

NAME	TSELE RAKUBUTU
STUDENT NUMBER	512306
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SUPERVISOR	ASSOCIATE PROFESSOR JASON COHEN
CO-SUPERVISOR	PROFESSOR HELENE GELDERBLOM (UNISA)
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PLAGIARISM DECLARATION

I declare that this is my own, unaided work except as acknowledged in the text. It is being submitted in partial fulfilment for the Degree of Master of Commerce at the University of the Witwatersrand, Johannesburg. It has not been submitted for any other degree or examination at this or any other university.

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ABSTRACT

Multi-touch technology, used in consumer products such as the iPad, enables users to register multiple points of contact at the same time; this enables a user to interact with a touch screen interface using several fingers on one hand, or even both hands. This affords interface designers the opportunity to define gestural interactions based on what is most natural for users and not on merely what can be recognised and processed by technology. In light of this, the research question that this study aimed to address was: what is the most intuitive user-defined gesture set for conducting an informational search on a multi-touch tablet web browser?

In addressing this research question, the aim of this study was to create a user-defined gesture set for conducting an informational search on a multi-touch tablet web browser, based on gestures elicited from participants with little or no experience with touch screen devices. It was necessary to use these participants as users who are familiar with touch screen interfaces would draw upon the gestures they have learnt or used before, and would therefore be biased in the gestures they proposed. Inexperienced or naïve users would simply provide gestures that came naturally to them, providing a more accurate reflection of what a typical, unbiased user would do. A set of hypotheses, relating to the gestures that would be elicited from this participant group, were drawn up and investigated. These investigations yielded the following key findings:

- The use of two-handed gestures should be limited.
- If two-handed gestures are developed for a specific function, an alternative one-handed gesture should be made available.
- It is not be advisable to create completely novel gestures for tablet web browsing that do not correspond to any of the ways in which desktop web browsing is performed.
- Should novel gestures be developed for tablet web browsing, gestures that are desktop computing adaptations, including those that require menu access, should be made available as alternatives to users.
- Tasks should be designed in such a way that they may be completed with a variety of gestures.
- Complex tasks should be designed in such a way that they may be achieved through varying combinations of gestures.

These findings may assist interface designers and developers in the gestures they design or develop for their applications. In addition to these findings, the study presents a coherent, user-defined gesture set that may be used in practice by designers or developers.

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1. INTRODUCTION

In recent years, touch screen technologies have grown tremendously, generating significant appeal in the general public (Wang, Cao, Ren and Irani, 2009). The appeal of touch screen devices may be attributed to the natural and easy way of interacting with the interfaces by using a bare finger rather than traditional intermediary devices such as keyboards or mice (Wang et al., 2009). Touch screens with multi-touch technology, in particular, have been increasingly incorporated into consumer products (Bachl, Tomitsch, Wimmer and Grechenig, 2010). These multi-touch interfaces enable users to use multi-finger touches and hand gestures to manipulate digital objects directly, allowing them to interact with digital media on display surfaces (Chung, Fang and Quek, 2008). Unlike the traditional single touch or pen-based interfaces, which restricted the types of gestures users could make, these interfaces enable greater freedom in expressing gestures, allowing for more natural and intuitive gestures (Chung et al., 2008; Freeman, Benko, Morris and Widgor, 2009).

Products that contain these multi-touch interfaces range from large interactive walls and tabletop devices in public exhibitions spaces such as aquariums and museums to smaller, hand-held and portable devices such as mobile phones and tablets (Hinckley, Yatani, Pahud, Coddington, Rodenhouse, Wilson, Benko, Buxton, 2010; Hinrichs and Carpendale, 2011; Schoeffmann, Ahlström and Beecks, 2011). The latter, specifically tablet devices, are the focus of this study, with a notable example being the Apple iPad. Apple reported that three million units of the first generation iPad were sold in eighty days after its release in April 2010 (Harrison and Barrios, 2010) with the same number of units being sold in just four days for the third generation iPad in March 2012 (Muller and Kerris, 2012).

Multi-touch interfaces, used in the iPad as well as other devices, are able to register multiple points of contact occurring at the same time, thus enabling a user to interact with an interface using several fingers and both hands (Han, 2005). This allows interface designers the opportunity to define gestural interactions based on what is most efficient and natural for users and not on merely what can be recognised and processed by technology (Mauney, Howarth, Wirtanen and Capra, 2010). As a result, it may be argued that this makes interaction with the interface more intuitive, especially for novice users (Jiao, Deng and Wang, 2010). With increasing numbers of novice users using multi-touch devices, and specifically iPads and other tablet devices, it is of paramount importance to investigate the user experience of interacting with such interfaces (Bachl et al., 2010). This is because the interface of any device directly influences its users' satisfaction, and that directly affects the device's success on the market (Bruno and Muzzupappa, 2010). With web browsing being the main activity done on iPads (Nguyen and Chaparro, 2010), the gestures used for web browsing on multi-touch tablet devices become essential to understand.

1.1 CONTEXT AND BACKGROUND

To provide an appreciation of the context and background of this study, user-defined gestures and informational searches are briefly discussed.

1.1.1 USER-DEFINED GESTURES

It has been suggested that manufacturers such as Apple, as well as the general developer community, are ignoring longstanding conventions of interaction design and introducing ill-conceived ones when it comes to designing gestural interfaces (Norman and Nielsen, 2010). While Norman and Nielsen (2010) acknowledge that new technologies require new methods, they assert that refusal to follow well-established principles that are universal and applicable regardless of the technology in question¹, results in interfaces being less usable. Norman and Nielsen (2010) therefore call for all manufacturers and developers to apply the principles and conventions that have been identified through Human Computer Interaction (HCI) research when designing gestures for touch screen interfaces. HCI research, however, does not provide practitioners with sufficient normative guidelines for creating gestures that appeal to users. Moreover, stringent application of HCI principles and conventions cannot guarantee that practitioners will be able to design gestures that are intuitive to users. For example, in one study, users preferred their own “user-defined gestures” over those developed by three qualified, HCI and gestural design experts (Morris, Wobbrock and Wilson, 2010).

This would suggest that more user participation in the design of gestures for multi-touch interfaces is required and that more needs to be understood about how users want to interact with multi-touch interfaces and what gestures are most intuitive to them. Lao, Heng, Zhang, Ling and Wang (2009) explain that the key to creating an intuitive gestural interface lies within the mapping rules for that interface. These rules determine which gesture is mapped to which function. The mapping between the functions of an application and the gestures that activate those functions should not be arbitrary (Lao et al., 2009), but should be aligned with users’ expectations. The alignment between how users intend on providing their gestural input, and the gesture(s) afforded by the interfaces for that input, is what makes the system intuitive to use.

1.1.2 INFORMATIONAL SEARCHES

With multi-touch tablet devices becoming popular in the public arena, web browsing on these devices is becoming increasingly commonplace. A limited survey of 51 iPad owners by Nguyen and Chaparro (2010) revealed that web browsing was the main activity that they did on their iPads. While the sample size of this survey is very small, it nonetheless gives an indication of the prevalence, and increasing importance, of web

¹ The principles presented are: visibility (also called perceived affordances or signifiers, feedback, consistency, non-destructive operations, discoverability (ability to discover all functions by systematic exploration of menus) and scalability.

browsing on multi-touch tablets. As the term “web browsing” covers varied activities, this study looks specifically at informational searching on the web using a search engine such as Google. When searching the web, users typically issue a query to a search engine, are presented with a list of results, and then may select one or more results in order to access the information they want (Downey, Dumais, Liebling and Horvitz, 2008). There are, however, different goals or intentions behind queries that are supplied to search engines. These queries, or the intent behind these queries, are classified as follows (Broder, 2002):

- Navigational – where the immediate intent is to reach a particular site
- Informational – where the intent is to acquire some information assumed to be present on one or more web pages
- Transactional – where the intent is to perform some web-mediated activity such as online shopping or downloading

Informational searches are the most common type of web searches (Broder, 2002; Rose and Levinson, 2004) and thus a worthwhile context for investigating the use of gestures for interacting with a touch screen interface.

1.2 RESEARCH PROBLEM

Many touch screen applications have their own specific gesture sets that are used to interact with digital objects and provide input (Lao et al., 2009). A gesture set is the set of gestures used throughout the application or interface, and is also called a gesture vocabulary (Nielsen, Störring, Moeslund and Granum, 2003). Many gesture sets use varying combinations of one finger tap interactions, which suggests that they have simply been adapted from the pointer-based paradigm used in popular operating systems, such as Windows (Micire, Desai, Courtemanche, Tsui and Yanco, 2009).

There are those who are not opposed to the approach of leveraging off pointer-based interactions in designing gesture sets (Wang et al., 2009). The key motivation for doing so is that users would be able to apply their existing knowledge of pointer-based interactions, based on desktop applications, which they are familiar with. Others, such as Lao et al. (2009), take a different stance however, and suggest that reducing Windows Icons Menus Pointers (WIMP) elements would actually improve the quality of touch screen interactions. They argue that multi-touch devices are capable of enabling exceptional freedom in gestural input but the use of single finger, one-point tap or drag interactions negates the benefits that this multi-touch technology offers.

With the conflicting views above, it has not yet been clearly determined whether users prefer pointer-based interactions in touch screen applications versus new and novel interactions that are divorced from traditional pointer-based interactions. We thus lack answers to the question of which gestures are most intuitive to users in different application contexts. An intuitive gesture is one where the gesture afforded by the interface

design is aligned to how users expect to provide input (Lao et al., 2009). Therefore, understanding users' expectations is critical in designing appropriate touch screen gesture sets.

Given the particular interest of this study in web browsing on multi-touch tablets, the specific research question that this study aims to address is: what is the most intuitive user-defined gesture set for conducting an informational search on a multi-touch tablet web browser?

1.3 AIM OF THE STUDY

The aim of this study was to create a user-defined gesture set for conducting an informational search on a multi-touch tablet web browser based on gestures elicited from participants. It is worthwhile to note that the participants were individuals who were familiar with conducting informational searches on desktops or laptops, but had little to no experience with any type touch screen device. It was necessary to use these participants as they would enable the researchers to analyse naïve users' preferred gestures (Wobbrock et al., 2009). Users who are familiar with touch screen interfaces would advertently or inadvertently draw upon the gestures they have learnt or used before, and would therefore be biased in the gestures they used. Inexperienced users are more likely to attempt gestures that come naturally to them and are less biased towards the use of gestures familiar to them through knowledge of one or more devices currently on the market. The user-defined gesture set was created by:

- Utilising the design science research paradigm and employing participatory design methods to elicit gestures specific to conducting an informational search on a tablet device. Eliciting gestures was achieved by applying the method employed by Wobbrock et al. (2009). This involved using participants who were unfamiliar with the touch-screen devices, showing them videos of various functions, and asking them to propose gestures that they felt best suited the functions shown to them.
- Using these elicited gestures to create one coherent gesture set for conducting an informational search.

1.4 IMPORTANCE AND CONTRIBUTION OF THE STUDY

Users are currently faced with a situation where gestural input for similar applications and functions differs across different brands of multi-touch tablet devices (Bachl et al., 2010). This situation is aggravated by the fact that manufacturers wish to protect their intellectual property and to disallow competitors from using their methods, and as such they introduce proprietary standards for the gestures that they have developed to prohibit others from using them (Bachl et al., 2010; Norman and Nielsen, 2010; Lao et al., 2009). In addition to this, there are also no standards that applications developers comply with. There are even situations where there are inconsistencies in gestures required by applications on the same device (Norman and Nielsen, 2010). Lao et al. (2009) explain that this happens because the definition of gestures, and how they are used, is often application-specific.

Given these circumstances, users may become confused as there are no standardised gestures across different manufacturers and applications (Bachl et al., 2010; Norman and Nielsen, 2010). They cannot transfer their skills between applications (Budi and Nielsen, 2010) or contexts (Norman and Nielsen, 2010). This is unlikely to change in the near future as there is currently no unified effort or organised activity to standardise gestures (Lao et al., 2009), and the use of proprietary standards, such as patents, clearly makes standardisation, which would ultimately benefit the users of touch screen devices, very difficult to achieve. One must, however, appreciate that companies or manufacturers invest heavily in building their intellectual property, which gives rise to the competitive nature of the market for multi-touch products. Given this competitiveness, it is of no surprise that many manufacturers do not publish their knowledge of gesture design or make it publicly available.

This study will be able to provide insights with respect to multi-touch tablet web browsing, with a specific focus on the gestures related to this activity. This is a worthwhile endeavour considering that touch screen interfaces are becoming more ubiquitous. As such, it is important to investigate the user experience of interacting with such interfaces (Nielsen et al., 2003; Bachl et al., 2010; Wobbrock et al., 2009; Frisch, Heydekorn and Dachsel, 2009; Micire et al., 2009; Norman and Nielsen, 2010), especially for an activity as common as conducting an informational search on a web browser. In addition to the insights arising from this investigation, a coherent gesture set will be produced as result of the study. The gestures from this gesture set, and the contexts within which they can be used, will be a direct contribution to current practice. This is because designers or developers may use these gestures, or modified versions of these gestures, in their designs. The primary beneficiaries of this study would therefore be designers of tablet web browsing applications; knowing the preferences of users would enable them to design more intuitive interactions that are easy to learn and use. The secondary beneficiaries would be the users of such tablet web browsing applications as they would benefit from interactions that have been designed to be more intuitive than those currently used.

1.5 DELIMITATIONS AND ASSUMPTIONS

This study focuses on the activity of conducting an informational search on a search engine using a tablet device. Other activities, including navigational or transactional searches as well as general browsing, are not addressed in this report. It should also be noted that only one search engine was used for the informational searches in the experiments – Google. This is because Google is the most commonly used search engine internationally, and, as at June 2012, enjoyed over 80% of the search engine market share (NetMarketShare, 2012; StatCounter, 2012; Clicky Web Analytics, 2012; StatOwl, 2012).

In terms of the web browser functions, it should be noted that only a selected subset of functions that support an informational search were analysed in this study. Tablet web browsers generally have numerous functions that facilitate or support any form of web search – analysis of all these functions would have been too large of an undertaking for this report.

1.6 STRUCTURE OF THE REPORT

The remainder of this research report will be structured as follows:

- Chapter 2 – Literature Review; provides the theoretical background for the study based on existing literature. It discusses related studies that are relevant to the research problem and introduces the hypotheses.
- Chapter 3 – Research Methodology; explains the research paradigm in which the study was conducted and the research methodology that was employed to elicit gestures from participants. It describes, and provides justification for, the data collection strategy that was utilised and an explanation of how the collected data was analysed.
- Chapter 4 – Data Analysis; provides the results arising from the analysis of the data that was collected, including the final user-defined gesture set. It shows how the results address each of the hypotheses.
- Chapter 5 – Discussion; discusses the various considerations for gesture design, emanating from the results presented in the previous chapter and the hypotheses. It explains the significance and implications of these results for the design of tablet web browsing gestures. Important results are highlighted and explanations are provided where there are unexpected results.
- Chapter 6 – Conclusion; provides the conclusions regarding the research problem. It evaluates whether the aims of the study were met by providing a brief summary of the research report. It highlights the limitations of the study and identifies future research directions.

2. LITERATURE REVIEW

This chapter begins by introducing gestures and discusses the need for participatory gesture design. The chapter reviews past research into gesture design for multi-touch devices and presents the shortcomings and contributions of that work. This leads to the presentation of the study's research question and to the derivation of six hypotheses each addressing an element of gesture design.

2.1 GESTURES AND GESTURE DESIGN

Wobbrock et al. (2009) present a Taxonomy of Surface Gestures based on the way the participants in their study performed and described their gestures. Based on this taxonomy, as well as contributions from Nielsen et al. (2003), Lao et al. (2009) and Hinrichs and Carpendale (2011), gestures may be identified and classified in terms of Gesture Form, Gesture Nature, Gesture Binding, and Gesture Flow. These classifications are detailed as follows:

- Gesture Form
 - Identification of the number of fingers used (Wobbrock et al., 2009).
 - Identification of which fingers were used (Wobbrock et al., 2009).
 - Identification of whether the gesture was static; static gestures are gestures where the hand and/or fingers have a fixed position over time (Nielsen et al., 2003; Stern, Wachs and Edan, 2008; Wobbrock et al., 2009).
 - Identification of whether the gesture was dynamic; dynamic gestures are ones where the hand trajectory and/or position varies over time (Nielsen et al., 2003; Stern, et al., 2008; Wobbrock et al., 2009).
 - Identification of what “touch style” was used; as explained by Lao et al. (2009), “touch styles” are the ways in which contact between the hand and the surface occurs. Elementarily Lao et al. (2009) explain “touch styles” as:
 - Distinctly with one finger – where contact is made with the fingertip of one finger
 - Distinctly with two fingers – where contact is made with the fingertips of two fingers that are separated from one another
 - Distinctly with three fingers – where contact is made with the fingertips of three fingers that are separated from one another
 - Distinctly with four fingers – where contact is made with the fingertips of four fingers that are separated from one another
 - Distinctly with five fingers – where contact is made with the fingertips of all five fingers that are separated from one another

- Palm – where contact is made with the palm of the hand and the inner surface of all five fingers
- Half-palm – where contact is made with the fingertips of the index, middle, ring and pinkie fingers closely kept together
- Fist – where contact is made with the bottom a clenched fist
- Vertical hand – where contact is made with the longitudinal side of the hand (not clenched)
- Identification of whether the gesture comprised a “press”; a “press” is where contact with the surface occurs in a fixed location and is prolonged (Lao et al., 2009).
- Identification of whether the gesture comprised a “tap”; a “tap” is where contact with the surface occurs in a fixed location and is brief (Lao et al., 2009).
- Identification of whether the gesture comprised a “drag”; a “drag” is where the contact with the surface varies in location over time (Lao et al., 2009) – Wobbrock et al. (2009) refer to this as a “path” in their taxonomy of gestures. There are various ways in which single finger dragging occurs:

Lao et al. (2009) further explain the various ways in which “dragging” occurs:

- Single finger dragging, where the finger could move in any given direction (Lao et al., 2009)
 - A variation of the drag is a “flick” which is motion similar to a drag, but is typically quicker; Hinrichs and Carpendale (2011) describe it as a brief and forceful touch that makes an item move rapidly in a certain direction
- Two finger dragging, typically the thumb and index finger or index and middle fingers, which can either be
 - “Bi-directional dragging”; where the two fingers are both moving in different directions
 - “Move closer”; where the two fingers both move towards each other; this gesture is also known as the “pinch” (Wobbrock et al., 2009; Micire et al., 2009)
 - “Move apart”; where the two fingers both move apart from one another
 - “Same direction”; where the two fingers both move in the same direction – a variation of this drag is a “two-finger flick” which shorter and quicker than the typical drag
 - Pivot; where one finger, typically the thumb, remains in one location and the other finger, typically the index finger, pivots around it in a clockwise or counter-clockwise direction – in the example provided by Lao et al. (2009),

however, the pivot is done with the index finger and middle finger, with the index finger being the axis

- Multi-finger dragging, which uses more than two fingers, which can either be
 - “Move closer”; where the fingers move towards a central axis – Nielsen et al. (2003) refers to this hand movement of “gathering the fingers” as adduction
 - “Move apart”; where the fingers move outward from a central axis – Nielsen et al. (2003) refers to this hand movement of “spreading the fingers” as abduction
 - “Same direction”; where all the fingers move in the same direction – a variation of this drag is a “multi-finger flick” as observed by Hinrichs and Carpendale (2011)
 - Pivot; where one finger, typically the thumb, remains in one location and the other fingers move
- Micire et al. (2009) also provide the “lasso” gesture which is the dragging of a finger in an ellipse around the object(s) to be selected – while typically done with one finger it may also be done with two fingers.
 - A variation of this gesture is the boundary box, in which a box, instead of an ellipse, is drawn.
- Identification of whether the gesture was simple; simple gestures are gestures that are a single hand/finger action; they do not contain repeated actions or other simple gestures (Lao et al., 2009). Wu et al. (2006), refer to these gestures as gesture primitives.
- Identification of whether the gesture was complex; complex gestures are gestures that comprise two or more simple gestures (Lao et al., 2009). Wu et al. (2006), refer to these gestures as compound gestures.
- For complex gestures, identification of whether the constituent gestures were performed sequentially or in parallel (Frisch et al., 2009).
- Gesture Nature
 - Identification of whether the gesture was symbolic; symbolic gestures are gestures that visually depict a symbol (Wobbrock et al., 2009), such as tracing the outline of a house (“”) to perform the function “go to home page”.
 - Identification of whether the gesture was physical; physical gestures are gestures that physically act on objects and ostensibly have the same effect on actual objects (Wobbrock et al., 2009) – for example, “throwing” an object off the screen to delete it (Wobbrock et al., 2009), or using a

half-palm drag gesture to drag an object from one area to another, in the same way as a small object on a table, say a card, may be moved in reality.

- Identification of whether the gesture was metaphorical; metaphorical gestures occur when a gesture acts on, with, or like something else (Wobbrock et al., 2009) – for example, swiping as if to turn a book page or tapping an imaginary button. Wobbrock et al. (2009) point out however that the gesture itself usually is not enough to reveal its metaphorical nature; the answer lies in the user's mental model.
- Identification of whether the gestures are abstract; abstract gestures are gestures that have no symbolic, physical, or metaphorical connection to their referents – their mapping is arbitrary, such as triple-tapping an object to delete it (Wobbrock et al., 2009). Wobbrock et al. (2009) point out however that while the mappings of these gestures are arbitrary, it does not necessarily mean that they are poor.
- Gesture Binding
 - Identification of whether the gesture was object-centric; object-centric gestures are gestures which are performed with respect to an object i.e. they are performed to a specific object or they produce a specific object such as performing a two finger “move apart” gesture on a picture in a webpage to enlarge it.
 - Identification of whether the gesture was world-dependent; world-dependent gestures are gestures that take the real world into context into consideration – such as dragging an object, perhaps a saved webpage, off the screen to delete it (this gesture has context of the edges or frame of the actual screen of the device).
 - Identification of whether the gesture was world-independent; world-independent gestures are that can generally be performed anywhere (Wobbrock et al., 2009).
 - Identification of whether the gesture had mixed dependencies; gestures that have mixed dependencies are gestures that are world-independent in one respect but world-dependent or object-centric in another (Wobbrock et al., 2009) – this may be seen with two-handed gestures where one hand acts on an object while the other hand holds the frame of the interface or rests on any location the interface and does not necessarily form part of the gesture. This is however typically seen with tabletop devices, where one hand may be placed on the interface solely to support the body while the other hand gestures; this is a situation that would rarely occur with tablet devices.
- Gesture Flow
 - Identification of whether the gesture was discrete; discrete gestures are gestures that are performed in their entirety, and once performed the system provides feedback (Wobbrock et al., 2009) – an example would be tapping on a link in a webpage to open that webpage (once the tap gesture is complete, the webpage opens).

- Identification of whether the gestures was continuous; continuous gestures are gestures that require on-going recognition by the system and feedback is provided while the gestures is being performed (Wobbrock et al., 2009) – an example would be scrolling down a webpage using a drag gestures (while the gesture is being performed, the interface is updated so that the content that is lower down the webpage moves up into the user’s view).

A summary of these classifications has been depicted in tabular form below.

Table 1: Classification of Touch Screen Gestures

Classification of Touch Screen Gestures					
Dimension	Attributes	Attribute Categories	Attribute Properties		
Gesture Form	Fingers used / part of hand used	Right Hand	Thumb		
			Index		
			Middle		
			Ring		
			Pinkie		
			Palm		
			Fist		
			Vertical hand		
		Left Hand	Thumb		
			Index		
			Middle		
			Ring		
			Pinkie		
			Palm		
			Fist		
			Vertical hand		
	Gesture motility	Static	Press	Press “touch style”	Distinctly with one finger
					Distinctly with two fingers
					Distinctly with three fingers
					Distinctly with four fingers
					Distinctly with five fingers
			Tap	Tap “touch style”	Palm
					Half-palm
					Fist
					Vertical hand
					Distinctly with one finger
		Dynamic	Drag	Single finger	Distinctly with two fingers
					Distinctly with three fingers
					Distinctly with four fingers
					Distinctly with five fingers
					Palm
					Half-palm
					Fist
					Vertical hand
					Drag
					Flick
					Lasso
					Boundary box

Classification of Touch Screen Gestures					
Dimension	Attributes	Attribute Categories	Attribute Properties		
				Two finger	“Bi-directional” drag
					“Move closer” drag / Pinch
					“Move apart” drag
					“Same direction” drag
					“Same direction” flick
					Pivot
					Lasso
					Boundary box
			Multiple finger / Other part of hand	“Move closer” drag / Adduction	
				“Move apart” drag / Abduction	
“Same direction” drag					
“Same direction” flick					
	Number of fingers	Ordinal number ranging from 1 to 10			
		Complexity	Simple		
			Complex / Compound	Ordering of constituent gestures	Sequential
Gesture Nature	Symbolic	N/A			
	Physical	N/A	Gesture physically acts on objects and ostensibly has the same effect on actual objects		
	Metaphorical	N/A	Gesture acts on, with, or like something else		
	Arbitrary	N/A	Gesture is arbitrarily mapped to referent		
Gesture Binding	Object-centric		Gestures performed with respect to an object i.e. performed to a specific object or they produce a specific object		
	Word-dependent	N/A	Gestures takes the real world into context into consideration		
	World-independent	N/A	Gestures are that can generally be performed anywhere		
	Mixed dependencies	N/A	Gestures is world-independent in one respect but world-dependent or object-centric in another		
Gesture Flow	Discrete	N/A	Gestures is performed in its entirety, and once completely performed the system provides feedback		
	Continuous	N/A	Gesture requires on-going recognition by the system and feedback is provided while the gestures is being performed		

It should be noted that the classifications above assist in describing the various gestures that may be used on tablet devices. They do not address what functions, or types of functions, should be assigned or mapped to those gestures, which is a vital step in developing an intuitive interface. The following section discusses how the users of a system can participate in determining these assignments or mappings.

2.2 PARTICIPATORY DESIGN

It is widely accepted in Information Systems (IS) and HCI literature that users should be involved in the development of interactive systems (Iivari, 2006). The involvement of users, as explained by Iivari (2006), may be:

- Informative or consultative – where users merely act as providers of information, objects of observation or commentators of predefined designs solutions
- Participative – where users are active agents in the design process and have decision-making power

The latter of the two options is the central tenet of participatory design – which may be explained as a set of theories, practices, and studies related to end-users as full participants in activities leading to software and hardware computer products and computer-based activities (Muller, 2009). The use of participatory design is, however, scarce.

Olsson (2004) highlights that while there is acknowledgement of the benefits of participatory approaches, such as the elicitation of more accurate user requirements (Mumford, 1995 cited by Howcroft and Wilson, 2003), their application in the design of information systems has been scarce. Olsson (2004) further notes that while the informative or consultative types of user involvement, such as heuristic evaluation, ranked significantly lower than ones with active user participation² their application has been far more pervasive.

Most often, users are represented by usability experts in the design process – this approach, however, does not entail active participation of actual users (Iivari, 2006). Moreover, when users are involved, they are asked to comment on predefined design solutions or merely provide information without being active participants in the design process (Olsson, 2004; Iivari, 2006). While it is noted that even this degree of user involvement is better than none, such approaches do however reinforce the division between designers and users (Fleischmann, 2006). The argument put forward by Fleischmann (2006) is that insofar as this division exists, technologies might not fulfil their full potential. Fleischmann (2006) points out that it is only when users are the designers of the very information technologies that they themselves use, that these technologies may be of greatest use to the communities they service.

2.2.1 PARTICIPATORY GESTURE DESIGN

Wobbrock et al. (2009) and Morris et al. (2010) assert that users should play a central, participative role in gesture design because gestures designed autonomously by system designers are not always reflective of what end-users would prefer. Wobbrock et al. (2009) point out that gestures designed by system designers are often designed with the greatest concern being the reliable recognition of those gestures by the system. However, this may not always ensure that the gestures correctly correspond with how users would naturally, or intuitively, expect to interact with interface elements – which is perhaps a more important concern for consumer-centric devices. Saffer (2009) and Wobbrock et al. (2009) propose that the responsibility of determining which gestures are the most appropriate and intuitive for specific actions should not be the sole responsibility of the system designers but that there should be a shared responsibility with the users of the

² This was based on a survey conducted with usability experts attending Computer Human Interaction (CHI) and Usability Professionals' Association (UPA) conferences.

interface as it is their knowledge and intuition that the usability of an interface relies on. Appendix A (Participatory Gesture Design Vs. Gesture Validation) provides two brief examples of why involving users through participatory gesture design is preferable to simply employing users to validate gestures that have been developed.

Various studies, such as Nielsen et al. (2003), Epps, Lichman and Wu (2006), Frisch et al. (2009), Micire et al. (2009), Mauney et al. (2010), Kane, Wobbrock, and Ladner (2011) have successfully taken the approach of eliciting gestures from users for touch screen interfaces and provide a number of contributions for going about this task. Some of these are summarised in the table below. It should be noted, however, that this is not an exhaustive account of all contributions by these researchers in terms of gesture elicitation – only those most pertinent to this study have been highlighted.

Table 2: Contributions for Gesture Elicitation Process

Researchers (Year of Publication)	Application Context	Contribution for Gesture Elicitation Process
Nielsen, Störing, Moeslund and Granum (2003)	Basic architectural design application (the application enables the user to place virtual 3D objects on the table, move them, and change their style settings)	Investigating interfaces of known applications to identify the functionalities for which gestures should be elicited from participants.
		Using a camera to record gestures, and using the video data to classify the gestures.
		Ensuring there is no feedback for the gestures participants perform (this is to enable them to exhibit their natural, unrevised and uninhibited behaviour).
Wobbrock, Aung, Rothrock and Myers (2005)	EdgeWrite Unistroke Alphabet; participants had to make unistroke gestures (these are gestures where the participant does not lift his / her finger until the gesture is complete) on a touchpad to indicate letters of the alphabet	Presenting the effects of the gesture (i.e. output that would be displayed as a result of the gesture) to participants and requesting them to perform the gesture that would cause that effect (i.e. the gesture required to produce the output displayed).
		Allowing participants to redo gestures if they are unsatisfied with them (before proceeding to the next gesture).
Epps, Lichman and Wu (2006)	General (Windows) operating system tasks	Identifying the need to reduce or remove the Window-centric elements in images presented to participants during experiments.
		Ensuring there is no feedback for the gestures participants perform (this is to enable them to exhibit their natural, unrevised and uninhibited behaviour).
Frisch, Heydekorn and Dachselt (2009)	Editing of node-link diagrams	Ensuring there is no feedback for the gestures participants perform (this is to enable them to exhibit their natural, unrevised and uninhibited behaviour).
		Requesting participants to “think aloud” while providing their gestures and to verbalise any thoughts or reasoning for the gesture(s) they are proposing.
		Requesting participants to provide ratings, using Likert scales, for each gesture they propose.

Researchers (Year of Publication)	Application Context	Contribution for Gesture Elicitation Process
		Setting the experimental tasks in a fixed order for each participant.
		Using a camera to record gestures, and using the video data to classify the gestures.
Wobbrock, Morris and Wilson (2009)	No specific application context; researchers were studying users' interactions with 2D shapes	Requesting participants to "think aloud" while providing their gestures and to verbalise any thoughts or reasoning for the gesture(s) they are proposing.
		Presenting the effects of the gesture (i.e. output that would be displayed as a result of the gesture) to participants and requesting them to perform the gesture that would cause that effect (i.e. the gesture required to produce the output displayed).
		Limiting or removing elements relating to Windows or Macintosh operating systems that may be viewable to participants during experiments.
		Ensuring there is no feedback for the gestures participants perform (this is to enable them to exhibit their natural, unrevised and uninhibited behaviour).
		Allowing participants to assume a widget or digital object is presented when proposing a gesture, should they feel that one is required. Participants are required to explain what the widget is, the form they expected it to take and how they expect it to work.
		Requesting participants to provide ratings, using Likert scales, for each gesture they proposed.
Micire, Desai, Courtemanche, Tsui and Yanco (2009)	Controlling Robot Teams	Recording participants' hands from different angles, and using the video data to classify the gestures.
		Requesting participants to "think aloud" while providing their gestures and to verbalise any thoughts or reasoning for the gesture(s) they are proposing.
		Limiting or removing elements relating to Windows or Macintosh operating systems that may be viewable to participants during experiments.
		Ensuring there is no feedback for the gestures participants perform (this is to enable them to exhibit their natural, unrevised and uninhibited behaviour).
		Allowing participants to assume a widget or digital object is presented when proposing a gesture, should they feel that one is required. Participants are required to explain what the widget is, the form they expected it to take and how they expect it to work.
		Placing no time limits on the participants when proposing gestures.

