found that participants tended to get to the answers by search engines. All bookstores in this study provide a search engine, which usually located at the top of the page. In the process of finding each book, three quarter of the time participants started with the search engine. This was unexpected. We hoped by giving users category and book description that they would find books by certain path. And hence the observation would provide us how users find where to click. However, participants ignored the categories and started with search by keyword or authors. In the case of first book, both participants knew the book title from book description. Hence they chose to use search engine. However, we were unable to gather information on how participants recognized what to click.

3.3.7 Limitations and Summary

We found that it was hard to design a task which was not too complicated and yet complicated enough for our purpose. For example, book search was the right amount of the complication. However, there were many different paths involved. We expected participants to follow one specific path but they chose different paths to reach the goal. Our path was finding books by following book categories. In this study, the path participants chose was to use search engines instead. This also showed that every participant had different strategy of problem solving. Participants brought their past experiences into problem solving. Note that their problem solving did not include using help feature. During this experiment, participants did have some difficulties with simple search function. However, no participants looked to the help feature.

Another problem occurred when we designed the task. Commands come with many different form of representations. When the users are familiar with the screen controls, they act automatically to the controls and we are unable to track what cues indicate the commands. The best situation for us to track cues is when the users are not so familiar with the commands. However, there are too many cues involved in the applications or web sites. Even though book search involved mostly links, links come many different forms. Some are underlined. Some have different colour. And some come in graphics. All of these contributed to the indication of cues. Different web site used different combinations of these factors as well. Even within the web site, it is not consistent. One web site we found has two different ways to represent the links: underlined text in the menu section and coloured text in the page content. We could not completely separate them to test which one is more influence than the other. As the result, we could not find out which visual cues indicate the clickability and their functions.

In this study, we had a small sample size. This was because after running two participants, we realized that the behaviours of these two participants represent how users in general would respond to the task of search. Their responses to the instruction of book search were using search engine first. Therefore, we did not a large pursue sample size.

3.4 Chapter Summary and Discussion

We learned several things from Survey and Real application observations. First, we were unable to track which cues indicate the commands. This is because participants acted automatically to well-known screen controls. In other words, participants interact with the applications based on their previous experience and knowledge of the applications and websites. However, there is no direct access to their past experience and knowledge. Even though questionnaires can be used, it only showed us the types of experiences participants encountered but not how they encountered these experience. We were unable to learn their experience and knowledge from the observations of their behaviours either. Second, no matter how carefully we constructed the tasks so that participants had to perform a certain sequence of actions, participants usually achieved the task by using other sequence of actions. This shows us that each individual has his or her own strategy of problem solving. Application usually provide several different ways to finish tasks. Third, each command is made up with two or more cues. For example, icons are basically represented by images. Some icons have labels, some have mouse over effects to indicate the functions of icons. This makes it hard to know which cue indicates the functionalities of screen controls. Lastly, it is not easy to find features in the applications that were unfamiliar to users. This is because real applications within a class today have similar layout and graphical representations in design.

To improve the design of future studies, there are several possibilities. One possibility is give participants a specific instruction not to use the search engine. This will eliminate the search engine path of finding books. Another possibility is to be more careful where the books are located. For example, the books are located within the first page their category lists and in other pages of search engine results. The other possibility is to vary web sites or applications one visual cue at time. However, these possible improvements are limited by the complexity of web sites and applications, as well as several factors we have no control of. First, we have no control of web sites. The web sites are changing all the time. We have no control when the web sites we used would change their layout or design. Second, there are not many online bookstore web sites. Hence, it is not easy to keep the variation of web sites as little as possible. Third, finding a book that all web sites carries is also not easy. Most online bookstores carry either one or two categories of books or small collections of all categories. Lastly, what we would like to control is visual cues. However, these visual cues are fixed in the applications or web sites. We can not control where and how many cues appear.

Recall that our goal was to find out which visual cues communicate to users effectively. We had difficulties to draw conclusions from what we learned from real applications and web sites. Hence it led us to find a new method that would help us to find out what visual cues indicate the clickability, which is discussed in the next chapter.

Chapter 4

Studies Of Abstract Screens

4.1 Motivation and Overview

In the studies reported in previous chapters, we used real applications as our stimuli. While using real applications as stimuli provided ecological validity, we had difficulty drawing conclusions from the resulting data. There were a number of reasons. The first reason is that real applications have strong semantic associations for users. Users interact with the applications based on their previous experience and knowledge about the applications and web sites. However, their previous experience and knowledge is not directly accessible to us. In addition, it is impossible to accurately infer the prior knowledge from their observable behaviours. The second reason is that real applications provide several different paths to achieve any given task. When the participants were given a task intended to force them to use unfamiliar features, participants completed the tasks by applying familiar features in novel ways. The third reason is that cues of each functionality are closely inter-related and often convergent. For example, there was no way to separate the effects of graphical language and intention since both tended to suggest the same outcome. The fourth reason is that real applications are compatible overall and within a given class of applications. This means that layouts and graphical representations in design are similar and makes it hard to find features in the applications that users are unfamiliar with.

These limitations show the current state of software and web site design. The past twenty years of research in human-computer interaction were a success. Software and web site designers have built successful strategies for the information design of their software. Conventions have been developed so that users may adopt new applications quicker and easier. On the other hand, these limitations also show that real applications are not good stimuli in our study. Visual cues of the screen controls and strong prior semantic associations of the real applications are inseparable. They blend so well together that their effects are confounded. We needed stimuli without these confounds to overcome these limitations. We needed stimuli with completely separable cues and the fewest possible semantic associations. Hence, we developed a set of abstract screens.

(a) Stimulus 01 in Study 1

(b) Stimulus 22 in Study 1

Figure 4.1: Sample Abstract Stimuli

Figure 4.1 shows examples of abstract screens. These abstract screens are much simpler than any existing real application or web site. There are several advantages from using these abstract screens over real applications. First, there are no multiple paths to reach the goal of the action. The abstract screen is the application itself and all the possible actions in the application are presented in one screen. Given an intention, users have to perform the action on that one screen and the goal can only be achieved by clicking on one of the commands. Second, there is little skill transfer involved. Here, the skill refers to what users learned about "clickability". There is little skill transfer because the stimuli are not based on any existing real applications or e-commerce web sites. Participants cannot really use what they learned previously about the semantics of real applications. However, they may use what they previously learned about screen controls. Third, it is easier to control the number of cues used in the stimuli. For each command, we can decide how many cues to represent the command on the screen. These abstract screens can test as few cues as possible at one time. In other words, the cues would be separated as much as possible. Hence, we can figure out which visual cues communicate to users effectively.

However, there are still some limitations. First, a subject's past experience can never be removed even though it is not as strong as before. Whenever users encounter applications they have never used before, they would use their previous experience to judge where and how to perform the actions. Therefore, we can not remove this factor but only reduce its effects. Since these abstract screens are not based on any existing real applications or e-commerce web sites, the influence of previous knowledge and experience is reduced. Another limitation is the cues. No matter how we design the screens, layout is one cue which can not be separated from rest of cues. Layout is always there whenever the application uses graphical representations to represent the functions of the application. Another problem is colour. Colour has different meanings for different cultures. For example, red in Chinese culture means good but in traffic system means danger. In other words, using colour alone may cause some confusion. This is the same with images. For example, the mail box icon is familiar to people in America because it appears as a mailbox in their literature and physical life. However, a mailbox in Italy looks like an American style trash can icon [24]. Hence, some cues, such as colour and image, need other cues to help express their function better.

We conducted two abstract screen studies. The purpose of these studies is not only to understand the users but also to determine which cues play important roles in the perception of clickability. To analyze the data, we used simple statistics.

4.2 Abstract Screen Study 1

In this section, we describe the design of the first abstract screens study, including the study and task design, participants, and the systems used. Before going into details of the design, here is a general description of the abstract screens: Each abstract screen has two parts. The top part contains at least one question. The question represents what goal the participant was trying to accomplish for the given stimuli. Bottom part contains an application screen we created. This application screen contains screen controls: several buttons, text, or images. The abstract screens were designed using as few number of cues at one time as possible. This abstract screen study, as well as the next study, used a set of these abstract screen. Figures 4.1, 4.2, and 4.3 are examples of abstract screens.

4.2.1 Study Design

Overall Design

Since it was difficult to draw useful conclusions from the results of the studies described in the last chapter, we created abstract screens to capture users' understanding of clickability. The main purpose of this study was to test the use of abstract screens. In this study, we manipulated graphical language, such as colour, and location of visual cues.

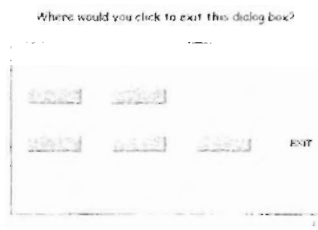


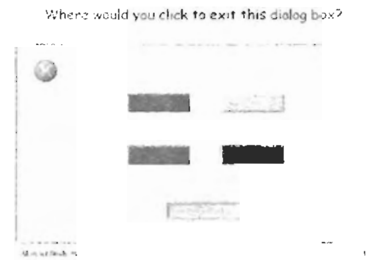
Figure 4.2: First Abstract Screen

Stimuli

We started with the intended action. We asked "Where would you click to exit the dialog box?" across all stimuli in this study because exiting a dialog box is a common function. The next step was creating dialog boxes. We chose only two factors, location and graphical language, for this study. Location refers to where the screen control is located. Graphical language refers to the graphical representation of the control. We would like to know how much influence is by graphical language and to what extent. Hence we chose these two factors is that the exiting function usually located at lower-right corner of the dialog box. We first created a dialog box using five buttons and a word "EXIT" (Figure 4.2). The button was screen-captured from an existing Windows application. Then we created a series of dialog boxes by manipulating one or two factors. Note that graphical language includes images, colour, and text. We manipulated these factors by rearranging the layout of the elements, changing or removing the word, labelling buttons, using a colour button or different style button, and adding images. For example, we replaced the open-door image on the top-left corner of Stimulus #30 with an image of "X" to create Stimulus #31 (Figure 4.3). Note that all text used in the stimuli are closing dialog boxes in real applications.

While creating those abstract screens, we conducted four pre-pilot studies. For each pre-pilot study, each participant was given twenty stimuli. There were a total of ten non-computing/engineering (Non-CE) and six computing/engineering (CE) participants in four studies. The purpose of these pre-pilot studies was to remove some duplicate stimuli and to test if these stimuli would work. Over four pre-pilot studies, we created 54 stimuli in total. Based on the responses of four pre-pilot studies, we selected 36 of them for a pilot study. There were two reasons for reducing the amount of stimuli. First, the number of stimuli

(a) Stimulus 30 in Study 1



(b) Stimulus 31 in Study 1

Figure 4.3: Sample Abstract Stimuli

in the original set was too large, and we did not want to tire our participants. Second, we wanted to eliminate stimuli with similar effects. If two stimuli had similar layouts and similar responses pattern, we kept only one of them. We did not make any additional change to the stimuli after the pilot study. The full stimuli are presented in Appendix D.

4.2.2 Study Task

There were 36 stimuli. We arranged the stimuli in three different orders by shuffling stimuli. Participants were randomly given one ordering set. This would limit any stimuli ordering effects. We asked participants to answer questions in the stimuli as quickly as possible. In other words, we asked them to respond using their instincts. We also told them that there is no correct answer for these stimuli. Participants reported their responses verbally to the observer. Note that their responses time was not recorded, which may measure the difficulty of stimuli.

4.2.3 Participants and Sample Size

Participants were all university or college students.However, we chose students as our subjects for two reasons. First, it is easy to schedule study sessions with students. Second, we would like to compare subjects with similar background. This helps to reduce the difference between individual subjects.

There were eleven participants, six males and five females, seven Computing Science/Engineering and four Non-Computing Science/Engineering students. Participants ranged from 19 to 29 years old. CE participants were older because they were graduate students and Non-CE participants were undergraduate students. The hours of spending on computer ranged from

4.5 to 60 hours per week. CE participants spent on average 40 hours per week on a computer while Non-CE participants spent only on average 9 hours on computers per week on a computer [1].

The following is information of participants' experience on applications and websites:

- Desktop

  Participants were all familiar with at least one version of Microsoft Windows. However, five out of eleven participants, who were all CE participants, know Mac OS and three participants know other desktop. All CE participants except one answered what other desktops they know. The most frequent answer was Linux. Other desktops are Unix and FreeBSD. However, one participant hardly use this other desktop and two participants did not tell us how frequently they used other desktops.

- Applications

  Since Microsoft Windows is the most used operating system, we asked how frequently participants used Microsoft applications Word, Excel, and PowerPoint. CE participants used these applications more than Non-CE participants. In fact, Non-CE participants used Word only. Among CE participants, the most frequently used application is Word, followed by PowerPoint, then Excel.

- Web Browsers

  Since all participants are familiar with Microsoft Windows, it is not surprising to see all of them use Internet Explorer.The second most popular browser is Mozilla or Netscape. However, only CE computing science participants used it. Only a few participants used other type of browsers.

- Web Sites

  All participants use the Google search engine often.We chose the Amazon shopping web sites because it is a popular and well known shopping web site. Yahoo maps represents information web sites. Participants did not use web sites such as Amazon or Yahoo maps frequently.

- Hot Keys (Short-cut Keys)

  CE participants had more knowledge and used more frequently hot keys than Non-CE participants.

[1] The complete statistics of participants' background can be found in Appendix G.1.1.

In summary, CE participants had more experience on different applications and web sites than Non-CE participants[2].

4.2.4 Schedule and Setting

The duration of each study was 20 – 30 minutes. Participants were scheduled based on their preferences. The study were held either at the room ASB 9834 in Simon Fraser University Burnaby Campus or at the locations of the participants' choice.

4.2.5 Software and Hardware Systems

The study was done on a laptop running Microsoft Windows XP and PowerPoint 2000. All stimuli were designed as PowerPoint presentation slides.

4.2.6 Results – Ordinal Statistics

Before going to describing our results, let us recall the goal of this study. We were looking for a method to capture users' understanding of clickability. In other words, how do users know where to click? What features of visual forms of screen controls indicate the clickability and screen controls' functionalities? We also investigated for how context influences clickability. An additional purpose of this study was to test the idea of abstract screens.

The layout of the buttons was the most important factor. We found that 60% of the time, participants clicked at the lower right most button, image or word. However, there were a few exceptions. First, participants preferred a word when it looked like a possible HTML link. Examples are in Table 4.1(a). There are four underlined words — "Cancel" in Stimulus #9, "Close" in Stimulus #8, "EXIT" in Stimulus #10, and "OK" in Stimulus #4. They all were placed at the top of the screen and had relatively higher hitting rate than the lower right most location. Some labels could also override the effect of layout. In the study, we had several words and images as possible functions to "exit" the dialog box. Of those labels, the word "EXIT" got most of the attention from participants even when it was placed in the centre of the screen (See Table 4.1(b)). This is because the intention we gave to the participants was to "exit" the dialog box. Similarly, an open-door image got relatively higher attention. Other words like "Cancel", "Close" and "OK", which also indicate the function of exiting, were not as strong influence as "EXIT". Words like "Open"

[2] The complete statistics of participants' computer usage can be found in Appendix G.1.1.

Table 4.1: Hit Rate of Individual Cues in Study 1

Total number of participants = 11 = Total number of expected hits for each stimulus

% of actual hits = # of actual hits / # of expected hits

(a) Underlined Words

Stimulus	Word	Location	% of actual hits
S-04	OK	Top Right	45%
S-08	Close	Top Right	73%
S-09	Cancel	Top Left	45%
S-10	EXIT	Top Left	82%

(b) Words

Word	# of stimuli which contains the word	# of expected hits	Average of actual hits
EXIT	6	66	56 (85%)
Opened Door Image	3	33	23 (70%)
Cancel	3	33	22 (67%)
Close	3	33	17 (52%)
OK	4	44	21 (47%)
Open	1	11	01 (18%)
Save	1	11	00 (00%)

(c) Stimulus #30

Location	Visual Cue	% actual hits
Top Right (Row 1)	Opened Door Image	64%
Row 2, Centre Left	Red Button	00%
Row 2, Centre Right	Regular Button	00%
Row 3, Centre Left	Green Button	00%
Row 3, Centre Right	Blue Button	09%
Buttom Centre (Row 4)	Light Blue, Larger Button	27%

(d) Word - OK

Stimulus	Location	# of actual hits		Notes
		CE	Non-CE	
S-01	Bottom Right	4	1	
S-04	Top Right	4	1	Underlined word
S-06	Bottom Left	4	1	
S-17	Bottom Right	4	2	

NB. For complete list of individual cues' hit rate, see Table G.3

and "Save", which close dialog boxes in the real applications, were not considered a way to exiting the dialog box.

There is also an exception where graphical language outweighs location. Graphical representation such as an image or a different styled button had more relative attention when it was recognized as a command. An example is Stimulus #30 (Figure 4.3(a)). Table 4.1(c) shows the hitting rate of all items on the Stimulus #30. The opened-door image had a far higher hitting rate than any button and was seven times as high as the strongest location, the bottom centre.

In addition to these exceptions, there was also an interesting difference between the group of CE participants and Non-CE participants. The word "OK" (Table 4.1(d)) seems to appeal to Non-CE participants less than for CE participants. Non-CE participants tended to choose a button which has more visual attention (e.g., different colour, or style).

4.2.7 Summary

The result indicates that abstract screens can be used to understand how users choose where and what to click. However, we did not investigate how context (generic vs. Web vs. dialog) influences the interpretation of labels in this study.

There are some concerns over reliability. In this study, there were ten participants who also participated in the pilot study. As an estimate of reliability, we looked up their previous responses. The number of response changes ranges from 3 to 23 (8% to 64%). The average number of response changes is 9.6 (27%). This gave us the conclusion that users' responses are changing overtime. However, since we did not ask subjects to fill out background questionnaires in the pilot study and it was not our intention, we were unable to determine the causes. It would be interesting to study the causes of changing behaviours in the future though. On the other hand, we are now aware that any conclusion we made from the data we gathered would have some variability.

We learned that location seems to be the most powerful factor in general. Participants generally chose the lower-right most item to perform the exit function. This is partially attributed to the context we gave to our participants — exiting the dialog box. Nonetheless there are some exceptions. Sometimes, factors such as image, colour, and text overcome the power of location. In other words, how participants perceived the items would also determine their behaviour. If participants perceived a word as an active function of exit, then they would select the word. Another question raised in this study was whether the context matters — how would users respond if the question changes from "exiting the dialog box" to "bold the selected text"?

4.3 Abstract Screen Study 2

In this section, we describe the design of the second abstract screen study, including the study and task design, participants, and the systems used. Note that the basic structure of stimuli is the same as the first study.

4.3.1 Study Design

Overall Design

After our first abstract screen study, there were a few things that needed to be improved. First, we needed to design our stimuli in a systematic way (details in 4.2.7). More precisely, how the cues would be varied from one stimuli to another. For example, only one cue is varied and at a certain location. Also, we needed to narrow down the number of cues involved in the design. There were too many cues in the last design. We would like to test individual cue. Lastly, we needed a better definition of dimension or strategy.

From the last study, we knew that location is a strong cue. Location could be more powerful than simulated affordance such as protrusion ($2\frac{1}{2}$ D button). It is determined by the given context and layout. And it is the background for all interpretations. The other expectation is that perceived functional relationship determines the interpretations of labels or perceived force. In other words, perceived force is influenced by context. Another factor which also influences perceived force is location. We defined that strong perceived force is resistant to location within context and weak perceived force is susceptible to location. In summary, the variables we manipulated were two visual cues (labels and protrusion) and the action goals (intentions) with different contexts and layouts.

Stimuli

We narrowed down three different layouts of buttons: 3x3, or square, for the general context, Γ (a layout commonly used on web sites), and J (a layout commonly used for Microsoft Windows dialog boxes). Buttons are 2 1/2 D and gray rectangular style. To test simulated affordance, or protrusion, we used a 2D rounded edge rectangular style button (see Appendix E). Labels of the buttons were "Stay", "Bold", "Exit", "Next", "Home", "Help", "Save", symbol "bar", symbols "→", "←", and "X". These labels were selected to show their associations with intention. Possible intentions include exiting the dialog box, going to the next step and getting help.

The stimuli were created based on six different categories:

- Location in generic context

  All three layouts were used in the design. Since the context is generic, we modified the questions to reflect the context. The questions are as follows?

  1. "Where would you click to go to the next step?",
  2. "Where would you click to complete the current operation?", and
  3. "Where would you click to display help?"

  From the previous study, we expected participants would click at the lower-right most button to complete the current operation. The purpose of the three intentions was to check whether participants would change their responses. The purpose of this section was to get initial responses of participants in a general context.

  There were a total of three stimuli, one for each layout.

- Location within the context

  All three layouts were used under two different contexts. One context was web site and the other was dialog box. In the web context, we asked:

  1. "Where would you click to go to the next page?",
  2. "Where would you click to go to the Home page?", and
  3. "Where would you click to display the FAQ?"

  Similarly, in the dialog box context we asked:

  1. "Where would you click to go to the next step?",
  2. "Where would you click to exit this dialog?", and
  3. "Where would you click to display help?"

  The purpose of this section was to compare how participants shift their responses from general context to web or dialog context.

  There were a total of six stimuli, one for each layout and each context.

- Labels at non-forceful locations

  All layouts were used in the design. The question was "Where would you click to complete the current operation?" Based on the observations from our previous study, we defined any location which is not on the diagonals as non-forceful. Each label was tested at two randomly-selected non-forceful locations in each layout. To reflect the context of layout, some labels were not used in the design. All four symbols were used in the design. To reflect the web context, "Next", "Help", and "Home" were used in the Γ layout. "Bold", "Stay", "Save" and "Exit" were used in the square and J layouts.

  In this section, we would like to see how much label influence participants' responses. There were eight, seven, and eight labels in square, Γ, and J layouts respectively. There was a total of 46 stimuli, two locations for each label.

- Labels against location

  All layouts were used in the design. The question was "Where would you click to complete the current operation?" Each label was tested at three forceful locations in each layout. Again, to reflect the context of layout, some labels were not used in the design. All four symbols were used in the design. To reflect the web context, "Next", "Help", and "Home" were used in Γ layout. "Bold", "Stay", "Save", and "Exit" were used in square and J layouts.

  Again, we would like to see how much label influences participants' responses. There were eight, seven, and eight labels in square, Γ, and J layouts respectively. The total number of stimuli was 69, three locations for each label.

- Labels within functional relationship

  We only used 2x2 square layout in this group. Labels were "Bold", "Italic", "Stay", and some non-exiting words. The first stimulus contained "Stay" and nonsense words. The next two stimuli contained "Bold", "Italic", and nonsense words. These three stimuli would show us whether the behaviour of participants would change based on the words they understand. The last three stimuli were based on the previous two stimuli, and we added a context. The question was still "Where would you click to complete the current operation?"

  In this section, we would like to know whether known and non-exiting words played a role in the responses. There were a total of six stimuli.

- Graphical language (protrusion) against location

  All layouts were used in the design. Again, the question was "Where would you click to complete the current operation?" All buttons were 2D except one was $2\frac{1}{2}$ D. All forceful locations were used in the design.

  The purpose of this section was to test how protrusion affected participants' responses. There were 25 locations from all layouts. Hence, the total was 25 stimuli.

Note that we did not design labels on all possible locations. Because we already had 155 stimuli in total. Stimuli were organized into five sections (in the order of presentation to participants):

1. Location in generic context (3 stimuli)
2. Location against labels or protrusion (140 stimuli)
3. Location in web context (3 stimuli)
4. Labels within functional relationship (6 stimuli)
5. Location in dialog box context (3 stimuli)

The second section had too many stimuli so we reduced to 40 stimuli first. We asked two participants to go through the whole study as a pilot. Based on these two set of responses, we re-selected 45 stimuli in the second section for the second abstract study. For 3x3 layout, there were five stimuli of labels at non-forceful locations and four stimuli of protrusions. For Γ and J layouts, each contained 15 stimuli of forceful locations and three stimuli of protrusions. The full stimuli are presented in Appendix E.

4.3.2 Study Task

There were 70 stimuli in five sections, including the instruction pages. All participants were given stimuli in the same order. Unlike the last study, we did not control for possible ordering effects because there are many different orders of stimuli: the order of sections, the order of stimuli within each section, or both. Note that the stimuli in the second section were randomized order. Participants were informed that there are three layouts but not their relations to the contexts. We asked participants to answer questions in the stimuli as quickly as possible. In other words, they were asked to respond with their instincts. They were also told that there is no correct answer in those stimuli. Participants reported their responses verbally to the observer. Note that in sections 1, 3, and 5 which had three given intentions, participants were asked to respond to all questions.

4.3.3 Participants and Sample Size

Participants were all university or college students, either in Computing Science/Engineering (CE) or Non-Computing Science/Engineering (Non-CE). We chose students as our subjects for two reasons. First, it is easy to schedule study sessions with students. Second, we would like to compare subjects with similar background. This helps to reduce the differences between individual subjects.

There were twenty two participants, ten males and twelve females, eleven from each group. Participants ranged from 18 to 30 years old. The hours of spending on computer ranged from 5 to 144 per week. CE participants spent on average 38 hours per week on computers while Non-CE participants spent on average 32 hours on computers each week [3]. One Non-CE participant spent an average of 144 hours per week on the computer. Without this person, the group average was 20.5 hours per week.

Here is a summary of their experience on applications and websites.

- Desktop

  Participants were all familiar with at least one version of Microsoft Windows. However, 3 out of 22 participants used Mac OS and 6 participants used other desktops. All CE participants except one listed the other desktops they know. The most frequent answer is Linux. Other desktops are Unix and DOS. However, three participants rarely used other desktops they knew and two participants did not tell us how frequently they used other desktops.

- Applications

  We asked how frequently participants used Microsoft applications — Word, Excel, and PowerPoint. CE participants used these applications more than Non-CE participants. The most frequently used application is Word, followed by Excel and PowerPoint.

- Web Browsers

  Since all participants were familiar with Microsoft Windows, it was not surprising to see all of them except one use Internet Explorer.The second most popular browser was

[3]The complete statistics of participants' background can be found in Appendix G.2.1.

Mozilla or Netscape in both groups. Only three CE participants used other browsers but one rarely uses it.

- Web Sites

  The majority of participants used the Google search engine often. We chose the Amazon shopping web site because it is a popular and well known shopping web site. Yahoo maps represents information web sites. The majority of participants did not use these two web sites frequently.

- Hot Keys (Short-cut Keys)

  CE participants knew and used hot keys more frequently than Non-CE participants.

In summary, CE participants had more experience on different applications and web sites than Non-CE participants[4].

4.3.4 Schedule and Setting

The duration of this study was 20 – 30 minutes. Participants were scheduled based on their preferences. The study was held either at room ASB 9834 in Simon Fraser University Burnaby Campus or at locations of the participants' choice.

4.3.5 Software and Hardware Systems

The study was done on a laptop running Microsoft Windows XP and PowerPoint 2000. All stimuli were designed as PowerPoint presentation slides.

4.3.6 Results

Since we found abstract screens offers a possibility to help us capture users' understanding of clickability, our focus was on finding answers raised from the earlier studies:

- What features of visual forms indicate clickability?
- Does context (generic vs. Web vs. dialog) affect users' responses?
- How do variations in layout affect users' responses?
- Does functional relationship influence the interpretation of labels?

[4] The complete statistics of participants' computer usage can be found in Appendix G.2.1.

Recall that we had three different layouts in the Study 2: 3x3, Γ, and J layout. We defined global position numbers for all buttons in all three layouts. Figure 4.4 shows the global position numbers for each layout. Each layout is represented as a 5x5 grid. If the number in the grid is black, it represents a button in that layout, otherwise it is gray. For example, in the 3x3 layout, the buttons are numbered as 1, 3, 5, 11, 13, 15, 21, 23, and 25. Similarly, 1 – 4, 6, 11, 16, and 25, are button numbers in the Γ layout, and 5, 10, 15, 20, and 22 – 25 are button numbers in the J layout. All position numbers in the data analyses refer to this global position number set.

Position for 3x3 Layout

1	2	**3**	4	**5**
6	7	8	9	10
11	12	**13**	14	**15**
16	17	18	19	20
21	22	**23**	24	**25**

Position for Γ Layout

1	**2**	**3**	**4**	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Position for J Layout

1	2	3	4	**5**
6	7	8	9	**10**
11	12	13	14	**15**
16	17	18	19	**20**
21	**22**	**23**	**24**	**25**

Figure 4.4: Global Position Number For Each Layout In Study 2

Also recall that we had five sections in this study:

1. Location in generic context (3 stimuli)
2. Location against labels or protrusion (45 stimuli)
3. Location in web context (3 stimuli)
4. Labels within functional relationship (6 stimuli)
5. Location in dialog box context (3 stimuli)

There were three questions given in sections 1, 3 and 5. For the first section, the context was generic and the questions were:

1. Where would you click to go to the next step?
2. Where would you click to complete the current operation?
3. Where would you click to display help?

For the third section, the context was the World Wide Web and the questions were:

1. Where would you click to go to the next page?
2. Where would you click to go to the Home page?
3. Where would you click to display the FAQ?

For the fifth section, the context was a dialog box and the questions were:

1. Where would you click to go to the next step?
2. Where would you click to exit this dialog?
3. Where would you click to display help?

We did not analyze the data for section 4 because we considered this section unsuccessful (see Section 4.3.7). Hence, we only analyzed sections 1, 2, 3, and 5.

Ordinal Statistics

We first discuss the effect of context. For each context, each layout and each question, the total responses of each position was calculated and then graphed as bubbles on a 5x5 grid. For comparison purposes, we combined the three layouts which had the same context and question, producing 9 graphs showed in Figure 4.5.

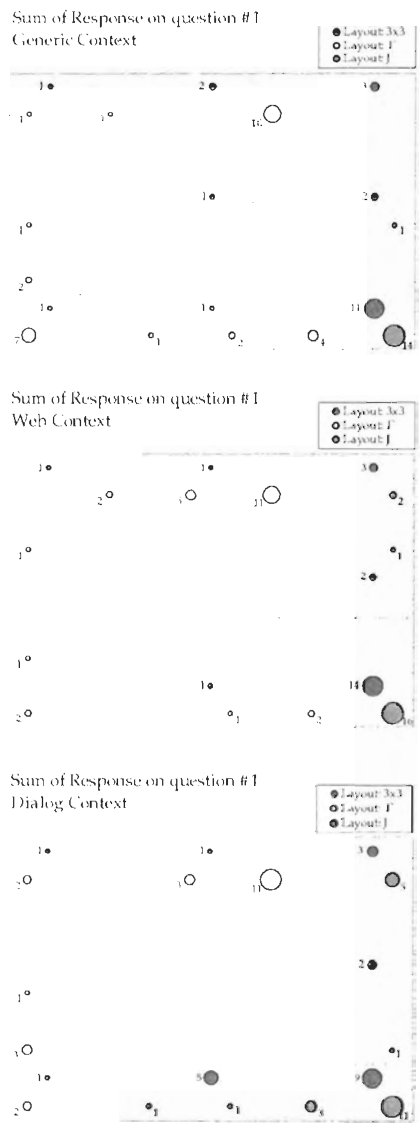


Figure 4.5: (a) Question 1

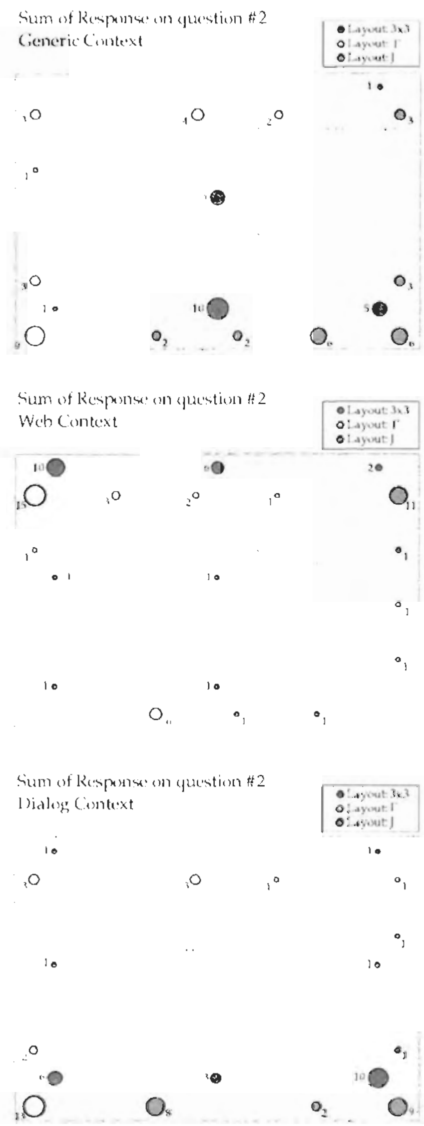


Figure 4.5: (b) Question 2

Figure 4.5: Ordinal Data, Study 2

NB. Area of circle = Number of hits

See notes on the next page for reading these graphs.