Researchers (Year of Publication)	Application Context	Contribution for Gesture Elicitation Process
Mauney, Howarth, Wirtanen and Capra (2010)	Twenty-eight miscellaneous actions commonly done on handheld devices	Ensuring there is no feedback for the gestures participants perform (this is to enable them to exhibit their natural, unrevised and uninhibited behaviour).
		Presenting the effects of the gesture (i.e. output that would be displayed as a result of the gesture) to participants and requesting them to perform the gesture that would cause that effect (i.e. the gesture required to produce the output displayed). This was done pictorially however and with video.
		Using a camera to record gestures, and using the video data to classify the gestures.
Kane, Wobbrock, and Ladner (2011)	No specific application context; researchers were studying users' interactions with 2D shapes	Limiting or removing elements relating to Windows or Macintosh operating systems that may be viewable to participants during experiments.
		Presenting the effects of the gesture (i.e. output that would be displayed as a result of the gesture) to participants and requesting them to perform the gesture that would cause that effect (i.e. the gesture required to produce the output displayed).
		Using a camera to record gestures, and using the video data to classify the gestures.

Ashbrook and Starner (2010) specifically point out that the work of Wobbrock et al. (2009) provides a good model for designers to follow during the initial, formative phase of creating a gestural system; it puts forward a way of creating a user-defined gesture set that correctly reflects user behaviour but also provides consistency within the gesture set (Wobbrock et al., 2009). Morris et al. (2009) also consider the user-defined gesture elicitation used by Wobbrock et al. (2009) to be exemplary. The study conducted by Wobbrock et al. (2009) was therefore used as the basis for the participatory gesture design process of this study (which is discussed in great detail in Chapter 3 – Research Methodology).

It is worth noting that from the research mentioned above, only Mauney et al. (2010) and Kane et al. (2011) addressed handheld touchscreen devices. Gesture elicitation has predominantly been done on tabletop devices. In addition, it should be pointed out that the application contexts that have been investigated have not specifically addressed the use of search engines or web browsers for conducting any form of web search. These shortcomings in literature therefore give rise to this study's research question: what is the most intuitive user-defined gesture set for conducting an informational search on a multi-touch tablet web browser? This research question will be addressed through the user-defined gesture set produced as a result of this study, complemented by a set of hypotheses, which are discussed below.

2.3 CONSIDERATIONS FOR GESTURE DESIGN

Pointer-based interactions, which are facilitated by pointing devices as such mice and trackballs, are different to direct-touch interactions. An example of one such difference is the precision of the mouse pointer for target selection in comparison to imprecision of the fingertip (Wang et al., 2009; Norman and Nielsen, 2010; Bachl, Tomitsch, Wimmer and Grechenig, 2010; Budiu and Nielsen, 2011). Another example is the fact that users can reach distant positions of the screen, or even move around the screen, with minor movements of their hands when using a mouse, unlike with touch screen devices where users need to cover those distances with their arms and hands, which may lead to muscle fatigue (Bachl et al., 2010). It would therefore not be advisable to simply transpose the way in which pointer-based interactions are designed to the design of direct touch interactions as there are a variety of issues that need to be taken into consideration. The following are issues addressed:

- The use of one-handed gestures in comparison to the use of two handed gestures; addressing users' use of one hand or both hands when gesturing.
- The influence of the pointer-based paradigm in the use of gestures; addressing how the pointer-based paradigm usually used in popular operating systems, such as Windows, have a bearing on users' gesture.
- Gesture re-use; addressing how users tend to use the same gesture to accomplish different tasks.

2.3.1 ONE-HANDED GESTURES VS TWO-HANDED GESTURES

In their investigation of user-defined gestures for tabletop devices, Wobbrock et al. (2009) report that participants preferred to use one hand rather than two. For each task, participants were asked to perform a one-handed and a two-handed gesture, and then indicate which they preferred. Wobbrock et al. (2009) found that participants preferred one-handed gestures for 25 of the 27 tasks, with preference for the remaining two tasks being equally divided between one and two-handed gestures. There was not a single task for which two-handed gestures were preferred. It is important to note, however, that Wobbrock et al. (2009) were not examining a specific application context but were simply studying users' interactions with 2D shapes (circles, triangles, squares etc.).

A study conducted by Frisch et al. (2009) yielded similar results. Their study specifically investigated how individuals edited node-link diagrams on an interactive tabletop. Participants were requested to complete a series of diagram editing tasks using three different approaches; with one hand only (whereby they could use any or all the fingers on that hand), with two hands, and with a pen and a hand (being used in combination with one another). They were then asked to indicate which of the three they preferred. What Frisch et al. (2009) discovered was that one-hand interaction was preferred for most of the tasks. There were two exceptions, however, where two-handed gestures were preferred. These exceptions were for the *scale node*

task (where the size of a single node was either increased or decreased) and the *zoom diagram* task (where the size of the entire diagram was either increased or decreased). For these two tasks, two-handed gestures were rated higher than their one-handed counterparts.

Despite investigating a different application context, the results from Hinrichs and Carpendale (2011) support those of Frisch et al. (2009). Hinrichs and Carpendale (2011) conducted a field study at the Vancouver Aquarium to investigate how visitors, adults as well as children, interacted with a large interactive table exhibit using multi-touch gestures. They found that users preferred to gesture with one hand instead of two – with the resizing being the only exception, as with Frisch et al. (2009). For resizing, 70% of all observed actions were done with both hands.

A similar preference for one-handed gestures was observed by Morris et al. (2010). In a study aimed at understanding users' preferences for surface gestures, Morris et al. (2010) asked twenty-two participants to rate a set of 81 gestures. This gesture set consisted of user-defined gestures as well as gestures designed by three experienced HCI researchers (Morris, Wobbrock and Wilson). The participants, who were uninformed as to which gestures were user-defined and which were designed by the researchers, rated the suitability of gestures for the actions they were designed to perform. One of the findings presented by Morris et al. (2010) was that their participants generally preferred one-handed gestures as opposed to two-handed gestures. They reported that one-handed gestures received higher ratings than two-handed gestures in terms of the match between gestures and their corresponding commands and in terms of the ease of performing the gestures.

Based on the studies above, the following hypothesis may be made:

Hypothesis 1: When asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, the use of one-handed gestures is more likely to be observed than the use of two-handed gestures.

2.3.2 THE INFLUENCE OF THE POINTER-BASED PARADIGM

Many touch screen applications predominantly use single finger, tap interactions, which suggests that they have simply been adapted from the pointer-based paradigm used in popular Graphical User Interface (GUI) operating systems, such as Windows (Micire et al., 2009). This may result from the fact that this pointer-based paradigm is so ingrained in users' interactions with computer interfaces that users still use their pointer-based mental models to interact with digital objects on touch screen interfaces (Wobbrock et al., 2009); they simply substitute the mouse pointer with their finger. The details for how this affects user-defined gestures, is addressed below.

2.3.2.1 The Effect of the Pointer-Based Paradigm on User-Defined Gestures

Micire et al. (2009) explain that the gestures that participants propose are heavily influenced by their prior experience, particularly the standard pointer-based interaction that most users have become accustomed to through using a mouse. They note that the tap was the gesture most used by participants in their study as it is roughly analogous to the “click” of the mouse. During their field study at the Vancouver Aquarium, Hinrichs and Carpendale (2011) found that visitors to the aquarium had a similar affinity to using their index fingers. They report that the index finger was used in the most frequently applied gestures for flicking and dragging pictures. Epps et al. (2006) report a similar inclination by participants in terms of using their index finger. Epps et al. (2006) presented static images of a Windows desktop and asked participants to perform common desktop computing tasks on the tabletop with their hands. Despite users largely performing gestures above the surface to accomplish these tasks, they found that the index finger the most common finger used during gesturing as it accounted for more than two thirds of all the responses provided. Epps et al. (2006) explained that the prolific use of the index finger may have resulted from the “Windows-centric” screen shots presented to the participants during the study.

Micire et al. (2009) found, however, that when participants proposed gestures for tasks that are uncommon in the mouse-driven paradigm of interaction, they were more likely to put forward novel gestures that did not simply mimic the mouse pointer. These types of gestures exploit multi-touch capabilities, which the simple simulation of mouse pointers does not. Micire et al. (2009) looked specifically at creating a user-defined gesture set for controlling robot teams on multi-touch tabletop surfaces, a fairly uncommon task domain for most computer users. They explain that in other studies, the tasks performed were largely desktop computing tasks whereas in their study the task domain of controlling robot teams was outside of the traditional desktop computing paradigm. As such, they had predicted that their results would differ from those of previous studies.

In contrast to Wobbrock et al. (2009) who discovered that users preferred using a single finger on a single hand, Micire et al. (2009) observed an almost unanimous willingness of participants to use multi-hand and multi-finger gestures and report that a significant number of their participants (90%) used gestures that involved multiple fingers on the same hand. Disappointingly however, Micire et al. (2009) found that these kinds of multi-finger gestures only made up 8.9% of their overall user-defined gesture set, indicating how heavily the pointer-based interaction paradigm still influenced users’ gestures. This finding is further ratified by Wobbrock et al. (2009), whose study suggests that even when tasks are not necessarily common to users in the pointer-based interaction paradigm of the desktop, this paradigm is so ingrained in users’ minds that it dominates how users approach interactions with interfaces, and therefore greatly influences the gestures they

propose. Wobbrock et al. (2009) found that about 72% of gestures in their study were mouse-like one-point touches or paths.

Web browsing as a task domain is highly familiar to many users. Furthermore, it is mainly familiar within the mouse-driven or pointer-based paradigms as web browsing has been done mainly on desktop or laptop machines. It is therefore expected that if users were requested to propose gestures for web browsing, they might find it difficult to create new and novel gestures that exploit multi-touch technology i.e. gestures that do not simply mimic the mouse-type or pointer-based interactions for web browsing on desktops, which they are accustomed to.

Based on the studies above, the following hypotheses may be made:

Hypothesis 2A: When asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, the majority of participants will use gestures that are adaptations of desktop computing, with single finger taps substituting mouse clicks and single finger drags substituting mouse drags.

Moreover, given that the index finger is the finger typically used when performing a mouse click or drag (Cechanowicz, Irani and Subramanian, 2007) it is further proposed that:

Hypothesis 2B: When asking novice users to simulate tasks related to an informational search on a multi-touch tablet device the majority of participants will provide gestures using their index fingers.

2.3.2.2 The Need for Menus in Gestural Interfaces

Mauney et al. (2010) report that participants requested a menu when they had difficulty thinking of a gesture; this was despite requests by moderators for participants to create gestures that did not require menu access. Wobbrock et al. (2009) found this to be the case in their study as well which illustrates the need for gestures to co-exist with traditional GUI elements, such as menus, that users have become accustomed to.

The necessity for gestures and menus to co-exist on touch screen interfaces is highlighted by Norman and Nielsen (2010). Norman and Nielsen (2010) point out that the advantage of GUIs was that commands no longer had to be memorised but that all operations available to users were discoverable by the systematic exploration of menus. They lament that this is not currently the case with gestural interfaces as many misuse or even exclude menus, the use and application of which is understood and advocated in HCI research. This is one of the several areas where Norman and Nielsen (2010) raise the concern that tried and tested principles of interface design are being ignored in designing gestural interfaces. They explain that while they appreciate that gestural interfaces are still in their infancy and require a great deal of exploration and experimentation,

they advise that longstanding principles proven through HCI research, should still be applied in gestural interface design.

For the application domain of web browsing, which has traditionally existed in the desktop paradigm, it would be expected that users would want menu access.

Based on the studies above, the following hypothesis may be made:

Hypothesis 2C: When asking novice users to simulate tasks related to an informational search on a multi-touch tablet device, the majority of participants will incorporate the use of menus (main menus and context menus) into their gestures.

2.3.3 GESTURE RE-USE

Lao et al. (2009) assert that the key to creating an intuitive gestural interface lies within the mapping rules (that determine which gesture is mapped to which function) for that interface. The mapping between the functions of an application and the gestures that activate those functions should not be arbitrary (Lao et al., 2009), but should be aligned with users' expectations. The alignment between how users intend on providing their gestural input, and the gesture(s) afforded by the interfaces for that input, is what makes the system intuitive to use. Understanding users' expectations is therefore critical in designing appropriate mappings between functions and gestures.

Lao et al. (2009) note that there needn't always be a strict one-to-one mapping between functions and gestures. They explain that there are situations where one gesture may be mapped to several functions. This is achieved by having different "interactive contexts" during which the gesture may be used. For example, the gesture of using a single finger to drag a picture vertically from the top to the bottom of the screen or using the same gesture to scroll up or down a page will result in different outputs because of the context of their use. Wu, Shen, Ryall, Forlines and Balakrishnan (2006) make the same observation, and refer to this use of the same gesture to accomplish different tasks as gesture re-use, pointing out that with gesture re-use users would need to learn and memorise fewer unique gestures. This would make gesture re-use preferable to users.

Based on the studies above, the following hypothesis may be made:

Hypothesis 3A: When asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, gesture re-use will be observed i.e. participants will attempt using the same gesture to accomplish different tasks (in different interactive contexts).

One of the ways in which gesture re-use occurs is in the sequencing of gestures. Lao et al. (2009) highlight that there are situations where complex tasks, which typically map to high-level intentions such as “search the photos in my photo collection”, should not be mapped to a single gesture. They suggest that such tasks need to be divided into their fundamental sub-tasks and that those sub-tasks should instead be mapped directly to gestures. Lao et al. (2009) advise that this approach be taken with all complex tasks and point out that the more complex a gesture is, the fewer the people who will be able to perform it. This appears to be a prudent approach given that Wobbrock et al. (2009) and Mauney et al. (2010) point out that there tends to be higher agreement between users for the simpler gestures, than those that are complex. This suggests that mapping a complex task to a single gesture may not be an advisable option as many users may disagree with that mapping and find it an unintuitive way of completing that complex task. Wu et al. (2006) further justify the approach of breaking down complex tasks into their fundamental gestures, by arguing that with this approach the system would need to recognize fewer gestures. They also posit that users would also need to learn and memorise fewer unique gestures (only the sequence of multiple simpler gestures).

Micire et al. (2009) also endorse this sequencing of gestures but point out that various combinations of gestures may be used to achieve a particular goal. They recommend that the system must, therefore, be able to recognise these various combinations as being valid for achieving that goal. This approach is especially advantageous when one considers that users may decompose a task in different ways. Experts and novices, for example, differ in the coarseness of granularity with which they view the constituent sub-tasks of a problem (Buxton, 1986 cited by Wu et al. (2006)). It would therefore be essential to allow for gesture sequencing or combinations that allow for a goal or a task to be achieved in a variety of ways. This is further justified by the Hinrichs and Carpendale (2011) who observed (in their field study at the Vancouver Aquarium) that the users of the tabletop interface would sequence “drag/move”, “enlarge/shrink”, “rotate”, “tap”, “sweep”, “flick”, and “hold” actions/gestures in different ways to achieve various high level intentions.

Based on the studies above, the following hypothesis may be made:

Hypothesis 3B: When asking novice users to simulate gestures for complex tasks related to an informational search on a multi-touch tablet device, participants will sequence gestures but in different combinations based on their judgment of how the task should be decomposed.

2.4 CONCLUSION

The chapter discussed how gestures may be classified and presented an updated Taxonomy of Gestures. It discussed participatory gesture design, and submitted the various contributions that other researchers have made with respect to gesture elicitation. It was noted, however, that gesture elicitation research has predominantly been conducted on tabletop devices and that the application contexts that have been

investigated have not specifically addressed the use of search engines or web browsers for conducting any form of web search. Thus the existing literature has not adequately described the most intuitive user-defined gesture set for conducting an informational search on a multi-touch tablet web browser.

In addressing this research question, the chapter also presented 6 hypotheses. These were based on a review of literature addressing gesture design. This review suggested that users generally prefer to use one-handed gestures, as opposed to two-handed gestures (H1), and specifically prefer to use their index fingers (H2B). It also indicated that users considerably draw upon their experiences of desktop computing when gesturing (H2A), notably the use of menus (H2C). The review further suggested that users re-use gestures to accomplish different tasks (H3A) and will also combine gestures in different ways to accomplish the same tasks (H3B).

3. RESEARCH METHODOLOGY

It has been noted that gesture sets designed by HCI experts may not always be the most intuitive to naïve users and that eliciting gestures from users through participatory design is a recommendable approach (Nielsen et al, 2003; Micire et al, 2009; Wobbrock et al, 2009; Morris et al, 2010; Heydekorn, Frisch, and Dachsel, 2011). Following this recommendation, this study set out to create a user-defined gesture set for conducting an informational search on a multi-touch tablet web browser based on gestures elicited from participants through a participatory design approach.

This chapter discusses the design science research paradigm and the research methodology that was employed to elicit gestures from participants. It describes, and provides justification for, the data collection strategy that was utilised – specifically describing the apparatus that was used, the participants from whom the data was collected and the methods and procedures that were employed to elicit the required data from the participants. It then provides an explanation of how the data was analysed.

3.1 RESEARCH PARADIGM

This study was conducted within the design science research paradigm. Design science research involves the design of novel or innovative artefacts, including computer interfaces, and the analysis of the use and/or performance of such artefacts with the aim of improving them as well as understanding the behaviour associated with them (Vaishnavi and Kuechler, 2011). It is inventive or creative by nature, and is fundamentally a problem-solving activity (Adikari, McDonald and Collings, 2006; Hevner, March, Park and Ram, 2004; Vaishnavi and Kuechler, 2011).

Design science differs from behavioural science or natural science quite significantly. The aim of behavioural or natural science is discovery of the truth i.e. amassing a body of knowledge about objects or phenomenon in nature or society that describes, explains and even predicts how they behave and interact with each other (Hevner et al., 2004; Vaishnavi and Kuechler, 2011). The aim of design science, however, is the creation of utility i.e. forming body of knowledge about artificial or man-made objects and phenomena designed to meet certain desired goals (Vaishnavi and Kuechler, 2011) through the construction, and where necessary evaluation and reconstruction, of these artificial objects or phenomena until the said goals are reached (Hevner et al., 2004).

Hevner et al. (2004) highlight, however, that truth and utility are inextricably intertwined – truth informs design and utility informs theory. It should be noted that while natural laws or behavioural theories inform the design of the innovative artefacts that design science research produces, existing theory is often

inadequate or only applicable in a specific environment (Hevner and March, 2003). As a result, researchers have to draw upon their experience, creativity, intuition and general problems solving methods to build artefacts (Hevner and March, 2003). A design science research effort, therefore, may produce a few contributions (Vaishnavi and Kuechler, 2011; Piirainen, Gonzalez and Kolfschoten, 2010; Hevner et al., 2004):

- The production of new knowledge (to a certain community) about the artefact itself, as well as the method or methodology of creating or constructing it.
- The artefact itself, which can then be utilised by members of that community.

Adikari et al. (2006) point out that design science research is especially suited to Human Computer Interaction (HCI) as HCI is a discipline that primarily focuses on the design, evaluation and implementation of interactive systems and therefore easily lends itself to this paradigm of research. HCI researchers Carroll and Kellogg (1989 as cited in Vaishnavi and Kuechler, 2011) even propose that HCI artefacts themselves may be most effective medium for theory development in HCI. Design science research was hence found to be the most appropriate paradigm for this study, which has the primary aim of creating a user-defined gesture set for conducting an informational search on a multi-touch tablet web browser based on gestures elicited from participants who have little or no experience with touch screen devices. The way in which gestures for this gesture set were elicited is described below.

3.2 DATA COLLECTION

Wastell, Sauer and Schmeink (2009, p 345) note that “doing design science necessarily involves design work, regarding both the design of the ‘experimentation’ (field or laboratory) and of the artefact itself”. The design of both the experiments and artefact for this study was based on the prior work of Nielsen et al. (2003), Wobbrock et al. (2005), Wobbrock et al. (2009) Frisch et al. (2009) and Micire et al. (2009) who elicited gestures from participants (the average number of participants used across the aforementioned studies was 19, and ranged from 7 to 31) through a series of experimental tasks.

Similarly, various experimental tasks, which are detailed below, were conducted to elicit gestures from the study’s participants. During the elicitation process, participants were requested to think aloud as they executed their experimental tasks, as conducted by Frisch et al. (2009), Wobbrock et al. (2009) and Micire et al. (2009). This verbal, “think-aloud” data provide verbal explanations and reasoning for participants’ gestures. In addition to the gesture and think-aloud data, gesture ratings which represented the participants’ perception of the quality of their gestures in terms of suitability and ease of performance, were elicited from participants.

This section details how all the aforementioned data were collected. It explains the apparatus used, the setting in which these experiments were done and the participants from whom this data was collected. This section also provides details of how the experiments were conducted to ensure that the data collected was sound and accurate.

3.2.1 APPARATUS

The study was conducted on a multi-touch tablet called the Apple iPad 2. This tablet has a 247.38 mm (diagonal) Light-Emitting Diode (LED) widescreen multi-touch display with a 2048-by-1536-pixel resolution (Apple, 2012). Its dimensions are as follows (Apple, 2012):

- Height: 241.2 mm
- Width: 185.7 mm
- Depth: 9.4 mm
- Weight: 652 g

All participants used the same tablet device in the experiments; therefore no disparities in results can be attributed to differences in the hardware and/or software used.

3.2.2 EXPERIMENT SETTING

The experiments were conducted in a HCI laboratory. This laboratory consisted of a participant room and an observer room which were separated by a one-way mirror. The experiments were conducted on the iPad described in the previous section, at a table in the participant room. The participants were seated during the experiments.

The participant room was equipped with two built-in, high resolution, overhead cameras that were operated from the observer room. In addition to these cameras, two standalone video cameras were positioned at the table where the participants' gestures were elicited. All four cameras recorded the participants' video data unobtrusively and were positioned to optimally capture the finger, hand and arm movements that participants made (Nielsen et al., 2003; Frisch et al., 2009; Wobbrock et al., 2009; Micire et al., 2009). This quartet of cameras provided different views or angles of the participants' finger and hand gestures during the experiment activities (Wobbrock et al., 2009). A separate microphone was used to record the audio think-aloud data during the experiments. Noldus and Camtasia Studio software was used to combine and synchronise the different video recordings and the audio data into a single video. Below is a picture of the laboratory set-up; it shows the two standalone cameras as well as one of the built-in, high definition cameras (the second built-in camera is out of view in this picture).



Figure 1: Laboratory set-up – Standalone cameras and rear built-in camera (front built-in camera out of view)

3.2.3 PARTICIPANTS

Twenty participants (ranging from 27 years of age, to 65 years of age) served as volunteers and were given no compensation for participating. A convenience sampling approach was used; participants were mainly university staff, as with Wobbrock, Aung, Rothrock and Myers (2005) and Frisch et al. (2009). While this means that participants were recruited fairly quickly and at little cost, the disadvantage of this approach is that the participants may not be representative of the general population, which threaten the generalisability of the study's findings.

3.2.3.1 Eligibility Criteria

This section defines the criteria that were used in selecting participants that would be appropriate for the study.

The inclusion criteria that were used were:

- The required application domain knowledge i.e. familiarity with conducting an informational search on a desktop / laptop web browser using the functionality detailed below in Table 3: Web Browsing Functions.
- Little or no experience with any form of touch screen device – including touch screen phones or tablets.

The approach of using participants with little or no touch screen experience was adopted by Wobbrock et al. (2009) as it enables researchers to observe naïve users' natural gestures. Participation of inexperienced or naïve users therefore better highlights discrepancies between how users would want to execute certain functions and what designers prescribe or recommend (Wobbrock et al., 2009; Morris et al., 2010). Further rationale for involving participants that have little or no experience with touch screen devices is that doing so reduces the bias of gestures that participants propose. Users who are familiar with touch screen interfaces would advertently or inadvertently draw upon the gestures they have learnt or used before, and would therefore be biased in the gestures they used. Micire et al. (2009) point that participants that had had prior experience with touch screen devices were biased in the types of gestures they used, citing, for example, that iPhone users used significantly more “pinch” gestures for zooming. Inexperienced or naïve users simply provided gestures that they felt came naturally to them, providing a more accurate reflection of what a typical, unbiased user would prefer.

The only exclusion criterion that was used was that participants needed to be 18 years of age, or older; no other demographic characteristics were used as exclusion criteria.

3.2.4 PROCEDURE

The procedure adopted to elicit gestures from study participants for conducting an informational search on a multi-touch tablet device, and using those gestures to create a user-defined gesture set, was similar to that used by Nielsen et al. (2003), Wobbrock et al. (2005), Wobbrock et al. (2009) and Frisch et al. (2009). The procedural steps for data collection employed in this study are the first two steps in the procedure that Nielsen et al. (2003) put forward for finding an appropriate gesture set for any given application. These steps were:

- Finding the functions – this entailed identifying the functions which would be employed in an informational search, for which gestures would be elicited from participants
- Collecting gestures from the user domain – this entailed eliciting gestures, for the functions that had been identified, from the participants and recording these gestures

These steps are described in greater detail in the sub-sections below.

3.2.4.1 Finding the functions

Nielsen et al. (2003), note that the first step in developing an intuitive gesture set for an application is to identify the functions for that application. In this case the application is a web browser on a multi-touch tablet device, used for conducting an informational search on the web. Nielsen et al. (2003) advise that the user interfaces of existing similar applications should be used to identify the needed functions. This is to appraise all current functionality for the application context and to ensure that the necessary functions are taken into consideration. It is important to note that the activity of accessing a search engine, and conducting an informational search can only be achieved through the use of a web browser, and the various functions afforded to user by the web browser. Existing web browsers were identified and the functions that enable or support informational searches were therefore analysed.

A comparison of 80 web browsers, comprising of both tablet and desktop web browsers, resulted in the functions tabulated in Table 3 (Web Browsing Functions) below – which were found to be main functions across the cross-section analysed. Table 1 (Reviewed Tablet Web Browsers) illustrates the tablet web browsers that were reviewed and Table 2 (Reviewed Desktop Web Browsers) illustrates the desktop web browsers reviewed.

Table 3: Reviewed Tablet Web Browsers

No.	Browser Name	Version Reviewed	Website URL	Platform
1	360 Web Browser	5.1	http://www.digitalpoke.com/360/	Apple
2	AllInOne Browser	1.0.12	http://www.allinonebrowser.com/home-ipad.php	Apple
3	Apollo Browser	2.5	http://itunes.apple.com/us/app/apollo-browser-+-addons-like/id470154924?mt=8 (official site unavailable)	Apple
4	Atomic Browser	6.0.1	http://atomicwebbrowser.com/	Apple
5	Beaver Browser	2.3	http://www.crowbarsolutions.com/products/beaver/	Android
6	Boat Browser	3.1	http://www.boatmob.com/	Android
7	Browser Duo	1.1	http://mcleanmobile.com/products/ipad-apps/browser-duo/	Apple
8	Browser+ HD	1.1	http://www.browserplusapp.com/	Apple
9	Chrome for Andriod	0.18.4409.239 6	http://www.google.com/intl/en/chrome/android/features.html	Android
10	Cloud Browse	4.4	http://www.alwaysontechnologies.com/cloudbrowse/	Apple
11	CloudSurfer	1.2.1	http://www.touchutility.com/products-3/cloudsurfer/	Apple
12	Diigo Browser	3.0	http://itunes.apple.com/us/app/diigo-browser-chrome-like/id432838105?mt=8 (official site unavailable)	Apple
13	Dolphin Browser HD	1 (Android); 4.1 (Apple)	http://dolphin-browser.com/	Android + Apple
14	Dual Browser	1.4.1	http://dualbrowser.19e3.com/	Apple

No.	Browser Name	Version Reviewed	Website URL	Platform
15	DualWeb Browser	1.05	https://play.google.com/store/apps/details?id=com.mu.dualweb&feature=search_result (official site unavailable)	Android
16	Espier Browser	1.0.0	http://espier.org/2_en.html	Android
17	Firefox Mobile	10.0.4	http://www.mozilla.org/en-US/mobile/features/	Android
18	Grazing Web Browser	2.1.10.1	http://www.grazingbrowser.com/	Apple
19	iCab Mobile	5.7.5	http://www.icab-mobile.de/	Apple
20	iLunandscape 3	3.3.0	http://www.lunandscape.tv/Products/iLunandscape/features.aspx	Apple
21	InBrowser	1.75	http://tompodapps.com/	Android
22	iSwifter	4.5	http://itunes.apple.com/us/app/iswifter/id388857173?mt=8 (official site unavailable)	Apple
23	Kikin	1.9.0	http://www.kikin.com/features	Apple
24	Maxthon Mobile	1.5	http://www.maxthon.com/	Android
25	Mercury Web Browser	5.3	http://www.ilegendsoft.com/software/mercurybrowser/	Apple
26	Mobicip Safe Browser	2.8.4	http://www.mobicip.com/	Apple
27	NetFront™ Life Browser v2	2.3.1	http://www.netfrontlife.com/cgi/nflife.cgi?a=app&aname=browser2	Android
28	Night Browser	1.0	http://www.collect3.com.au/nightbrowser	Apple
29	Ninesky	2.3.0	http://ninesky.com/index_en.html	Android
30	Opera Mobile	12.0.2 (Android)	http://www.opera.com/mobile/features/tablets/	Android + Apple
31	Overscreen	1.6.1	https://play.google.com/store/apps/details?id=com.myboyfriendisageek.airbrowser&feature=related_apps (official site unavailable)	Android
32	PERFECT Web Browser	5.0	http://www.perfectbrowser.com/	Apple
33	Photon Flash Player Browser	1.8	http://www.appsverse.com/Browser	Apple
34	Puffin Browser	2.2.5065 (Android) ; 2.2.3 (Apple)	http://www.cloudmosa.com/	Android + Apple
35	QQ Browser	2.8 (Android); 1.1 (Apple)	http://3gqq.qq.com/	Android + Apple
36	Safari	5.1	http://www.apple.com/safari/what-is.html	Apple
37	ScudWeb eXtreme Web Browser	1.0 (Android); 2.1 (Apple)	http://scudwebapp.com/	Android + Apple
38	Secret Browser	1.8.0	http://secretbrowserapp.com/	Apple
39	Skyfire	4.1.0 (Android); 4.1.1 (Apple)	http://www.skyfire.com/en/for-consumers/	Android + Apple
40	Sleipnir Mobile	2.0.4 (Android); 3.3.2 (Apple); 1.5.0.0 (Windows Mobile)	http://www.fenrir-inc.com/	Android + Apple
41	Super Prober Web Browser	3.0	http://scimobile.com/?p=96	Apple
42	Switch ~ Multi-User Web Browser	1.8.1	http://switchapp.net/	Apple

No.	Browser Name	Version Reviewed	Website URL	Platform
43	Terra Browser	1.3.6	http://readdle.com/products/terra/	Apple
44	UC Browser	7.8.0 (Android); 7.1.1.53 (Apple)	http://www.ucweb.com/English/UCbrowser/index.html	Android + Apple
45	xScope Mobile	6.50	http://x-labs.net/	Android

Table 4: Reviewed Desktop Web Browsers

No.	Name	Version	Website URL	Platform
1	Acoo Browser	1.98.744	http://www.acoobrowser.com/	Windows
2	Amaya	11.4.4	http://www.w3.org/Amaya/Overview.html	Windows
3	Avant	Build 169, 4.8.2012	http://www.avantbrowser.com/default.aspx?uil=en-us	Windows
4	Browse3D	3.5	http://www.browse3d.com/	Windows
5	Camino Browser	2.1	http://caminobrowser.org/	Mac
6	Cayman Browser	2.2	http://www.caymanbrowser.com/index.html	Windows
7	Comodo Dragon	18.3	http://www.comodo.com/dragon/intl/en-GB/browserchoice/index.html	Windows
8	Crazy Browser	3.10	http://www.crazybrowser.com/	Windows
9	Deepnet Explorer	1.5.3	http://www.deepnetexplorer.com/	Windows
10	Enigma Browser	4.5	http://www.suttondesigns.com/	Windows
11	Epic Browser	1.9.3	http://www.epicbrowser.com/index.html	Windows
12	Epiphany	3.4.1	http://projects.gnome.org/epiphany/	Mac
13	GNU IceCat	9.0.1	http://www.gnu.org/software/gnuzilla/	Mac
14	Google Chrome	18.0.1025.168	https://www.google.com/chrome	Windows
15	GOSURF	2.84.903.8452	http://www.gosurfbrowser.com/?go=home&ln=en	Windows
16	GreenBrowser	6.2.0427	http://www.morequick.com/indexen.htm	Windows
17	iCab	4.8	http://www.icab.de/	Mac
18	Internet Explorer 9	9.0.8112.16421IC	http://windows.microsoft.com/en-US/internet-explorer/downloads/ie	Windows
19	K-Meleon	1.5.4	http://kmeleon.sourceforge.net/	Windows
20	Lunascape	6.6.0	http://www.lunascape.tv/Default.aspx	Windows
21	Maxthon	3.3.6.1000	http://www.maxthon.com/	Windows
22	Midori	4.5	http://twotoasts.de/index.php/midori/	Windows
23	Mozilla Firefox	12.0	http://www.mozilla.org/en-US/firefox/new/	Windows
24	Netscape Navigator	9.0.0.6	http://netscape-browser.en.softonic.com/	Windows
25	OmniWeb	5.11.1	http://www.omnigroup.com/products/omniweb/overview/	Mac
26	Opera	11.62	http://www.opera.com/browser/	Windows
27	RockMelt	0.16.91.371	http://www.rockmelt.com/#	Windows
28	SeaMonkey	2.7.2	http://www.seamonkey-project.org/	Windows
29	ShenzBrowser	1.1	http://www.browsersite.com/B2.htm	Windows
30	SlimBrowser	6.01.032	http://www.slimbrowser.net/en/	Windows
31	SRWare Iron	18.0.1050.0	http://www.srware.net/en/software_srware_iron_download.php	Windows
32	Stainless	0.8	http://www.stainlessapp.com/	Mac
33	Wyzo	3.6.4	http://www.wyzo.com/	Windows

No.	Name	Version	Website URL	Platform
34	xB Browser	3.9.10.24	https://xerobank.com/download/index.html	Windows
35	Zac Browser	1.5	http://zacbrowser.com/	Windows

It should be noted that only the functions that directly enabled or supported the activity of conducting an informational search on the front-end were analysed. The functions that related to background configurations, preferences and settings were excluded from the analyses of functions. These excluded functions include, but are not limited to:

- Network/proxy configurations
- Encryption settings
- General security settings
- General privacy settings
- JavaScript settings
- Cookie and cache management
- Password management
- Language settings
- Appearance/skin preferences
- Really Simple Syndication (RSS) settings
- Add-on/plugin management
- Importing or exporting of bookmarks or any form of syncing
- Pop-up settings
- Keyword shortcuts
- Extension management
- Download settings

It was discovered that various web browsers had functions or add-ons that were either unique to them or were uncommon across the surveyed web browsers³. Such functions were also omitted from the list. Only the functions implemented in most of the browsers that are fundamental to the actual activity of conducting an informational search were analysed. Various categories for these functions identified during the analysis of the web browsers. These categories are as follows:

- Website Navigation; this category deals with navigation between websites or webpages that enables users to revert and proceed to webpages that have been opened – this excludes the use of links for navigating between websites

³ For example, Acoo Browser has a built-in calculator used to evaluate mathematical expressions. Cayman Browser has voice engines that read web page aloud in any of 10 languages. GreenBrowser has a customisable “Boss Key” that hides the browser once pressed.