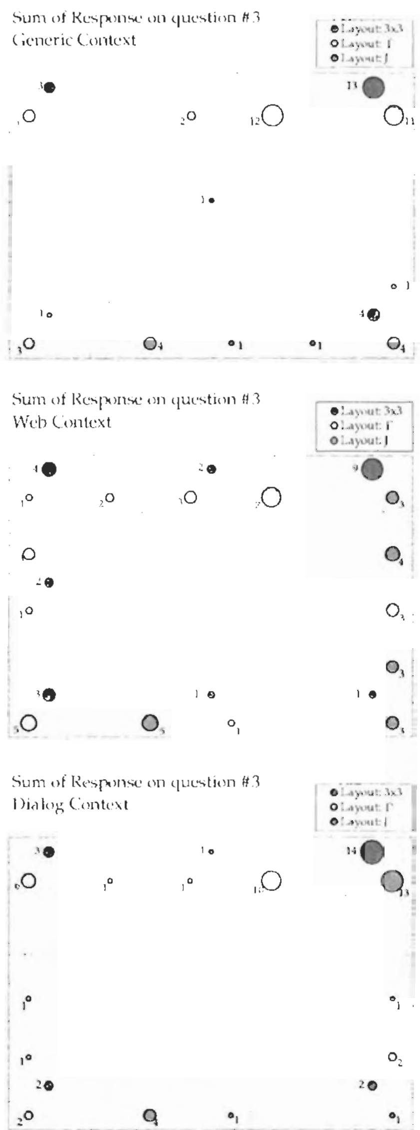


Figure 4.5: (c) Question 3

Notes on reading Figure 4.5:

- Each graph represents a context and a question. The graph contains all responses from all layouts.
- All responses are placed based on their global positions in the 5x5 grid.
- Responses are placed also based on their layouts: from the top, counter-clockwise within the position, in the order of 3x3, Γ, and J layouts.
- The number beside each circle = the number of hits.

Figure 4.5: Ordinal Data, Study 2

NB. Area of circle = Number of hits

We first look at the intention of going to next step or page (Figure 4.5(a)). The most frequently selected position is 25 (available in 3x3 and J layouts), and then 4 (only available in Γ). This showed us that participants expected the command's location at the lower-right of the application or web site. The next most expected choice would be at the top-right.

The second intention is most expected completing the current operations (Figure 4.5(b)). Participants had to interpret this request in terms of whatever the current operation might be. The responses were more diverse, but most of the responses were located at the bottom row in generic and dialog context and the top row for web context. The observer of this study asked some participants what operation they had in mind. Some were thinking "OK" button, some were "X" at the top-right corner of the application windows, and some said next step.

The third intention is finding where to get help (Figure 4.5(c)). Higher hit numbers were located at position 4 or 5. Recall that position 4 in Γ layout is the right most button. The top-right corner was the most popular response from the participants. One exception is the uniform responses on the right side of the J layout in web context. It seemed that participants were uncertain where this function would be located in this layout for this context. Perhaps help is not a frequently used function. On the other hand, most participants believed that it should occur somewhere at the right most side of the screen.

Comparing across the rows of Figures 4.5(a) – 4.5(c), we see that context does have an effect on users' responses. The results of generic context were similar to the dialog context. Most responses were located at the bottom row, but when the context was web, most responses located at the top row. The generic context was given before the web or dialog context. This also suggests that participants might have responded to the unfamiliar layout (3x3 layout) based on their experience of applications, not web sites.

The location with the highest number of hits is at location 25 with 16 hits, which is about 72% of the total 22 participants (J layout of web context in Figure 4.5(a)). In fact, there were only 15 out of 27 conditions which had one location with at least 50% hit. Here the condition refers to the context, layout and intention. From Figure 4.5(a), we see that most button positions had a few responses. Some participants randomly selected a button when they could not recall where these functions were located.

Also note that 15 responses, from six participants, had two or three functions placed at the same location. There were five locations where had two or three functions placed: 5, 25 in 3x3 layout, 4, 21 in Γ layout, and 1, 25 in J layout. Eight responses were from generic context, three from web context, and four from dialog context. One participant responded this way in all contexts and layouts. Since we did not have post-questionnaire, it was hard to interpret these behaviours. However, we may say that these locations were more favorable.

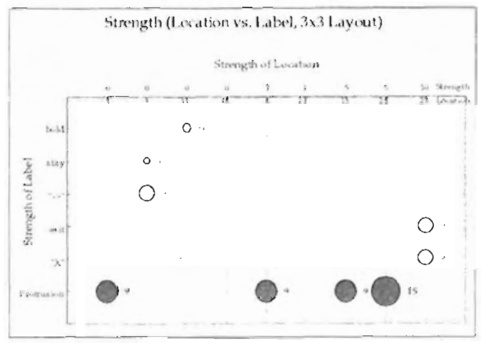
Ordinal Statistics – Label

Section 2 of this study tested how labels and protrusion affected participants' responses. Each of the 45 stimuli contained a single label or protruding button along with a set of plain buttons. This section used question #2 in the generic context — "Where would you click to complete the current operation?". If the labels or protrusion had strong influence on participants' responses, then we should receive higher responses at locations where the labels or protrusion were presented. If there was no impact, the responses should be similar to question #2 in the generic context. Figure 4.6 shows the results for label versus location[5]. The strength of locations is the number of hits on that location on question #2 in generic context. The strengths in Figure 4.6 are arranged from left to right, weakest to strongest. The strength of the label in a layout is based on the total number of hits on that label within the layout. Labels are arranged from to top to bottom, weakest to strongest. The area of the circles indicates the number of hits for the label at that location (i.e. larger circles indicate larger number of hits).

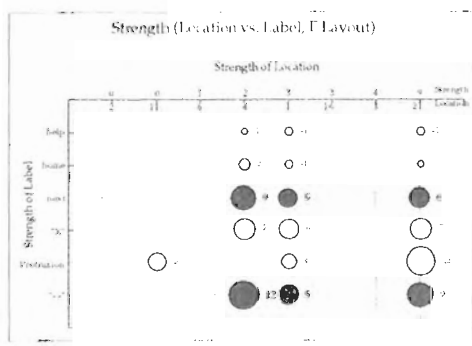
From Figure 4.6, protrusion in general was more powerful than any labels, especially when it was located on the diagonals — positions 1, 13 and 25 — and positions 5 and 21. The label "→" in Γ and J layouts was also more powerful than all the words. In the 3x3 layout, the protrusion at position 25, the second strongest location, was three times stronger than label "X" and label "Exit" at position 23, the strongest location of all nine locations. This may be because we computed strength of location using a different set of intentions than for the strengths of the features. Recall in Study 1 that the most likely location participants would choose was the lower-right most item, or position 25. With two other intentions presented at same time, participants could alter their ideal selections of completing the current operation to other locations.

Notice that each number of participants who selected "X" at each of the three different positions in the Γ layout were close (Figure 4.6(b)). These three locations were at the corners of the layout. On the other hand, participants preferred "X" at the bottom-right most location in the J layout. We could not compare label "X" in the 3x3 layout with other layouts, because, we tested only one non-forceful location in 3x3 layout and three forceful

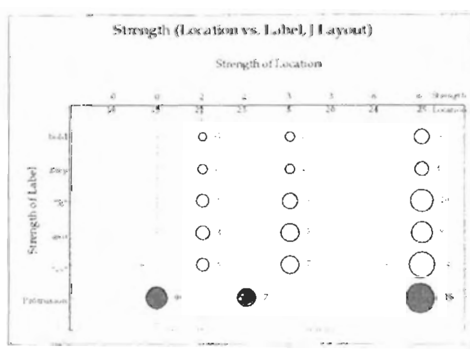
[5]For the label or protrusion and its number of hits in global positions, see Figure G.1.



(a)



(b)



(c)

Figure 4.6: Ordinal Label Data in Strength, Study 2

NB. Area of circle = Number of hits,

locations in other layouts.

In Figure 4.6(b), the "→" label received more responses from participants at the top-right most location, which was a weaker position. The "Next" label had a similar effect. "Bold", "Stay", "Help", and "Home" did not affect the responses of the participants. This implies that these labels were strongly negative to the intention of "completing the current operation".

An interesting fact is that the highest individual hitting score in Figure 4.6 was 15 out of 22 (68%), but the highest total hitting rate for individual labels in each layout was 48% (see Table 4.2). In other words, no more than 50% of participants would be swayed by the label or protrusion. Also, the power of most labels or protrusion was still influenced by location. One example is "Exit" in the J layout (Figure 4.6(c)). Position 22 was the weakest location among the three locations where "Exit" presented, and it received the lowest hitting rate of the three. Position 25, however, was the strongest location and received the highest hitting rate of the three.

Layout	Label	# of stimuli	# of expected responses	Total number of responses	% of hits
3x3	Protrusion	4	88	42	48%
Γ	→	3	66	26	39%
J	Protrusion	3	66	31	47%

Table 4.2: Highest % of Hits in Each Layout, Study 2
For complete label count, see Table G.6.

Table 4.3 gives us another way to look at the data. The hit rate was collected based on positions. Hence, there were a total of 25 entries — 9, 8 and 8 locations for the 3x3, Γ, and J layouts respectively. About a quarter of the time, participants selected a position where there was no label or protrusion presented at that position. 15 out 25 entries had a higher number of actual hits than the expected number (Table 4.3(a)). In fact, 9 entries had no label or protrusion presented in any stimulus and yet received at most 37 hits for individual stimulus (Table 4.3(b)). In total (see Table 4.3(b)), there were 251 out of 990 hits, about 25% (quarter of the time). In fact, during the study, we noticed that many participants made a different selection when there was a label or protrusion presented at their usual choices. This suggests that labels and protrusion did not have very strong influence.

Table 4.3(c) shows the positions with the highest hit rate for each layout. Note that a location strength in a layout is the number of hits on that location in that layout. And the rank of a location strength (last column of Table 4.3(c)) is how strong that location

Table 4.3: Hit Rate in Study 2

Our expectation: If a label or protrusion is a strong visual cue, then participants would select that label or protrusion at any location.

Total number of participants = 22 = Total number of expected hits for each stimulus

A: Total number of expected hits for each position(= 22 × C)

B: Total number of (actual) hits for each position

Total hits = Sum of A for all positions = Sum of B for all position

C: Number of labels/protrusion at the position (= Number of stimuli containing labels/protrusion)

D: label/protrusion presented

% of actual hits = Total number of actual hits / Total number of expected hits

% of hits = Total number of hits / Total number of actual hits

E: Number of hits WITHOUT D / Number of hits WITH D

(a) A vs. B

Layout	Total number of Positions	Number of positions where $A > B$	Number of positions where $A < B$	Number of positions WITHOUT any D
3x3	9	4	5	2
Γ	8	3	5	4
J	8	3	5	3
Total	25	10	15	9

(b) Positions Without D

Layout	Number of positions	Lowest Actual Hits	Highest Actual Hits	Total Hits
3x3	2	1 (1%)	37 (19%)	38 (19%)
Γ	4	25 (6%)	31 (08%)	114 (29%)
J	3	22 (6%)	54 (14%)	99 (25%)
Total	9	48 (5%)	122 (12%)	251 (25%)

(c) Highest Number of Hits in Each Layout

Layout	Position	C	A	B	% of actual hits	Rank of Strength on Stimulus
3x3	25	1	22	77	350%	2
Γ	4	5	110	124	113%	4
J	25	6	132	165	126%	1
Total	54	12	264	346	131%	N/A

(d) Total Hits

Layout	Total Hits	Total hits WITH D	Total hits WITHOUT D	Highest E
3x3	198	058 (29%)	140 (71%)	4 (Position 25)
Γ	396	091 (23%)	305 (77%)	3 (Position 04)
J	396	106 (27%)	290 (73%)	4 (Position 25)
Total	990	255 (26%)	735 (74%)	N/A

NB. For complete list of individual cues' hit rate, see Table G.7

is within that layout. In the Table 4.3(c), the highest number of actual hits in 3x3 and J layouts occurred on some of the strongest positions. However, the highest number of actual hits in Γ layout (position 4) was a weaker location. The strongest location for Γ layout (position 21) had the second highest number of hit. Position 4 was located at the right side of the layout and position 21 was located at the left side of the layout. This showed that participants might prefer right than left.

Also, the ratios of individuals without label/protrusion hits over individual with label/protrusion hits were varied (Table 4.3(d)). Some ratio were as high as four to one. This showed not only how much influence labels and protrusion presented but also the most preferred positions, number 25 and 4.

4.3.7 Limitation and Summary

Limitations

Some problems occurred during the study. The first was the ambiguity of the question we asked — "Where would you click to complete the current operation?" Participants had to make their own assumptions of what "completing the current operation" meant. The observer asked a few participants what their assumptions were. Some participants considered completing the current operation as terminating the current program that was running, some considered as going to the next step, and some treated as asking where the "OK" button was located. Hence in any future study, the question has to be less ambiguous.

The second problem was in the functional relationship section. We presented a line of text next to all the labelled buttons. One word in the text was highlighted. However, this context was not obvious to most participants. One possible reason may have been the text itself. The line read "Hello, dear participant". To most of the participants, this might be just a greeting rather than thext to be edited. Another reason was that the text was surrounded by a box. Some users thought it was something clickable. To correct this problem, one possible solution is to give longer text and remove the box.

The third problem was in the labelled buttons section. Due to the large amount of possible stimuli, we had to cut some stimuli out. Therefore, we only tested non-forceful locations in the square layout and forceful locations in both Γ and J layouts. However, the number of stimuli tested in each layout was uneven. We only had five stimuli in non-forceful locations while 15 stimuli in the other two layouts. It was interesting that some of non-forceful locations turn out to be powerful cues in the sections of testing location in layout and context. As a result, we were unable to fully compare the data within each layout.

Another problem was the choices of labels. We used the symbols "→" and "X" in all layouts, the words "Stay", "Bold", "Exit" in square and J layouts, and the words "Help", "Next", "Home" in Γ layout. The words "Help", 'Next", and "Home" do not correspond to the words "Stay", "Bold", and "Exit". Also, the words "Stay" and "Bold" have the same degree of effects within the context and intention which was unexpected.

One minor problem was that we had about 45 stimuli in the second section. It seemed too long, and participants got a little impatient and felt dread toward the end of this section.

Another minor problem is that we compared between different types of visual cues. In this study, we used to compare protrusion and labels, which may not be the best choices. Labels put meanings into buttons whereas protrusion is a property of buttons. Hence, protrusion may be better compared with other visual cues, such as coloured of buttons, which are also properties of buttons.

Summary

Recall there were several questions we tried to answer:

- What features of visual forms indicate clickability?
- Does context affect users' responses?
- How do variations in layout affect users' responses?
- Do functional relationships influence the interpretation of labels?

In general, protrusion seems to work better than labels. Labels which related to the intentions were also powerful. However, less than 50% of participants chose the label or protrusion. An interesting fact to remember is that some participants actually avoid labels or protrusions. Location is still a powerful factor which is we expected. We also concluded that context did affects users' responses. Participants' reponses changed from the bottom to the top of the screen when the context changed from generic or dialog context to web context. Layout had little effect on users' responses. We did not see dramatic differences between layouts. Lastly, we previously explained our failure of testing functional relationship and how to improve that in future studies.

There are two things that need to be taken into account in future studies. First, we gave participants three basic layouts with three generic intentions at the beginning of this study. This helped us understand how participants behave without any other factors. However, this section might have some impact on the next section – location against labels and protrusions. Participants might have responded with the two other intentions in mind even though we specified only one intention for this section.

Second, Section 2 was too long. Participants got impatient at the end. We need a smaller and more systematic combination of stimuli to present to the users.

4.4 Chapter Summary

In this chapter, we examined the possibility of using abstract screen to capture users' understanding of clickability.The result shows that abstract screen has potential in understanding users' notion of clickability.

First, recall that we tried to answer the following questions:

- What features of visual forms indicate clickability?
- Does context affect users' responses?
- How do variations in layout affect users' responses?
- Do functional relationships influence the interpretation of labels?

Here are our findings:

- Location is a very strong cue, sometimes even more powerful than any simulated affordance, such as protrusion.
- Protrusion is powerful when located at the lower or right side of the stimuli. It is more powerful than labels.
- Labels might overpower locations when they are related to the uers' intentions.
- Intentions and context direct users' responses.
- Layout has little effect on users' responses.
- There are always several rules applied on each stimuli.
- Users do change over time.