- Interaction with Page Content; this category deals with users' interactions with any elements relating to the following:
 - Stopping or restarting the process of loading the webpage content
 - Panning around the page, be it downwards, upwards or sideways to view page content
 - Enlarging or decreasing the size of the page content i.e. "zooming in" or "zooming out"
 - Finding, inputting and handling textual content on the webpage
- Tab Browsing; this category deals with the opening and closing of browsing tabs
- Management of Browsing History; this category deals with the viewing and deletion of browsing history
- Bookmarking / Management of Favourites; this category deals with the adding and opening of bookmarks or "favourites"
- Saving to Memory; this category deals with saving webpage, as well as images on the webpage, to memory
- Miscellaneous; this category deals with functions that did not fall within any of the aforementioned categories – these are:
 - Request help
 - Close the web browser

These are tabled below in their respective categories; it should be noted that the column entitled "Order During Experiment" provides the order in which the functions were presented to participants during the experiments.

Table 5: Web Browsing Functions

No.	Function	Description	Order During Experiment
Website Navigation			
1	Go to previous webpage	The user informs the browser to return to the previous page. This may also be referred to as the "Go back" function.	2
2	Go to next webpage	The user informs the browser to navigate to the page that he / she had navigated from.	3
Interaction with Page Content			
3	Input search query	The user inputs a search query into the search engine.	1
4	Stop loading webpage content	The user stops the browser while it is in the process of loading a webpage's content.	4
5	Refresh / reload webpage content	The user informs the page to refresh / reload its content.	5
6	Pan down the webpage	The user pans down the web page (in a vertical direction). This may also be referred to as "scrolling down".	8
7	Pan up the webpage	The user pans up the web page (in a vertical direction). This may also be referred to as "scrolling up".	9
8	Pan across the webpage	The user pans across the web page (in a horizontal direction from left to right). This may also be referred to as "scrolling across".	10

No.	Function	Description	Order During Experiment
9	Make webpage content larger	The user makes the content of the page (text and images) larger and hence easier to view. This may also be referred to as “zooming in”.	6
10	Make webpage content smaller	The user makes the content of the page (text and images) smaller. This may also be referred to as “zooming out”.	7
11	Search for text on the webpage	The user searches for a particular string of text on the current page.	11
12	Copy a section of text on the webpage	The user copies a section of text on the current page.	12
13	Paste section of text into search engine	The user pastes a section of copied text into the search engine	13
Tab Browsing			
14	Open link on the webpage in new tab	The user opens a web link on the current page using in a new browsing tab.	14
15	Open a new browsing tab	The user creates a new browsing tab.	15
16	Close a browsing tab	The user closes a browsing tab.	16
Management of Browsing History			
17	View record of visited pages	The user views the record of all the pages that he / she has visited. This is may also be referred to as “viewing the history”.	17
18	Delete entry from record of visited webpages	The user deletes an entry from the record of visited pages. This may also be referred to as “deleting a history entry / item”.	18
Bookmarking / Management of Favourites			
19	Save current webpage address within the browser for viewing at a later stage	The user saves the current page address in the web browser for later access. This may also be referred to as “adding a bookmark / favourite”.	19
20	Call up saved webpage address	The user accesses a web page address that had been previously saved. This may also be referred to as “opening a bookmark / bookmarked page / favourite”.	20
Saving to Memory			
21	Save image on webpage to memory	The user saves an image on the current page to the device’s hard drive.	21
22	Save current webpage to memory	The user saves the current page to device’s hard drive.	22
Miscellaneous			
23	Request help	The user requests information from the browsers about how to do a certain function or for additional information about any component of the browser. This is akin to “help”, but the word “help” is being avoided as it might introduce bias.	23
24	Close web browser	The user closes the web browser application.	24

3.2.4.2 *Collect Gestures from User Domain*

The second step was collecting, or eliciting, gestures from prospective users of the application. Nielsen et al. (2003) explain that the goal of this step is to elicit the gestures from study participants for the functions identified in the first step. This should be done while participants are under camera surveillance. Camera surveillance ensures that all gestures are captured and may be reviewed in detail at a later stage. The think-aloud data, which is also captured by the cameras and microphone, as well as gesture ratings, both of which provide crucial complementary data to the actual elicited gestures, were also collected in this step.

The approach adopted for gesture elicitation was similar to that used by Wobbrock et al. (2005), Wobbrock et al. (2009) and Kane et al. (2011) in that participants were presented with the effects of the gesture (i.e. output that would be displayed as a result of the gesture) and the participants were required to provide the gesture that would cause that effect (i.e. the touch screen gesture required to produce the output displayed). These effects are called referents (Wobbrock et al. 2005; Wobbrock et al., 2009) and will be referred to as such henceforth.

A referent illustrating each of the web browsing functions in Table 5 (Web Browsing Functions) was created. These referents used were short video recordings (with an average duration of 11.2 seconds). As an example, the referent for “Go to previous webpage” showed

1. A certain web page (the results of a search query on Google) – as seen in Figure 2 below.
2. A link on the webpage being clicked (a link for one of the search results is clicked) – as shown in Figure 3 below.
3. That webpage being changing to a different web page (the corresponding website for the link that was clicked is shown) – as seen in Figure 4 below,
4. The browser reverting to the original web page (back to the results on Google, with the link that had been opened being displayed in the typical purple colour that signifies that it was opened) – as shown in Figure 5 below.

Below are screenshots from the “Go to previous webpage” referent’s video, as explained above.

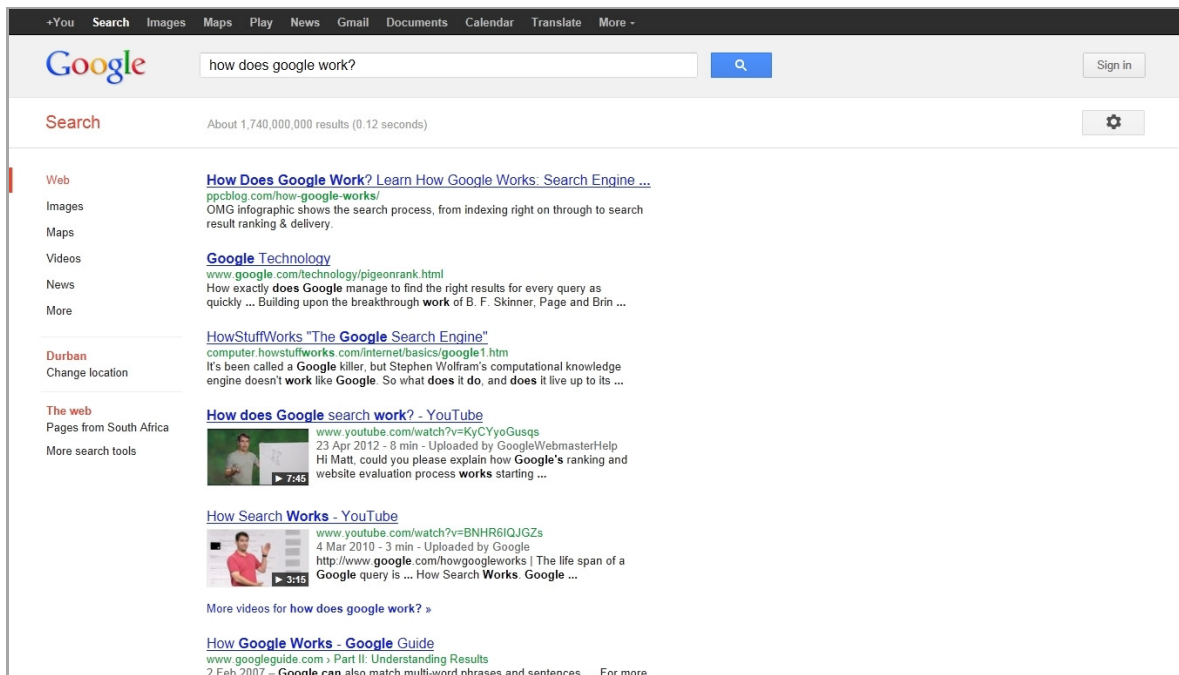


Figure 2: Referent for “Go to previous webpage” – The results of a search string on Google

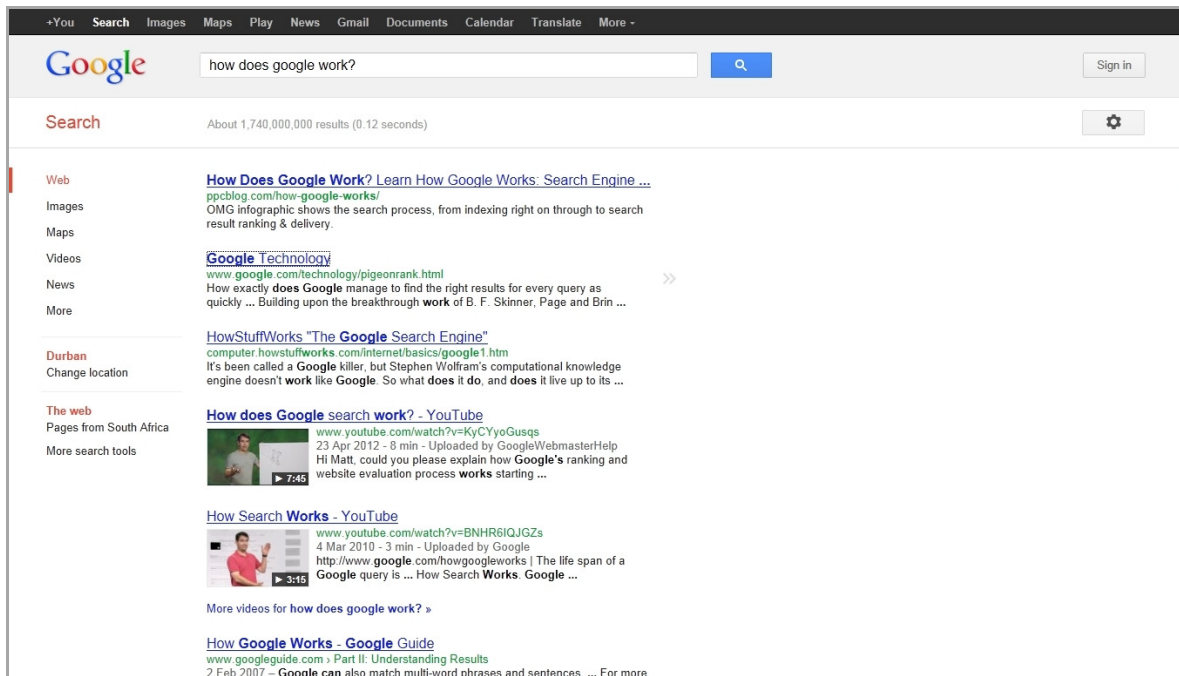


Figure 3: Referent for “Go to previous webpage” – One of the links is selected

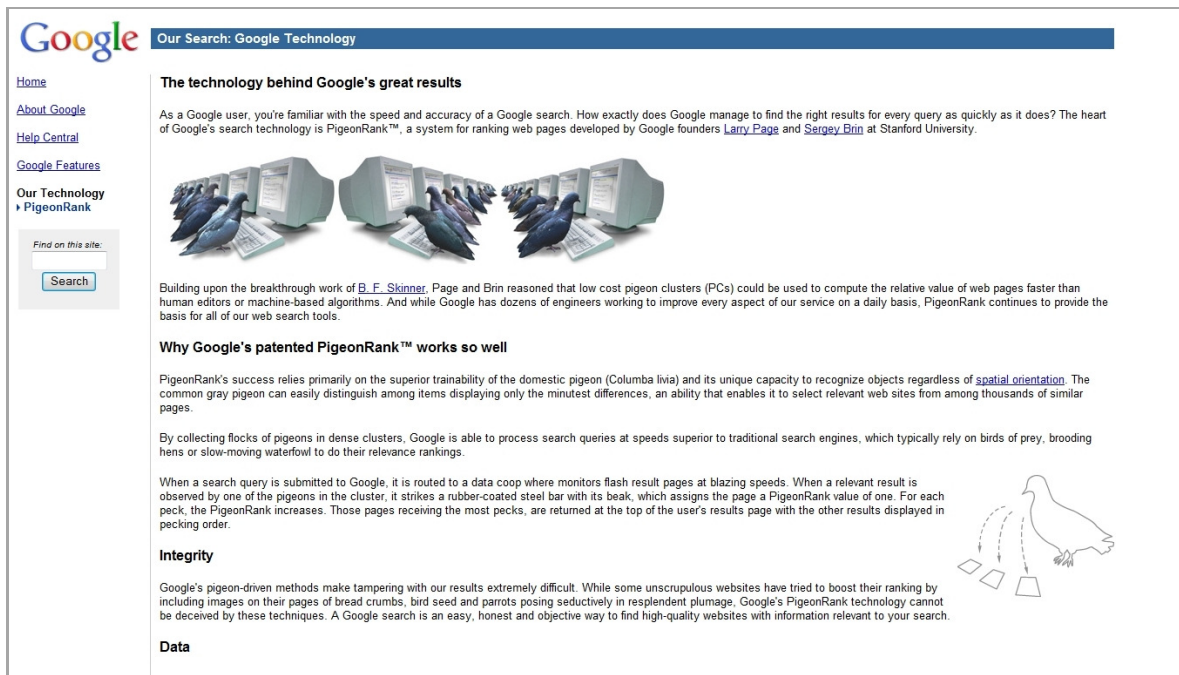


Figure 4: Referent for "Go to previous webpage" – The corresponding webpage appears

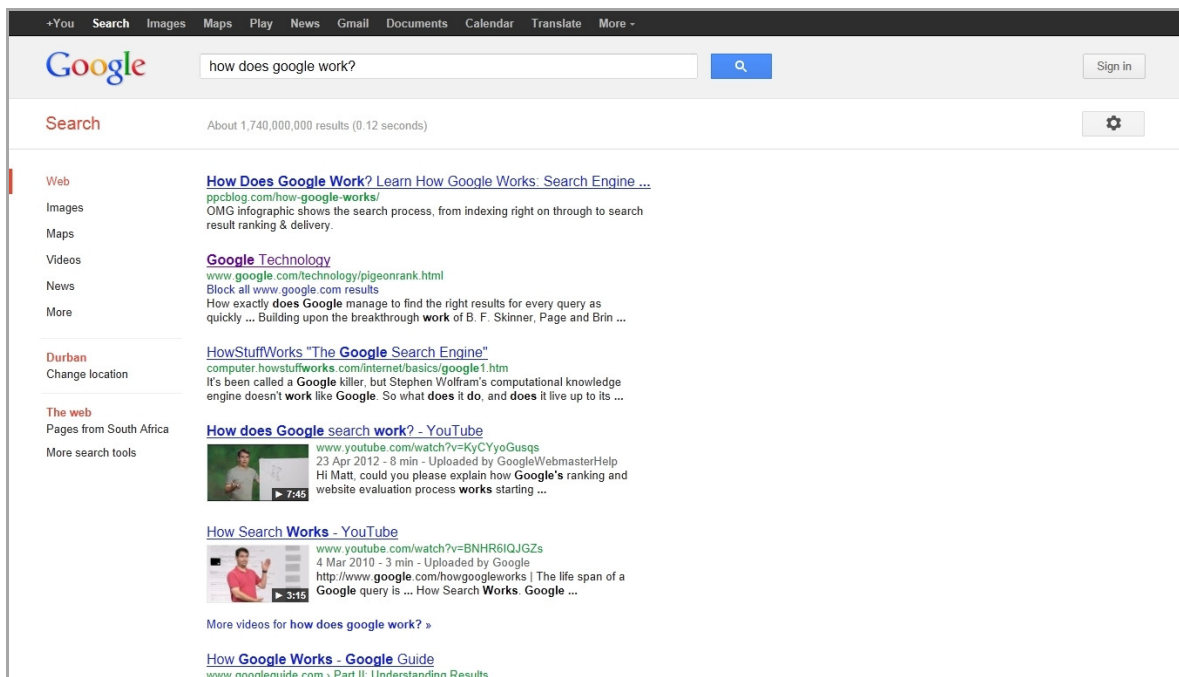


Figure 5: Referent for "Go to previous webpage" – Browser reverts to the results page, with the link that had been opened being displayed in purple

Referents were presented to participants on the iPad (at full screen) and the participants were then requested to propose gestures that matched the referents – each one in turn. To ensure the participants’ complete understanding of each referent, the researchers explained each referent to the participants prior to showing it to them, explained the event(s) in the referent while showing it to them for the first time, and if required, showed it to the participants several times, addressing any questions the participants had, until the participants indicated they understood it. The video referents of the web browser ensured that no specific elements relating to Windows or the Macintosh were displayed; this was to avoid bias (Wobbrock et al., 2009). Similar to Micire et al. (2009) the elements that were avoided included menus, title bars and buttons.

When the participants wished to offer a gesture or gestures, a thin glass sheet was placed over the iPad. The referent video was then played, and the participants performed the gesture(s) for the event(s) in the video, as if interacting with the iPad. The purpose of the glass sheet was to inhibit actual input to the iPad which would disrupt the referent video. Wobbrock et al. (2009) explain that with such an approach, the lack of feedback is beneficial as it creates a “monologue” where all participants’ input is always acceptable, and therefore enables participants to exhibit their natural, unrevised and uninhibited behaviour. The use of feedback would not facilitate such an environment as feedback may deter participants’ actions, causing them to revise their actions and not to act as they naturally would have (Wobbrock et al., 2009). Therefore, as with Wobbrock et al. (2009) and Frisch et al. (2009), there was no feedback provided to the participants during their gesture elicitation. Figure 6 below shows the iPad with the glass sheet covering while a participant provides a gesture.

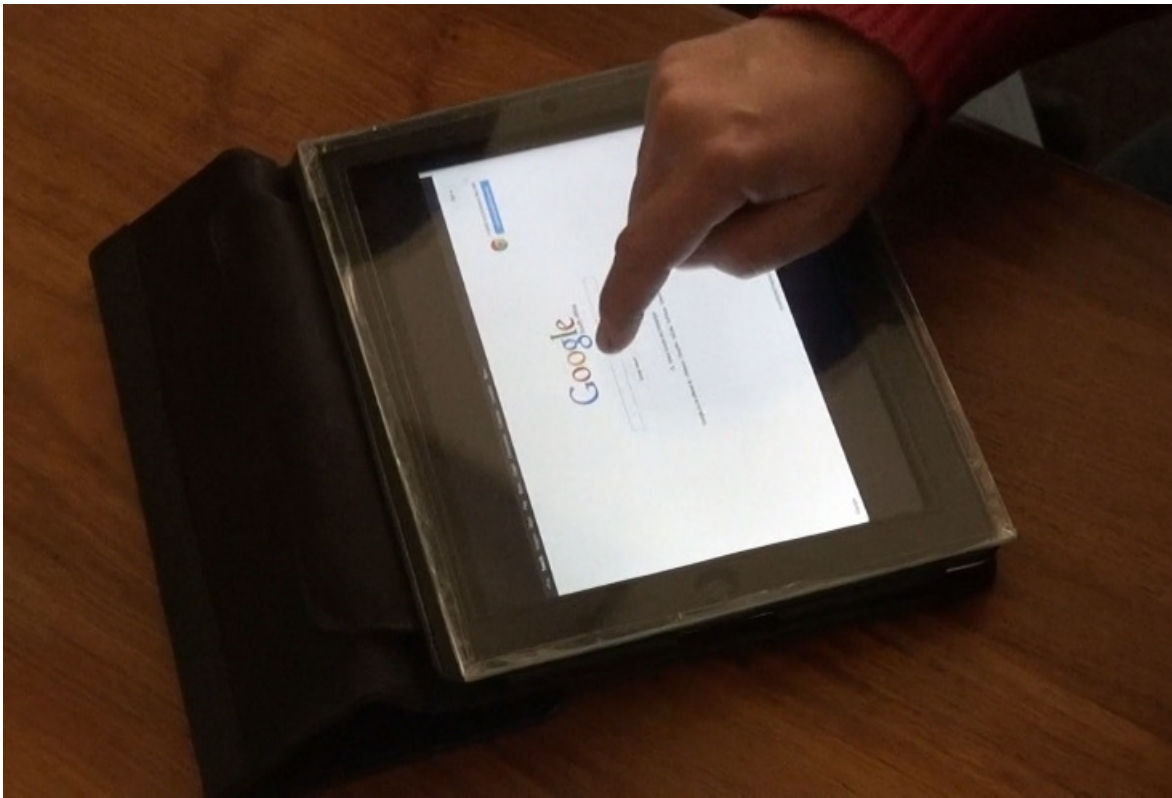


Figure 6: A participant providing a gesture

As with Wobbrock et al. (2005), if participants were unsatisfied with the gesture(s) they had proposed, they were allowed to redo them. However, once that gesture was committed to by the participant for that referent, it could no longer be changed (Wobbrock et al., 2005). Where participants felt that an additional widget (digital object) was required on the interface for a particular activity, they were allowed to assume it was present – provided they explained in detail what the widget was, the form they expected it to take and how they expected it to work (Micire et al., 2009; Wobbrock et al., 2009). Examples of widgets from Micire et al. (2009) and Wobbrock et al. (2009) included typical Windows elements such as menus and buttons.

Participants were informed only of the details essential to proposing intelligible gestures; it was explained to them that they could use one or more fingers, as well as one or both hands, highlighting that they can use any part or shape of their finger(s) and/or hand(s) in any way they want, as long as they expressed the gesture which they felt would best perform the function shown in the referent (Micire et al., 2009). The only constraint that was placed upon them was that the finger(s) and/or hand(s) had to make contact with the glass sheet placed on top of the tablet device. As was done by Nielsen et al. (2003), participants were informed not to think technically about whether the gestures would be recognisable or not, but simply to provide the gestures that came naturally to them. As previously mentioned, participants were requested to think aloud while providing their gestures (Frisch et al., 2009; Wobbrock et al., 2009; Micire et al., 2009). This think-aloud protocol, that requires participants to verbalise their thoughts as they gesture, is a standard usability

evaluation protocol (Wu et al., 2006). Wobbrock et al. (2009) explains that an analysis of the video recordings, coupled with the participants' verbalised thoughts provides rich qualitative data that illuminates the participants' mental models. As the cameras in the HCI laboratory captured both audio and video data, no notes relating to the think-aloud data were taken during the sessions; the think-aloud data was analysed along with the video data after the experiments.

At the beginning of each session, following an introductory explanation of the research and experiments, participants were requested to complete a questionnaire concerning basic demographic data and their previous experiences. The questionnaire and introductory explanation are available in Appendix B (Experiment Procedure and Consent Form). The data obtained was:

- Age
- Gender
- Right-handedness or left-handedness
- Level of experience with using Google
- Level of experience with any type touch screen interface

Participants were also requested to provide ratings, using Likert scales, for each gesture they proposed – which was done immediately after performing that gesture (Wobbrock et al., 2009; Frisch et al., 2009). The first Likert scale, which elicited ratings for the suitability of the proposed gesture for the referent displayed, read, “The gesture I picked is a good match for its intended purpose” (Wobbrock et al., 2009). The second scale, which elicited ratings for the ease with which the proposed gesture could be performed, read, “The gesture I picked is easy to perform” (Wobbrock et al., 2009). Five point Likert scales were employed, both of which elicited ordinal responses from 1 = *strongly disagree* to 5 = *strongly agree*.

The researchers avoided showing participants any examples of gestures that currently exist, as this would have introduced bias to the gestures they proposed. There were no time limits imposed on the participants for proposing gestures for the referents (Micire et al., 2009). Participants partook in the experiments individually, and the experimental tasks followed a fixed order for each participant (Frisch et al., 2009) as presented in Table 5 (Web Browsing Functions) above. It was envisaged that each session would take approximately 45 minutes, but over time the sessions became shorter as the researchers became more adept at managing the sessions, recording software and the information required from participants. The sessions ultimately took approximately 25 to 30 minutes to complete.

3.3 DATA ANALYSIS

This section discusses the various types of data that were analysed and how this analysis was conducted. The processes for analysing the collected data was based on prior work by Nielsen et al. (2003), Wobbrock et al.

(2005), Wobbrock et al. (2009) and Micire et al. (2009). Ethical considerations and limitations of the methods are also addressed.

3.3.1 VIDEO DATA

The video data was evaluated in order to extract the gestures that the participants used in their interactions. This was done by extracting the gestures that each participant performed for each of the referents. These gestures were then classified using the classifications presented in the previous chapter (Table 1: Classification of Touch Screen Gestures). Following these classifications, the gestures were then assigned to their respective functions, represented through the various referents. The outcome of this assignment of gestures to functions is the user-defined gesture set.

3.3.1.1 *Creation of Gesture Set*

Following the elicitation and the classification of all proposed gestures, the study aimed to use the elicited gestures to create a coherent gesture set for conducting an informational search on a multi-touch tablet device. This was done by assigning the proposed gestures to the functions they had been proposed for. Assignment of gestures to functions was based on *agreement* between the different participants; that is, the gesture that had been proposed the most number of times by different participants for a specific referent would be assigned to that referent (Wobbrock et al., 2005; Wobbrock et al., 2009). It is important to note that the other gestures that were proposed for that referent, i.e. those that were proposed less frequently, were not discarded, but were also assigned to the referent where permissible (Frisch et al., 2009; Lao et al., 2006; Micire et al., 2009; Wobbrock et al., 2009). This is because different people, or the same people at different times and situations, might use different gestures for completing the same task (Lao et al., 2009). What determined the permissibility of assignment was whether these gestures had conflicts. Three types of conflicts exist; conflicts within participants' own gesture sets, internal conflicts and external conflicts. These are explained below.

3.3.1.1.1 Conflicts within Participants' Own Gesture Sets

As with Wobbrock (2005) participants were required to resolve conflicts among their own gesture sets i.e. participants were instructed not to propose the same gesture for different referents where the interactive contexts was the same. For example, a participant would not be permitted to use a single finger drag from the left edge of the screen towards the middle of the screen for the "Go to next page" referent and use the same gesture for the "Go to the previous page" referent as the interactive contexts for these referents are identical. The participant would, however, be permitted to use that gesture when highlighting an entry from a menu list on the left edge of the screen, showing the record of visited webpages for the referent "Delete entry from record of visited pages". While each participant successfully resolved the conflicts within their own gesture

sets, two other types of conflicts still had to be resolved once all participants had provided their gesture sets. The first of these two types was conflicts across participants in the gestures proposed for the same referent. These were dubbed “internal conflicts”. The second was conflicts across participants in the gestures proposed for different referent. These were dubbed “external conflicts”. Both of these are discussed below.

3.3.1.1.2 Internal Conflicts

Internal conflicts occurred when a participant’s gesture for a certain referent conflicted with another participant’s gesture for that same referent. This was observed, for example, with the referent “Input search query”. In this instance, four participants performed a single-finger tap on the Google textbox to position the cursor and indicated that upon doing so, an on-screen keyboard should automatically appear. Another participant however, performed a single-finger tap on the Google textbox to position the cursor, after which he manually “flicked up the keyboard” by performing a single-finger flick gesture at the lower edge of the screen. There was therefore a conflict in terms of what a single-finger tap gesture on the Google textbox should result in. To resolve this conflict, and all other conflicts, the gesture that had been proposed the most number of times by different participants for that referent was assigned to that referent and the one that was in the minority was excluded from the final gesture set. While the conflicting gesture was excluded, other gestures that did not have internal conflicts were still considered for inclusion in the final gesture set for that referent even if only proposed by a minority of participants. This was to allow for alternatives in performing that function.

3.3.1.1.3 External Conflicts

External conflicts occurred when different participants used the same gesture, within identical interactive contexts, for different referents. This was observed, for example, with the referents “Stop loading webpage content” and “Open a new browsing tab”. One participant used a single-finger double-tap gesture on the webpage to stop loading the webpage content. Two participants, however, used the same gesture to open a new browsing tab. Given that the gesture had been used twice as many times for the referent “Open a new browsing tab” it was therefore assigned that referent. This meant that the single-finger double-tap gesture was excluded from the gestures for “Stop loading webpage content”, while other gestures proposed for that referent, that had no external conflicts, were included.

Once all the conflicts had been resolved, the agreements scores were then calculated. As previously mentioned, assignment of gestures to functions was based on *agreement* between the different participants; agreement scores are a means of quantifying to what extent this *agreement* occurred for each referent. These are discussed below.

3.3.2 AGREEMENT SCORES

In addition to the assignment of gestures to referents, the suitability of the gesture assignments was also evaluated. This was done by determining the degree of agreement between participants for gesture assignments. Wobbrock et al. (2005) explains that in theory, if all participants propose the same gesture for a specific referent, then agreement is 100%. If, however, all participants propose different gestures for the same referent, then agreement is 0%. It was therefore expected that agreement would range between these two boundaries for all referents presented.

To measure this agreement for each referent, agreement scores were calculated (Wobbrock et al., 2005; Wobbrock et al., 2009). An agreement score is a single number that reflects the degree of agreement among participants (Wobbrock et al., 2009). This was done by taking all gestures that had been proposed for a specific referent, and based on their classifications, grouping identical gestures together. These groups, which represents the frequency with which the different gestures were proposed by different people, were then used to compute the agreement score A using the following formula (Wobbrock et al., 2009);

$$A = \frac{\sum_{r \in R} \sum_{P_i \subseteq P_r} \left(\frac{|P_i|}{|P_r|} \right)^2}{|R|}$$

where, r is a referent in the set of all referents R , P_r is the set of proposed gestures for referent r , and P_i is a subset of identical gestures from P_r . The range for A is therefore $[|P_r|^{-1}, 1]$. As an example, for the “Input search query” referent, the 20 participants’ gestures created 7 groups of gestures, where the first group comprised 10 identical gestures, the second group comprised 4 identical gestures, the third group comprised 2 identical gestures, with the remaining four groups being unary groups of unique gestures. The group sizes were therefore as follows: 10, 4, 2, 1, 1, 1, 1.

Using these group sizes and the formula, the agreement score for “Input search query” was calculated as follows:

$$A_{\text{Input search query}} = \left(\frac{10}{20} \right)^2 + \left(\frac{4}{20} \right)^2 + \left(\frac{2}{20} \right)^2 + \left(\frac{1}{20} \right)^2 + \left(\frac{1}{20} \right)^2 + \left(\frac{1}{20} \right)^2 + \left(\frac{1}{20} \right)^2 = 0.310$$

In contrast, the “Pan across the page” referent resulted in 4 groups of gestures with the following group sizes: 15; 3, 1, 1. The calculation for the agreement score was therefore:

$$A_{\text{Pan across the page}} = \left(\frac{15}{20} \right)^2 + \left(\frac{3}{20} \right)^2 + \left(\frac{1}{20} \right)^2 + \left(\frac{1}{20} \right)^2 = 0.590$$

There was therefore greater agreement for the “Pan across the page” gesture than the “Input search query” gesture, meaning that the suitability of the gestures assigned to the “Pan across the page” referent is greater than that of the “Input search query” referent.

Measuring agreement, which is done by calculating agreement scores, is important because the greater the agreement between different participants in the gestures used for a referent, the more likely it is that other novice users would also agree or subscribe to using those gestures. Those functions, represented through their referents, with low agreement can be identified. These are the functions that users would likely struggle with their gestures. The gestures for such functions would need to be investigated further. Therefore, while agreement scores may not address the study’s hypotheses, they are relevant and important to the user-defined gesture set produced.

3.3.3 THINK-ALoud DATA

The physical form of a gesture, i.e. the gesture as it is observed through the eyes of spectators, may not always reveal the nature of the gesture. The think-aloud data, which was participants’ narrations, explaining their thought processes for the gestures they were proposing while they were simulating the gestures, was used in revealing the nature of these gestures. It assisted in revealing the participants’ mental models within the context of the referent, enabling the gesture’s nature to be classified.

Content analysis was used to analyse the think aloud data. The think-aloud data was unitised according to the different referents, per participant. Each unitised text segment was then coded; coding is “a process of classifying and categorizing text data segments into concepts or “codes” which can then be used to uncover patterns in the data” (Bhattacharjee, 2011, p 115). The coded data was then analysed to determine which themes occurred most frequently and in what contexts (Bhattacharjee, 2011). These themes, when analysed in conjunction with the gesture form, provided the essential information needed to determine whether the gesture being proposed was symbolic, physical, metaphorical or arbitrary.

3.3.4 GESTURE RATINGS

Based on the subjective Likert scale ratings provided by each participant for each gesture proposed, average “gesture goodness” ratings (based on the scale of “The gesture I picked is a good match for its intended purpose”) and “gesture ease” ratings (based on the scale of “The gesture I picked is easy to perform”) were calculated (Wobbrock et al, 2009). This provided an opportunity to evaluate the extent to which participants adjudged their gestures to be suitable for the referents they had proposed them for, as well as how easy they considered them to be to perform.

Those functions, represented through their referents, with low gesture ratings are functions that users would likely struggle with – either in terms of their mapping (reflected through the “gesture goodness” rating) or in terms of how easy it is, physically, to perform them (reflect through the “gesture ease” rating), or both. The gestures for such functions would need to be investigated further. Therefore, while gesture ratings may not address the study’s hypotheses, they are relevant and important to the user-defined gesture set produced in that they indicate which gestures are suitable and may be used exactly as how they were observed, and which might require further analysis.

3.3.5 ETHICAL CONSIDERATIONS

Before commencement of the study, ethical clearance was provided by the University of the Witwatersrand’s School of Economic and Business Sciences Post Graduate Degrees Committee, with the following ethics number issued: CINFO/1002.

Participants were informed, prior to their participation in the study (please refer to Appendix B – Experiment Procedure and Consent Form), that video and audio recordings of the experiments would be taken. All participants signed a consent form acknowledging that video and audio recordings will be captured, and allowing the researchers to use this material. Participants were also free to grant or deny the researchers permission to insert images their participation (generally limited to their hands) in this research report. Participants were also made aware that would be free to withdraw from the experiments at any stage and for any reason if they wished to do so.

The video and audio recordings as well as information participants provided was only used for the purposes of the study. Instead of using participants’ names, codes for each participant were created, and these were used in the analysis. No information that can uniquely identify any of the participants is present in this research report, ensuring the anonymity of all participants. Only the researchers involved in this study are aware of the identities of all participants.

3.4 CONCLUSION

The chapter discussed and justified the research methodology adopted for the study, given its objective to create a user-defined gesture set for conducting an informational search on a multi-touch tablet web browser based on gestures elicited from participants. It discussed the data collection strategy, including the experiment setting, which had 4 cameras set up to capture participants’ gestures and comments while executing experimental tasks on the Apple iPad 2. These cameras enabled participants’ gestures to be examined from different angles. This enriched the analysis of the gesture video data, which the chapter discussed in detail, especially the procedure for assigning gestures to referents. The analysis of agreement

scores, think-aloud data and gesture ratings were also discussed before the chapter concluded with ethical considerations for the study.

4. DATA ANALYSIS

This chapter presents the results arising from the analysis of the data that was collected. The data analysis addresses the study's research question, tests the study's six hypotheses and presents the final user-defined gestures set. The analysis is structured as followed:

1. Presenting the demographics of participants
2. Classifying and analysing the gestures provided by participants. More specifically,
 - a. Describing the elicited gestures and testing the six hypotheses related to the dimension of Gesture Form
 - b. Describing the elicited gestures along the remaining dimensions of Gesture Nature, Binding and Flow
3. Analysing the subjective preference ratings provided by participants
4. Calculating agreement scores and providing an analysis of the scores
5. Creating a user-defined gesture set for each of the 24 referents based on the process described in the previous chapter, informed by the preceding analyses, especially the classified gestures.

4.1 DEMOGRAPHICS OF PARTICIPANTS

A total of 20 participants participated in the study. The average age of participants was 40, ranging from 27 to 65. Of the 20 participants, 6 participants were male and 14 were female, while 17 were right-handed and 3 were left-handed. The table below shows the breakdown of the participants of their handedness.

Table 6: Handedness and Gender of Participants

	Male	Female
Right-handed	3	14
Left-handed	3	0

17 participants of the 20 participants reported that they used Google frequently, while 2 used it occasionally and 1 used it sparingly. With respect to the usage of touch screen devices, including touch screen phones, 9 reported that they had rarely used any type of touch screen device, 3 had limited exposure, while 8 had never used any type of touch screen device. The table below shows the breakdown of the participants' usage of touch screen devices.

Table 7: Participants' Usage of Touch Screen Devices

	Male	Female
Occasional	1	2
Rare	3	6
Never	2	6

4.2 CLASSIFICATION OF GESTURES

This section provides the results of the gesture classification process. Classifications were based on review of the video footage of participants simulating gestures, in conjunction with their think-aloud data. The classifications were completed by one researcher, with a second, more experienced, researcher reviewing the same video and think-aloud data and appraising these classifications. This process was employed to increase the reliability of the classifications.

4.2.1 SUB-CATEGORIES USED IN GESTURE CLASSIFICATION

As described in Chapter 3, gestures can be classified using these 4 dimensions:

- Form; this relates to which and how many part(s) of the hand(s) were used and how these part(s) made contact with the screen (encompassing, among other things, whether the gesture was static or dynamic, simple or complex)
- Nature; this relates to whether the gesture was symbolic, physical, metaphorical or arbitrary
- Binding; this relates to whether the gesture was object-centric, world-dependent, world-independent, or had mixed dependencies
- Flow; this relates to whether the gesture was discrete or continuous

Each of the gestures elicited from the participants for the 24 web browsing functions presented in Chapter 3 was classified using each of the above dimensions. This was done by reviewing the video data, supported by the think-aloud data, for each gesture, and classifying that gesture according to Table 4 (Classification of Touch Screen Gestures) as presented in Chapter 3. During the classification process, it was identified that the sub-categories within the Gesture Form dimension could not cater for 34 of the gestures that had been proposed. In total, 17 additions were required in order to cater for these gestures. These additions are tabulated below.

Table 8: Classification of Touch Screen Gestures – Additional Categories

Classification of Touch Screen Gestures – Additional Categories					
Dimension	Attributes	Attribute Categories	Attribute Properties		
Gesture Form	Fingers used	Right Hand	Half-closed vertical hand		
			Lower palm (area of the palm close to the wrist)		
	Gesture motility	Static	Press	Press “touch style”	Thumb-index finger circle
			Tap	Tap “touch style”	Two finger double tap
					Three finger double tap
					Double vertical hand tap
					Two palm “move apart” tap
					Lower palm
					Single finger double tap
					Jump
					Single finger triple tap
		Dynamic	Drag	Single finger	Fingertip/Stylus Handwriting
				Two finger	Oblique “move closer” drag
				Multiple finger / Other part of hand	Oblique “move apart” drag
					Palm (from right to left)
					Vertical hand (from left to right / from right to left)
					Half-closed vertical hand (downwards / upwards)

Furthermore, it was observed that certain sub-categories within the Gesture Form dimension were not used at all by any of the participants. It should be pointed out that the sub-categories in the Gesture Form dimension were predominantly based on previous studies that investigated table-top gestures. A possible explanation for these gestures not being used by any participants is that they might have considered these gestures to be less easy to perform or less fitting than the gestures they proposed on the tablet device. Additionally, the smaller screen size of a tablet device, in comparison to the larger screen size of a table-top device, may also explain why these gestures were observed in previous studies and not this one. These unused gestures are tabulated below.

Table 9: Classification of Touch Screen Gestures – Unused Categories

Classification of Touch Screen Gestures – Unused Categories					
Dimension	Attributes	Attribute Categories	Attribute Properties		
	Fingers used / part of hand used	Right Hand	Fist		
		Left Hand	Fist		
		Static	Press	Press “touch style”	Distinctly with three fingers
					Distinctly with four fingers
					Distinctly with five fingers

Classification of Touch Screen Gestures – Unused Categories					
Dimension	Attributes	Attribute Categories	Attribute Properties		
Gesture Form	Gesture motility				Palm
					Half-palm
					Fist
					Vertical hand
		Dynamic	Tap	Tap “touch style”	Distinctly with five fingers
					Half-palm
					Fist
			Drag	Two finger	“Bi-directional” drag
					“Same direction” flick
					Pivot
				Multiple finger / Other part of hand	Lasso
					Pivot

While the Gesture Form dimension required amendments to its sub-categories, those of the other three dimensions, namely Gesture Nature, Gesture Binding and Gesture Flow, sufficiently catered for all the gestures proposed.

4.3 RESULTS OF GESTURE CLASSIFICATIONS

Following the classification of all the gestures that were proposed by the participants, various observations could be made. This section details those observations. Before doing so however, it is important to note that all the participants provided gestures for all 24 referents (which had each been presented to them as short video recordings illustrating a web browsing function) with the exception of one participant. It was not possible to elicit gestures from this participant for two referents; referent 14 (Open link on the web page in new tab) and referent 18 (Delete entry from record of visited pages). Thus a total of 478 $((19 \times 24) + (22))$ gestures were observed.

4.3.1 GESTURE FORM

The observations relating to the Gesture Form dimension are provided below.

4.3.1.1 One-handed and Two-handed Gestures Used

The hypothesis that addressed the use of one-handed and two-handed gestures was:

Hypothesis 1: When asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, the use of one-handed gestures is more likely to be observed than the use of two-handed gestures.

Data relating to this hypothesis are presented below i.e. the frequencies with which one-handed and two-handed gestures were used, across the 24 referents.

Table 10: One-hand and Two-handed Gestures Used

Referent	One-Handed Gestures Used	Two-Handed Gestures Used
1 – Input search query	19	1
2 – Go to previous webpage	20	0
3 – Go to next webpage	20	0
4 – Stop loading webpage content	20	0
5 – Refresh / reload webpage content	20	0
6 – Make webpage content larger	17	3
7 – Make webpage content smaller	17	3
8 – Pan down the webpage	20	0
9 – Pan up the webpage	20	0
10 – Pan across the webpage	20	0
11 – Search for text on the webpage	18	2
12 – Copy a section of text on the webpage	19	1
13 – Paste section of text into search engine	18	2
14 – Open link on the webpage in a new tab	19	0
15 – Open a new browsing tab	19	1
16 – Close a browsing tab	20	0
17 – View record of visited webpages	19	1
18 – Delete entry from record of visited pages	19	0
19 – Save current webpage address within the browser for viewing at a later stage	20	0
20 – Call up saved webpage address	19	1
21 – Save image on webpage to memory	18	2
22 – Save current webpage to memory	20	0
23 – Request help	20	0
24 – Close web browser	18	2
Total	459	19

In summary:

- All 24 referents had one-handed gestures whereas only 11 referents had two-handed gestures.
- Of the 478 gestures that were provided, 459 (96.025%) were one-handed, and 19 (3.975%) were two-handed.

These data support the hypothesis that participants are more inclined to use one-handed gestures as opposed to two-handed gestures for carrying out the tasks associated with an information search using a browser on a tablet device.

The following section specifies exactly which finger it is that participants prefer to use, and further specifies details pertaining to which parts of the hands, left and right, were used by participants.

4.3.1.2 Adaptations of Desktop Computing

Two hypotheses relating to desktop computing adaptations were:

Hypothesis 2A: When asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, the majority of participants will use gestures that are adaptations of desktop computing, with single finger taps substituting mouse clicks and single finger drags substituting mouse drags.

Hypothesis 2C: When asking novice users to simulate tasks related to an informational search on a multi-touch tablet device, the majority of participants will incorporate the use of menus (main menus and context menus) into their gestures.

The data tabulated below provides the number of participants that used gestures which were adaptations of desktop computing i.e. participants that used single finger taps and drags that were synchronous to mouse clicks and drags respectively. With respect to compound gestures, it should be noted that if any of the constituent gestures were synchronous to mouse clicks or drags, the participant was included in the enumeration.

Furthermore, the data below also provides the number of participants that assumed menus in the gestures they provided. Given that menus are a specific type of desktop computing adaptation, it should be noted that these participants are automatically included in the enumeration for users that used adaptations of desktop computing.

Table 11: Use of Desktop Computing Adaptations

Referent	Number of Participants That Used Desktop Computing Adaptations	Number of Participants That Used Menus
1 – Input search query	15	0
2 – Go to previous webpage	13	0
3 – Go to next webpage	12	0
4 – Stop loading webpage content	15	0
5 – Refresh / reload webpage content	17	1
6 – Make webpage content larger	4	0
7 – Make webpage content smaller	4	0
8 – Pan down the webpage	10	0
9 – Pan up the webpage	10	0
10 – Pan across the webpage	2	0
11 – Search for text on the webpage	14	2
12 – Copy a section of text on the webpage	18	7
13 – Paste section of text into search engine	15	4
14 – Open link on the webpage in a new tab	15	3
15 – Open a new browsing tab	13	2
16 – Close a browsing tab	15	0
17 – View record of visited webpages	11	3

Referent	Number of Participants That Used Desktop Computing Adaptations	Number of Participants That Used Menus
18 – Delete entry from record of visited pages	15	3
19 – Save current webpage address within the browser for viewing at a later stage	17	4
20 – Call up saved webpage address	19	3
21 – Save image on webpage to memory	15	7
22 – Save current webpage to memory	13	8
23 – Request help	14	2
24 – Close web browser	15	0
Summation	311	49

In summary:

- Of the 486 gestures provided (compound gestures counted as unitary gestures), 311 (63.992%) were adaptations of desktop computing.
- Of the 311 gestures that were desktop computing adaptations, 49 (10.082% of all gestures provided) required the use of menus.

These data support Hypothesis 2A as the majority of gestures provided were adaptations of desktop computing. Hypothesis 2C, however, is rejected as only a small percentage of gestures required the use of menus. A possible explanation for this is that these participants typically use menus sparingly when web browsing.

4.3.1.3 *Parts of Each Hand Used*

The hypothesis that addressed which finger(s) or part(s) of the hand that would be most used was:

Hypothesis 2B: When asking novice users to simulate tasks related to an informational search on a multi-touch tablet device the majority of participants will provide gestures using their index fingers.

Data relating to this hypothesis are presented below i.e. the frequency with the various parts of the hands (including fingers), were used in gesturing. This was in accordance with the revised Gesture Form sub-categorises explained in Section 1.3 (Sub-categories Used In Gesture Classification) above. It should be noted that due to the use of complex gestures that may involve different fingers, the sum total of all hand parts (including fingers) used for any referent, could exceed 20 (the total number of participants).

Table 12: Frequency of Hand Parts Used

Referent	Right Thumb	Right Index	Right Middle	Right Ring	Right Pinkie	Right Palm	Right Hand – Vertical	Right Hand – Half-closed	Right Lower Palm	Left Thumb	Left Index	Left Middle	Left Ring	Left Pinkie	Left Palm	Left Hand – Vertical
1 – Input search query	1	14	4	1	1	0	0	0	0	0	3	1	1	1	0	0
2 – Go to previous webpage	0	8	4	1	1	0	0	0	0	1	4	4	0	0	0	0
3 – Go to next webpage	0	10	9	1	1	0	0	0	0	0	0	2	0	0	0	0
4 – Stop loading webpage content	0	6	7	0	0	2	0	0	0	0	3	2	0	0	0	0
5 – Refresh / reload webpage content	1	6	11	1	1	0	0	0	0	0	3	1	0	0	0	0
6 – Make webpage content larger	6	10	8	1	1	0	1	0	0	2	4	2	1	1	0	1
7 – Make webpage content smaller	6	10	8	1	1	0	1	0	0	2	4	2	1	1	0	1
8 – Pan down the webpage	2	9	7	0	0	0	0	1	0	0	1	1	1	1	0	0
9 – Pan up the webpage	1	10	6	0	0	0	1	0	0	0	2	1	1	1	0	0
10 – Pan across the webpage	1	12	5	0	0	0	1	0	0	0	1	1	1	1	0	0
11 – Search for text on the webpage	1	9	8	0	0	1	0	0	0	0	0	3	0	0	1	0
12 – Copy a section of text on the webpage	1	13	7	0	0	0	0	0	0	0	0	2	0	0	0	0
13 – Paste section of text into search engine	1	12	10	1	0	0	0	0	0	0	0	3	0	1	0	0
14 – Open link on the webpage in a new tab	0	12	8	0	0	0	0	0	0	0	0	2	0	0	0	0

Referent	Right Thumb	Right Index	Right Middle	Right Ring	Right Pinkie	Right Palm	Right Hand – Vertical	Right Hand – Half-closed	Right Lower Palm	Left Thumb	Left Index	Left Middle	Left Ring	Left Pinkie	Left Palm	Left Hand – Vertical
15 – Open a new browsing tab	0	9	7	0	0	1	0	0	0	0	0	3	0	0	1	0
16 – Close a browsing tab	0	13	5	1	2	0	0	0	0	0	0	3	0	0	0	0
17 – View record of visited webpages	0	9	5	0	0	0	1	0	0	0	2	4	1	0	0	0
18 – Delete entry from record of visited pages	0	11	6	0	0	0	0	0	1	0	0	2	0	0	0	0
19 – Save current webpage address within the browser for viewing at a later stage	1	9	7	0	0	0	0	0	0	1	1	3	0	0	0	0
20 – Call up saved webpage address	0	12	6	0	0	0	0	0	0	1	1	2	0	0	0	0
21 – Save image on webpage to memory	2	11	10	1	0	1	0	0	0	1	2	2	0	0	1	0
22 – Save current webpage to memory	1	11	8	0	0	1	0	0	0	0	0	1	0	0	1	0
23 – Request help	0	9	10	0	0	0	0	0	0	0	1	1	0	0	0	0
24 – Close web browser	1	9	6	0	0	1	2	0	0	0	1	1	0	0	0	2
Total	26	244	172	9	8	7	7	1	1	8	33	49	7	7	4	4

In summary:

- All referents had gestures that involved at least one part of the left hand (the left middle finger), and at least two parts of the right hand (the right index and middle fingers).
- Of all 587 times that hand parts were used in gesturing, parts of the right hand were used 475 times (80.920%) and parts of the left hand were used 112 times (19.080%).
- The part of the hand that was most used was the right index finger, which was used a total of 244 times (41.567%).
- The second most used part of the hand was the right middle finger, which was used a total of 172 times (29.302%); this means that the right index and right middle fingers account for 70.869% of all gestures.

These data support the hypothesis that participants are more inclined to use their index fingers when gesturing. Interestingly, the middle finger, which is used by most right-handed people for “right-clicking” with a mouse, is the second most used part of the hand.

What can also be drawn from these data is that the right hand is favoured over the left, however one should remain cognisant of the fact that only 3 out of the 20 participants, which is 15%, were left-handed. According to Raymond and Pontier (2004, cited by Llaurens, Raymond and Faurie, 2009) left-handed people, at most, make up 25.9% of the population, while Faurie, Schiefenhövel, Le Bomin, Billiard and Raymond (2005, cited by Llaurens et al, 2009) report this figure to be 26.9%. It evident, therefore, that the sample was not representative of the general population in terms of handedness.

4.3.1.4 Simple and Compound Gestures Used

Simple gestures are gestures that make use of a single hand or finger action; they do not contain repeated actions or other simple gestures (Lao et al, 2009). Wu et al (2006), refer to these gestures as gesture primitives. Compound gestures, on the other hand, are gestures that comprise two or more simple gestures (Lao et al, 2009) done either in parallel or sequentially (Frisch et al, 2009). Wu et al (2006), refer to these gestures as compound gestures.

The frequency with which simple and compound gestures were used is tabulated below. It should be noted that all two-handed gestures are compound gestures by virtue of the fact there will be two contact points, at the very least, with the touch screen (whether in parallel or sequentially). It should further be noted that one-handed gestures may either be simple or complex. A one-handed, four-finger drag, for example, is a

compound gesture as it is effectually four drags done in parallel. Another example of a one-handed, complex gesture would be a double-tap done with one finger. This is because it comprises two taps done sequentially.

Another consideration is that a compound gesture consisting of a sequence of gestures, may comprise one or more sequential or parallel gestures. A simple example is one of the gestures for the referent “Save image on webpage to memory” where the participants tapped once on the image to be saved with her finger (the first phase of the gesture), and placed the palms of both hands on the image to save it (the second phase of the gesture). In this instance, the single finger tap and the palm taps are done sequentially, however the palm taps are done in parallel. Such a gesture is therefore both sequential and parallel; the first phase and the second phase are done sequentially, and the second phase comprises two palms taps done in parallel.

Table 13: Frequency of Simple and Compound Gestures

Referent	Simple Gestures	Sequential Compound Gestures	Parallel Compound Gestures
1 – Input search query	16	4	0
2 – Go to previous webpage	19	0	1
3 – Go to next webpage	19	0	1
4 – Stop loading webpage content	17	1	2
5 – Refresh / reload webpage content	17	2	1
6 – Make webpage content larger	10	2	10
7 – Make webpage content smaller	10	1	9
8 – Pan down the webpage	19	0	1
9 – Pan up the webpage	19	0	1
10 – Pan across the webpage	19	0	1
11 – Search for text on the webpage	12	6	3
12 – Copy a section of text on the webpage	4	16	1
13 – Paste section of text into search engine	7	11	2
14 – Open link on the webpage in a new tab	8	10	1
15 – Open a new browsing tab	14	6	1
16 – Close a browsing tab	17	1	2
17 – View record of visited webpages	13	7	1
18 – Delete entry from record of visited pages	2	17	2
19 – Save current webpage address within the browser for viewing at a later stage	6	13	2
20 – Call up saved webpage address	1	19	1
21 – Save image on webpage to memory	1	18	5
22 – Save current webpage to memory	4	14	3
23 – Request help	12	7	1
24 – Close web browser	14	2	4
Total	280	157	56

In summary:

- All 24 referents had both simple and complex gestures.

- Of the 493 gestures that were provided, 280 (56.795%) were simple, and 213 (43.205%) were compound.
- Of the compound gestures, 157 (31.846% of all gestures provided) were sequential and 56 (11.359% of all gestures provided) were parallel.

These data suggest that participants generally prefer to use simple gestures, followed by sequential complex gestures. The simple gestures that are used tend to be static, as the following sections illustrates, with the one finger tap being the most commonly used gestures.

4.3.1.5 *Gesture Re-Use Across All Referents*

The data presented below relates to the first hypothesis about gesture re-use:

Hypothesis 3A: When asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, gesture re-use will be observed i.e. participants will attempt using the same gesture to accomplish different tasks (in different interactive contexts).

It should be noted that in determining all the gestures that were used, and re-used, all compound gestures were decomposed into their constituent gestures; this decomposition was based on the revised Gesture Motility sub-categorises explained in Section 1.3 (Sub-categories Used In Gesture Classification) above.

To copy a section of text, for example, one participant pressed her finger at the start of the text to be copied, and then dragged that finger over the text she wanted copied. This compound gesture (which comprises two gestures done sequentially) was decomposed to a press gesture and a drag. Another example is where a participant wanted to save an image on the webpage by:

1. Performing a one finger lasso gesture around the image to be saved – causing it to be highlighted.
2. Pressing on the image to bring up a menu.
3. Tapping once on the option to save the image from the context menu.

The first gesture is a lasso gesture, the second gesture is a press and third gesture is a tap.

It should be noted that the orientation of the gestures was not taken into consideration in these classifications. This means that a one-finger drag gesture is classified as such regardless of whether it was a drag from the top to the bottom of the screen, or vice versa, or from the left to the right, or vice versa, or from the bottom right corner to the top left corner, or vice versa.

The following table presents the frequency with which each gesture (according to the Gesture Motility classifications) was executed. Despite appearing on the Gesture Motility classifications, it should be pointed

out that the following gestures are automatically classified as sequential gestures as they comprise two or more gestures done sequentially:

- One Finger Double Tap ; comprises two taps (i.e. the “Tap – Distinctly with One Finger” gesture) done in quick succession
- Two Finger Double Tap; comprises two two-finger taps (i.e. the “Tap – Distinctly with Two Fingers” gesture) done in quick succession
- Three Finger Double Tap; comprises two three-finger taps (i.e. the “Tap – Distinctly with Three Fingers” gesture) done in quick succession
- One Finger Triple Tap; comprises three taps (i.e. the “Tap – Distinctly with One Finger” gesture) done in quick succession
- Fingertip / Stylus Handwriting; comprises various drags done sequentially
- One Finger Boundary Box; comprises four drags (i.e. the “One Finger Drag” gesture) done sequentially
- Two Finger Boundary Box; comprises six drags (i.e. the “One Finger Drag” gesture) done sequentially
- One Finger Jump; comprises two taps (i.e. the “Tap – Distinctly with One Finger” gesture) done sequentially on different locations of the screen
- Vertical Hand Double Tap; comprises two taps with the vertical side of the hand (i.e. the “Tap – Vertical Hand” gesture) done in quick succession

As mentioned above, all the compound gestures were decomposed into their constituent, simple gestures.

Table 14: Frequency of all Gestures Used

Referent	1 – Input search query					2 – Go to previous webpage					3 – Go to next webpage					4 – Stop loading webpage content					5 – Refresh / reload webpage content					6 – Make webpage content larger					7 – Make webpage content smaller				
	15	13	12	17	17	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4						
Tap – Distinctly with One Finger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Tap – Distinctly with Two Fingers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Tap – Distinctly with Three Fingers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Tap – Distinctly with Four Fingers	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Press – Distinctly with One Finger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Press – Distinctly with Two Fingers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Palm Tap (Lengthwise)	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Palm Tap (Breadthwise)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
One Finger Double Tap	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Two Finger Double Tap	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Three Finger Double Tap	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
One Finger Triple Tap	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
One Finger Jump	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Vertical Hand Double Tap	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Lower Palm Tap	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Two Palm "Move Apart" Tap	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
One Finger Drag	3	4	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Two Finger Same Direction Drag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
One Finger Flick	2	2	1	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Multiple Finger Same Direction Drag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Fingertip / Stylus Handwriting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
One Finger Lasso	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Two finger "Move Apart" Drag	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Two Finger "Move Closer" Drag / Pinch	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Two Finger Oblique "Move Apart" Drag	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Two Finger Oblique "Move Closer" Drag	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Multiple Finger "Move Apart" Drag	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Multiple Finger "Move Closer" Drag	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Multiple Finger Same Direction Flick	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Vertical Hand Drag (Right to Left)	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Vertical Hand Drag (Left to Right)	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Half-closed Vertical Hand Drag (Downwards)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Half-closed Vertical Hand Drag (Upwards)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Thumb-Index Finger Circle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
Tap – Vertical Hand	0	0	0	0	0	0	0	0	0	0	0	0	0																						

[illegible]

From the data in the table above, it is possible to determine the total number of times a gesture was used. This data is tabulated below.

Table 15: Frequency of Each Gesture

Gesture	Frequency Across All Referents
Press – Distinctly with One Finger	16
Press – Distinctly with Two Fingers	2
Thumb-Index Finger Circle	1
Tap – Distinctly with One Finger	349
Tap – Distinctly with Two Fingers	2
Tap – Distinctly with Four Fingers	4
Palm Tap (Breadthwise)	6
Palm Tap (Lengthwise)	3
Two Palm "Move Apart" Tap	3
Lower Palm Tap	1
One Finger Drag	166
One Finger Flick	45
One Finger Lasso	7
One Finger Boundary Box	7
Fingertip / Stylus Handwriting	2
Two Finger "Move Closer" Drag / Pinch	8
Two finger "Move Apart" Drag / Pinch	8
Two Finger Same Direction Drag	5
Two Finger Oblique "Move Closer" Drag	2
Two Finger Oblique "Move Apart" Drag	2
Two Finger Boundary Box	1
Multiple Finger "Move Closer" Drag	3
Multiple Finger "Move closer" drag / Adduction In a Downward Motion	1
Multiple Finger "Move Apart" Drag	2
Multiple Finger Same Direction Drag	2
Multiple Finger Same Direction Flick	4
Palm Drag (Right to Left)	1
Vertical Hand Drag (Right to Left)	4
Vertical Hand Drag (Left to Right)	5
Half-closed Vertical Hand Drag (Downwards)	1
Half-closed Vertical Hand Drag (Upwards)	1
One Finger Double Tap	16
One Finger Jump	3
One Finger Triple Tap	1
Vertical Hand Double Tap	1
Two Finger Double Tap	2
Three Finger Double Tap	1
Total	688

From Table 14 (Frequency of all Gestures Used), one can identify 15 gestures were not re-used; these gestures were used by a single participant for a single referent. These gestures are:

- Three Finger Double Tap
- One Finger Triple Tap
- Vertical Hand Double Tap
- Lower Palm Tap
- Half-closed Vertical Hand Drag (Downwards)
- Half-closed Vertical Hand Drag (Upwards)
- Thumb-Index Finger Circle
- Two Finger Boundary Box
- Multiple Finger “Move closer” drag (Downwards)
- Palm Drag (Right to Left)
- Tap – Distinctly with Four Fingers (while this gesture was used on 4 occasions, it should be noted that on all 4 of these occasions it was used by a single participant for a single referent)
- Two Palm “Move Apart” Tap (while this gesture was used on 3 occasions, it should be noted that on all 3 of these occasions it was used by a single participant for a single referent)
- Two Finger Oblique “Move Apart” Drag (while this gesture was used on 2 occasions, it should be noted that on all 2 of these occasions it was used by a single participant for a single referent)
- Two Finger Oblique “Move Closer” Drag (while this gesture was used on 2 occasions, it should be noted that on all 2 of these occasions it was used by a single participant for a single referent)
- Multiple Finger “Move Apart” Drag (while this gesture was used on 2 occasions, it should be noted that on all 2 of these occasions it was used by a single participant for a single referent)

Collectively, these 15 gestures, which were not re-used, account for 3.343% of all the gestures produced across all 24 referents. This illustrates the extent to which gesture re-use occurred. There are, in fact, 5 gestures that can be identified, which were re-used fairly extensively. These are:

- The one finger tap, which was used a total of 349 times (50.727%)
- The one finger drag, which was used a total of 166 times (24.128%)
- The one finger flick, which was used 45 times (6.541%)
- The one finger press, which was used 16 times (2.343%)
- The one finger double-tap, which was used 16 times (2.326%)

These 5 gestures account for 86.065% of all the gestures produced. This illustrates the great extent to which gesture re-use occurred, therefore supporting Hypothesis 3A.

Furthermore, these data suggest that participants generally opt to use one finger gestures; the 5 gestures above, which were the one re-used most, are all gesture done with one finger. The one finger tap gesture was used the most number of times (349 times). This accounts for 50.727% of all the gestures used across all the participants. This is noteworthy because this gesture is roughly analogous to the mouse click (Micire et al, 2009) and suggests that participants were still drawing on the pointer-based paradigm used in popular GUI operating systems when proposing their gestures, as found by Micire et al (2009) and Wobbrock (2009). It is also worthwhile to note that after the one finger tap, the one finger drag is the next gesture most used by participants as it accounts for 24.128% of all gestures performed. This means that these two gestures account for 74.855% of all gestures. This further supports Hypothesis 2A, which stated that the majority of participants will use gestures that are adaptations of desktop computing, with a single finger taps substituting mouse clicks and single finger drags substituting mouse drags.

4.3.1.6 *Gesture Re-Use in Gesture Sequences*

The results presented above provide an overview of gesture re-use. Those results do not however specifically address the re-use of *sequential compound* gestures. The hypothesis that addressed this was:

Hypothesis 3B: When asking novice users to simulate gestures for complex tasks related to an informational search on a multi-touch tablet device, participants will sequence gestures but in different combinations based on their judgment of how the task should be decomposed.