In these studies, we failed to test functional relationships which we plan to test in future studies. There are some improvements for the design. First, one section in second study had 45 stimuli. It was too long for participants. One possible improvement is using fewer stimuli or divide the stimuli into smaller sections. Second, we did not test the exact same locations on all labels and protrusion. Hence we were unable to compare locations across all layouts. In future studies, we have to be more careful selecting stimuli from a large set of stimuli. Third, we did not have the 5x5 grid while designing stimuli. Hence the global positions of each layout did not necessarily represent the actual position on the screen. We will keep a global pattern in mind when designing future studies. Lastly, the intention in the first study, "exit the dialog box", had a very strong influence to the participants responses. In contrast, the intention in the second study, "complete the current operation", turned out to be too ambiguous. In future studies, we would like intentions have some effects but not as in the first study and yet not ambiguous to participants.

In summary, abstract screens do give us an opportunity to understand how users' know where to click. We have confidence in establishing our goal of understanding users' perception of clickability with improvements to our abstract screen studies.

Chapter 5

Conclusion

Our goal is to improve the screen design so that users have less difficulty determining where to click. We studied the theory of affordance. It offers us the idea of creating screen controls independent of the context. In order to apply affordance to the screen design, we need a theory of affordance for "clickability". This theory not only includes the theory of affordance, but also takes any factors which are closely related to the design into account. Hence, we also studied theories related to visual perceptions.

Over the years, convention of computer screen design have been established. Instead of creating a new design of visual cues for screen design, it is easier to adapt it from current convention. Some visual cues in current design may be more effective than others. Hence it is important to know users' understanding of clickability. We first held a survey and an observational study. However, we were unable to draw any detailed conclusions from these studies. We thought we could gather information about users' understanding of clickability by observing them interact with computer systems. However, it was difficult to know by observation which visual cues indicate clickability. This is because it is hard to separate the effects of visual cues due to the fact that some clickable items are made of more than one visual cues. Also, there are usually many different paths, sequences of actions, to perform the same task. And we had a difficult time to controlling the path that users followed. Since users respond to the familiar screen controls quickly, the observational study did not offers any information of how they know where to click. Furthermore, it was hard to find any screen controls which were unfamiliar to users. We needed better stimuli to study affordances of clickability. Hence we developed simple abstract screens.

Using simple abstract screens avoided the problem of multiple paths. We can control the number of cues involved in the studies and test individual cues with as little inter-relation as possible. Hence we held two studies using abstract stimuli. There were several key findings about perception of clickability. First, location is a very powerful cue, especially at the lower right corner of the abstract screen. Sometimes it is more powerful than any simulated affordance, such as protrusion or labels. Second, protrusion is more powerful when it is located at the lower or right side of the layout. It is also more powerful than any label. Third, labels overpower locations when they are closely related to the intention. However, labels have little effect on users' responses when they are not directly related to the intention. Lastly, users' responses are directed by the intentions and contexts. Users have learned where the different types of screen controls are located on the screen and how they appear on the screen. For example, all windows have a close command on the top right corner of windows. It is in the form of a button with label "X". Hence, users have some expectations of where and how screen controls should appear, based on given intentions and contexts.

Our studies show that both Gibson's and Norman's theories of affordance are important. Gibson's theory offers us the idea of creating screen controls independent of the context. Screen controls like $2\frac{1}{2}$ D buttons, which have properties that look like perform physically, are independent of the context. Norman's theory points out the importance of perceived affordance. It is important whether users are able to perceive them as controls of the commands. For example, buttons with "Stay" are generally not perceived as controls of "exiting dialog box". Therefore, both theories of affordance are important to design screen affordance.

It is too early for us to provide any design guidelines. However, based on current results, here are a few suggestions:

- Place functions related to "exit a dialog box" or "complete the current operation" at lower right corner.
- Use protrusion ($2\frac{1}{2}$ D) to draw attention to the most important commands
- For best effect, labels must match the exact language in which users describe their intention.

Future Directions

For future studies, here are some improvements to the current design of abstract stimuli and studies:

- Be careful with the intention. In the first abstract study, we asked participants to "exit the dialog box", and our question strongly influenced to the users' responses. In the second abstract study, the question "complete the current operation" was too ambigous. In all future studies, the intention should have some influence to participants' responses but not as strong in the first study and yet not ambiguous to them.

- Watch out for order effects. Recall that we had five sections in the second abstract study. The first section had three intentions. It might have influenced on how users interpreted the second section, which only had one intention. Users might have responded with the two other intentions in mind. We would like to avoid this in the future.

- Better study design. In the second section of the second abstract study, we had five stimuli to test unforceful locations in 3x3 layout and 15 stimuli to test forceful locations in each Γ and J layout. As a result, tested locations were not in all three layouts and we were unable to analyze the data across different layouts.

- Choose the right amount of stimuli. We had 45 stimuli in one section of the second abstract study. This section was too long and users got impatient at the end. We should either break them into smaller sections or test fewer stimuli at one time.

- Re-design the functional relationship test. We did not successfully test functional relationship in the second abstract study. We had only one line of text, partially highlighted. Users might not have perceived this way. One possible improvement is to create a document setting — more text on the screen, and few highlighted words.

- Vary layouts based on an overall pattern. We did not have the overall pattern (the 5x5 grid) when we designed the stimuli. Hence the global positions did not correspond very well to the actual positions on the screen. We will have a global pattern when we design new abstract screens in the future.

- Compare labels in different languages. In our design, labels only occured at one location. It would be interesting to see users' responses to all labelled buttons in an unfamiliar/made-up language.

In addition, we would like to use the Rasch model to analyze our data. Rasch model constructs an interval scale for the data, which not only shows the ranking of items, as but also the relative differences between items. It allows us to use more tightly controlled statistics.

Also, in future studies, we may ask users where a particular button is located to test how intention affects layouts. Currently, participants' responses are recorded by hand. A Java program might also be developed to record participants' responses and their responses time. We may also use this program to trace the cursor movement. Also, we divided participants into two groups: computing scientists/engineers and non-computing scientists/engineers. Another possible group division for future studies would be right-handed vs. left-handed users. Lastly, we so far only have university/college students as our subjects. We would like to include other ages, professional or new computer users in the future.

Appendix A

Research Ethics Approvals

SIMON FRASER UNIVERSITY

OFFICE OF RESEARCH ETHICS

BURNABY, BRITISH COLUMBIA
CANADA V5A 1S6
Telephone: 604-291-3447
FAX: 604-268-6785

May 28, 2003

Ms. Christina Lee
Graduate Student
School of Computing Science
Simon Fraser University

Dear Ms. Lee:

Re: Capturing users' perception of clickability

The above-titled ethics application has been granted approval by the Simon Fraser Research Ethics Board, at its meeting on May 26, 2003 in accordance with Policy R 20.01, "Ethics Review of Research Involving Human Subjects".

Sincerely,

Dr. Hal Weinberg, Director
Office of Research Ethics

Appendix B

Materials For All Studies

Consent

User Interface Assessment

Informed Consent Form

You are invited to participate in a research study that will compare the effectiveness and ease of learning of new computer interfaces. I am a research assistant in the Simon Fraser School of Computing Science.

Your identity will not be recorded in this study. All the data will be filed under a numeric code. There will be no way of identifying you from the data. Note that this data may be made publicly available on the World Wide Web for other researchers to perform further analyses. However, these researchers will have no way of knowing that it is your data.

Your participation is entirely voluntary and your decision whether or not to participate will involve no penalty or loss of benefits to which you are otherwise entitled. If you are an SFU student, no course grade will be affected by your participation. If you decide to participate, you are free to discontinue participation at any time without any penalty.

If you have any questions about the research at any time, please call me, Christina Lee, 604.291.3610 or my advisor, Professor Arthur Kirkpatrick, 604.291.4190. If you have any complaints about this experiment, you may contact either of us or the Director of the School of Computing Science, Simon Fraser University. If you have any questions about your rights as a participant in a research project, please contact the University Research Ethics Review Committee, c/o Office of the View President, Research, Simon Fraser University, Burnaby, BC, V5A 1S6.

You will be offered a copy of this form to keep for your records.

You may obtain a copy of the research results by contacting me or Professor Kirkpatrick after March, 2003.

Your signature below indicates that you have read and that you understand the information provided above, that you willingly agree to participate, that you may withdraw your consent at any time and discontinue participation at any time without penalty or loss of benefits to which you are otherwise entitled, that you will receive a copy of this form, and that you are not waiving any legal claims, rights or remedies.

Signature ________________ Date ______________

Name (please print) ________________________

Background Questionnaire

Code # ________

BACKGROUND QUESTIONNAIRE

We'd like to know a little bit about you. This form only refers to you by a code number, not your name. No one will be able to connect these answers to you.

Age:________

Gender: female ___ male ___

First language: ______________________________

Department (if student or faculty): ______________________

About how many hours a week do you use a computer? _____ hours a week

Experience
How much have you used the English-language versions of the following programs and Web sites:

	Never	Have used it a little	Used it a lot, but not currently	Currently use it every week	Currently use it every day
Microsoft Word					
Microsoft Excel					
Microsoft PowerPoint					
Windows XP (released in 2002)					
Windows 2000 (released in 2000)					
Other versions of Windows (ME, 98, 95, NT, 3.1)					
MacOS X (released in 2001)					
MacOS 9 or earlier (released before 2001)					
Other desktop:					
Internet Explorer					
Netscape or Mozilla					
Other Web browser					
Amazon Web site					
Yahoo maps web site					
Google Web site					

How regularly do you use "hot keys" (Alt- or Control-keys)?

Please pick the closest answer:

_____ I never use them

_____ I know from one to three and use them occasionally

_____ I know from one to three and use them most times I use the computer

_____ I know quite a few and use them all the time

Appendix C

Material For Real Application Observation

C.1 Additional Table in Pilot study

This is the table that generate the graph in the pilot study of duplicating one page document:

Brand	Lowest price	Highest price
Acer	1440	2899
Compaq	2249	3795
IBM	1299	5795
Sony	1699	4999
Toshiba	1695	5310

C.2 Instructions

Here are the instructions we gave to participants in real application observation, described in Chapter 3. There were two different versions:

Version 1

D:\MSc work\website-tasks\task-G1L1-G.doc

Websites Task (G1L1 - G)

Instruction:

In this study, you are asked to browse **six** different online bookstore websites. For each website, a book description is given. Using the description, please do your best to find the book title with the latest available version, its ISBN and current price. The descriptions in quotes are extracted from the corresponding websites.

Note that some of the websites also sells other products besides books. In this case, please go to their books section before you start the required task.

If you any questions regarding this procedure, please ask the observer prior to this task. You may start anytime when you are ready.

D:\MSc work\website-tasks\task-G1L1-G.doc

1. www.bn.com

This books is a special edition of the classic children's series by Lewis to celebrate the 50th anniversary. "Featuring the original illustrations, newly painted in full color by award-winning illustrator Baynes, this incredible volume is a must-have for anyone who wants to step into the unforgettable world of Narnia time and time again."

This book is "compelling for younger readers, and those who come to Narnia as older 'participants' may find themselves analyzing the Christian allegory that Lewis infused throughout the texts. However, in light of concerns about gender or ethnic representations, some readers may have concerns about the stereotypical manner in which a number of characters are constructed."

Book Title: ______________________________

Book ISBN: ______________________________

Current Price: ______________________________

2. www.chapters.indigo.ca

"The women had no chance. The men were nothing but one of six teams capable of winning. So said the critics and naysayers. But on February 21st and 24th, 2002, the women and men of Canada's ___ teams completed an historic double, a perfect sweep of ___ gold at Salt Lake 2002. ... For the men, it represented the end of a fifty-year drought that went back to the '52 Edmonton Mercurys. For the women, the win was sweet revenge for an unexpected loss at Nagano in 1998. For all of Canada, the wins not only satisfied a nation infatuated with ___—it helped define and re-affirm the country's identity."

Category: Sports
Author(s): First name is Andrew
Publisher: Fenn Publishing Company Ltd

Book Title: ______________________________

Book ISBN: ______________________________

Current Price: ____________________

3. **www.page1book.com**

"For the more than 40 million Americans living with arthritis, daily activities can be a challenge. The Arthritis Foundation's newest book, *"book title"*, offers handy tips for doing laundry, gardening, working at a computer and more. Written in a concise tip format, the book gives hints on handling pain, fatigue, stress and dieting."

Category: General Health
Publisher: Longstreet Press, Inc.

Book Title: ____________________

Book ISBN: ____________________

Current Price: ____________________

4. **www.powells.com**

This is a true crime story of the main author Abagnale's life. He "was one of the most daring con men, forgers, imposters, and escape artists in history." Abagnale is a high school drop out and did all kinds of criminal work before he was twenty-one. " Known by the police of twenty-six foreign countries and all fifty states as ' The Skywayman,' Abagnale lived a sumptuous life on the lam – until the law caught up with him."

Book Title: ____________________

Book ISBN: ____________________

Current Price: ____________________

5. **www.walmart.com**

"Mention the comic strip Zits to teenagers or their parents and they'll eagerly launch into a long list of their favorite stories and strips that made it to the refrigerator door, making Zits the most effective form of communication between parents and their teens since the Post-it note. …

D:\MSc work\website-tasks\task-G1L1-G.doc

This latest collection ... marks the eighth collection of the strip, which now appears in more than 1,000 newspapers worldwide."

Category: Home & Garden › Pets & Hobbies › Humor › Cartoons & Comics
Author(s): Last names are Scott & Borgman

Book Title: ____

Book ISBN: ____

Current Price: ____

6. **www.alibris.com**

"'*Book title* Woodhouse, handsome, clever, and rich, with a comfortable home and happy disposition seemed to unite some of the best blessings of existence; and had lived nearly twenty-one years in the world with very little to distress or vex her', and so begins *author* comic masterpiece *book title*."
"... *book title* Wodehouse is a privileged and attractive young woman who, although she displays characteristics of snobbery and self-delusion, manages to outweigh these not all-together likable attributes with compassion and intelligence. *Book title* fancies herself a superb judge of human character and becomes entrenched in the amorous affairs of her friends. In doing so, she remains oblivious to her own romantic possibilities, and the resulting comical misunderstandings are highly entertaining."

Category: Fiction & Literature > Literary Criticisms > English
Author(s): First name is Jane

Book Title: ____

Book ISBN: ____

Current Price: ____

THE END.

Thank you for your participation!!

Version 2

D:\MSc work\website-tasks\task-G1L1-L.doc

Websites Task (G1L1 - L)

Instruction:

In this study, you are asked to browse **six** different online bookstore websites. For each website, a book description is given. Using the description, please do your best to find the book title with the latest available version, its ISBN and current price. The descriptions in quotes are extracted from the corresponding websites.

Note that some of the websites also sells other products besides books. In this case, please go to their books section before you start the required task.

If you any questions regarding this procedure, please ask the observer prior to this task. You may start anytime when you are ready.

D:\MSc work\website-tasks\task-G1L1-L.doc

1. www.bn.com

This books is a special edition of the classic children's series by Lewis to celebrate the 50th anniversary. "Featuring the original illustrations, newly painted in full color by award-winning illustrator Baynes, this incredible volume is a must-have for anyone who wants to step into the unforgettable world of Narnia time and time again."

This book is "compelling for younger readers, and those who come to Narnia as older 'participants' may find themselves analyzing the Christian allegory that Lewis infused throughout the texts. However, in light of concerns about gender or ethnic representations, some readers may have concerns about the stereotypical manner in which a number of characters are constructed."

Book Title: ____

Book ISBN: ____

Current Price: ____

2. www.chapters.indigo.ca

"The women had no chance. The men were nothing but one of six teams capable of winning. So said the critics and naysayers. But on February 21st and 24th, 2002, the women and men of Canada's ___ teams completed an historic double, a perfect sweep of ___ gold at Salt Lake 2002. ... For the men, it represented the end of a fifty-year drought that went back to the '52 Edmonton Mercurys. For the women, the win was sweet revenge for an unexpected loss at Nagano in 1998. For all of Canada, the wins not only satisfied a nation infatuated with ___—it helped define and re-affirm the country's identity."

Category: Sports
Author(s): First name is Andrew
Publisher: Fenn Publishing Company Ltd

Book Title: ____

Book ISBN: ____

D:\MSc work\website-tasks\task-G1L1-L.doc

Current Price: ______________________________

3. www.page1book.com

"For the more than 40 million Americans living with arthritis, daily activities can be a challenge. The Arthritis Foundation's newest book, *"book title"*, offers handy tips for doing laundry, gardening, working at a computer and more. Written in a concise tip format, the book gives hints on handling pain, fatigue, stress and dieting."

Category: General Health
Publisher: Longstreet Press, Inc.

Book Title: ______________________________

Book ISBN: ______________________________

Current Price: ______________________________

4. www.powells.com

This is a true crime story of the main author Abagnale's life. He "was one of the most daring con men, forgers, imposters, and escape artists in history." Abagnale is a high school drop out and did all kinds of criminal work before he was twenty-one. " Known by the police of twenty-six foreign countries and all fifty states as ' The Skywayman,' Abagnale lived a sumptuous life on the lam – until the law caught up with him."

Book Title: ______________________________

Book ISBN: ______________________________

Current Price: ______________________________

5. www.walmart.com

"Mention the comic strip Zits to teenagers or their parents and they'll eagerly launch into a long list of their favorite stories and strips that made it to the refrigerator door, making Zits the most effective form of communication between parents and their teens since the Post-it note. ...

This latest collection ... marks the eighth collection of the strip, which now appears in more than 1,000 newspapers worldwide."

Category: Home & Garden › Pets & Hobbies › Humor › Cartoons & Comics
Author(s): Last names are Scott & Borgman

Book Title: ____

Book ISBN: ____

Current Price: ____

6. www.1000sofdiscountbooks.com

"Denise Linn draws on her Native American roots, as well as the teachings of other cultures, to create an eclectic but carefully crafted spiritual program for anyone wishing to venture on their own retreat. After helping you choose the Quest that is right for you - from a group Quest in the wilderness to a day of silence at home, from a personal Guided Quest to a solitary Garden Quest - this practical, engaging book will show you how to discover your life's purpose, find mystery and wonder at the core of your life, release limiting beliefs about yourself, call for a vision, harness the power of the Sacred Circle, confront and free yourself from fears, experience your connection to nature, heal emotional wounds, and develop peace of mind."

Category: Religion/Spirituality
Author(s): First name is Denise

Book Title: ____

Book ISBN: ____

Current Price: ____

THE END.

Thank you for your participation!!

C.3 Post-Questionnaire

Code # ___________

POST QUESTIONNAIRE

We'd like to know a little about your web usage. This form only refers to you by a code number, not your name. No one will be able to connect these answers to you.

About how many hours a week do you browse websites? _____ hours a week

Types of work you do when browsing websites:
(rank all that is applied, starting with the most frequent use as 1)

- ___ E-mail
- ___ Banking
- ___ Chat
- ___ Read
  - ___ News
  - ___ Articles/Magazines
  - ___ Financial figures – stocks, mutual fund etc
  - ___ Fun stuff – comics, cartoons etc
  - ___ Others : __________________
- ___ On-line games
- ___ Browsing online store and/or shopping
- ___ Others : ______________________

Do you use web search engine? Yes No

If the answer is yes, how often?

A. At least once everyday
B. At least once every week
C. At least once every month
D. Once every 2or more monthes

Which browser(s) you use most?

____

Do you use library catalog system? Yes No

If the answer is yes, how often?

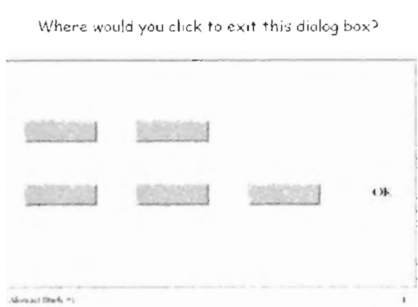
A. At least once everyday
B. At least once every week
C. At least once every month
D. Once every 2or more monthes

Appendix D

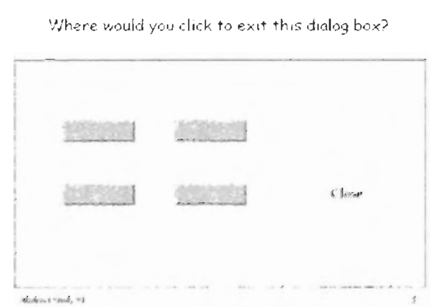
Abstract Screen Stimuli, Study 1

This appendix contains all abstract screens used in first abstract study which is described in Chapter 4.

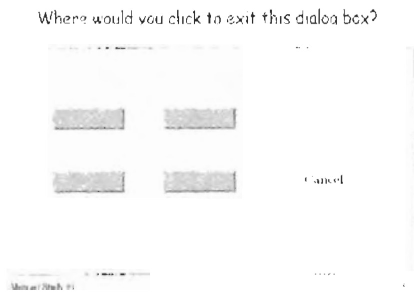
There are total of 36 stimuli in first abstract study. In the study, stimuli were given in different order across participants to reduce possible ordering effects. Here stimuli are organized by their similarity.



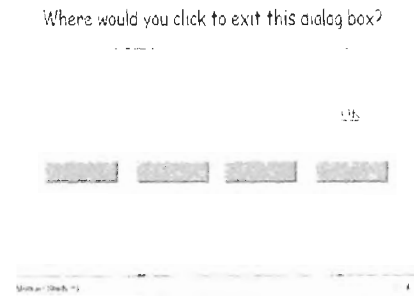
Stimulus 01



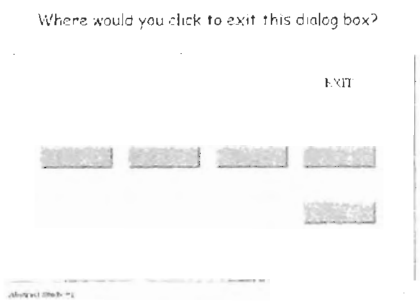
Stimulus 02



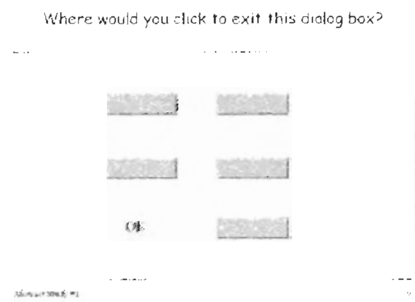
Stimulus 03



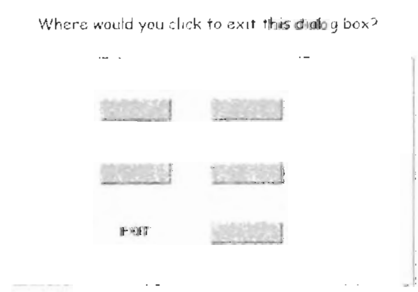
Stimulus 04



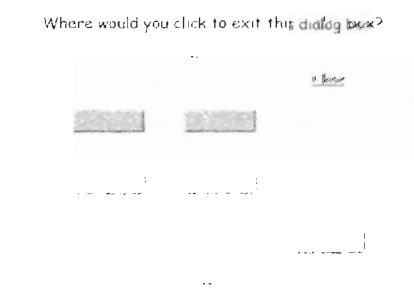
Stimulus 05



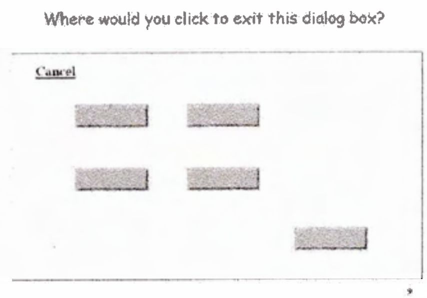
Stimulus 06



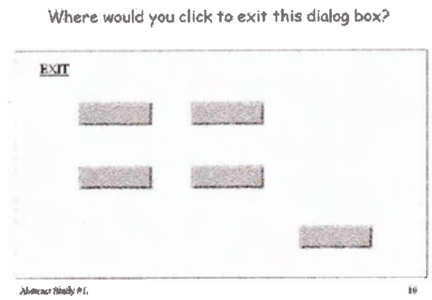
Stimulus 07



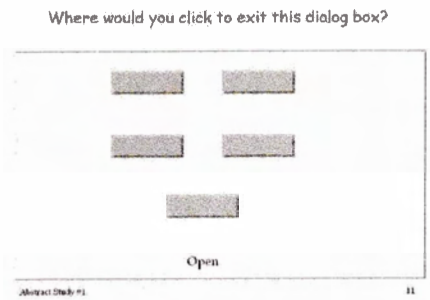
Stimulus 08



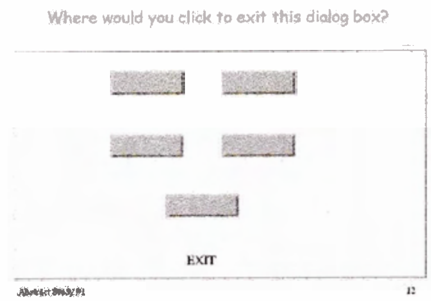
Stimulus 09



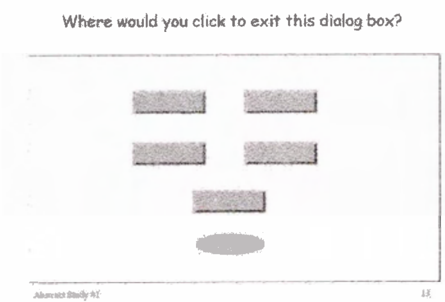
Stimulus 10



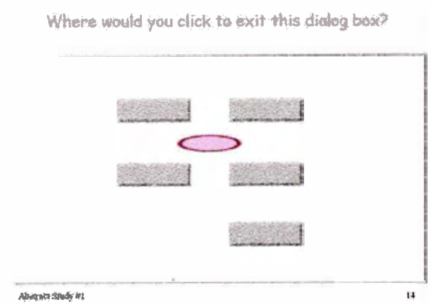
Stimulus 11



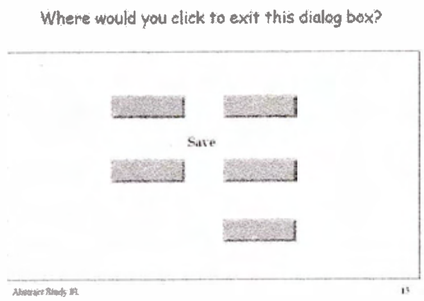
Stimulus 12



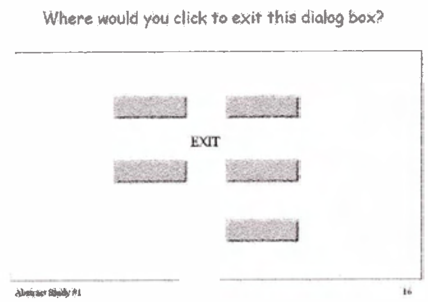
Stimulus 13



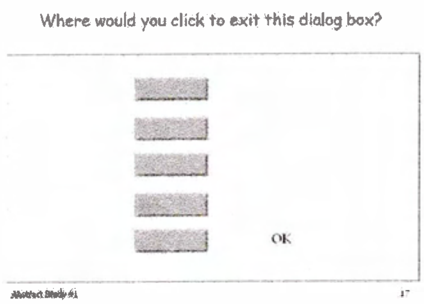
Stimulus 14



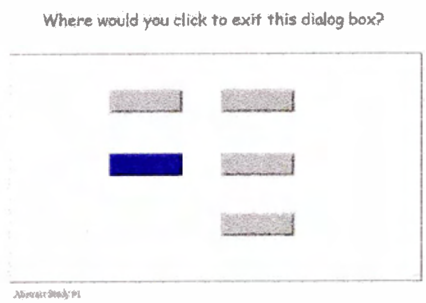
Stimulus 15



Stimulus 16



Stimulus 17



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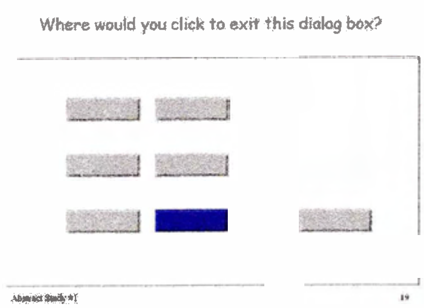
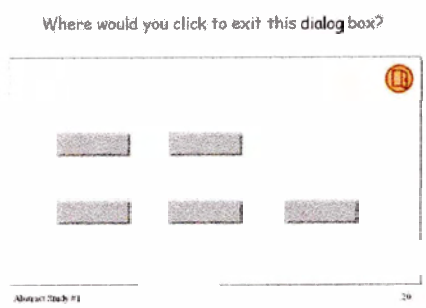
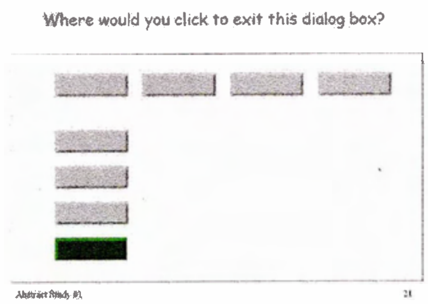


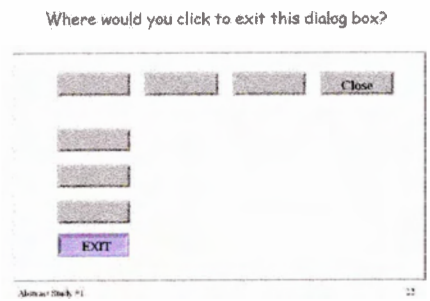
Stimulus 19



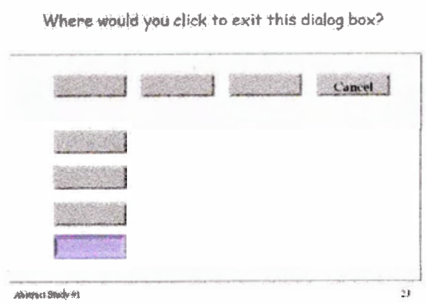
Stimulus 20



Stimulus 21



Stimulus 22



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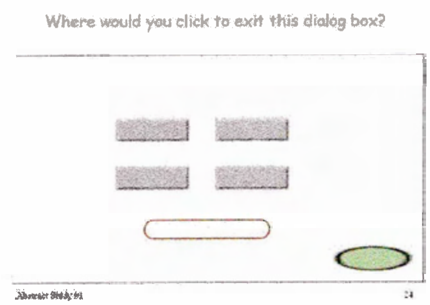
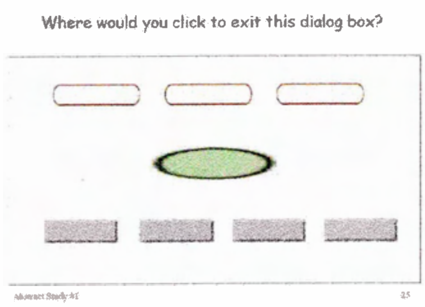
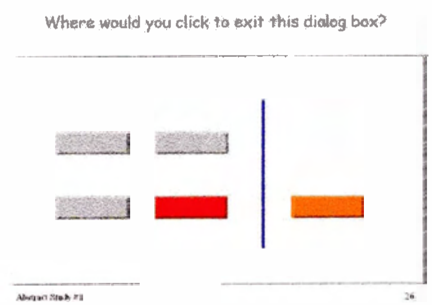


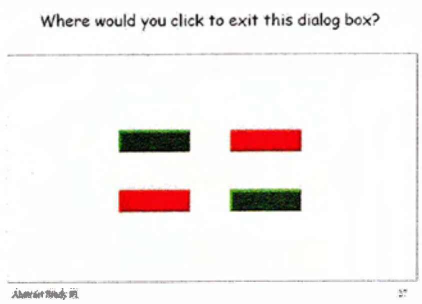
Stimulus 24



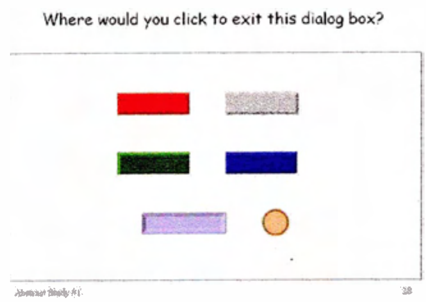
Stimulus 25



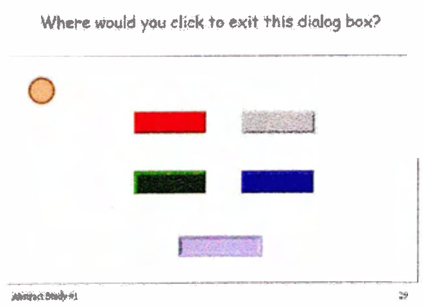
Stimulus 26



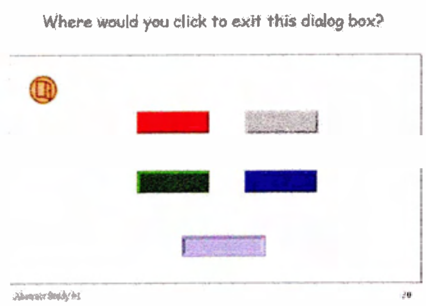
Stimulus 27



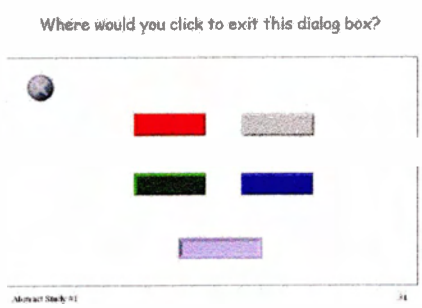
Stimulus 28



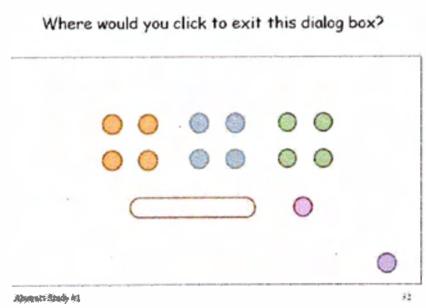
Stimulus 29



Stimulus 30



Stimulus 31



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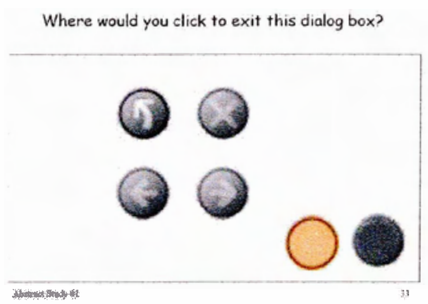
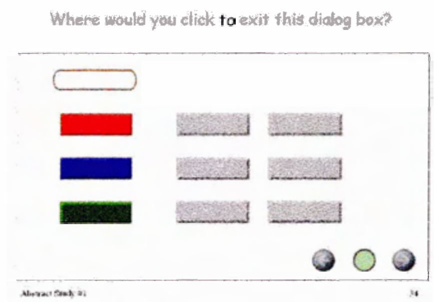
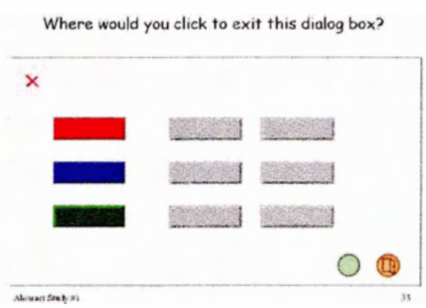