Data relating to this hypothesis are tabulated below i.e. the frequency with which each gesture (according to the Gesture Motility classifications) was executed in sequential, compound gestures. As with the previous sub-section, the following gestures are automatically classified as sequential gestures as they comprise two or more gestures done sequentially:

- One Finger Double Tap
- Two Finger Double Tap
- Three Finger Double Tap
- One Finger Triple Tap
- Fingertip / Stylus Handwriting
- One Finger Boundary Box
- Two Finger Boundary Box
- One Finger Jump

It should also be noted that the orientation of the gestures was not taken into consideration in these classifications. This means that a one-finger drag gesture is classified as such regardless of whether it was a

drag from the top to the bottom of the screen, or vice versa, or from the left to the right, or vice versa, or from the bottom right corner to the top left corner, or vice versa.

Table 16: Gesture Re-Use in Sequential Compound Gestures

Referent	Participant Number	Sequential Compound Gestures Used by Participants (Constituent Gestures Delimited by Commas)	Gestures Re-Used For Referent (Frequency of Use)
Referent 1 – Input search query	3	Fingertip / Stylus Handwriting	Fingertip / Stylus Handwriting (2)
	12	Fingertip / Stylus Handwriting	
	14	Tap – Distinctly with Four Fingers, Tap – Distinctly with Four Fingers, Tap – Distinctly with Four Fingers, Tap – Distinctly with Four Fingers	
	16	Tap – Distinctly with One Finger, One Finger Drag	
Referent 2 – Go to previous webpage	N/A	None	None
Referent 3 – Go to next webpage	N/A	None	None
Referent 4 – Stop loading webpage content	3	One Finger Double Tap	None
Referent 5 – Refresh / reload webpage content	12	One Finger Double Tap	None
	18	One Finger Flick, Tap – Distinctly with One Finger	
Referent 6 – Make webpage content larger	6	Two finger “Move Apart” Drag, Two finger “Move Apart” Drag	Two finger “Move Apart” Drag (3)
	20	One Finger Drag, Two finger “Move Apart” Drag	
Referent 7 – Make the content to the webpage smaller	6	Two Finger “Move Closer” Drag / Pinch, Two Finger “Move Closer” Drag / Pinch	None
Referent 8 – Pan down the webpage	N/A	None	None
Referent 9 – Pan up the webpage	N/A	None	None
Referent 10 – Pan across the webpage	N/A	None	None
Referent 11 – Search for text on the webpage	3	Palm Tap (Breadthwise), Palm Tap (Breadthwise), Palm Tap (Breadthwise), Palm Tap (Breadthwise)	One Finger Drag (8) Tap – Distinctly with One Finger (5)
	5	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	6	One Finger Drag, One Finger Drag, One Finger Drag, One Finger Drag	

Referent	Participant Number	Sequential Compound Gestures Used by Participants (Constituent Gestures Delimited by Commas)	Gestures Re-Used For Referent (Frequency of Use)
	7	One Finger Drag, One Finger Drag, One Finger Drag, One Finger Drag	
	15	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	One Finger Flick, Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
Referent 12 – Copy a section of text on the webpage	2	One Finger Drag, Tap – Distinctly with One Finger	One Finger Drag (19) Tap – Distinctly with One Finger (16) Tap – Distinctly with One Finger (16) One Finger Double Tap (2)
	3	One Finger Drag, One Finger Drag	
	4	One Finger Drag, Tap – Distinctly with One Finger	
	5	One Finger Drag, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	6	One Finger Drag, One Finger Drag	
	7	Press – Distinctly with One Finger, One Finger Drag	
	9	One Finger Drag, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	11	One Finger Drag, Tap – Distinctly with One Finger	
	13	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	14	One Finger Drag, One Finger Drag	
	15	Press – Distinctly with One Finger, One Finger Drag	
	16	One Finger Double Tap, One Finger Drag, One Finger Flick, Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
	17	One Finger Drag, Tap – Distinctly with One Finger	
	18	One Finger Drag, Tap – Distinctly with One Finger	
	19	Press – Distinctly with One Finger, One Finger Drag, Tap – Distinctly with One Finger	
	20	One Finger Double Tap, Tap – Distinctly with One Finger, One Finger Drag	
	1	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	2	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	3	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Press – Distinctly with One Finger, One Finger Drag,	

Referent	Participant Number	Sequential Compound Gestures Used by Participants (Constituent Gestures Delimited by Commas)	Gestures Re-Used For Referent (Frequency of Use)
Referent 13 – Paste section of text into search engine	4	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	Tap – Distinctly with One Finger (24) Press – Distinctly with One Finger (4) One Finger Drag (3)
	5	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	13	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	15	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	Tap – Distinctly with One Finger, One Finger Flick, Press – Distinctly with One Finger, One Finger Drag, Tap – Distinctly with One Finger	
	17	Press – Distinctly with One Finger, One Finger Drag	
	18	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	19	Tap – Distinctly with One Finger, Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
	20	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
Referent 14 – Open link on the webpage in a new tab	4	One Finger Double Tap	One Finger Drag (6) Tap – Distinctly with One Finger (5) One Finger Double Tap (4) One Finger Jump (2)
	5	One Finger Drag, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	8	One Finger Double Tap	
	10	One Finger Jump	
	11	Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
	12	One Finger Drag, One Finger Drag, One Finger Drag, One Finger Drag, One Finger Drag	
	13	One Finger Jump	
	15	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	One Finger Double Tap	
	17	One Finger Double Tap	
	3	Two Palm "Move Apart" Tap, Two Palm "Move Apart" Tap, Two Palm "Move Apart" Tap	
	5	One Finger Drag, Tap – Distinctly with One Finger,	

Referent	Participant Number	Sequential Compound Gestures Used by Participants (Constituent Gestures Delimited by Commas)	Gestures Re-Used For Referent (Frequency of Use)
Referent 15 – Open a new browsing tab		Tap – Distinctly with One Finger	One Finger Drag (6) Tap – Distinctly with One Finger (4) One Finger Double Tap (2)
	8	One Finger Double Tap	
	12	One Finger Drag, One Finger Drag, One Finger Drag, One Finger Drag, One Finger Drag	
	14	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	17	One Finger Double Tap	
Referent 16 – Close a browsing tab	11	One Finger Drag, One Finger Drag	None
Referent 17 – View record of visited webpages	3	Tap – Vertical Hand, Tap – Vertical Hand	Tap – Distinctly with One Finger (8) One Finger Flick (2) Press – Distinctly with One Finger (2)
	9	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	11	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	12	One Finger Drag, One Finger Drag, One Finger Drag	
	15	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	One Finger Flick, Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
	19	One Finger Flick, Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
	1	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	3	One Finger Drag, Lower Palm Tap	
	4	One Finger Drag, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	5	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	6	Tap – Distinctly with One Finger, One Finger Drag, One Finger Drag, One Finger Drag	
	8	One Finger Drag, Tap – Distinctly with One Finger	
	9	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	10	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	

Referent	Participant Number	Sequential Compound Gestures Used by Participants (Constituent Gestures Delimited by Commas)	Gestures Re-Used For Referent (Frequency of Use)
Referent 18 – Delete entry from record of visited pages	11	One Finger Drag, One Finger Drag	Tap – Distinctly with One Finger (27) One Finger Drag (13)
	12	One Finger Drag, One Finger Drag, One Finger Drag, One Finger Drag	
	13	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	15	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	Tap – Distinctly with One Finger, One Finger Flick, Tap – Distinctly with One Finger	
	17	One Finger Drag, Tap – Distinctly with One Finger	
	18	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	19	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	20	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
Referent 19 – Save current webpage address within the browser for viewing at a later stage	1	Two Finger Same Direction Drag, Tap – Distinctly with One Finger	Tap – Distinctly with One Finger (19) One Finger Drag (3)
	5	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	6	One Finger Drag, One Finger Drag	
	7	Press – Distinctly with One Finger, One Finger Drag	
	9	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	10	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	11	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	12	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	13	One Finger Jump	
	14	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	15	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	19	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	1	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	3	Two Finger Double Tap, One Finger Drag	
	4	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	

Referent	Participant Number	Sequential Compound Gestures Used by Participants (Constituent Gestures Delimited by Commas)	Gestures Re-Used For Referent (Frequency of Use)
Referent 20 – Call up saved webpage address	5	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	Tap – Distinctly with One Finger (31) One Finger Double Tap (6) One Finger Drag (2)
	6	One Finger Drag, Tap – Distinctly with One Finger	
	7	One Finger Double Tap, One Finger Double Tap	
	8	Tap – Distinctly with One Finger, One Finger Double Tap	
	9	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	10	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	11	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	12	One Finger Double Tap, Tap – Distinctly with One Finger	
	13	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	14	One Finger Double Tap, Tap – Distinctly with One Finger	
	15	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	17	One Finger Double Tap, Tap – Distinctly with One Finger	
	18	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	19	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	20	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	1	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	Tap – Distinctly with One Finger (19)
	2	One Finger Lasso, Tap – Distinctly with One Finger	
	3	One Finger Lasso, Three Finger Double Tap	
	4	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger, Two Finger Boundary Box, Tap – Distinctly with One Finger	
	5	One Finger Drag, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	6	One Finger Boundary Box	
	7	One Finger Drag, One Finger Drag, Tap – Distinctly with One Finger	
	8	One Finger Boundary Box, One Finger Double Tap	

Referent	Participant Number	Sequential Compound Gestures Used by Participants (Constituent Gestures Delimited by Commas)	Gestures Re-Used For Referent (Frequency of Use)
Referent 21 – Save image on webpage to memory	9	One Finger Drag, Tap – Distinctly with One Finger	One Finger Drag (9) One Finger Boundary Box (4) One Finger Lasso (3) Press – Distinctly with One Finger (2)
	10	One Finger Drag, One Finger Drag	
	11	One Finger Lasso, Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
	12	One Finger Boundary Box, Tap – Distinctly with One Finger	
	13	Tap – Distinctly with One Finger, Palm Tap (Breadthwise), Palm Tap (Breadthwise)	
	14	One Finger Drag, One Finger Drag, One Finger Drag	
	15	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	Two finger “Move Apart” Drag, One Finger Flick, Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
	18	One Finger Boundary Box, Tap – Distinctly with One Finger	
	20	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
Referent 22 – Save current webpage to memory	3	Two Finger Same Direction Drag, Tap – Distinctly with One Finger	Tap – Distinctly with One Finger (15) One Finger Drag (8) One Finger Boundary Box (2) Press – Distinctly with One Finger (2)
	5	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	6	One Finger Boundary Box	
	7	One Finger Drag, One Finger Drag, Tap – Distinctly with One Finger	
	8	One Finger Boundary Box, One Finger Double Tap	
	9	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	10	One Finger Drag, One Finger Drag	
	11	One Finger Lasso, Press – Distinctly with One Finger, Tap – Distinctly with One Finger	
	13	One Finger Drag, One Finger Drag	
	14	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	15	One Finger Drag, Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	16	One Finger Flick, Tap – Distinctly with One Finger	
	18	Press – Distinctly with One Finger, One Finger Drag,	

Referent	Participant Number	Sequential Compound Gestures Used by Participants (Constituent Gestures Delimited by Commas)	Gestures Re-Used For Referent (Frequency of Use)
		Tap – Distinctly with One Finger	
	20	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
Referent 23 – Request help	3	One Finger Drag, Tap – Distinctly with One Finger	One Finger Drag (8) Tap – Distinctly with One Finger (5)
	6	One Finger Drag, One Finger Drag, One Finger Drag, One Finger Drag	
	7	One Finger Double Tap	
	11	One Finger Drag, One Finger Drag, One Finger Drag	
	12	One Finger Triple Tap	
	16	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
	20	Tap – Distinctly with One Finger, Tap – Distinctly with One Finger	
Referent 24 – Close web browser	6	One Finger Drag, One Finger Drag	One Finger Drag (4)
	19	One Finger Drag, One Finger Drag	

From the data in the table above, it is possible to determine all the gestures that were re-used in sequential compound gestures. These are:

- Tap – Distinctly with One Finger; used a total of 194 times
- One Finger Drag; used a total of 89 times
- One Finger Double Tap; used a total of 14 times
- Press – Distinctly with One Finger; used a total of 10 times
- One Finger Boundary Box; used a total of 6 times
- Two finger “Move Apart” Drag; used a total of 3 times
- One Finger Lasso; used a total of 3 times
- Fingertip / Stylus Handwriting; used a total of 2 times
- One Finger Flick; used a total of 2 times
- One Finger Jump; used a total of 2 times

Of the 325 gestures used in sequential compound gestures, the one finger tap was used 194 times (59.692%), and the one finger drag was used 89 times (27.385%), meaning that these two gestures account for 87.192% of all gestures re-used in sequential gestures. Despite this, it should be noted that only 10 gestures, out of the 39 presented in the Gesture Motility classifications were re-used in sequential compound gestures for 24 referents. These data support Hypothesis 3B.

Having explored the Gesture Form dimension, the following section presented the data relating to the Gesture Nature dimension.

4.3.2 GESTURE NATURE

This section describes the elicited gestures in terms of Gesture Nature. Gesture Nature refers to whether gestures are symbolic, physical, metaphorical or arbitrary. There were no a-priori hypotheses specified for this gesture dimension. The analysis therefore focuses on the descriptive analysis of Gesture Nature as an essential attribute of gestures (Wobbrock et al, 2009). Findings relating to this dimension are moreover required to create the user-defined gesture set, which is a key output of this study.

It was a straightforward endeavour to classify the nature of simple gestures (i.e. determining whether the gesture was symbolic, physical, metaphorical or arbitrary). This was not the case with complex gestures however. Complex gestures were decomposed into their constituent gestures as explained above in section 1.4.1.3 (Static and Dynamic Gestures Used) and the nature of each of these gestures was then classified. As a result, certain referents have more than 20 gestures that are classified.

It is also worth mentioning that the form of gestures do not determine their nature. For example, in the referent for “deleting a history entry / item” one participant traced an “X” on the item to be deleted. This gesture is symbolic in nature, given that it visually depicts a symbol to activate the “delete entry / item” function. Both drags that make up this gesture (one for each line of “X”) are therefore classified as being symbolic in nature. For the very same referent, another participant “rubbed out” the item to be deleted by dragging her fingertip 4 times over the item to be deleted as if “rubbing it out. This gesture is metaphorical as the participant uses her fingertip as if it were an eraser. The 4 drags that constitute this gesture are therefore classified as being metaphorical in nature. Therefore, although drag gestures were used in both instances, they had different gesture natures.

The observations relating to the gesture nature dimension are tabulated below.

Table 17: Frequency of Gestures by Gesture Nature Dimension

Referent	Metaphorical	Symbolic	Physical	Arbitrary
1 – Input search query	20	0	4	0
2 – Go to previous webpage	20	0	0	0
3 – Go to next webpage	20	0	0	0
4 – Stop loading webpage content	15	0	2	3
5 – Refresh / reload webpage content	17	1	0	3
6 – Make webpage content larger	19	1	1	3
7 – Make webpage content smaller	19	1	0	3
8 – Pan down the webpage	20	0	0	0
9 – Pan up the webpage	20	0	0	0
10 – Pan across the webpage	20	0	0	0
11 – Search for text on the webpage	16	1	1	15
12 – Copy a section of text on the webpage	32	2	5	7
13 – Paste section of text into search engine	11	1	9	18
14 – Open link on the webpage in a new tab	10	5	5	7
15 – Open a new browsing tab	18	5	0	6
16 – Close a browsing tab	15	2	3	1
17 – View record of visited webpages	17	4	3	5
18 – Delete entry from record of visited pages	28	4	9	3
19 – Save current webpage address within the browser for viewing at a later stage	24	0	3	5
20 – Call up saved webpage address	35	0	2	4

Referent	Metaphorical	Symbolic	Physical	Arbitrary
21 – Save image on webpage to memory	23	0	6	17
22 – Save current webpage to memory	22	2	2	11
23 – Request help	15	9	0	4
24 – Close web browser	19	4	0	1
Total	475	42	55	116

In summary:

- All referents had gestures that were metaphorical in nature.
- Of all 688 gestures, 476 (69.186%) were metaphorical in nature, 116 (16.860%) were arbitrary, 54 (7.849%) were physical and 42 (6.105%) were symbolic.

These data suggest that participants generally find metaphorical gestures more intuitive to use, and as will be seen in the next section, these metaphorical gestures, tend to be object-centric, such as tapping on an imaginary button.

4.3.3 GESTURE BINDING

This section describes the elicited gestures along the Gesture Binding dimension. Gesture Binding is the third essential attribute of all gestures (Wobbrock et al, 2009) and refers to whether the gesture was object-centric, world-dependent, world-independent, or had mixed dependencies. There were no specific hypotheses proposed for this dimension and the analysis is descriptive Findings relating to this dimension also input into the creation of the user-defined gesture set.

It was a straightforward endeavour to classify simple gestures (i.e. determining whether the gesture was object-centric, world-dependent, world-independent or had mixed dependencies). This was not the case with complex gestures however. Complex gestures were decomposed into their constituent gestures as explained above in section 1.4.1.3 (Static and Dynamic Gestures Used) and each of these gestures was then classified. As a result, certain referents have more than 20 gestures that are classified.

It is also worth mentioning that the form of gestures do not determine their binding. For example, in the referent for “request help” one participant traced a question mark on the screen – this consisted of curved drag (denoting the curved part of the question mark) and a tap (denoting the dot below the curved part). This gesture could be made at any point and at anywhere on the screen, and was hence both the drag and the tap were classified as world-independent. For the same referent, several participants simply wanted to tap a “Help” button. This gesture was classified as object-centric as it was done to a specific object, a button. Therefore, although both gestures had a tap, these taps had different gesture bindings.

The observations relating to the gesture binding dimension are tabulated below.

Table 18: Frequency of Gestures by Gesture Binding Dimension

Referent	Object-centric	Mixed dependencies	World-dependent	World-independent
1 – Input search query	17	0	7	0
2 – Go to previous webpage	13	0	3	4
3 – Go to next webpage	12	0	4	4
4 – Stop loading webpage content	15	0	0	5
5 – Refresh / reload webpage content	17	0	1	3
6 – Make webpage content larger	8	0	8	8
7 – Make webpage content smaller	6	0	8	9
8 – Pan down the webpage	2	0	12	6
9 – Pan up the webpage	2	0	12	6
10 – Pan across the webpage	2	0	13	5
11 – Search for text on the webpage	18	0	6	9
12 – Copy a section of text on the webpage	44	0	1	1
13 – Paste section of text into search engine	38	0	1	0
14 – Open link on the webpage in a new tab	27	0	0	0
15 – Open a new browsing tab	24	0	5	0
16 – Close a browsing tab	19	0	2	0
17 – View record of visited webpages	22	0	6	1
18 – Delete entry from record of visited pages	43	0	1	0
19 – Save current webpage address within the browser for viewing at a later stage	26	4	0	2
20 – Call up saved webpage address	41	0	0	0
21 – Save image on webpage to memory	40	2	2	2
22 – Save current webpage to memory	26	2	8	1
23 – Request help	16	3	0	9
24 – Close web browser	13	2	9	0
Total	491	13	109	75

In summary:

- All referents had gestures that had an object-centric binding.

- Of all 688 gestures, 492 (71.512%) had an object-centric binding, 109 (15.843%) had a world-dependent binding, 74 (10.756%) had a world-independent binding and 13 (1.889%) had mixed dependencies.

These data suggest that participants find gestures that act on specific objects, such as buttons and text-boxes, as more intuitive.

4.3.4 GESTURE FLOW

This section describes the findings related to the final attribute – Gesture Flow. Gesture flow refers to whether the elicited gesture is discrete (the gesture is performed in its entirety, and once performed the system provides feedback) or continuous (the gesture requires on-going recognition by the system and feedback is provided while the gesture is being performed). Once again, there were no a-priori hypotheses related to this dimension and the results are presented descriptively.

The observations relating to the gesture flow dimension are provided below. Complex gestures were analysed as single gestures.

Table 19: Frequency of Gestures by Gesture Flow Dimension

Referent	Discrete	Continuous
1 – Input search query	16	4
2 – Go to previous webpage	19	1
3 – Go to next webpage	19	1
4 – Stop loading webpage content	20	0
5 – Refresh / reload webpage content	19	1
6 – Make webpage content larger	5	15
7 – Make webpage content smaller	5	15
8 – Pan down the webpage	0	20
9 – Pan up the webpage	0	20
10 – Pan across the webpage	1	19
11 – Search for text on the webpage	17	3
12 – Copy a section of text on the webpage	0	20
13 – Paste section of text into search engine	6	14
14 – Open link on the webpage in a new tab	5	14
15 – Open a new browsing tab	18	2
16 – Close a browsing tab	18	2
17 – View record of visited webpages	13	7

Referent	Discrete	Continuous
18 – Delete entry from record of visited pages	3	16
19 – Save current webpage address within the browser for viewing at a later stage	6	14
20 – Call up saved webpage address	1	19
21 – Save image on webpage to memory	1	19
22 – Save current webpage to memory	7	13
23 – Request help	17	3
24 – Close web browser	20	0
Total	236	242

In summary:

- Of the 24 referents, there were 2 that solely had discrete gestures and 3 that solely had continuous gestures; the other 15 referents had a combination of both discrete and continuous gestures.
- Of the 478 gestures that were provided, 236 (49.372%) were discrete, and 242 (50.628%) were continuous.

With a difference of 1.256% between discrete and continuous gestures, it is quite evident that no overall substantial differences exist in user preferences relating to this dimension. However, the preferences are discernible at the referent level with 11 referents (1, 2, 3, 4, 5, 11, 15, 16, 17, 23, 24) eliciting mostly discrete gestures, whilst 13 referents (6, 7, 8, 9, 10, 12, 13, 14, 18, 19, 20, 21, 22) elicited compound gestures. The discrete gestures were mostly used in the Website Navigation and Miscellaneous categories of web browser functions, the stopping and restarting the loading of the webpage as well as inputting and searching for text of the webpage. Compound gestures were used mostly in the Interaction with Page Content, Tab Browsing, Management of Browsing History, Bookmarking / Management of Favourites and Saving to Memory categories of web browser functions.

4.4 GESTURE RATINGS

Given that the participants were permitted to gesture with one or both hands, using any part or shape of their finger(s) and/or hand(s) in any way they wanted, it was expected that the gesture ratings would be high. If this was not the case, careful attention would need to be paid to those functions, represented through their referents, with low gesture ratings as other users would likely struggle with these – either in terms of their mapping (reflected through the “gesture goodness” rating) or in terms of how easy it is, physically, to perform them (reflect through the “gesture ease” rating), or both. The gestures for such functions would need to be investigated further and improved, to ensure the final user-defined gesture set is intuitive.

The average of the “gesture goodness” ratings (based on results of the Likert scale for the statement “The gesture I picked is a good match for its intended purpose”) and “gesture ease” ratings (based on results of the Likert scale for the statement “The gesture I picked is easy to perform”) are tabulated below.

Table 20: Overall Gesture Ratings

Referent	Gesture Goodness	Gesture Ease
1 – Input search query	4.650	4.550
2 – Go to previous webpage	4.600	4.750
3 – Go to next webpage	4.550	4.750
4 – Stop loading webpage content	4.400	4.550
5 – Refresh / reload webpage content	4.150	4.550
6 – Make webpage content larger	4.600	4.650
7 – Make webpage content smaller	4.600	4.600
8 – Pan down the webpage	4.700	4.700
9 – Pan up the webpage	4.700	4.700
10 – Pan across the webpage	4.600	4.650
11 – Search for text on the webpage	4.450	4.250
12 – Copy a section of text on the webpage	4.500	4.450
13 – Paste section of text into search engine	4.350	4.400
14 – Open link on the webpage in a new tab	4.632	4.474
15 – Open a new browsing tab	4.400	4.400
16 – Close a browsing tab	4.400	4.450
17 – View record of visited webpages	4.400	4.500
18 – Delete entry from record of visited pages	4.579	4.474
19 – Save current webpage address within the browser for viewing at a later stage	4.200	4.200
20 – Call up saved webpage address	4.400	4.250
21 – Save image on webpage to memory	4.550	4.500
22 – Save current webpage to memory	4.350	4.600
23 – Request help	4.400	4.500
24 – Close web browser	4.700	4.750
Average Ratings	4.494	4.527

The summary, in terms of gesture goodness ratings, is as follows:

- The highest gesture goodness rating was 4.700, which was calculated for referent 8 (“Pan down the webpage”), 9 (“Pan up the webpage”) and 24 (“Close web browser”).
- The lowest gesture goodness rating was 4.150, which was calculated for referent 5 (“Refresh / reload webpage content”).

These data suggest that overall participants adjudged their gestures to be suitable for the referents they had proposed them for as they were all rated highly (all gesture goodness ratings were above 4 on a 5 point scale). No function’s gestures would therefore need to be investigated in terms of their suitability. While participants felt that the gestures they provided for referent 5 were not as suitable as those they had provided for other referents, the gesture goodness rating for this referent was still high and would therefore not warrant investigation.

The summary, in terms of gesture ease ratings, is as follows:

- The highest gesture ease rating was 4.750, which was calculated for referent 2 (“Go to previous webpage”), 3 (“Go to next webpage”) and 24 (“Close web browser”).
- The lowest gesture ease rating was 4.200, which was calculated for referent 19 (“Save current webpage address within the browser for viewing at a later stage”).

These data suggest that overall participants adjudged their gestures to be physically easy to perform as they were all rated highly (all gesture goodness ratings were above 4 on a 5 point scale). No function’s gestures would therefore need to be investigated in terms of being difficult to perform. While participants felt that the gestures they provided for referent 19 were not as easy to perform as those they had provided for other referents, the gesture ease rating for this referent was still high and would therefore not warrant investigation.

It is worth noting that 9 referents had gesture ratings there were above the average gesture goodness rating as well as the average gesture ease rating. These 9 referents are as follows:

- 1 – Input search query
- 2 – Go to previous webpage
- 3 – Go to next webpage
- 6 – Make webpage content larger
- 7 – Make webpage content smaller
- 8 – Pan down the webpage
- 9 – Pan up the webpage
- 10 – Pan across the webpage
- 24 – Close web browser

This implies that while participants felt that the gestures they had proposed for other referents were good (either in terms of suitability to the function or ease of performance), they felt that the ones they had proposed for these referents were optimal, exemplified by referent 24, that had the highest gesture goodness rating as well as the highest gesture ease rating. The gestures for these referents are ones that users are likely to find highly satisfactory in the final user-defined gesture set.

4.5 AGREEMENT SCORES

The agreement scores are presented below. An agreement score is a single number that reflects the degree of agreement among participants regarding the assignment of gestures to functions (Wobbrock et al, 2009). This was done by taking all gestures that had been proposed for a specific gesture, and based on their classifications, grouping identical gestures together so that each group represents the frequency with which the a specific gesture was proposed by different people. These groups are then used to compute the agreement score (formula reported in Chapter 3). The agreement scores for all referents are tabulated below from the lowest agreement score to the highest.

Table 21: Agreement Scores

Referent	Agreement Score (Lowest to Highest)
Referent 21 – Save image on webpage to memory	0.060
Referent 13 – Paste section of text into search engine	0.105
Referent 22 – Save current webpage to memory	0.105
Referent 18 – Delete entry from record of visited pages	0.108
Referent 12 – Copy a section of text on the webpage	0.110
Referent 19 – Save current webpage address within the browser for viewing at a later stage	0.140
Referent 6 – Make webpage content larger	0.145
Referent 7 – Make webpage content smaller	0.145
Referent 17 – View record of visited webpages	0.225
Referent 20 – Call up saved webpage address	0.235
Referent 14 – Open link on the webpage in a new tab	0.247
Referent 1 – Input search query	0.310
Referent 15 – Open a new browsing tab	0.345
Referent 23 – Request help	0.380
Referent 11 – Search for text on the webpage	0.390
Referent 3 – Go to next webpage	0.425
Referent 2 – Go to previous webpage	0.475
Referent 8 – Pan down the webpage	0.490
Referent 9 – Pan up the webpage	0.490
Referent 24 – Close web browser	0.515
Referent 16 – Close a browsing tab	0.575
Referent 4 – Stop loading webpage content	0.585
Referent 10 – Pan across the webpage	0.590
Referent 5 – Refresh / reload webpage content	0.650
Average	0.327

In summary:

- The lowest agreement score was 0.060, which was calculated for referent 21 (“Save image on webpage to memory”).
- The highest agreement score was 0.650, which was calculated for referent 5 (“Refresh / reload webpage content”).

To provide context for these agreement scores (to determine whether they are high or low) the average of the agreement scores was compared to the average agreement scores calculated by Wobbrock et al. (2009). The average agreement score above was higher than those calculated by Wobbrock et al. (2009) – the highest calculated by Wobbrock et al. (2009) being 0.32. This suggests that agreement for the gestures in user-defined gesture set is overall satisfactory. Agreement is particularly good for 12 referents (2, 3, 4, 5, 8, 9, 10, 11, 15, 16, 23, 24), all of which are above the average agreement score. These referents mostly represent the Website Navigation, Interaction with Page Content, Tab Browsing and Miscellaneous categories of web browser functions.

Wobbrock et al (2009) and Mauney et al (2010) note that there tends to be higher agreement (i.e. similar way of thinking) between users for the simpler tasks, than those that are complex. This implies that the gestures with high agreement scores were considered to be simpler and the ones with low agreement scores were considered to be more complex. This means that the table above also presents the referents by complexity from the participants’ perspective, with the most complex at the top and the least complex at the bottom.

Having presented the analysis of the various dimensions of the gestures elicited, the following section uses the findings to propose a final gesture set for each of the 24 referents used in the study.

4.6 USER-DEFINED GESTURE SET

The final user-defined gesture set for conducting an informational search on a multi-touch tablet web browser, based on gestures elicited from participants, was successfully completed using the method provided in Chapter 3 (section 3.3.1.1 Creation of Gesture Set). All conflicts were resolved, resulting in a coherent gesture set with the gestures (and their non-conflicting alternatives) for each of the 24 referents, as presented⁴

⁴ Some of the images used in creating the illustrations below were used courtesy of the following websites:

- <http://www.kickerstudio.com/blog/2008/12/touchscreen-stencils/>
- <http://www.clker.com/>
- <http://commons.wikimedia.org/>
- <http://openclipart.org/>
- <http://footage.shutterstock.com/>

below. Key information relating to these gestures is presented below, for detailed information on each of the gestures please refer to Appendix C (Detailed Information on User-Defined Gesture Set).

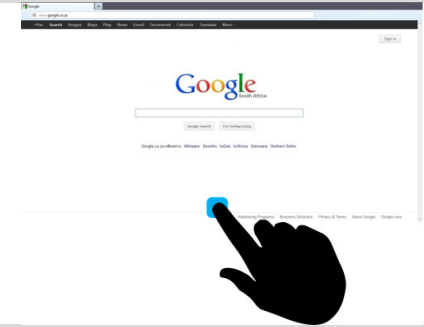
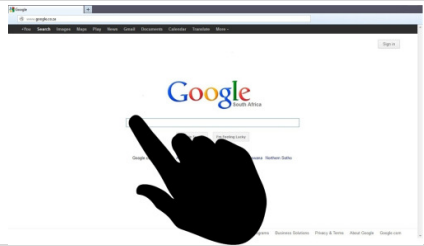
4.6.1 Referent 1 – Input Search Query

The key points relating to this referent are as follows:

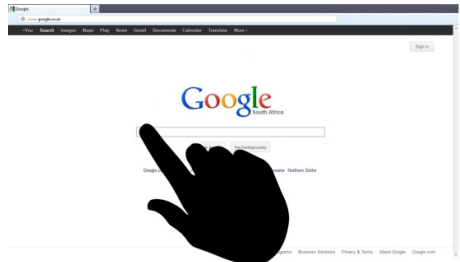
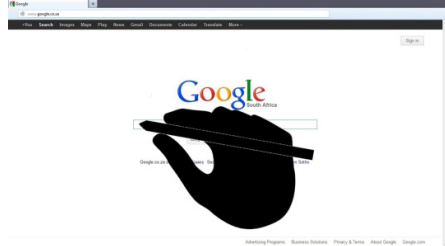
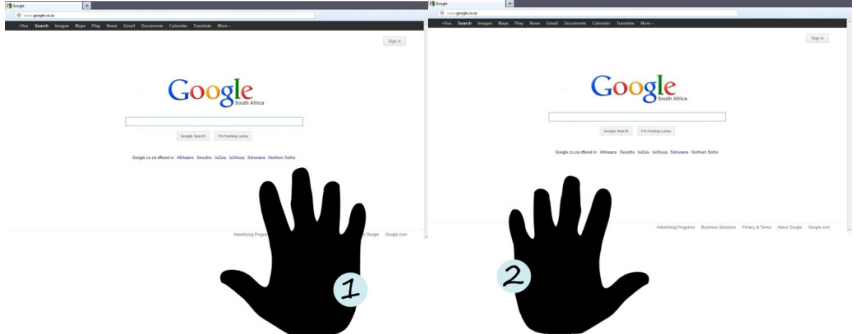
- 20 gestures were elicited.
- 1 gesture was excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Keyboard Button”; proposed by 9 participants.
 - Gesture 2 – Single Tap on Google Textbox; proposed by 5 participants.
 - Gesture 3 – Flick Keyboard Up; proposed by 1 participant.
 - Gesture 4 – Write in Google Textbox with a Fingertip; proposed by 1 participant.
 - Gesture 5 – Write in Google Textbox with a Stylus; proposed by 1 participant.
 - Gesture 6 – Simulate Typing Action; proposed by 1 participant.
- The agreement score for this referent was 0.310 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 22: Gestures Assigned to Referent 1 – Input Search Query

Referent 1 – Input Search Query		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 1 – Single Tap on “Keyboard Button”	The user calls up a keyboard by tapping once on a “keyboard button”.	
Gesture 2 – Single Tap on Google Textbox	The user calls up a keyboard by tapping once on the Google textbox.	
Gesture 3 – Flick Keyboard Up	The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen.	

Referent 1 – Input Search Query

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 4 – Write in Google Textbox with a Fingertip	The user uses his / her fingertip as if it is a pen to “write” the search query in the Google textbox.	 A screenshot of the Google homepage with a black silhouette of a hand. The index finger is pointing at the search input field, indicating the action of writing a query.
Gesture 5 – Write in Google Textbox with a Stylus	The user uses a stylus to “write” the search query in the Google textbox.	 A screenshot of the Google homepage with a black silhouette of a hand holding a stylus. The stylus is positioned over the search input field, indicating the action of writing a query.
Gesture 6 – Simulate Typing Action	To bring up a keyboard, the participant pretends that he / she is typing on the screen. This gesture begins with a tap of the right index, right middle, right ring and right pinkie finger (in any order) in quick succession. This is followed by with a tap of the left index, left middle, left ring and left pinkie finger (in any order) in quick succession. This is followed with a tap of the right index, right middle, right ring and right pinkie finger (in any order) in quick succession. This is followed by	 Two screenshots of the Google homepage. The left screenshot shows a black silhouette of a right hand with fingers spread, labeled with a circled '1'. The right screenshot shows a black silhouette of a left hand with fingers spread, labeled with a circled '2'. This illustrates the sequence of hand movements for simulating typing.

Referent 1 – Input Search Query		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
	with a tap of the left index, left middle, left ring and left pinkie finger (in any order) in quick succession.	

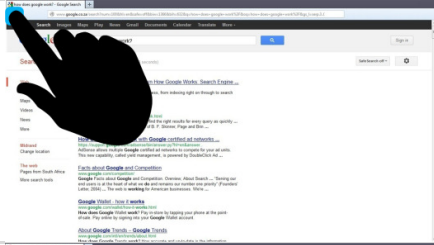
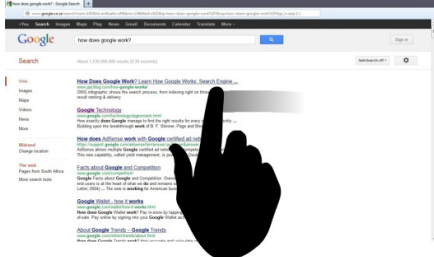
4.6.2 Referent 2 – Go to Previous Webpage

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 2 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 2 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Back Button”; proposed by 13 participants.
 - Gesture 2 – Drag Finger from Right to Left; proposed by 4 participants.
- The agreement score for this referent was 0.475 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 23: Gestures Assigned to Referent 2 – Go To Previous Webpage

Referent 2 – Go to Previous Webpage		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap on “Back Button”	The user taps on the “Back” button.	
Gesture 2 – Drag Finger from Right to Left	The user performs a drag gesture from right to left.	

4.6.3 Referent 3 – Go to next webpage

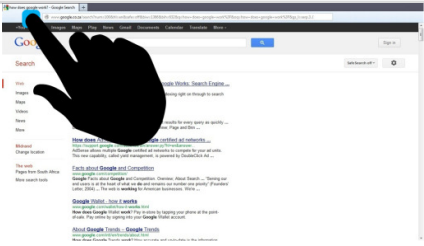
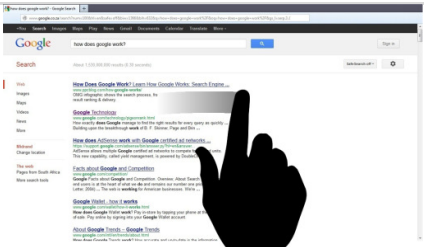
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 4 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 2 gestures were assigned to this referent:

- Gesture 1 – Single Tap on “Forward Button”; proposed by 12 participants.
- Gesture 2 – Drag Finger from Left to Right; proposed by 4 participants.
- The agreement score for this referent was 0.425 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 24: Gestures Assigned to Referent 3 – Go To Next Webpage

Referent 3 – Go to next webpage		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap on “Forward Button”	The user taps on the “Forward” button.	
Gesture 2 – Drag Finger from Left to Right	The user performs a drag gesture from left to right.	

4.6.4 Referent 4 – Stop loading webpage content

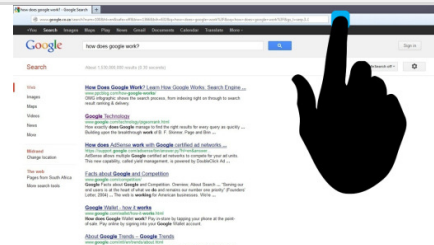
The key points relating to this referent are as follows:

- 20 gestures were elicited.

- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 3 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Stop Button”; proposed by 15 participants.
 - Gesture 2 – Palm Tap; proposed by 2 participants.
 - Gesture 3 – Single Tap on Screen; proposed by 2 participants.
- The agreement score for this referent was 0.585 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 25: Gestures Assigned to Referent 4 – Stop loading webpage content

Referent 4 – Stop loading webpage content		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 1 – Single Tap on “Stop Button”	The user stops the webpage from loading by tapping once on a “stop button”.	

Referent 4 – Stop loading webpage content

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 2 – Palm Tap	The user stops the webpage from loading by tapping once on the screen with the palm of the hand.	
Gesture 3 – Single Tap on Screen	The user stops the webpage from loading by tapping once on the screen with a single finger.	

4.6.5 Referent 5 – Refresh / reload webpage content

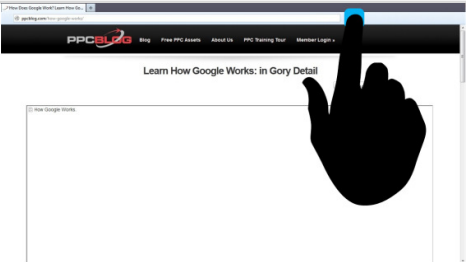
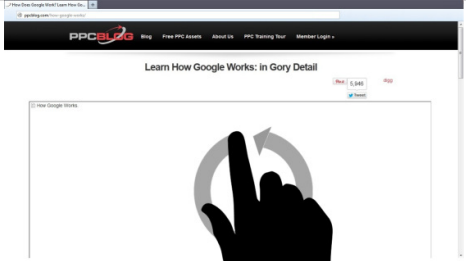
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 3 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 2 gestures were assigned to this referent:

- Gesture 1 – Single Tap on “Refresh Button”; proposed by 16 participants.
- Gesture 2 – Trace Circle; proposed by 1 participant.
- The agreement score for this referent was 0.650 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 26: Gestures Assigned to Referent 5 – Refresh / reload webpage content

Referent 5 – Refresh / reload webpage content		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 1 – Single Tap on “Refresh Button”	The user refreshes / reloads the webpage by tapping once on a “refresh button”.	
Gesture 2 – Trace Circle	The user refreshes / reloads the webpage by tracing a circle (in an anti-clockwise direction) on the screen.	

4.6.6 Referent 6 – Make webpage content larger

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 1 gesture was excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 3 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 7 gestures were assigned to this referent:
 - Gesture 1 – Drag Two Fingers Apart; proposed by 5 participants.
 - Gesture 2 – Single Tap on “Magnify Button”; proposed by 4 participants.
 - Gesture 3 – Drag Five Fingers Apart; proposed by 3 participants.
 - Gesture 4 – Drag Finger to Corner of Screen; proposed by 1 participant.
 - Gesture 5 – Drag Two Palms Apart; proposed by 1 participant.
 - Gesture 6 – Drag Two Fingers Apart - Using Both Hands; proposed by 1 participant.
 - Gesture 7 – “Magnifying Scale” Widget; proposed by 1 participants.
- The agreement score for this referent was 0.145 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 27: Gestures Assigned to Referent6 – Make webpage content larger

Referent 6 – Make webpage content larger		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Drag Two Fingers Apart	The user makes the webpage content larger by dragging his / her thumb and index finger apart.	
	The user may also use fingers on different hands.	
Gesture 2 – Single Tap on “Magnify Button”	The user makes the webpage content larger by tapping on a “magnify button”.	

Referent 6 – Make webpage content larger

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 3 – Drag Five Fingers Apart	The user makes the webpage content larger by placing all 5 fingers on the screen and dragging them all apart from each other.	
Gesture 4 – Drag Finger to Corner of Screen	The user makes the webpage content larger by dragging with a single finger an inner section of the screen to the corner of the screen.	
Gesture 5 – Drag Two Palms Apart	The user makes the webpage content larger by placing the sides of both hands on the screen (towards the centre of the page) and dragging them apart (the left hand towards the left edge of the screen, and the right hand towards the right edge of the screen).	

Referent 6 – Make webpage content larger

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 6 – Drag Two Fingers Apart - Using Both Hands	The user makes the webpage content larger by dragging his / her right thumb and index finger from the centre of the screen towards the bottom right and top right corners of the screen respectively. This is done while simultaneously dragging the left thumb and index finger from the centre of the screen to the bottom left and top left corners of the screen respectively.	
Gesture 7 – “Magnifying Scale” Widget	The user makes the webpage content larger using a scale at the bottom of the screen. Dragging the arrow rightwards enlarges the size of the content.	

4.6.7 Referent 7 – Make webpage content smaller

The key points relating to this referent are as follows:

- 20 gestures were elicited.

- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 4 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Drag Two Fingers Together; proposed by 5 participants.
 - Gesture 2 – Single Tap on “Minify Button”; proposed by 4 participants.
 - Gesture 3 – Drag Five Fingers Together; proposed by 2 participants.
 - Gesture 4 – Drag Finger from Corner of Screen; proposed by 1 participant.
 - Gesture 5 – Drag Two Fingers Together - Using Both Hands; proposed by 1 participant.
 - Gesture 6 – “Magnifying Scale” Widget; proposed by 1 participant.
- The agreement score for this referent was 0.145 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 28: Gestures Assigned to Referent7 – Make webpage content smaller

Referent 7 – Make webpage content smaller		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 1 – Drag Two Fingers Together	The user makes the webpage content smaller by dragging his / her thumb and index finger together.	

Referent 7 – Make webpage content smaller

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
	The user may also use fingers on different hands.	
Gesture 2 – Single Tap on “Minify Button”	The user makes the webpage content smaller by tapping on a “minify button”.	
Gesture 3 – Drag Five Fingers Together	The user makes the webpage content smaller by sprawling all 5 fingers on the screen and dragging them towards from each other.	

Referent 7 – Make webpage content smaller

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 4 – Drag Finger from Corner of Screen	The user makes the webpage content smaller by dragging with a single finger from the corner of the screen to the inner section of the screen.	
Gesture 5 – Drag Two Fingers Together - Using Both Hands	The user makes the webpage content smaller by dragging his / her right thumb and index finger from the bottom right and top right corners of the screen respectively towards the centre of the screen. This is done while simultaneously dragging the left thumb and index finger from the bottom left and top left corners of the screen respectively towards the centre of the screen.	

Referent 7 – Make webpage content smaller

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 6 – “Magnifying Scale” Widget	The user makes the webpage content larger using a scale at the bottom of the screen. Dragging the arrow leftwards decreases the size of the content.	

4.6.8 Referent 8 – Pan down the webpage

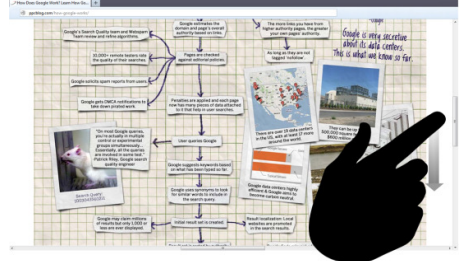
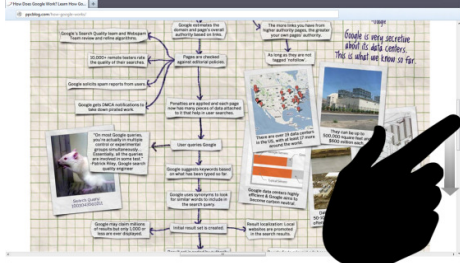
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 5 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 8 gestures were assigned to this referent:
 - Gesture 1 – Drag Finger Downward (Right Edge of Screen); proposed by 4 participants.
 - Gesture 2 – Drag Finger Downward (Scrollbar); proposed by 4 participants.
 - Gesture 3 – Flick Finger Downward (Right Edge of Screen); proposed by 2 participants.

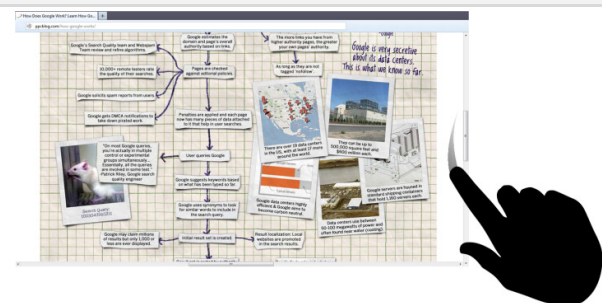
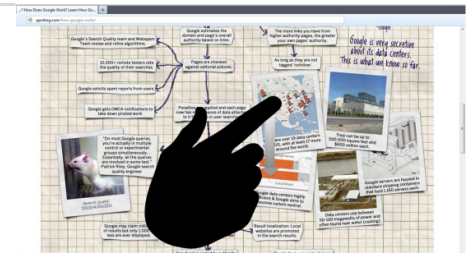
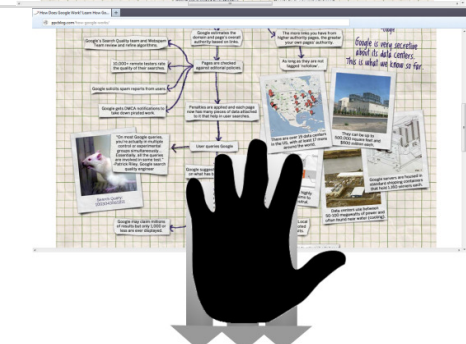
- Gesture 4 – Drag Finger Downward (Middle of Screen); proposed by 1 participant.
- Gesture 5 – Drag Multiple Fingers Downward; proposed by 1 participant.
- Gesture 6 – Flick Finger Downward (Bottom Edge of Screen); proposed by 1 participant.
- Gesture 7 – Flick Finger Downward (Scrollbar Arrow); proposed by 1 participant.
- Gesture 8 – Drag Half-Closed Palm Down; proposed by 1 participant.
- The agreement score for this referent was 0.490 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

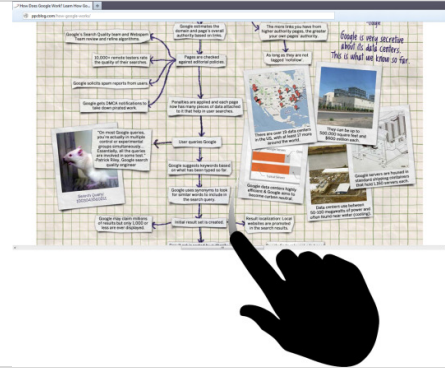
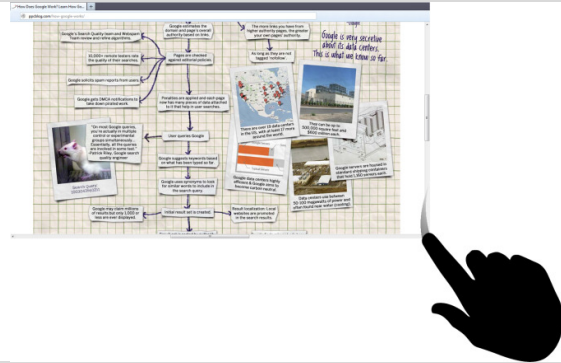
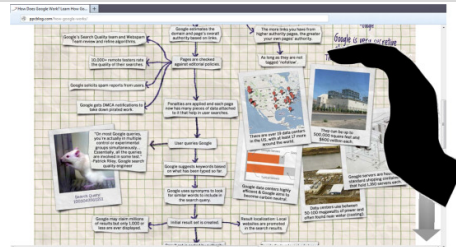
Table 29: Gestures Assigned to Referent 8 – Pan down the webpage

Referent 8 – Pan down the webpage		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Drag Finger Downward (Right Edge of Screen)	The user drags a single finger downwards on the right edge of the screen.	
Gesture 2 – Drag Finger Downward (Scrollbar)	The user drags a single finger downwards on the scrollbar.	

Referent 8 – Pan down the webpage

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 3 – Flick Finger Downward (Right Edge of Screen)	The user flicks a single finger downwards on the right edge of the screen.	 A screenshot of a webpage with a grid of images and text. A black silhouette of a hand is shown on the right edge of the screen, with the index finger flicking downwards.
Gesture 4 – Drag Finger Downward (Middle of Screen)	The user drags a single finger downwards in the middle of the screen.	 A screenshot of the same webpage. A black silhouette of a hand is shown in the middle of the screen, with the index finger dragging downwards.
Gesture 5 – Drag Multiple Fingers Downward	The user drags with the pinkie, ring, middle and index fingers from the top to the bottom of the screen.	 A screenshot of the same webpage. A black silhouette of a hand is shown at the bottom of the screen, with the pinkie, ring, middle, and index fingers dragging downwards.

Referent 8 – Pan down the webpage

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 6 – Flick Finger Downward (Bottom Edge of Screen)	The user flicks a single finger downwards at the bottom edge of the screen.	
Gesture 7 – Flick Finger Downward (Scrollbar Arrow)	The user flicks a single finger downwards on the scrollbar arrow that points down.	
Gesture 8 – Drag Half-Closed Palm Down	The user drags a half-closed palm from the top to the bottom on the right edge of the screen.	

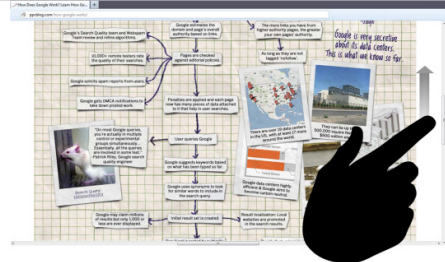
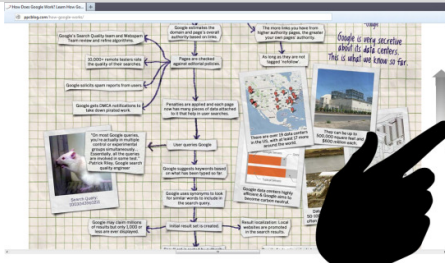
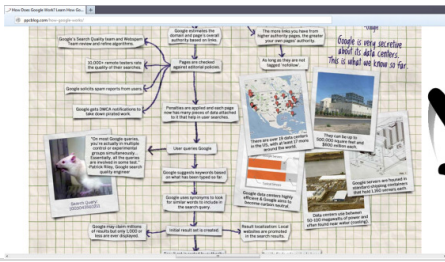
4.6.9 Referent 9 – Pan up the webpage

The key points relating to this referent are as follows:

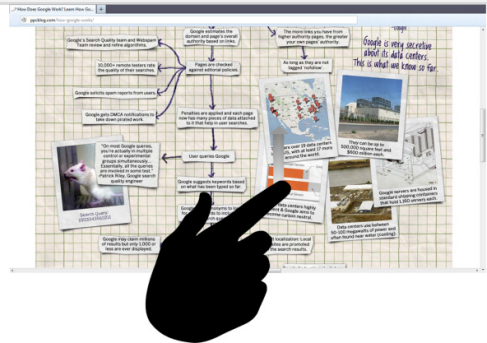
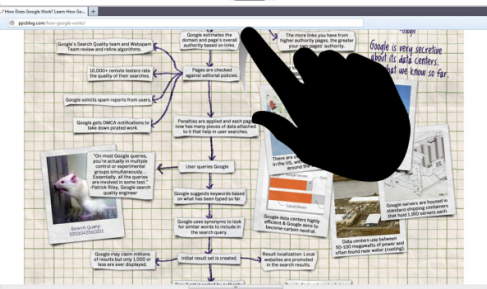
- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 5 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 8 gestures were assigned to this referent:
 - Gesture 1 – Drag Finger Upward (Right Edge of Screen); proposed by 4 participants.
 - Gesture 2 – Drag Finger Upward (Scrollbar); proposed by 4 participants.
 - Gesture 3 – Flick Finger Upward (Right Edge of Screen); proposed by 2 participants.
 - Gesture 4 – Drag Finger Upward (Middle of Screen); proposed by 1 participant.
 - Gesture 5 – Drag Multiple Fingers Upward; proposed by 1 participant.
 - Gesture 6 – Flick Finger Upward (Top Edge of Screen); proposed by 1 participant.
 - Gesture 7 – Flick Finger Upward (Scrollbar Arrow); proposed by 1 participant.
 - Gesture 8 – Drag Half-Closed Palm Up; proposed by 1 participant.
- The agreement score for this referent was 0.490 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

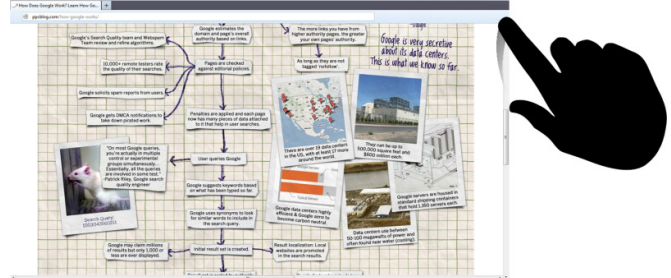
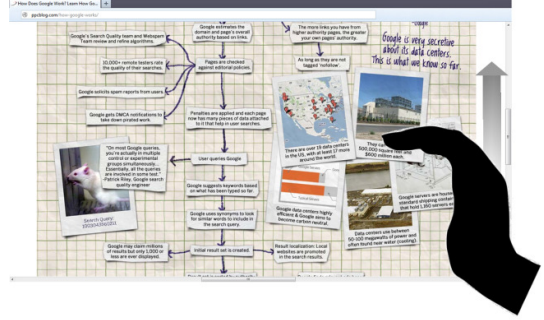
Table 30: Gestures Assigned to Referent 9 – Pan up the webpage

Referent 9 – Pan up the webpage		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Drag Finger Upward (Right Edge of Screen)	The user drags a single finger upwards on the right edge of the screen.	
Gesture 2 – Drag Finger Upward (Scrollbar)	The user drags a single finger upwards on the scrollbar.	
Gesture 3 – Flick Finger Upward (Right Edge of Screen)	The user flicks a single finger upwards on the right edge of the screen.	

Referent 9 – Pan up the webpage

Gesture Name	Gesture Summary	Gesture Illustration
Gesture 4 – Drag Finger Upward (Middle of Screen)	The user drags a single finger upwards in the middle of the screen.	
Gesture 5 – Drag Multiple Fingers Upward	The user drags from the bottom to the top of the screen with the pinkie, ring, middle and index fingers.	
Gesture 6 – Flick Finger Upward (Top Edge of Screen)	The user flicks a single finger upwards at the top edge of the screen.	

Referent 9 – Pan up the webpage

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 7 – Flick Finger Upward (Scrollbar Arrow)	The user flicks a single finger upwards on the scrollbar arrow that points up.	
Gesture 8 – Drag Half-Closed Palm Up	The user drags a half-closed palm from the bottom to the top on the right edge of the screen.	

4.6.10 Referent 10 – Pan across the webpage

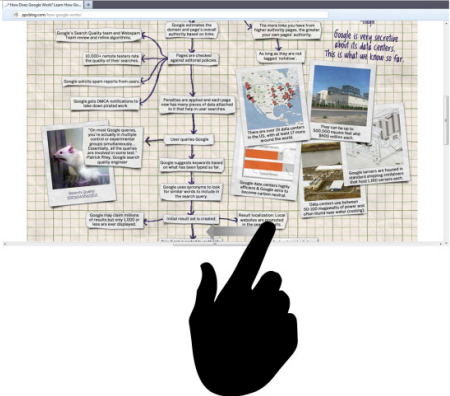
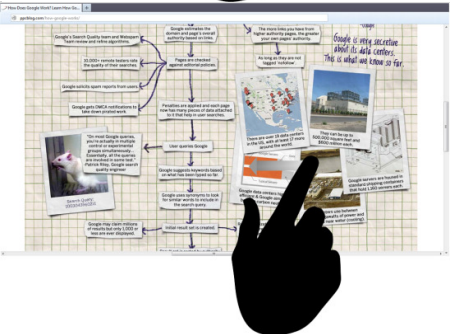
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 3 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).

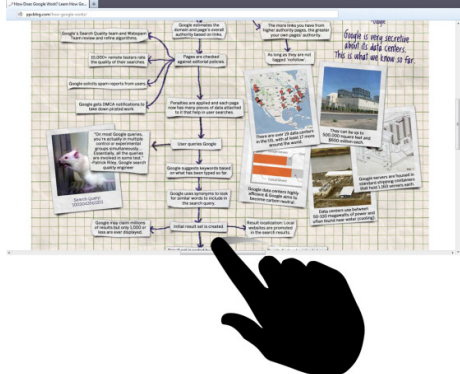
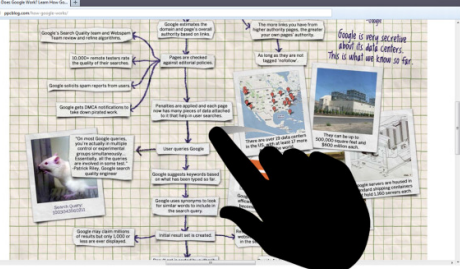
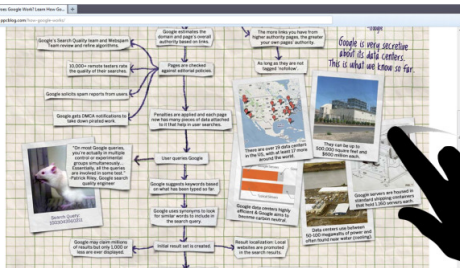
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 8 gestures were assigned to this referent:
 - Gesture 1 – Drag Finger Left (Bottom Edge of Screen); proposed by 4 participants.
 - Gesture 2 – Drag Finger Left (Middle of Screen); proposed by 3 participants.
 - Gesture 3 – Flick Finger Left (Bottom Edge of Screen); proposed by 2 participants.
 - Gesture 4 – Flick Finger Left (Middle of Screen); proposed by 1 participant.
 - Gesture 5 – Flick Finger Left (Right Edge of Screen); proposed by 1 participant.
 - Gesture 6 – Flick Finger Left (Scrollbar Arrow); proposed by 1 participant.
 - Gesture 7 – Drag Multiple Fingers Left; proposed by 1 participant.
 - Gesture 8 – Drag Vertical Hand Right; proposed by 1 participant.
- The agreement score for this referent was 0.590 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

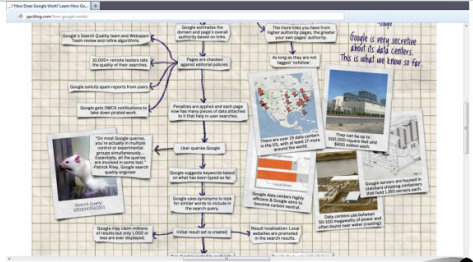
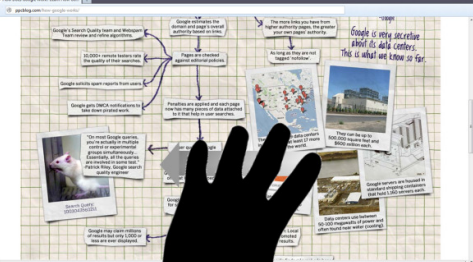
Table 31: Gestures Assigned to Referent 10 – Pan across the webpage

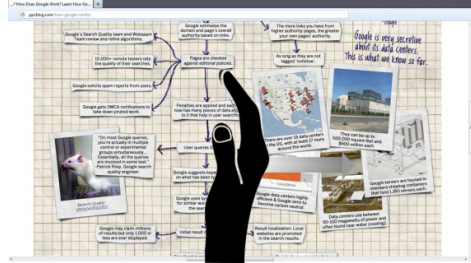
Referent 10 – Pan across the webpage		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Drag Finger Left (Bottom Edge of Screen)	The user drags a single finger from right to left at the bottom edge of the screen.	
Gesture 2 – Drag Finger Left (Middle of Screen)	The user drags a single finger from right to left in the middle of the screen.	

Referent 10 – Pan across the webpage

Gesture Name	Gesture Summary	Gesture Illustration
Gesture 3 – Flick Finger Left (Bottom Edge of Screen)	The user flicks a single finger from right to left at the bottom of the screen.	
Gesture 4 – Flick Finger Left (Middle of Screen)	The user flicks a single finger from right to left in the middle of the screen.	
Gesture 5 – Flick Finger Left (Right Edge of Screen)	The user flicks a single finger from right to left at the right edge of the screen.	

Referent 10 – Pan across the webpage

Gesture Name	Gesture Summary	Gesture Illustration
Gesture 6 – Flick Finger Left (Scrollbar Arrow)	The user flicks a single finger left to right on the scrollbar arrow that points right.	 
Gesture 7 – Drag Multiple Fingers Left	The user drags from the right to the left of the screen with the pinkie, ring, middle and index fingers.	 

Referent 10 – Pan across the webpage		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 8 – Drag Vertical Hand Right	The user drags the side of 1 hand from the right to the left in the middle of the screen.	

4.6.11 Referent 11 – Search for text on the webpage

The key points relating to this referent are as follows:

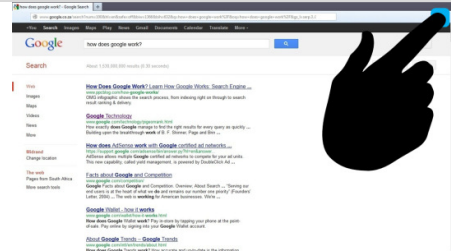
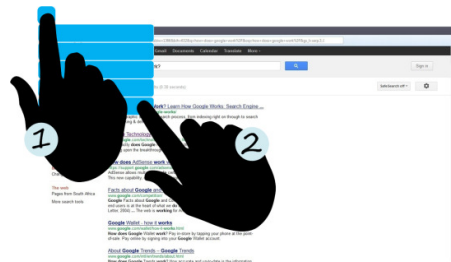
- 20 gestures were elicited.
- 2 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Search Button”; proposed by 12 participants.
 - Gesture 2 – Select Option from Main Menu; proposed by 2 participants.
 - Gesture 3 – Use Keyboard Shortcut (Alt + F); proposed by 1 participant.
 - Gesture 4 – Trace “Search Box”; proposed by 1 participant.
 - Gesture 5 – Tap with Both Palms; proposed by 1 participant.
 - Gesture 6 – “Search Circle”; proposed by 1 participant.

- The agreement score for this referent was 0.390 (the average agreement score was 0.327).

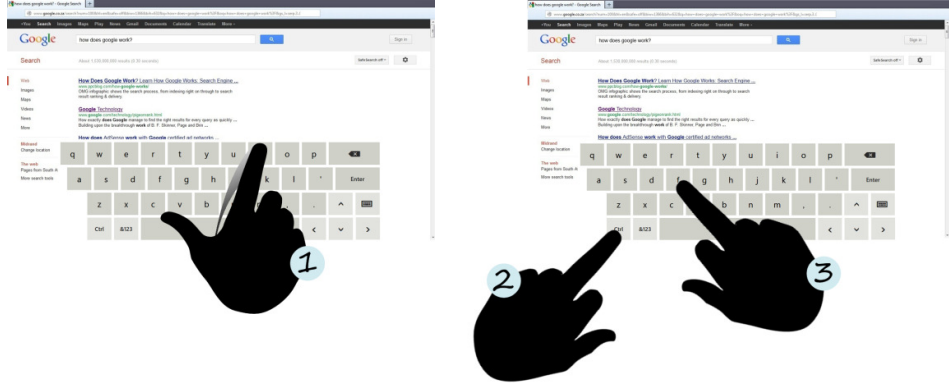
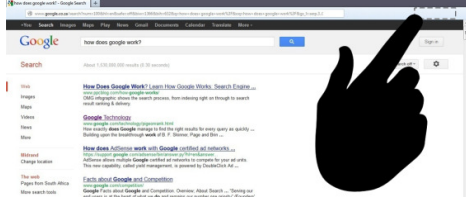
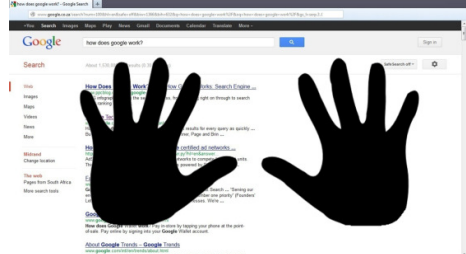
The gestures assigned to this referent are tabulated below.