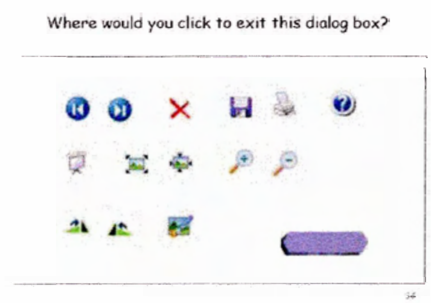
Stimulus 33



Stimulus 34



Stimulus 35



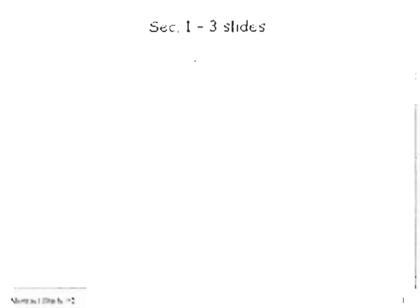
Stimulus 36

Appendix E

Abstract Screen Stimuli, Study 2

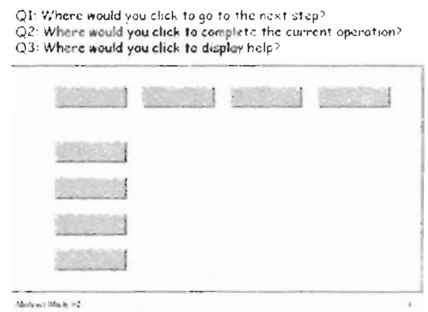
This appendix contains all abstract screens used in second abstract study which is described in Chapter 4.

There are total of 70 stimuli in second abstract study. Note that stimuli were given in the same order across participants.

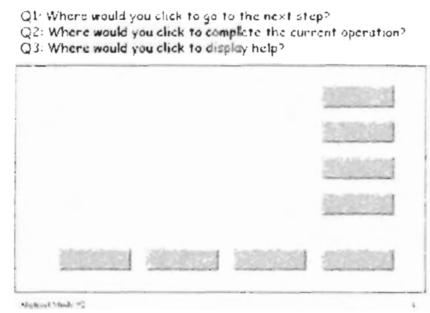


Stimulus 01

Stimulus 02



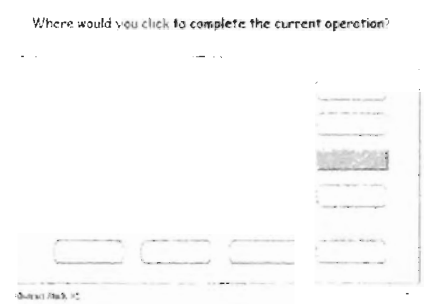
Stimulus 03



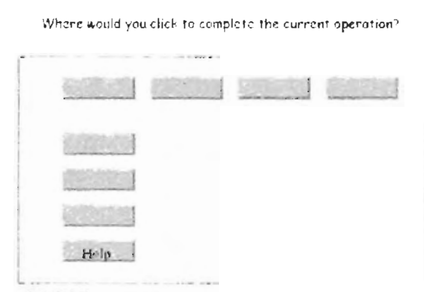
Stimulus 04

Stimulus 05

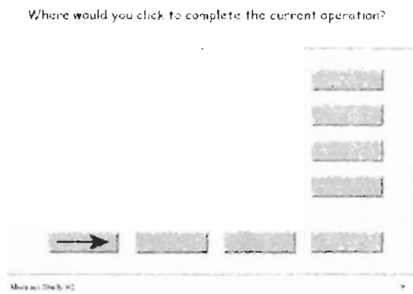
Stimulus 06



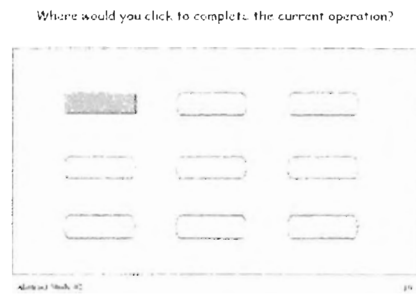
Stimulus 07



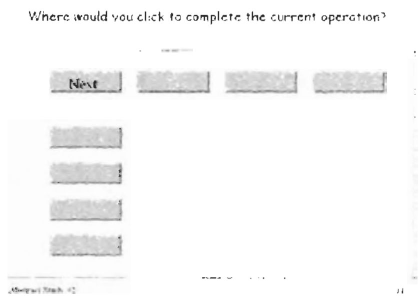
Stimulus 08



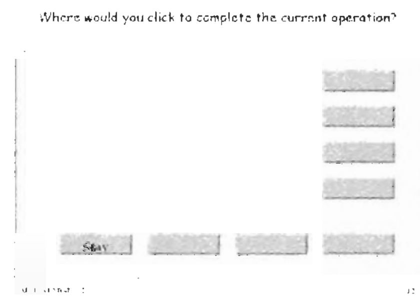
Stimulus 09



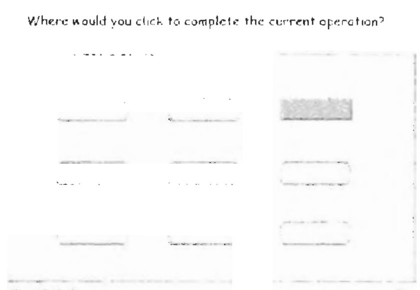
Stimulus 10



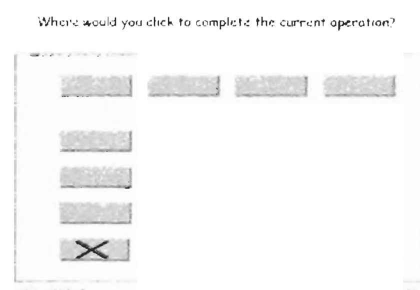
Stimulus 11



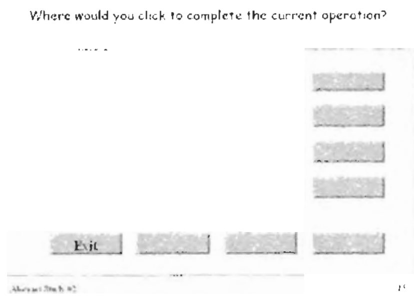
Stimulus 12



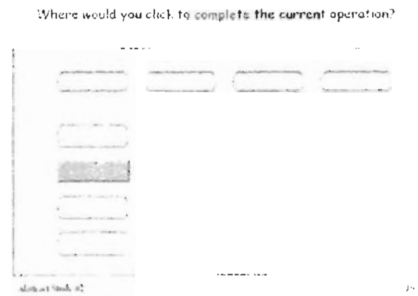
Stimulus 13



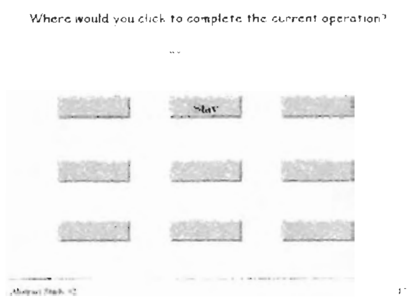
Stimulus 14



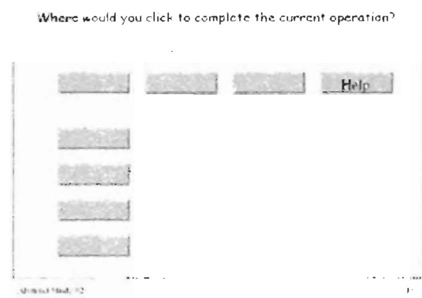
Stimulus 15



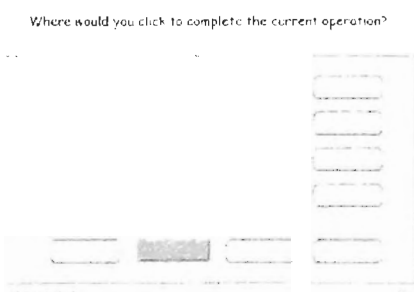
Stimulus 16



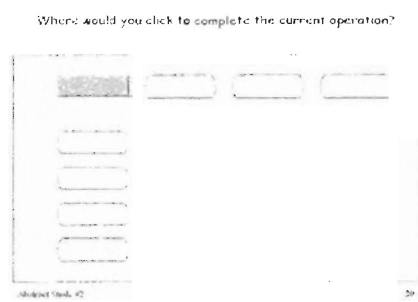
Stimulus 17



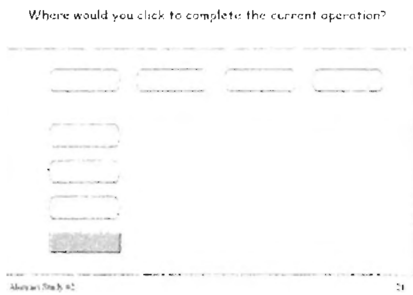
Stimulus 18



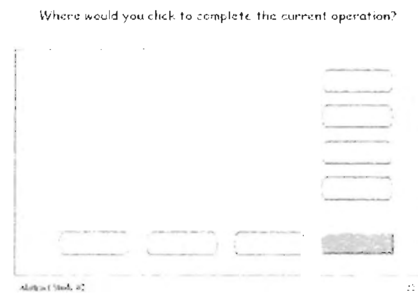
Stimulus 19



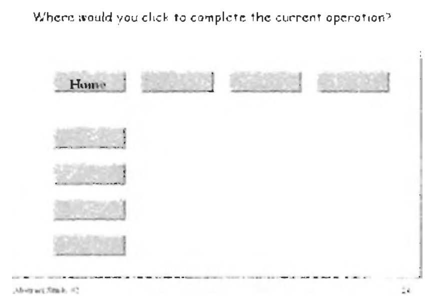
Stimulus 20



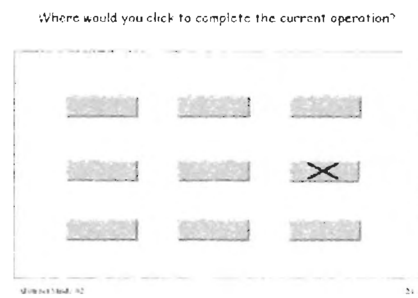
Stimulus 21



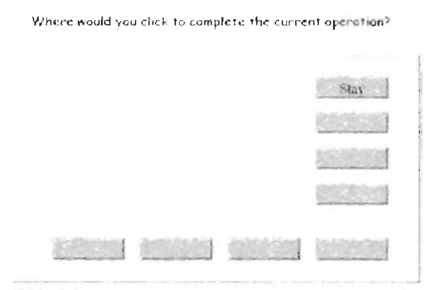
Stimulus 22



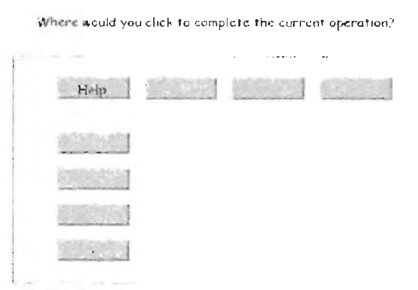
Stimulus 23



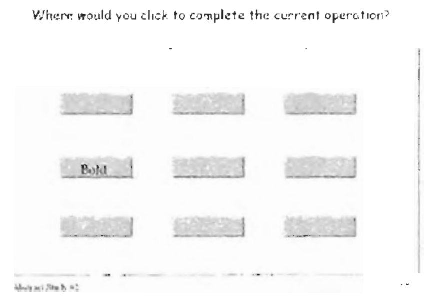
Stimulus 24



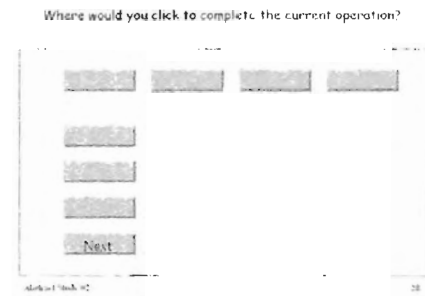
Stimulus 25



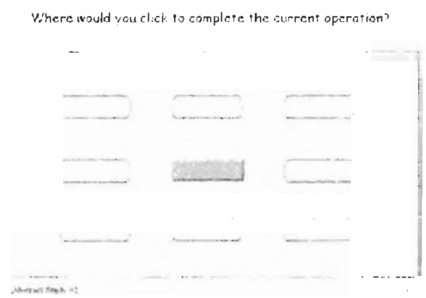
Stimulus 26



Stimulus 27



Stimulus 28



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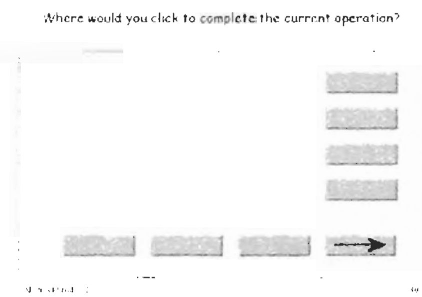

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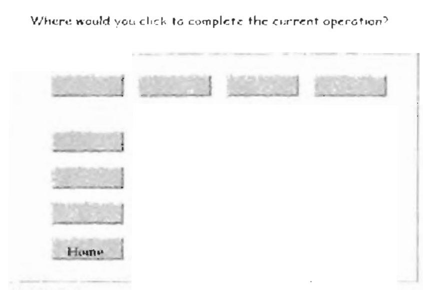

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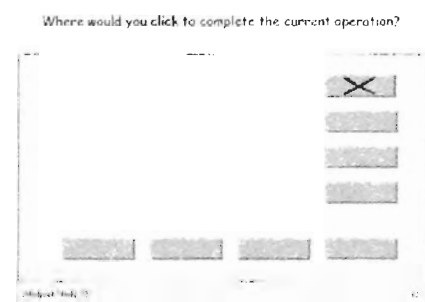

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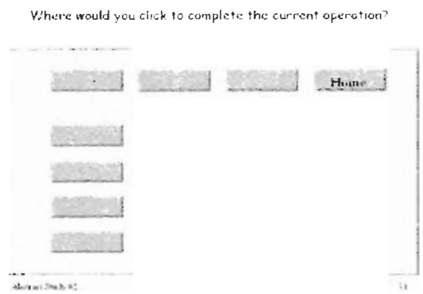

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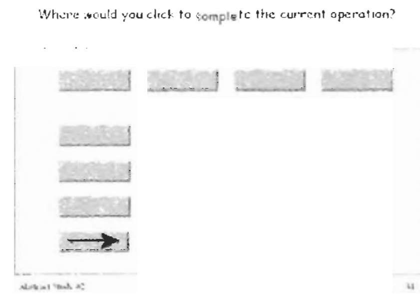

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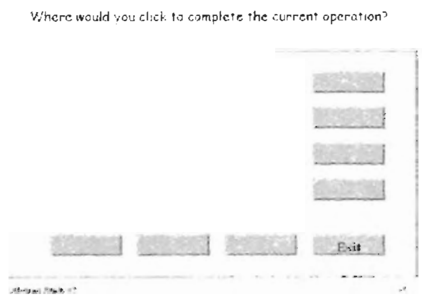

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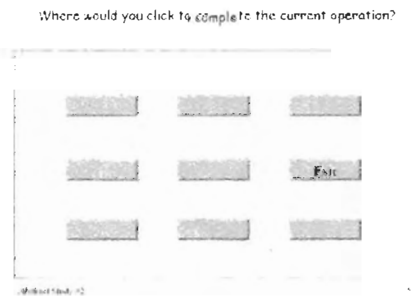

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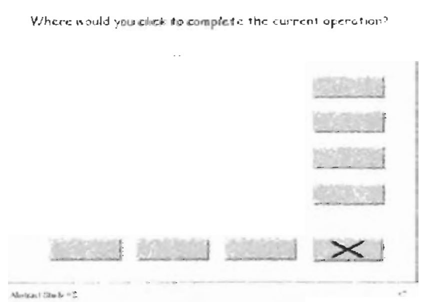

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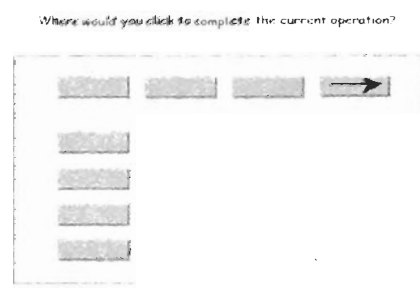

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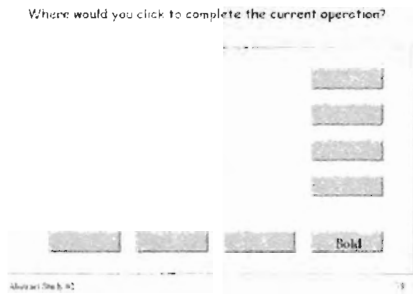

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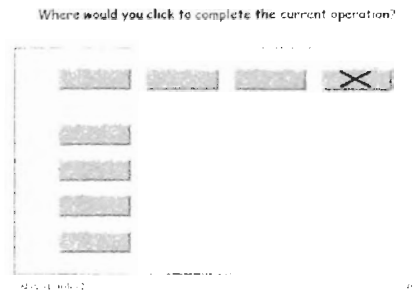

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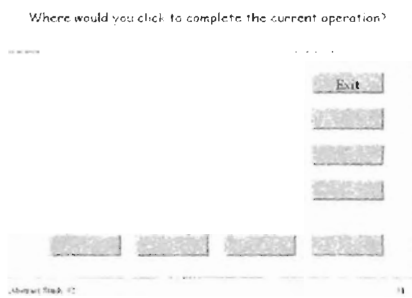

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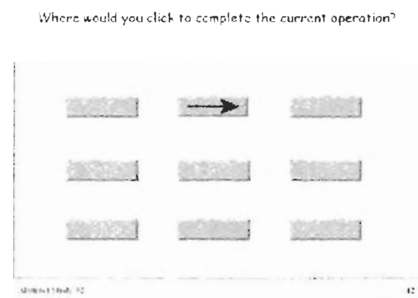
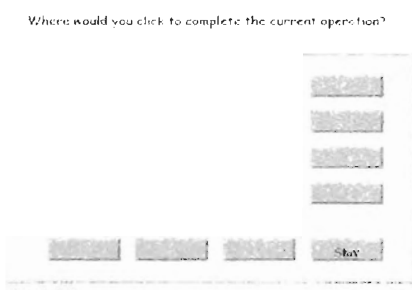


Stimulus 42



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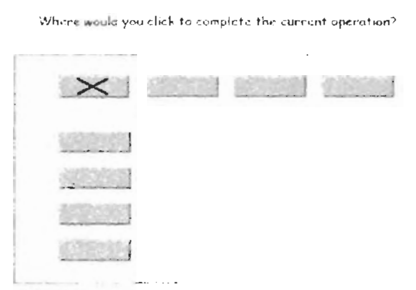
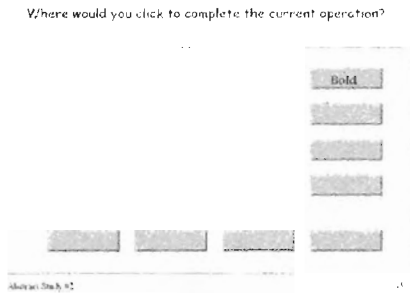
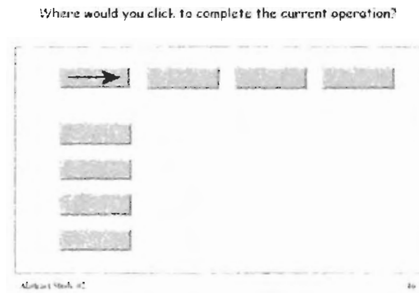


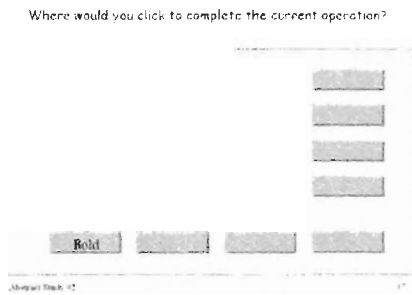
Stimulus 44



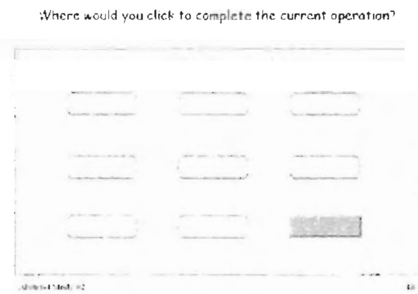
Stimulus 45



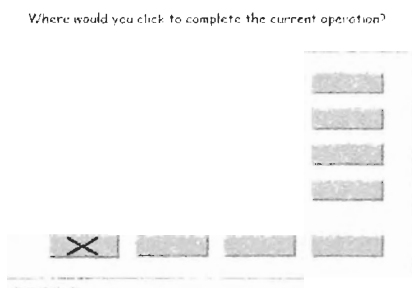
Stimulus 46



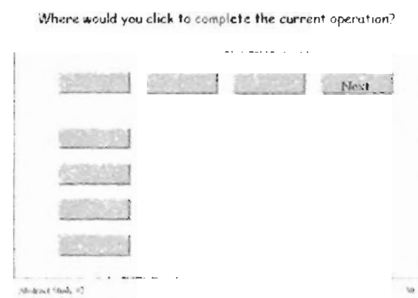
Stimulus 47



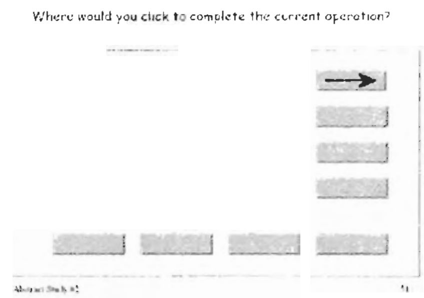
Stimulus 48



Stimulus 49



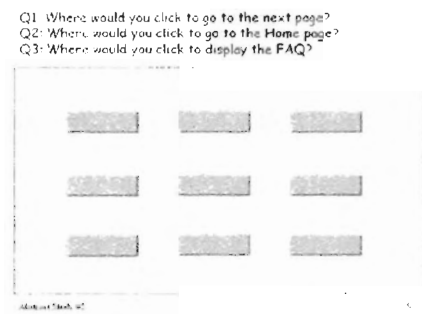
Stimulus 50



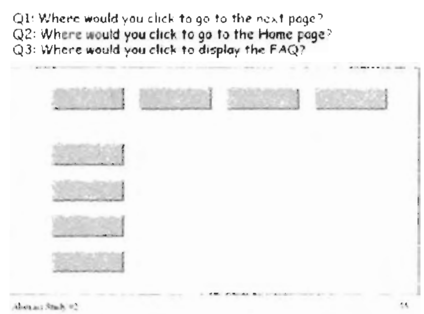
Stimulus 51

Stimulus 52

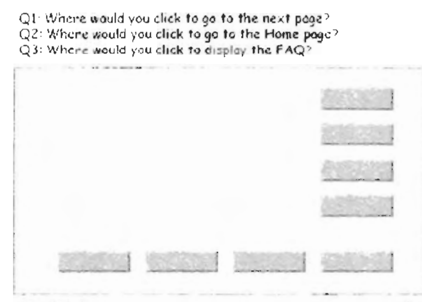
Stimulus 53



Stimulus 54



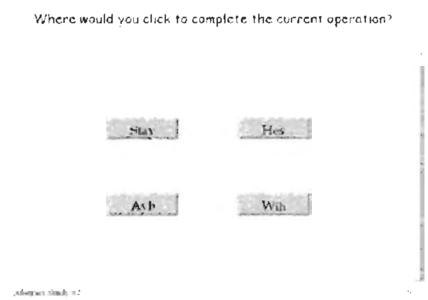
Stimulus 55



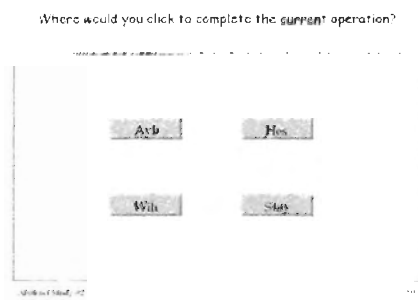
Stimulus 56

Stimulus 57

Stimulus 58

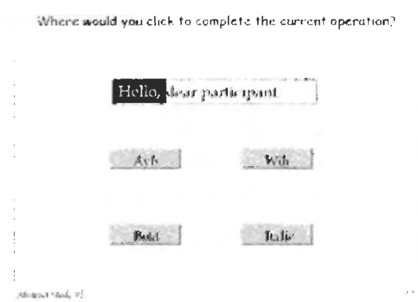


Stimulus 59

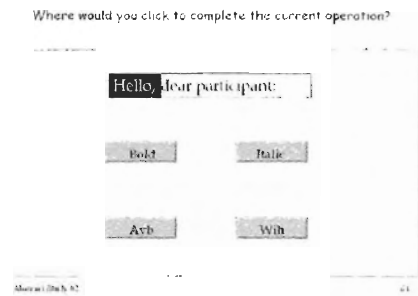


Stimulus 60

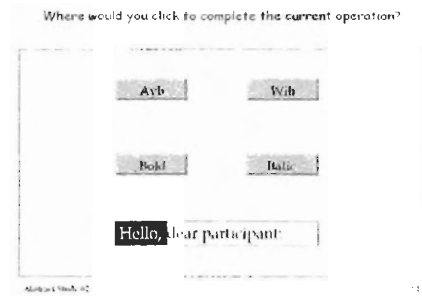
Stimulus 61



Stimulus 62



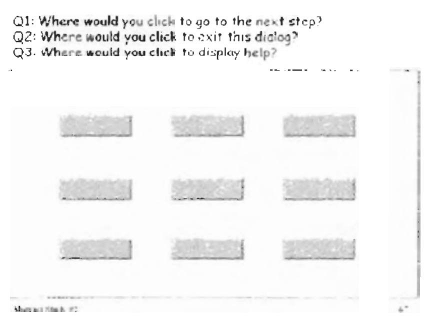
Stimulus 63



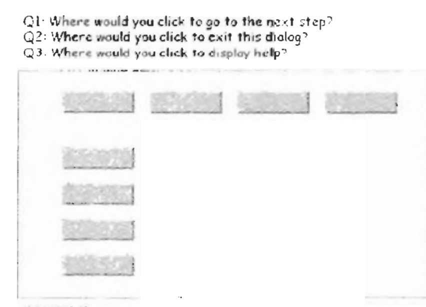
Stimulus 64

Stimulus 65

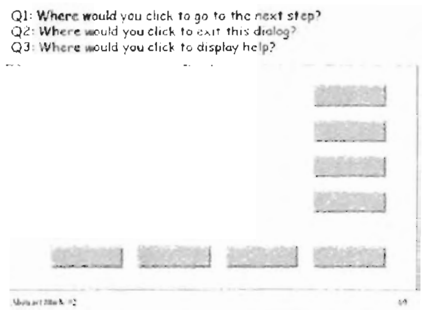
Stimulus 66



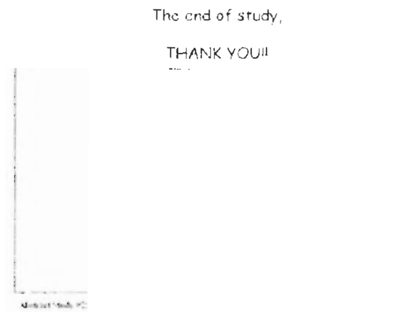
Stimulus 67



Stimulus 68



Stimulus 69



Stimulus 70

Appendix F

Additional Information Of Survey

This appendix contains information of the survey that is not described in Chapter 3.

F.1 Participants' Background

Here are the statstics of participants in the Survey:

(a) Gender

Female	5
Male	6
Total	11

(b) Group

CE	7
Non-CE	4
Total	11

(c) First Language

English	1
Others	10

(d) Others

Overall

	Age	Hours/week on Computer
Max	29	60
Min	19	4.5
Average	25.364	29.136

Group: CE

	Age	Hours/week on Computer
Max	29	60
Min	25	8
Average	27.286	40.429

Group: Non-CE

	Age	Hours/week on Computer
Max	24	20
Min	19	4.5
Average	22	9.375

Table F.1: Statistics of Participants in Survey

This following table is the tally of participants' responses on their computer application usage.

# of responses	Group: CE						Group: Non-CE					
	0	1	2	3	4	Notes	0	1	2	3	4	Notes
Windows XP	1	4		2				4				
Windows 2000			3	4				2		2		
Other versions of Windows		1	6							4		
Mac OS X		6		1				4				
Mac OS 9 or lower		6	1					4				
Other desktop	2	2	1	2		Linux, Solaris		4				
MS Word			1	6				1	1	2		
MS Excel			3	4				3	1			
MS PowerPoint			2	5				4				
Internet Explorer				7						4		
Netscape/Mozilla			3	4				4				
Other Browsers	1	4		2		Safari, Opera, Konqueror		3	1			
Amazon		5	2					3	1			
Yahoo maps		3	2	2				4				
Google				7						4		
Hot Keys	1			1	5				4			

Scale for all		Scale for Hot key
No Response	- 0 -	No Response
Never or Hardly use it	- 1 -	Never use
Used it a lot before	- 2 -	Know 1-3, use them occasionally
Currently use it	- 3 -	Know 1-3, use them most time
	- 4 -	Know 4+, use them all the time

Table F.2: Computer Usage of Participants in Survey

Appendix G

Additional Information Of Abstract Studies

G.1 Abstract Screen Study 1

In this section, we provide original data of participants' background and complete statistics tables and graphs.

G.1.1 Participants' Background

Here are the statstics of participants in the abstract stimuli task 1:

This following table is the tally of participants' responses on their computer application usage.

(a) Gender

Female	5
Male	6
Total	11

(b) Group

CE	7
Non-CE	4
Total	11

(c) First Language

English	1
Others	10

(d) Others

Overall

	Age	Hours/week on Computer
Max	29	60
Min	19	4.5
Average	25.364	29.136

Group: CE

	Age	Hours/week on Computer
Max	29	60
Min	25	8
Average	27.286	40.429

Group: Non-CE

	Age	Hours/week on Computer
Max	24	20
Min	19	4.5
Average	22	9.375

Table G.1: Statistics of Participants in Study 1

G.1.2 Ordinal Data

There is only one table for abstract study 1, Table G.3. It contains hitting rate of all visual cues. The table is organized by the cues: words, different shaped buttons, colour buttons, and images.