It should be noted that the participants were requested to provide gestures that would call up a textbox into which they could provide their search queries. The gestures for providing this search query were not elicited as these were addressed in Referent 1 – Input Search Query.

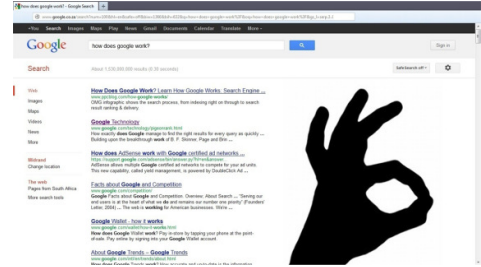
Table 32: Gestures Assigned to Referent 11 – Search for text on the webpage

Referent 11 – Search for text on the webpage		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap on “Search Button”	The user calls up a textbox into which he / she can provide the search query by tapping on a “search button”.	
Gesture 2 – Select Option from Main Menu	The user calls up a textbox into which he / she can provide the search query by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to provide a search query (Phase 2).	

Referent 11 – Search for text on the webpage

Gesture Name	Gesture Summary	Gesture Illustration
Gesture 3 – Use Keyboard Shortcut (Alt + F)	The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen (Phase 1). The user calls up a textbox into which he / she can provide the search query by using a keyboard shortcut – the user presses the “Ctrl” key (Phase 2) and taps the “F” key (Phase 3) while pressing it.	
Gesture 4 – Trace “Search Box”	The user calls up a textbox into which he / she can provide the search query by tracing a box to the right of the address bar.	
Gesture 5 – Tap with Both Palms	The user calls up a textbox into which he / she can provide the search query by tapping on the screen with both palms a couple of times. The palms taps are done in quick succession.	

Referent 11 – Search for text on the webpage

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 6 – “Search Circle”	The user calls up a textbox into which he / she can provide the search query by “making a circle” with the right thumb and right index finger, and placing these on the screen. This is achieved by twisting the wrist so that the length of the thumb and index finger are in contact with the touch screen.	

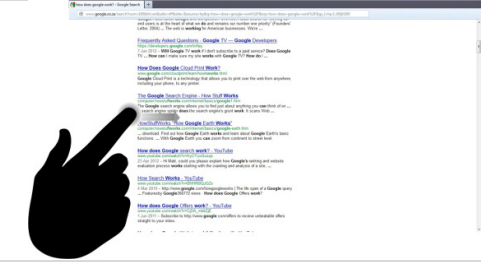
4.6.12 Referent 12 – Copy a section of text on the webpage

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 17 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 2 gestures were assigned to this referent:
 - Gesture 1 – Press and Drag Finger Over Text; proposed by 2 participants.
 - Gesture 2 – Single Tap on Words, Highlight and Copy; proposed by 1 participants.
- The agreement score for this referent was 0.110 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 33: Gestures Assigned to Referent 12 – Copy a section of text on the webpage

Referent 12 – Copy a section of text on the webpage		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Press and Drag Finger Over Text	The user copies a section of text pressing with a single finger where the text begins, and dragging the finger over the text (from left to right).	
Gesture 2 – Single Tap on Words, Highlight and Copy	The user copies a section of text by tapping on each of the words to be copied (Phase 1), tapping once on a “Highlight Button” – which highlights the words which were tapped (Phase 2), tapping once on a “Copy Button” – which copies the highlighted words (Phase 3).	

4.6.13 Referent 13 – Paste section of text into search engine

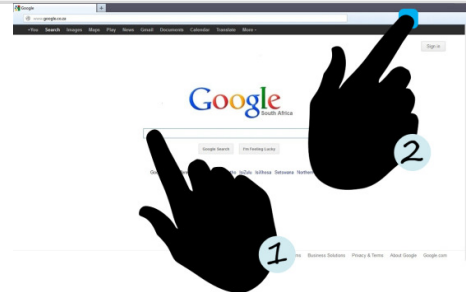
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 7 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).

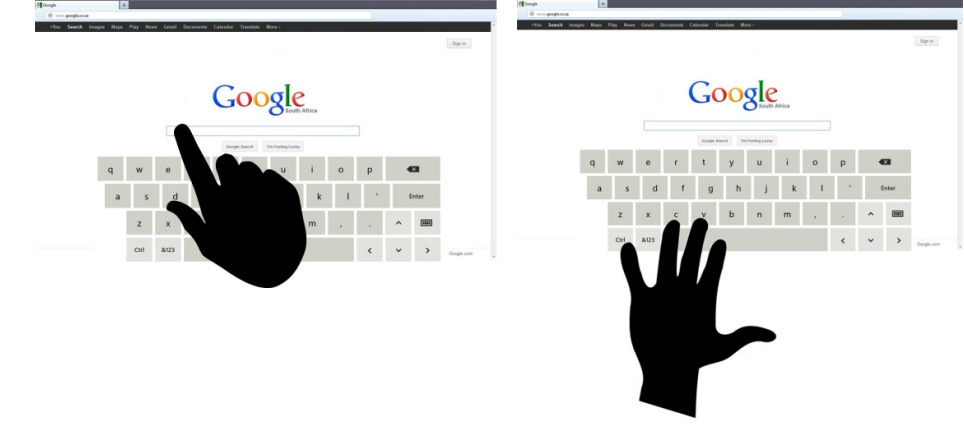
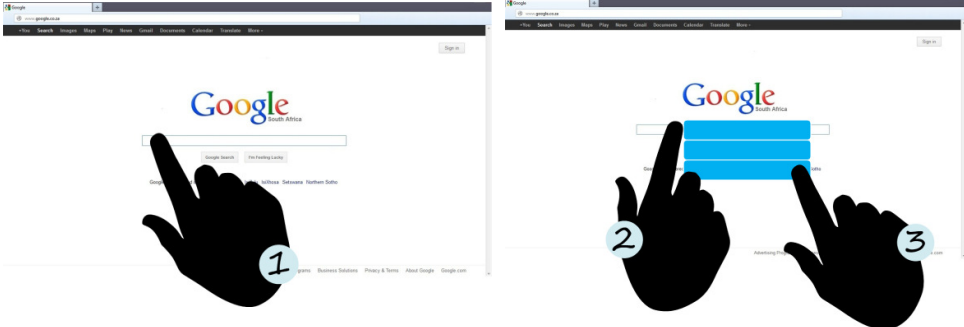
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 7 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on Google Textbox, Single Tap on “Paste Button”; proposed by 3 participants.
 - Gesture 2 – Use Keyboard Shortcut (Ctrl + V); proposed by 1 participant.
 - Gesture 3 – Select Option from Context Menu on Google Textbox; proposed by 2 participants.
 - Gesture 4 – Single Tap with Finger, Drag Finger Right; proposed by 1 participants.
 - Gesture 5 – Drag Finger Left on Google Textbox; proposed by 1 participant.
 - Gesture 6 – Two Finger Tap; proposed by 1 participant.
 - Gesture 7 – Drag Text from “Easel Button” or “Paste Button”; proposed by 1 participant.
- The agreement score for this referent was 0.105 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

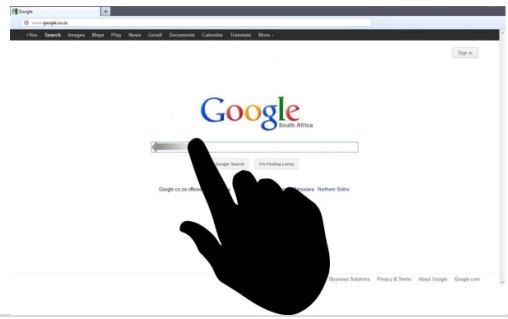
Table 34: Gestures Assigned to Referent13 – Paste section of text into search engine

Referent 13 – Paste section of text into search engine		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 1 – Single Tap on Google Textbox, Single Tap on “Paste Button”	The user pastes a section of text into Google by tapping once on the Google textbox (Phase 1), and tapping once on the “Paste Button”.	

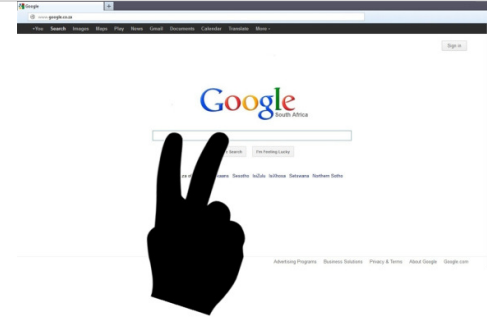
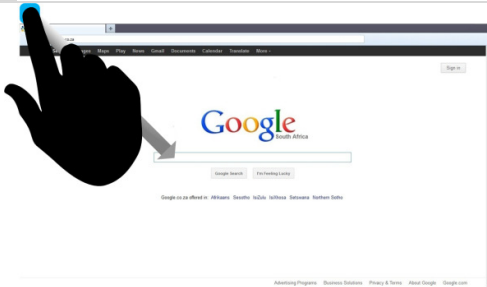
Referent 13 – Paste section of text into search engine

Gesture Name	Gesture Summary	Gesture Illustration
Gesture 2 – Use Keyboard Shortcut (Ctrl + V)	The user taps once on the Google text box to bring up the keyboard (Phase 1). The user uses a keyboard shortcut to paste the text – this comprises of pressing the “Ctrl” key (Phase 2) and tapping the “C” key (Phase 3) while pressing it.	
Gesture 3 – Select Option from Context Menu on Google Textbox	The user taps once on the Google textbox (Phase 1). The user taps again on the Google textbox – to the right of where the initial tap was done (Phase 2). Doing so bring up a context menu. The user taps once on the “Paste” menu item (Phase 3) to paste the text.	

Referent 13 – Paste section of text into search engine

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 4 – Single Tap with Finger, Drag Finger Right	The user presses on the Google textbox with the index finger (Phase 1). The user then taps with on the Google textbox with the middle finger (Phase 2), while still pressing with the index finger. The user then drags the middle finger to the right on the Google textbox (Phase 3) to paste the text.	
Gesture 5 – Drag Finger Left on Google Textbox	The user pastes a section of text into Google by dragging a finger from right to left on the Google textbox. This is not done along the entire length of the textbox, but towards the left edge of the textbox.	

Referent 13 – Paste section of text into search engine

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 6 – Two Finger Tap	The user pastes a section of text into Google by tapping once on the Google textbox with both the index and middle fingers.	 A screenshot of the Google homepage with a black silhouette of a hand performing a two-finger tap gesture on the search bar. The browser's address bar shows 'google.com'.
Gesture 7 – Drag Text from “Easel Button” or “Paste Button”	The user pastes a section of text into Google by dragging a finger from the “Easel Button” or “Paste Button” to the Google textbox.	 A screenshot of the Google homepage with a black silhouette of a hand performing a drag gesture. A grey arrow points from a button (representing the 'Easel Button' or 'Paste Button') to the search bar. The browser's address bar shows 'google.com'.

4.6.14 Referent 14 – Open link on the webpage in a new tab

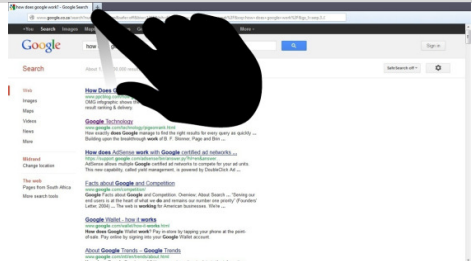
The key points relating to this referent are as follows:

- 19 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).

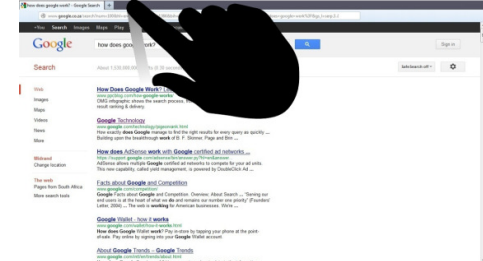
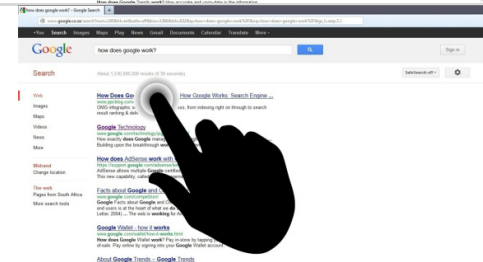
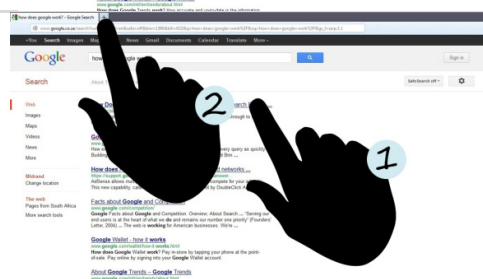
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 8 gestures were assigned to this referent:
 - Gesture 1 – Drag Link to “New Tab Button”; proposed by 4 participants.
 - Gesture 2 – Drag Link to “New Tab Area”; proposed by 4 participants.
 - Gesture 3 – Double Tap Link; proposed by 4 participants.
 - Gesture 4 – Single Tap on Link, Quickly Tap on “New Tab Button” (Jump); proposed by 2 participants.
 - Gesture 5 – Drag Link to “New Tab Area” with Two Fingers; proposed by 1 participant.
 - Gesture 6 – Press Link, Select Option From Context Menu; proposed by 1 participants.
 - Gesture 7 – Drag Finger Over Link, Select Option from Context Menu; proposed by 1 participants.
 - Gesture 8 – Draw “Tab” on Link; proposed by 1 participant.
- The agreement score for this referent was 0.247 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

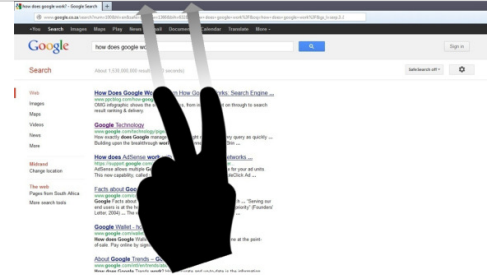
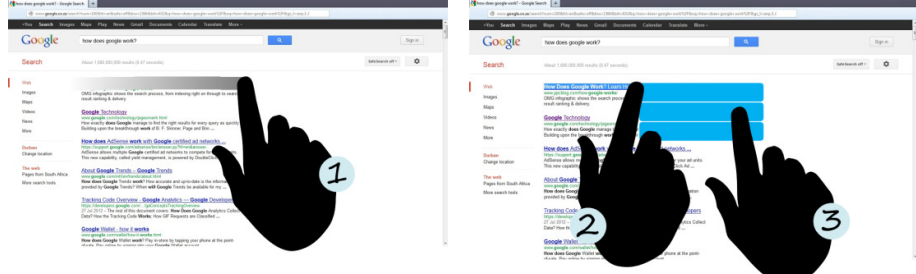
Table 35: Gestures Assigned to Referent14 – Open link on the webpage in a new tab

Referent 14 – Open link on the webpage in a new tab		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 1 – Drag Link to “New Tab Button”	The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Button”.	

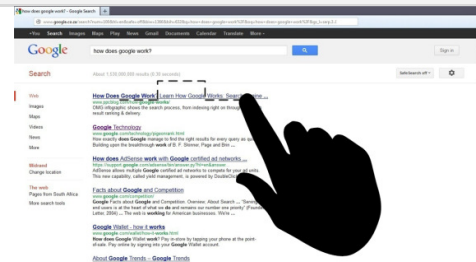
Referent 14 – Open link on the webpage in a new tab

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 2 – Drag Link to “New Tab Area”	The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”).	
Gesture 3 – Double Tap Link	The user opens a link on the webpage in a new tab by double tapping on the link.	
Gesture 4 – Single Tap on Link, Quickly Tap on “New Tab Button” (Jump)	The user opens a link on the webpage in a new tab tapping on the link (Phase 1) and quickly tapping on the “New Tab Button” immediately afterwards (Phase 2).	

Referent 14 – Open link on the webpage in a new tab

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 5 – Drag Link to “New Tab Area” with Two Fingers	The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”) with 2 fingers.	
Gesture 6 – Press Link, Select Option From Context Menu	The user opens a link on the webpage in a new tab by pressing on the link with 1 finger (Phase 1) – this brings up a context menu. The user then taps once on the relevant menu item (Phase 2).	
Gesture 7 – Drag Finger Over Link, Select Option from Context Menu	The user drags 1 finger over the link to be opened in a new tab (Phase 1) – this highlights the link. The user taps on the link to bring up a context menu (Phase 2). The user then taps on the relevant menu item (Phase 3).	

Referent 14 – Open link on the webpage in a new tab

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 8 – Draw “Tab” on Link	The user opens a link on the webpage in a new tab by drawing a “tab” on the link. This consists of a short drag to the right, a short drag up, another short drag to the right, a short drag down and a final drag to the right.	 A screenshot of a Google search results page for the query 'how does google work?'. A hand icon is shown drawing a tab on the first search result link, 'How Does Google Work?'. The hand starts at the bottom of the link, drags it to the right, then up, then right again, then down, and finally right to complete the tab shape.

4.6.15 Referent 15 – Open a new browsing tab

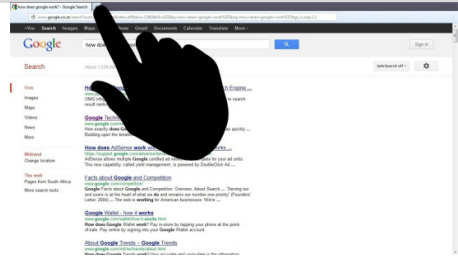
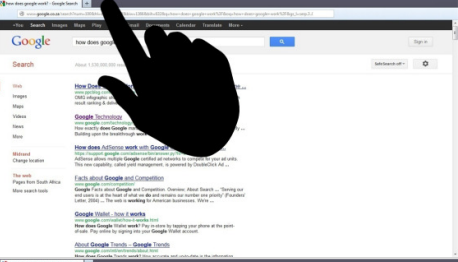
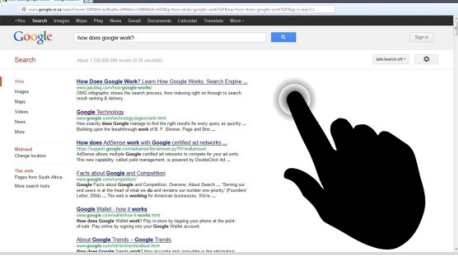
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “New Tab Button”; proposed by 11 participants.
 - Gesture 2 – Single Tap on “New Tab Area”; proposed by 3 participants.
 - Gesture 3 – Double Tap on Whitespace; proposed by 2 participants.
 - Gesture 4 – Select Option from Main Menu; proposed by 1 participant.
 - Gesture 5 – Draw “Tab” on “New Tab Area”; proposed by 1 participant.
 - Gesture 6 – Palm Taps While Moving Hands Apart; proposed by 1 participant.

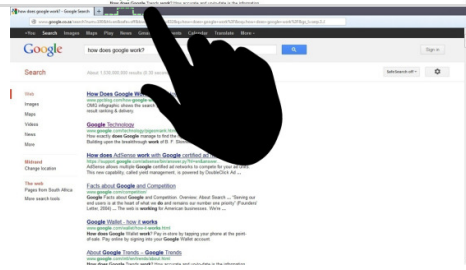
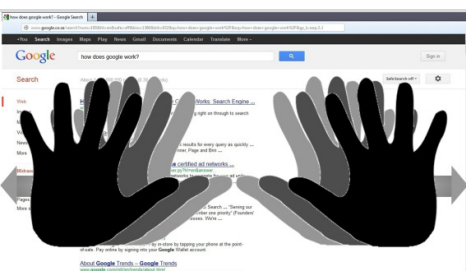
- The agreement score for this referent was 0.345 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 36: Gestures Assigned to Referent15 – Open a new browsing tab

Referent 15 – Open a new browsing tab		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap on “New Tab Button”	The user opens a new browsing tab by tapping once on the “New Tab Button”.	
Gesture 2 – Single Tap on “New Tab Area”	The user opens a new browsing tab by tapping once on the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”).	
Gesture 3 – Double Tap on Whitespace	The user opens a new browsing tab by double tapping with 1 finger on whitespace.	

Referent 15 – Open a new browsing tab

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 4 – Select Option from Main Menu	The user opens a new browsing tab by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1) and tapping once on a menu item that enables him / her to open a new browsing tab.	
Gesture 5 – Draw “Tab” on “New Tab Area”	The user opens a new browsing tab by drawing a “tab” on the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”). This consists of a short drag to the right, a short drag up, another short drag to the right, a short drag down and a final drag to the right.	
Gesture 6 – Palm Taps While Moving Hands Apart	The user opens a new browsing tab by tapping with the palms while moving the palms towards the edges of the screen; the left hand moves towards the left edge of the screen while the right hand moves towards the right edge.	

4.6.16 Referent 16 – Close a browsing tab

The key points relating to this referent are as follows:

- 20 gestures were elicited.

- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Close Tab” Cross; proposed by 15 participants.
 - Gesture 2 – Flick Tab “Off The Screen” With Multiple Fingers (Downward); proposed by 1 participant.
 - Gesture 3 – Drag Tab “Off The Screen” with Two Fingers; proposed by 1 participant.
 - Gesture 4 – Trace “X” on Tab; proposed by 1 participant.
 - Gesture 5 – Push Tab Beneath Adjacent Tab; proposed by 1 participant.
 - Gesture 6 – Single Tap on Tab; proposed by 1 participant.
- The agreement score for this referent was 0.575 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 37: Gestures Assigned to Referent 16 – Close a browsing tab

Referent 16 – Close a browsing tab		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap on “Close Tab” Cross	The user closes a browsing tab by tapping once on the “Close Tab” cross (“x”).	 A screenshot of a web browser interface. A hand icon is shown tapping the 'x' icon in the top right corner of a browser tab. The tab's title is 'Learn How Google Works: in Gory Detail'.
Gesture 2 – Flick Tab “Off The Screen” With Multiple Fingers (Downward)	The user closes a browsing tab by flicking the tab directly downwards using the index, middle, ring and pinkie fingers.	 A screenshot of a web browser interface. A hand icon is shown flicking a browser tab downwards. The tab's title is 'Works: in Gory Detail'.
Gesture 3 – Drag Tab “Off The Screen” with Two Fingers	The user closes a browsing tab by dragging the tab towards the left edge of the screen in a downward motion with 2 fingers.	 A screenshot of a web browser interface. A hand icon is shown dragging a browser tab towards the left edge of the screen. The tab's title is 'Learn How Google Works: in Gory Detail'.

Referent 16 – Close a browsing tab

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 4 – Trace “X” on Tab	The user closes a browsing tab by tracing an “X” on the tab i.e. dragging a finger diagonally from left to right, and then dragging the finger diagonally from right to left.	 A screenshot of a web browser with multiple tabs. A hand is shown tracing an 'X' over a tab titled 'Works: in Gory Detail'. The background shows a Google search page with the text 'Google (g)phic'.
Gesture 5 – Push Tab Beneath Adjacent Tab	The user closes a browsing tab by “pushing it beneath” an adjacent tab. This is done by dragging a finger from right to left over the tab.	 A screenshot of a web browser with multiple tabs. A hand is shown pushing a tab titled 'Learn H...y Detail' beneath another tab. The background shows a Google search page with the text 'Google (g)phic'.
Gesture 6 – Single Tap on Tab	The user closes a browsing tab by tapping on it once with 1 finger.	 A screenshot of a web browser with multiple tabs. A hand is shown tapping on a tab titled 'Works: in Gory Detail'. The background shows a Google search page with the text 'Google (g)phic'.

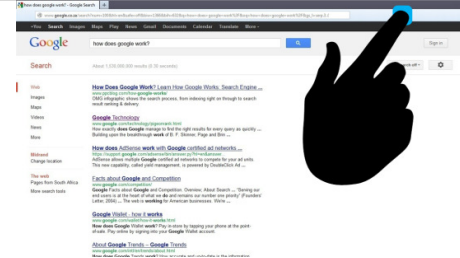
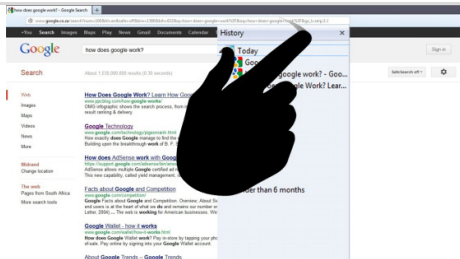
4.6.17 Referent 17 – View record of visited webpages

The key points relating to this referent are as follows:

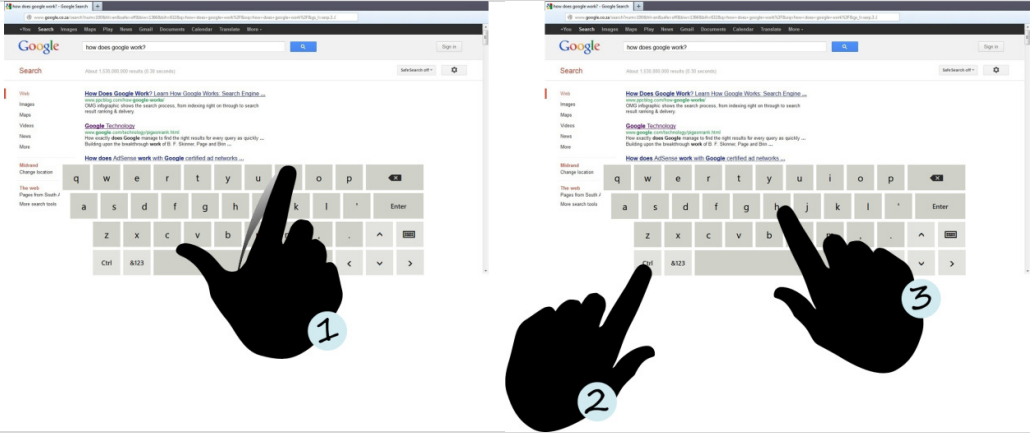
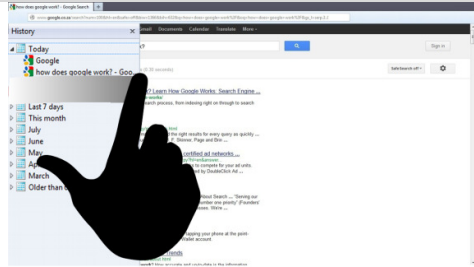
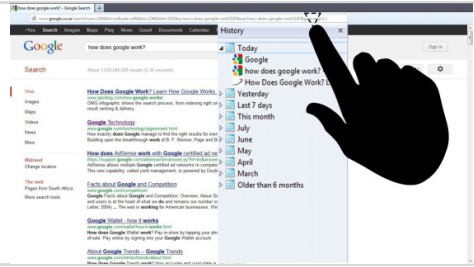
- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 7 gestures were assigned to this referent:
 - Gesture 1 – Single Tap On “History Button”; proposed by 8 participants.
 - Gesture 2 – Select Option From Main Menu; proposed by 3 participants.
 - Gesture 3 – Flick History “Out Of Address Bar”; proposed by 3 participants.
 - Gesture 4 – Use Keyboard Shortcut (Ctrl + H); proposed by 2 participants.
 - Gesture 5 – Drag History Bar Out From Left Edge of Screen; proposed by 1 participant.
 - Gesture 6 – Trace Triangle at Top of Screen; proposed by 1 participant.
 - Gesture 7 – Double Tap with Vertical Side of Hand; proposed by 1 participant.
- The agreement score for this referent was 0.225 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

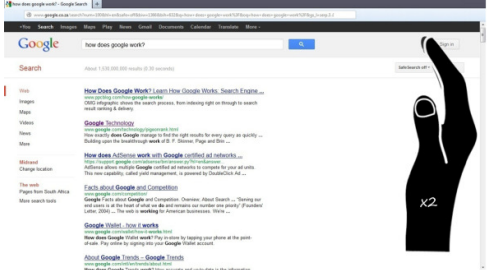
Table 38: Gestures Assigned to Referent 17 – View record of visited webpages

Referent 17 – View record of visited webpages		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap On “History Button”	The user views a record of visited webpages by tapping once on a “History Button”	
Gesture 2 – Select Option From Main Menu	The user views a record of visited webpages by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to view a record of visited pages (Phase 2).	
Gesture 3 – Flick History “Out Of Address Bar”	The user views a record of visited webpages by flicking the history record “out of the address bar”. This is done downwards on the address bar.	

Referent 17 – View record of visited webpages

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 4 – Use Keyboard Shortcut (Ctrl + H)	The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen (Phase 1). The user views a record of visited webpages by using a keyboard shortcut – the user presses the “Ctrl” key (Phase 2) and taps the “H” key (Phase 3) while pressing it.	
Gesture 5 – Drag History Bar Out From Left Edge of Screen	The user views a record of visited webpages by dragging the record out from left edge of the screen with a single finger drag from left to right.	
Gesture 6 – Trace Triangle at Top of Screen	The user views a record of visited webpages by tracing a triangle (upside down) on at the top of screen – around the region of the address bar. This done by performing 3 short drags from each of the sides.	

Referent 17 – View record of visited webpages

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 7 – Double Tap with Vertical Side of Hand	The user views a record of visited webpages by performing a double tap with the vertical side of the hand. This is done on the right edge of the screen.	

4.6.18 Referent 18 – Delete entry from record of visited pages

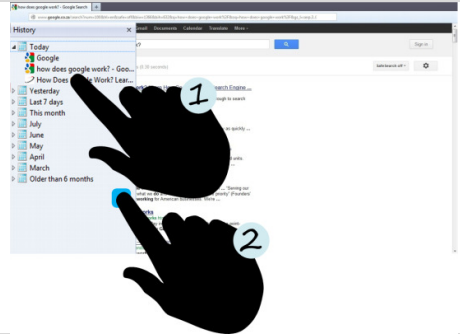
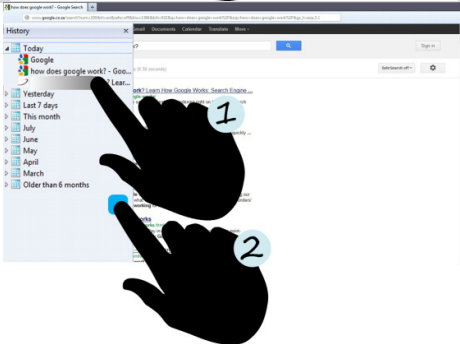
The key points relating to this referent are as follows:

- 19 gestures were elicited.
- 5 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 9 gestures were assigned to this referent:
 - Gesture 1 – Single Tap On History Item, Single Tap on “Delete Button”; proposed by 4 participants.
 - Gesture 2 – Drag Finger Over History Item, Single Tap on “Delete Button”; proposed by 1 participants.
 - Gesture 3 – Trace “X” on History Item; proposed by 1 participants.
 - Gesture 4 – Select Checkbox, Single Tap on “Delete Button”; proposed by 1 participant.
 - Gesture 5 – Single Tap And Drag Finger Over History Item, Trace “X” on History Item; proposed by 1 participant.
 - Gesture 6 – Select Option From Context Menu; proposed by 1 participant.