# of responses	Group: CE						Group: Non-CE					
	0	1	2	3	4	Notes	0	1	2	3	4	Notes
Windows XP	1	4		2				4				
Windows 2000			3	4				2		2		
Other versions of Windows		1	6							4		
Mac OS X		6		1				4				
Mac OS 9 or lower		6	1					4				
Other desktop	2	2	1	2		Linux, Solaris		4				
MS Word			1	6				1	1	2		
MS Excel			3	4				3	1			
MS PowerPoint			2	5				4				
Internet Explorer				7						4		
Netscape/Mozilla			3	4				4				
Other Browsers	1	4		2		Safari, Opera, Konqueror		3	1			
Amazon		5	2					3	1			
Yahoo maps		3	2	2				4				
Google				7						4		
Hot Keys	1			1	5				4			

Scale for all		Scale for Hot key
No Response	- 0 -	No Response
Never or Hardly use it	- 1 -	Never use
Used it a lot before	- 2 -	Know 1-3, use them occasionally
Currently use it	- 3 -	Know 1-3, use them most time
	- 4 -	Know 4+, use them all the time

Table G.2: Computer Usage of Participants in Study 1

Table G.3: Hit Rate of Individual Cues in Study 1

Total number of CE participants 7
Total number of Non-CE participants 4
Total number of participants 11

word: Cancel

Stimulus	Position	Where	# of expected hits	# of actual hits			% of actual hits		
				CE	Non-CE	Total	CE	Non-CE	Total
S-09	01	Top Left	11	5	0	5	71.43%	0.00%	45.45%
S-23	04	Top Right	11	6	2	8	85.71%	50.00%	72.73%
S-03	05	Bottom Right	11	6	3	9	85.71%	75.00%	81.82%
Total			33	17	5	22	80.95%	41.67%	66.67%

word: Close

S-08	01	Top Right	11	6	2	8	85.71%	50.00%	72.73%
S-22	04	Top Right	11	1	0	1	14.29%	0.00%	9.09%
S-02	05	Bottom Right	11	5	3	8	71.43%	75.00%	72.73%
Total			33	12	5	17	57.14%	41.67%	51.52%

word: EXIT

S-05	01	Top Right	11	6	4	10	85.71%	100.00%	90.91%
S-10	01	Top Left	11	6	3	9	85.71%	75.00%	81.82%
S-16	03	Centre	11	5	2	7	71.43%	50.00%	63.64%
S-07	05	Bottom Left	11	6	4	10	85.71%	100.00%	90.91%
S-12	06	Bottom Centre	11	6	4	10	85.71%	100.00%	90.91%
S-22	08	Bottom Left	11	6	4	10	85.71%	100.00%	90.91%
Total			66	35	21	56	83.33%	87.50%	84.85%

Table G.3: Hit Rate of Individual Cues in Study 1 (continued)

word: OK

Stimulus	Position	Where	# of expected hits	# of actual hits			% of actual hits		
				CE	Non-CE	Total	CE	Non-CE	Total
S-04	01	Top Right	11	4	1	5	57.14%	25.00%	45.45%
S-01	06	Bottom Right	11	4	1	5	57.14%	25.00%	45.45%
S-06	05	Bottom Left	11	4	1	5	57.14%	25.00%	45.45%
S-17	06	Bottom Right	11	4	2	6	57.14%	50.00%	54.55%
Total			44	16	5	21	57.14%	31.25%	47.73%

word: Open

S-11	06	Bottom Centre	11	1	1	2	14.29%	25.00%	18.18%

word: Save

S-15	03	Centre	11	0	0	0	0.00%	0.00%	0.00%

Different shape buttons

S-22	08	Bottom Left	11	6	4	10	85.71%	100.00%	90.91%
S-23	08	Bottom Left	11	1	1	2	14.29%	25.00%	18.18%
S-28	05	Bottom Left	11	2	1	3	28.57%	25.00%	27.27%
S-29	06	Bottom Centre	11	5	3	8	71.43%	75.00%	72.73%
S-30	06	Bottom Centre	11	1	2	3	14.29%	50.00%	27.27%
S-31	06	Bottom Centre	11	2	2	4	28.57%	50.00%	36.36%
S-36	15	Bottom Right	11	6	4	10	85.71%	100.00%	90.91%
Total			77	23	17	40	42.86%	66.67%	51.95%

Table G.3: Hit Rate of Individual Cues in Study 1 (continued)

Coloured Buttons

Stimulus	Position	Where	# of expected hits	# of actual hits			% of actual hits		
				CE	Non-CE	Total	CE	Non-CE	Total
S-18	03	Centre Left	11	1	1	2	14.29%	25.00%	18.18%
S-19	06	Bottom Centre	11	0	0	0	0.00%	0.00%	0.00%
S-21	08	Bottom Left	11	6	4	10	85.71%	100.00%	90.91%
Total			33	7	5	12	33.33%	41.67%	36.36%

S-27	01	Top Left	11	0	0	0	0.00%	0.00%	0.00%
S-27	02	Top Right	11	0	0	0	0.00%	0.00%	0.00%
S-27	03	Bottom Left	11	1	0	1	14.29%	0.00%	9.09%
S-27	04	Bottom Right	11	6	4	10	85.71%	100.00%	90.91%

S-26	04	Bottom Centre	11	0	2	2	0.00%	50.00%	18.18%
S-26	05	Bottom Right	11	7	2	9	100.00%	50.00%	81.82%

S-28	01	Top Left	11	0	0	0	0.00%	0.00%	0.00%
S-28	03	Centre Left	11	0	0	0	0.00%	0.00%	0.00%
S-28	04	Centre Right	11	0	0	0	0.00%	0.00%	0.00%

S-29	02	Row 2, Centre Left	11	0	0	0	0.00%	0.00%	0.00%
S-29	04	Row 3, Centre Left	11	0	0	0	0.00%	0.00%	0.00%
S-29	05	Row 3, Centre Right	11	0	0	0	0.00%	0.00%	0.00%

Table G.3: Hit Rate of Individual Cues in Study 1 (continued)

Coloured Buttons (continued)

Stimulus	Position	Where	# of expected hits	# of actual hits			% of actual hits		
				CE	Non-CE	Total	CE	Non-CE	Total
S-30	02	Row 2, Centre Left	11	0	0	0	0.00%	0.00%	0.00%
S-30	04	Row 3. Centre Left	11	0	0	0	0.00%	0.00%	0.00%
S-30	05	Row 3, Centre Right	11	0	1	1	0.00%	25.00%	9.09%
S-31	02	Row 2, Centre Left	11	0	0	0	0.00%	0.00%	0.00%
S-31	04	Row 3, Centre Left	11	0	0	0	0.00%	0.00%	0.00%
S-31	05	Row 3, Centre Right	11	0	0	0	0.00%	0.00%	0.00%
S-34	02	Row 2, Column 1	11	0	0	0	0.00%	0.00%	0.00%
S-34	05	Row 3, Column 1	11	0	0	0	0.00%	0.00%	0.00%
S-34	08	Row 4, Column 1	11	2	0	2	28.57%	0.00%	18.18%
S-35	02	Row 2. Column 1	11	0	0	0	0.00%	0.00%	0.00%
S-35	05	Row 3, Column 1	11	0	0	0	0.00%	0.00%	0.00%
S-35	08	Row 4. Column 1	11	0	0	0	0.00%	0.00%	0.00%

image: Oval

S-13	06	Bottom Centre	11	5	4	9	71.43%	100.00%	81.82%
S-14	03	Centre	11	0	1	1	0.00%	25.00%	9.09%
S-24	06	Bottom Right	11	7	4	11	100.00%	100.00%	100.00%
S-25	04	Centre	11	0	1	1	0.00%	25.00%	9.09%
Total			44	12	10	22	42.86%	62.50%	50.00%

Table G.3: Hit Rate of Individual Cues in Study 1 (continued)

image: Blank Circle

Stimulus	Position	Where	# of expected hits	# of actual hits			% of actual hits		
				CE	Non-CE	Total	CE	Non-CE	Total
S-28	06	Bottom Right	11	5	3	8	71.43%	75.00%	72.73%
S-29	01	Top Left	11	2	1	3	28.57%	25.00%	27.27%
Total			22	7	4	11	50.00%	50.00%	50.00%

S-33	05	Column 3, Bottom	11	2	1	3	28.57%	25.00%	27.27%
S-33	06	Column 4, Bottom	11	3	2	5	42.86%	50.00%	45.45%

image: Circle - Opened Door

S-20	01	Top Right	11	6	3	9	85.71%	75.00%	81.82%
S-30	01	Top Left	11	6	1	7	85.71%	25.00%	63.64%
S-35	12	Bottom Right	11	6	1	7	85.71%	25.00%	63.64%
Total			33	18	5	23	85.71%	41.67%	69.70%

image: Circle - X

S-31	01	Top Right	11	5	2	7	71.43%	50.00%	63.64%
S-35	01	Top Right	11	1	2	3	14.29%	50.00%	27.27%
S-33	02	Column 2, Top	11	2	1	3	28.57%	25.00%	27.27%
Total			33	8	5	13	38.10%	41.67%	39.39%

image: X

S-36	36	Row 1, Column 3	11	1	0	1	14.29%	0.00%	9.09%

Total of image X	44	9	5	14	32.14%	31.25%	31.82%

G.2 Abstract Screen Study 2

In this section, we provide original data of participants' background and complete statistics tables.

G.2.1 Participants' Background

Here are the statstics of participants in the abstract stimuli study 2:

(a) Gender

Female	12
Male	10
Total	22

(b) Group

CE	11
Non-CE	11
Total	22

(c) First Language

English	5
Chinese	10
Others	7

(d) Others

Overall

	Age	Hours/week on Computer
Max	30	144
Min	18	5
Average	23.333	34.636

Group: CE

	Age	Hours/week on Computer
Max	28	72
Min	18	20
Average	23	37.545

Group: Non-CE

	Age	Hours/week on Computer
Max	30	144
Min	19	5
Average	23.7	31.727

Table G.4: Statistics of Participants in Study 2

This following table is the tally of participants' responses on their computer application usage.

G.2.2 Ordinal Data

There are several graphs and tables for abstract study 2:

- Figure G.1 shows where the label or protrusion occured and its number of hits.
- Table G.6 shows the total number of hits for each label or protrusion in each layout.
- Tabel G.7 shows the total number of hits at each position.

# of responses	Group: CE						Group: Non-CE					
	0	1	2	3	4	Notes	0	1	2	3	4	Notes
Windows XP		7	1	3				4	1	6		
Windows 2000		2	2	7				5		6		
Other versions of Windows		1	6	4				4	3	4		
Mac OS X		11						11				
Mac OS 9 or lower		8	3					11				
Other desktop	1	5	1	4		Unix, Linux, Dos	1	9		1		Unix
MS Word			1	10					2	9		
MS Excel		4	3	4				6	1	4		
MS PowerPoint		4	4	3				6		5		
Internet Explorer				11				1		10		
Netscape/Mozilla		1	4	6				5	3	3		
Other browsers		9		2		Opera, Konqueror		11				
Amazon		7	2	2				11				
Yahoo maps		8	1	2				5	1	5		
Google			1	10				4		7		
Hot Keys			1	3	7			2	1	3	5	

Scale for all		Scale for Hot key
No Response	- 0 -	No Response
Never or Hardly use it	- 1 -	Never use
Used it a lot before	- 2 -	Know 1-3, use them occasionally
Currently use it	- 3 -	Know 1-3, use them most time
	- 4 -	Know 4+, use them all the time

Table G.5: Computer Usage of Participants in Study 2

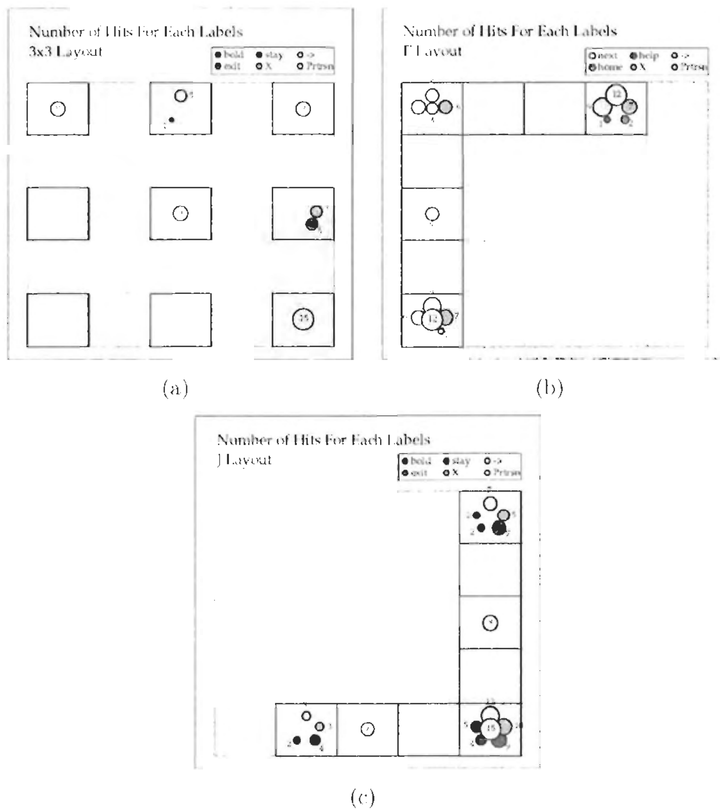


Figure G.1: Ordinal Label Data in Grid, Study 2
NB. Area of circle = Number of hits

3x3 Layout

Stimuli number	Local position	Global position	Label	# of responses	Sum of responses for the label	% of hits
S27	4	11	bold	0	0	0.00%
S17	2	3	stay	1	1	4.55%
S42	2	3	→	5	5	22.73%
S36	6	15	exit	5	5	22.73%
S24	6	15	X	5	5	22.73%
S10	1	1		9		
S13	3	5		9		
S29	5	13		9		
S48	9	25	Prtrsn	15	42	47.73%

Γ Layout

Stimuli number	Local position	Global position	Label	# of responses	Sum of responses for the label	% of hits
S18	4	4		1		
S26	1	1		0		
S08	8	21	Help	0	1	1.52%
S33	4	4		2		
S23	1	1		0		
S31	8	21	Home	1	3	4.55%
S50	4	4		9		
S11	1	1		5		
S28	8	21	Next	6	20	30.30%
S40	4	4		7		
S44	1	1		6		
S14	8	21	X	7	20	30.30%
S16	6	11		5		
S20	1	1		4		
S21	8	21	Prtrsn	12	21	31.82%
S38	4	4		12		
S46	1	1		5		
S34	8	21	→	9	26	39.39%

J Layout

Stimuli number	Local position	Global position	Label	# of responses	Sum of responses for the label	% of hits
S47	5	22		0		
S45	1	5		2		
S39	8	25	Bold	5	7	10.61%
S12	5	22		2		
S25	1	5		2		
S43	8	25	Stay	4	8	12.12%
S49	5	22		3		
S32	1	5		5		
S37	8	25	X	10	18	27.27%
S15	5	22		4		
S41	1	5		7		
S35	8	25	Exit	9	20	30.30%
S09	5	22		3		
S51	1	5		7		
S30	8	25	→	12	22	33.33%
S07	3	15		9		
S19	6	23		7		
S22	8	25	Prtrsn	15	31	46.97%

Table G.6: Individual Label Count of Study 2

# of participants 22 NB. % of hits = # of hits / # of total hits

3x3 (square) Layout

Location	# of labels /protrusion	# of expected hits	# of actual hits	location with label/ protrusion presented		location without label/ protrusion presented		strength based on Q2	
				# of hits	% of hits	# of hits	% of hits	#	rank
1	1	22	12	9	4.55%	3	1.52%	0	1
3	2	44	6	6	3.03%	0	0.00%	0	1
5	1	22	26	9	4.55%	17	8.59%	1	2
11	1	22	0	0	0.00%	0	0.00%	0	1
13	1	22	28	9	4.55%	19	9.60%	5	3
15	2	44	11	10	5.05%	1	0.51%	0	1
21	0	0	1	0	0.00%	1	0.51%	1	2
23	0	0	37	0	0.00%	37	18.69%	10	4
25	1	22	77	15	7.58%	62	31.31%	5	3
Total		198	198	58	29.29%	140	70.71%		

Γ Layout

Location	# of labels /protrusion	# of expected hits	# of actual hits	location with label/ protrusion presented		location without label/ protrusion presented		strength based on Q2	
				# of hits	% of hits	# of hits	% of hits	#	rank
1	6	132	37	20	5.05%	17	4.29%	3	4
2	0	0	25	0	0.00%	25	6.31%	0	1
3	0	0	28	0	0.00%	28	7.07%	4	5
4	5	110	124	31	7.83%	93	23.48%	2	3
6	0	0	30	0	0.00%	30	7.58%	1	2
11	1	22	18	5	1.26%	13	3.28%	0	1
16	0	0	31	0	0.00%	31	7.83%	3	4
21	6	132	103	35	8.84%	68	17.17%	9	6
Total		396	396	91	22.98%	305	77.02%		

J Layout

Location	# of labels /protrusion	# of expected hits	# of actual hits	location with label/ protrusion presented		location without label/ protrusion presented		strength based on Q2	
				# of hits	% of hits	# of hits	% of hits	#	rank
5	5	110	62	23	5.81%	39	9.85%	3	3
10	0	0	23	0	0.00%	23	5.81%	0	1
15	1	22	16	9	2.27%	7	1.77%	0	1
20	0	0	22	0	0.00%	22	5.56%	3	3
22	5	110	18	12	3.03%	6	1.52%	2	2
23	1	22	36	7	1.77%	29	7.32%	2	2
24	0	0	54	0	0.00%	54	13.64%	6	4
25	6	132	165	55	13.89%	110	27.78%	6	4
Total		396	396	106	26.77%	290	73.23%		

Table G.7: Hit Rate of Individual Position in Study 2

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