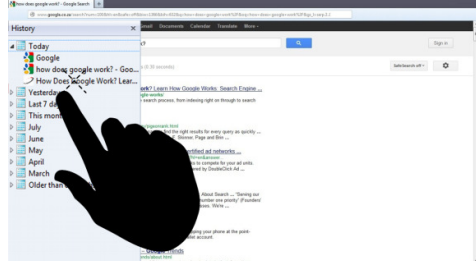
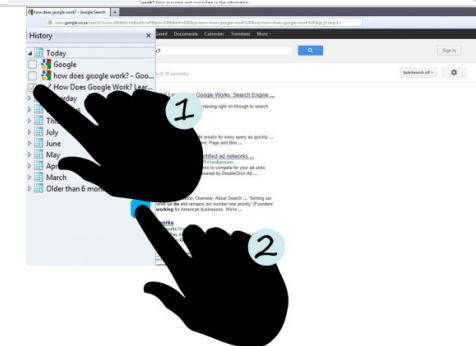
- Gesture 7 – Drag Finger Over History Item to “Rub It Out”; proposed by 1 participant.
- Gesture 8 – Select History Item and Delete Using Keyboard Button; proposed by 1 participant.
- Gesture 9 – Select History Item and “Rub It Out” With Hand; proposed by 1 participant.
- The agreement score for this referent was 0.108 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

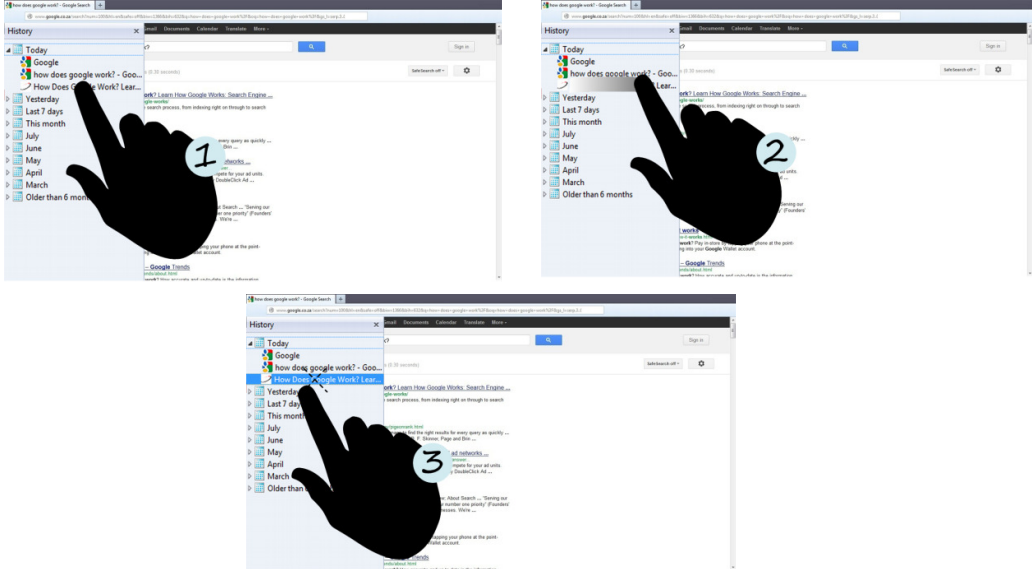
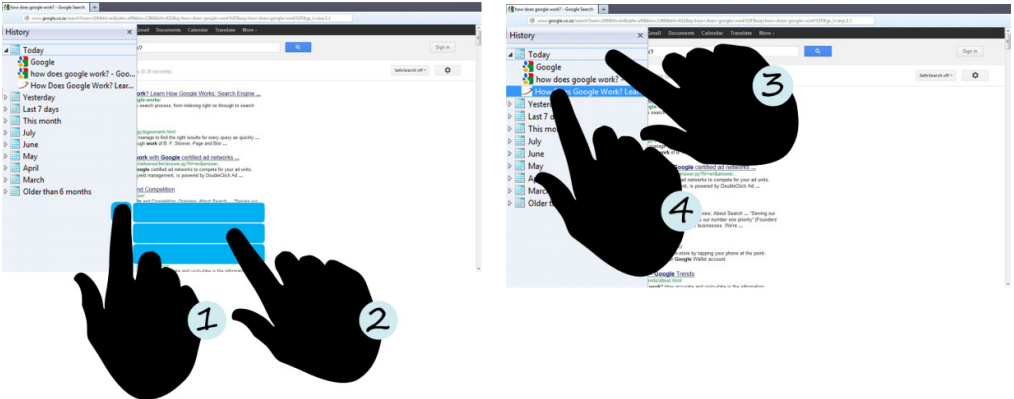
Table 39: Gestures Assigned to Referent 18 – Delete entry from record of visited pages

Referent 18 – Delete entry from record of visited pages		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap On History Item, Single Tap on “Delete Button”	The user deletes an item from the record of visited pages by tapping once on the item (Phase1) and tapping once on a “Delete Button”.	
Gesture 2 – Drag Finger Over History Item, Single Tap on “Delete Button”	The user deletes an item from the record of visited pages by dragging a finger over the item from left to right (Phase1) and tapping once on a “Delete Button”.	

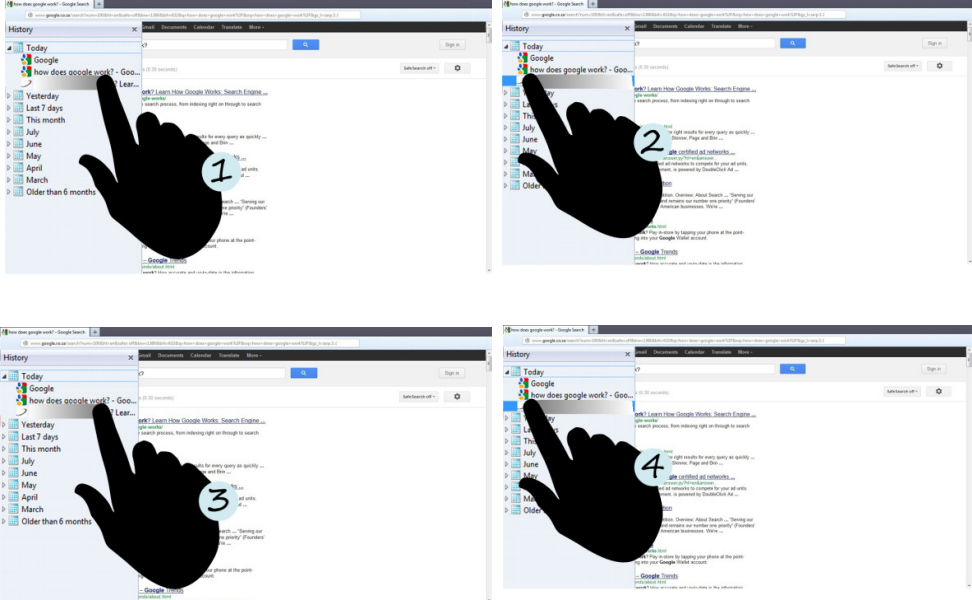
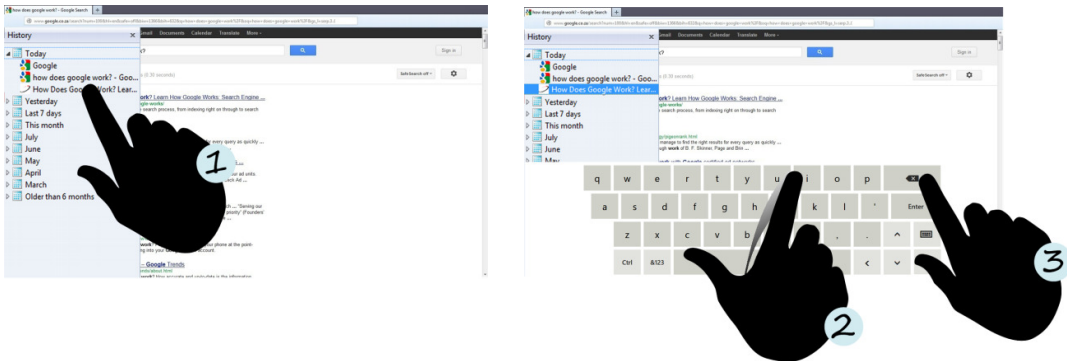
Referent 18 – Delete entry from record of visited pages

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 3 – Trace “X” on History Item	The user deletes an item from the record of visited pages by tracing an “X” over the item i.e. dragging a finger diagonally from left to right (Phase 1), and then dragging the finger diagonally from right to left (Phase 2).	 A screenshot of a web browser's history panel. A hand icon is shown tracing an 'X' over a history entry. The 'X' is formed by two diagonal strokes: one from the top-left to the bottom-right, and another from the top-right to the bottom-left.
Gesture 4 – Select Checkbox, Single Tap on “Delete Button”	The user deletes an entry from the record of visited pages by tapping on a checkbox alongside the item (Phase 1) and tapping on the “Delete Button”.	 A screenshot of a web browser's history panel. A hand icon is shown performing two actions: first, tapping a checkbox next to a history entry (labeled with a circled '1'), and second, tapping a 'Delete' button at the bottom of the panel (labeled with a circled '2').

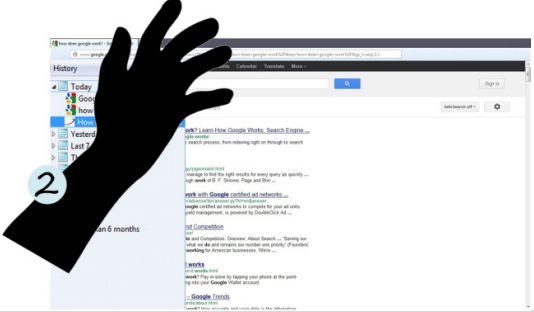
Referent 18 – Delete entry from record of visited pages

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 5 – Single Tap And Drag Finger Over History Item, Trace “X” on History Item	The user taps once on the item to be deleted (Phase 1). The user then drags a finger from left to right over the item (Phase 2). The user then traces an “X” over the item i.e. dragging a finger diagonally from left to right (Phase 3), and then dragging the finger diagonally from right to left (Phase 4) to delete it from the record of visited pages.	
Gesture 6 – Select Option From Context Menu	The user taps once on a button that calls up a context menu (Phase 1). The user then taps once on the menu item that activates the delete function (Phase 2). The user then taps once on the time period during which the item to be deleted exists (Phase 3) – in the illustration, the time period is “Today”. The user taps once on the item to delete it from the record of visited pages (Phase 4).	

Referent 18 – Delete entry from record of visited pages

Gesture Name	Gesture Summary	Gesture Illustration
Gesture 7 – Drag Finger Over History Item to “Rub It Out”	The user deletes an item of the record of visited pages by “rubbing out” the entry. This is done by dragging the finger from left to right over the item (Phase 1). The user then drags the finger from right to left over the item (Phase 2). The user then drags the finger from left to right over the item (Phase 3). The user then drags the finger from right to left over the item (Phase 4).	
Gesture 8 – Select History Item and Delete Using Keyboard Button	The user deletes an item from the record of visited pages using a keyboard shortcut. The user taps once on the item to be deleted (Phase 1). The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen (Phase 2). The user then deletes the item by tapping once on a “Delete” button on the keyboard.	

Referent 18 – Delete entry from record of visited pages

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 9 – Select History Item and “Rub It Out” With Hand	The user drags a finger from left to right over the item to be deleted (Phase 1). The user then “rubs it out” by tapping on it with the lower part of the palm (Phase 2). This is the only gesture during this part of the hand was used.	 

4.6.19 Referent 19 – Save current webpage address within the browser for viewing at a later stage

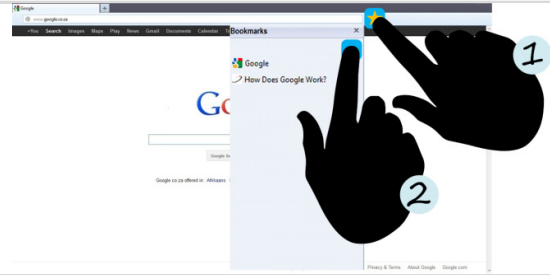
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 5 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 4 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Favourites Button”, Single Tap on “Add Button”; proposed by 5 participants.
 - Gesture 2 – Press on Webpage, Drag Webpage to “Favourites Button”; proposed by 1 participant.
 - Gesture 3 – Single Tap on Webpage, Quickly Tap on “Favourites Button” (Jump); proposed by 1 participants.
 - Gesture 4 – Select Option from Main Menu; proposed by 2 participants.

- Gesture 5 – Drag Webpage with Two Fingers to Address Bar; proposed by 1 participant.
- Gesture 6 – Drag Finger Over Address Bar Twice; proposed by 1 participant.
- The agreement score for this referent was 0.140 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

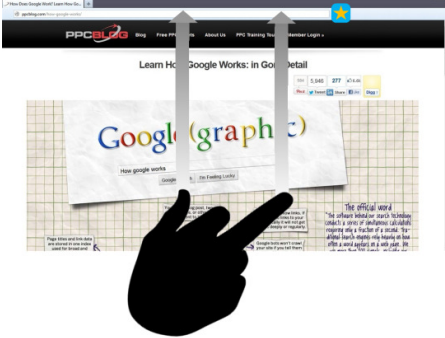
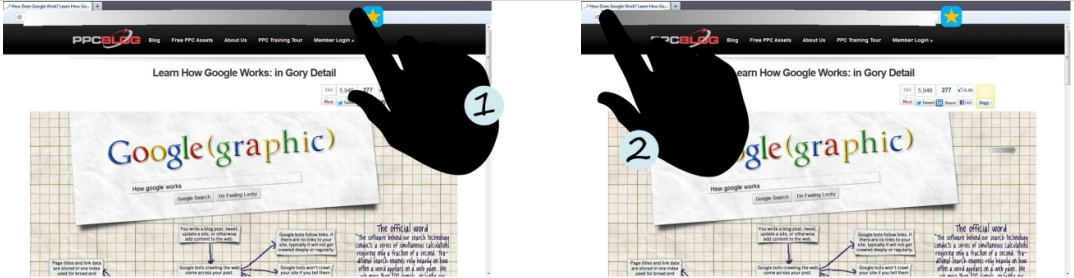
Table 40: Gestures Assigned to Referent 19 – Save current webpage address within the browser for viewing at a later stage

Referent 19 – Save current webpage address within the browser for viewing at a later stage		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap on “Favourites Button”, Single Tap on “Add Button”	The user saves the address of the current webpage within the browser by tapping once on the “Favourites Button” (Phase 1) – this calls up a list of webpages that has been saved, “Favourites”. The user taps once on the “Add Button” to save it.	
Gesture 2 – Press on Webpage, Drag Webpage to “Favourites Button”	The user saves the address of the current webpage within the browser by pressing on the webpage (Phase 1), and dragging it to the “Favourites Button” (Phase 2).	

Referent 19 – Save current webpage address within the browser for viewing at a later stage

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 3 – Single Tap on Webpage, Quickly Tap on “Favourites Button” (Jump)	The user saves the address of the current webpage within the browser by tapping on the page (Phase 1) and quickly tapping on the “Favourites Button”.	
Gesture 4 – Select Option from Main Menu	The user saves the address of the current webpage within the browser by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to save the webpage within the browser (Phase 2).	

Referent 19 – Save current webpage address within the browser for viewing at a later stage

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 5 – Drag Webpage with Two Fingers to Address Bar	The user saves the address of the current webpage within the browser by dragging the webpage to the address bar with 2 fingers.	
Gesture 6 – Drag Finger Over Address Bar Twice	The user saves the address of the current webpage within the browser by dragging a finger over the address bar from left to right (Phase 1). The user then drags the finger from right to left (Phase 2).	

4.6.20 Referent 20 – Call up saved webpage address

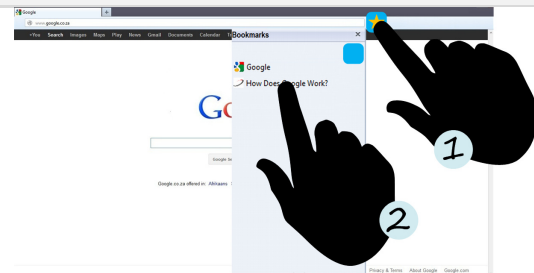
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 4 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).

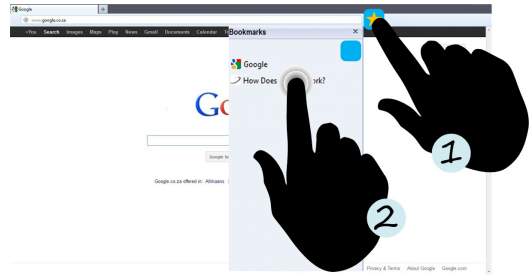
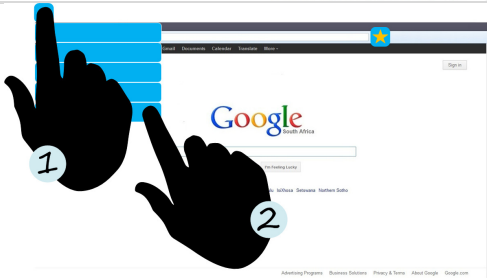
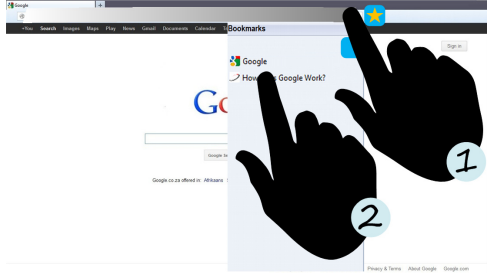
- 3 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 5 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Favourites Button”, Single Tap on “Saved Webpage”; proposed by 9 participants.
 - Gesture 2 – Single Tap on “Favourites Button”, Double Tap on “Saved Webpage”; proposed by 1 participant.
 - Gesture 3 – Select Option from Menu; proposed by 1 participant.
 - Gesture 4 – Drag Finger Over Address Bar, Single Tap on “Saved Webpage”; proposed by 1 participant.
 - Gesture 5 – Double Tap on Address Bar With Two Fingers, Drag Finger Over “Saved Webpage”; proposed by 1 participant.
- The agreement score for this referent was 0.235 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

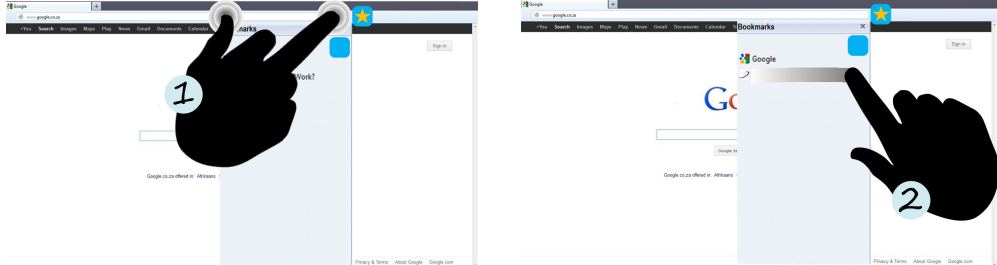
Table 41: Gestures Assigned to Referent 20 – Call up saved webpage address

Referent 20 – Call up saved webpage address		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 1 – Single Tap on “Favourites Button”, Single Tap on “Saved Webpage”	The user calls up a saved webpage address by tapping once on the “Favourites Button” (Phase 1) – this lists all the saved webpages. The user then taps once on the one he / she wants opened (Phase 2).	

Referent 20 – Call up saved webpage address

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 2 – Single Tap on “Favourites Button”, Double Tap on “Saved Webpage”	The user calls up a saved webpage address by tapping once on the “Favourites Button” (Phase 1) – this lists all the saved webpage addresses. The user then double taps on the one he / she wants opened (Phase 2).	
Gesture 3 – Select Option from Menu	The user calls up a saved webpage address by calling up a menu that lists all saved webpage addresses and selecting the appropriate option. This is done by tapping once on a button that calls up a menu of saved webpage addresses (Phase 1), and tapping once on the one he / she wants opened (Phase 2).	
Gesture 4 – Drag Finger Over Address Bar, Single Tap on “Saved Webpage”	The user calls up a saved webpage address by dragging a finger from left to right over the address bar (Phase 1) – this lists all the saved webpage addresses. The user then taps once on the one he / she wants opened (Phase 2).	

Referent 20 – Call up saved webpage address

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 5 – Double Tap on Address Bar With Two Fingers, Drag Finger Over “Saved Webpage”	The user calls up a saved webpage address by double tapping on the address bar with 2 fingers (Phase 1) – this lists all the saved webpage addresses. The user then drags a finger from left to right on the one he / she wants opened (Phase 2).	

4.6.21 Referent 21 – Save image on webpage to memory

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 2 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 5 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 10 gestures were assigned to this referent:
 - Gesture 1 – Lasso Image, Single Tap on “Save Button”; proposed by 1 participant.
 - Gesture 2 – Trace Box Around Image, Single Tap on “Save Button”; proposed by 2 participants.
 - Gesture 3 – Lasso Image, Select Option from Context Menu; proposed by 1 participant.
 - Gesture 4 – Trace Box Around Image, Double Tap Image; proposed by 1 participant.
 - Gesture 5 – Drag Finger Over Upper and Right Edge of Image, Single Tap on “Save Button”; proposed by 2 participants.
 - Gesture 6 – Single Tap on Image, Place Both Hands on Image; proposed by 1 participant.

- Gesture 7 – Select “Snipping Tool” from Main Menu, Drag Fingers Along Boundary of Image; proposed by 1 participant.
- Gesture 8 – Lasso Image, Double Tapping Image With Three Fingers; proposed by 1 participants.
- Gesture 9 –Tapping on Image with Two Fingers; proposed by 1 participant.
- Gesture 10 – Select Option from Special Image Context Menu; proposed by 1 participant.
- The agreement score for this referent was 0.060 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 42: Gestures Assigned to Referent 21 – Save image on webpage to memory

Referent 21 – Save image on webpage to memory		
<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 1 – Lasso Image, Single Tap on “Save Button”	The user saves an image on the webpage to memory by lassoing the image i.e. dragging the finger in an ellipse around the image (Phase 1), and tapping once on the “Save Button” (Phase 2).	

Referent 21 – Save image on webpage to memory

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 2 – Trace Box Around Image, Single Tap on “Save Button”	The user saves an image on the webpage to memory by drawing a box around the image i.e. dragging the finger in a rectangle around the image (Phase 1), and tapping once on the “Save Button” (Phase 2).	
Gesture 3 – Lasso Image, Select Option from Context Menu	The user saves an image on the webpage to memory by lassoing the image i.e. dragging the finger in an ellipse around the image (Phase 1), pressing on the image (Phase 2) to call up a context menu, and tapping once on the option that enables the user to save the image (Phase 3).	
Gesture 4 – Trace Box Around Image, Double Tap Image	The user saves an image on the webpage to memory by drawing a box around the image i.e. dragging the finger in a rectangle around the image (Phase 1), and double tapping with 1 finger (Phase 2).	

Referent 21 – Save image on webpage to memory

Gesture Name	Gesture Summary	Gesture Illustration
Gesture 5 – Drag Finger Over Upper and Right Edge of Image, Single Tap on “Save Button”	The user saves an image on the webpage to memory by dragging the finger along the upper and right edge of the image (Phase 1), and tapping once on the “Save Button” (Phase 2).	
Gesture 6 – Single Tap on Image, Place Both Hands on Image	The user saves an image on the webpage to memory by tapping once on the image (Phase 1). The user then places both hands on the image to save it (Phase 2).	
Gesture 7 – Select “Snipping Tool” from Main Menu, Drag Fingers Along Boundary of Image	The user saves an image on the webpage to memory by selecting a “Snipping Tool” from the main menu and “cutting out” the image to be saved. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the “Snipping Tool” option (Phase 1). The user then “cuts out” the image by tracing a box around the image.	

Referent 21 – Save image on webpage to memory

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
	To trace the left side of the box, the user drags the thumb and index apart (Phase 3). The trace the upper and lower sides of the box, the user drags the thumb and index finger, simultaneously from left to right along the length of the image (Phase 4). To trace the right side of the box, the user drags the thumb and index finger together (Phase 5).	
Gesture 8 – Lasso Image, Double Tapping Image With Three Fingers	The user saves an image on the webpage i.e. dragging the finger in an ellipse around the image (Phase 1), and double tapping with 3 fingers on the image (Phase 2).	

Referent 21 – Save image on webpage to memory

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 9 –Tapping on Image with Two Fingers	The user saves an image on the webpage to memory by tapping on the image with 2 fingers.	 The illustration shows a screenshot of a webpage titled 'Learn How Google Works: in Gory Detail'. A hand with two fingers pointing is shown tapping on a Google graphic that has been placed on the webpage. The graphic is a white sheet of paper with the Google logo and the word '(graphic)' in parentheses.
Gesture 10 – Select Option from Special Image Context Menu	The user saves an image on the webpage to memory by tapping on a special widget that is present on all images on webpages (Phase 1). When tapped, this widget calls up a context menu. The user then taps once on the option that enables him / her to save the image (Phase 2).	 The illustration shows the same webpage as in the previous row. A hand with two fingers pointing is shown tapping on a special widget (a blue rectangle) that is present on all images on webpages. A second hand with two fingers pointing is shown tapping on a context menu that has appeared on the screen. The context menu has two options: 'Save to memory' and 'Save to disk'.

4.6.22 Referent 22 – Save current webpage to memory

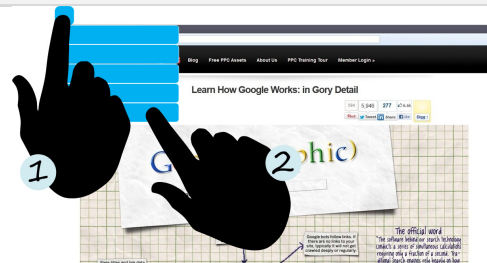
The key points relating to this referent are as follows:

- 20 gestures were elicited.

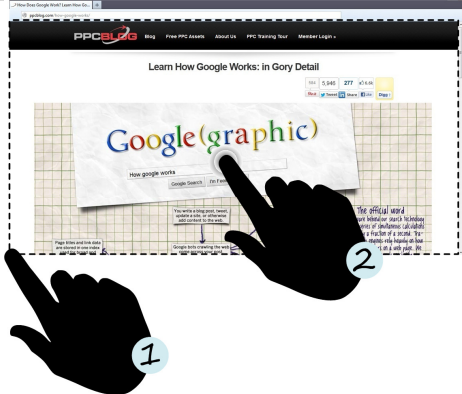
- 1 gesture was excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 7 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Select Option from Main Menu; proposed by 3 participants.
 - Gesture 2 – Single Tap on “Save Button”; proposed by 4 participants.
 - Gesture 3 – Trace Boundary Box on Webpage, Double Tap Webpage; proposed by 1 participant.
 - Gesture 4 – Drag Finger Over Upper and Right Edge of Webpage, Single Tap on “Save Button”; proposed by 1 participant.
 - Gesture 5 – Use Keyboard “Save Button”; proposed by 1 participant.
 - Gesture 6 – Select Option from Special Webpage Context Menu; proposed by 1 participant.
- The agreement score for this referent was 0.105 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 43: Gestures Assigned to Referent 22 – Save current webpage to memory

Referent 22 – Save current webpage to memory		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Select Option from Main Menu	The user saves the current webpage to memory by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to provide a search query (Phase 2).	

Referent 22 – Save current webpage to memory

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 2 – Single Tap on “Save Button”	The user saves the current webpage to memory by tapping once on a “Save Button”.	 A screenshot of a webpage titled "Learn How Google Works: in Gory Detail" with a "Google(graphic)" image. A hand icon is shown tapping a small button in the top right corner of the page.
Gesture 3 – Trace Boundary Box on Webpage, Double Tap Webpage	The user saves the current webpage to memory by drawing a box around the frame of the webpage i.e. dragging the finger in a rectangle around the current frame of the webpage (Phase 1), and double tapping with 1 finger (Phase 2).	 A screenshot of the same webpage. A dashed rectangular box outlines the main content area. Two hand icons are shown: one (labeled '1') tracing the bottom-left corner of the box, and another (labeled '2') double-tapping the bottom-right corner of the box.

Referent 22 – Save current webpage to memory

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 4 – Drag Finger Over Upper and Right Edge of Webpage, Single Tap on “Save Button”	The user saves the current webpage to memory by dragging the finger along the upper and right edge of the webpage (Phase 1), and tapping once on the “Save Button” (Phase 2).	The illustration shows a hand performing a drag gesture along the top and right edge of a webpage (Phase 1), followed by a tap on a 'Save' button (Phase 2). The webpage displayed is 'Learn How Google Works: in Gory Detail'.
Gesture 5 – Use Keyboard “Save Button”	The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen (Phase 1). The user then taps once on “Save Button” on the keyboard.	The illustration shows a hand performing a flick gesture from the bottom of the screen to reveal a keyboard (Phase 1), followed by a tap on a 'Save' button on the keyboard (Phase 2). The webpage displayed is 'Learn How Google Works: in Gory Detail'.

Referent 22 – Save current webpage to memory

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 6 – Select Option from Special Webpage Context Menu	The user saves the current webpage to memory by tapping on a special widget that is present on all on webpages (Phase 1). When tapped, this widget calls up a context menu. The user then taps once on the option that enables him / her to save the webpage (Phase 2).	

4.6.23 Referent 23 – Request help

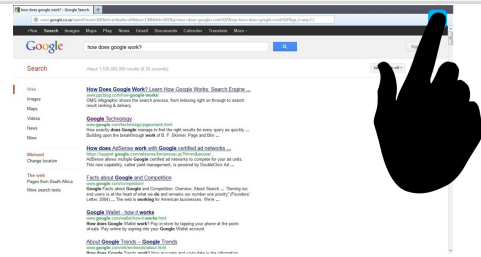
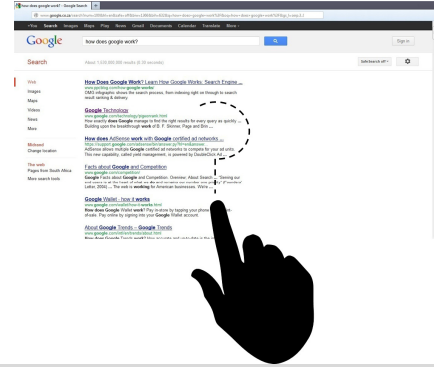
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 4 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 5 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Help Button”; proposed by 12 participants.
 - Gesture 2 – Trace a Question Mark in Middle of Screen; proposed by 1 participant.
 - Gesture 3 – Select Option from Main Menu; proposed by 1 participant.

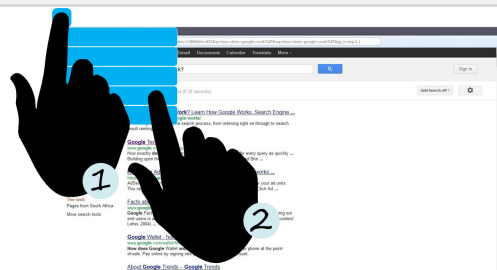
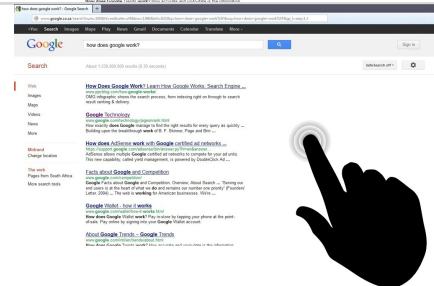
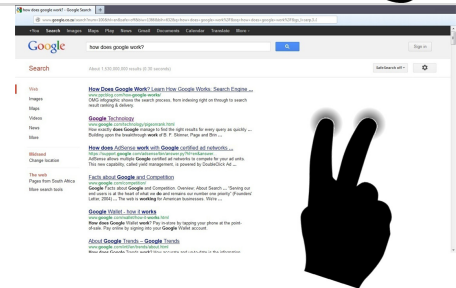
- Gesture 4 – Triple Tap on Screen; proposed by 1 participant.
- Gesture 5 – Two Finger Press on Screen; proposed by 1 participant.
- The agreement score for this referent was 0.380 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 44: Gestures Assigned to Referent 23 – Request help

Referent 23 – Request help		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap on “Help Button”	The user requests help by tapping once on a “Help Button”.	
Gesture 2 – Trace a Question Mark in Middle of Screen	The user requests help by tracing a question mark in the middle of the screen. This consists of a curved drag (denoting the curved part of the question mark) and a tap (denoting the dot below the curved part).	

Referent 23 – Request help

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 3 – Select Option from Main Menu	The user requests help by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that provides help (Phase 2).	
Gesture 4 – Triple Tap on Screen	The user requests help by tapping three times in quick succession with one finger.	
Gesture 5 – Two Finger Press on Screen	The user requests help by pressing on the screen with two fingers.	

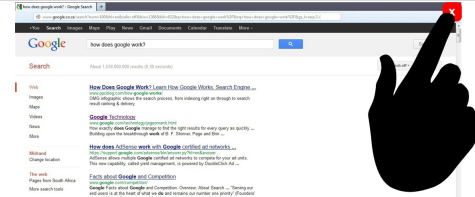
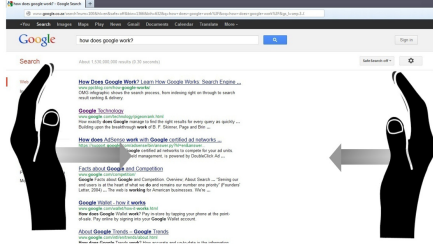
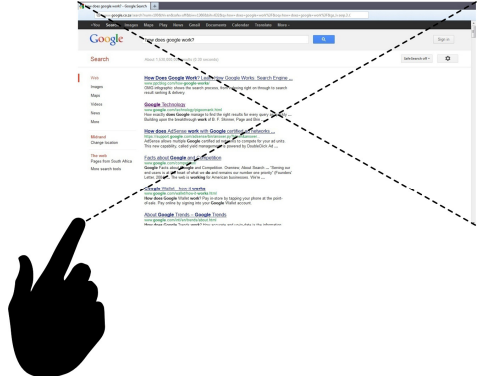
4.6.24 Referent 24 – Close web browser

The key points relating to this referent are as follows:

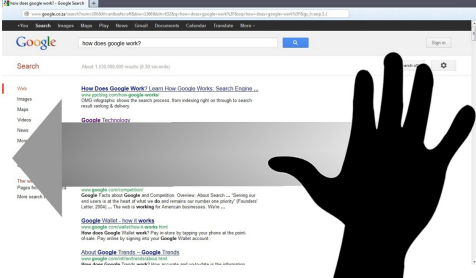
- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 4 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on "Close Button" (Top Right Corner of Screen); proposed by 14 participants.
 - Gesture 2 – Drag Hands from Left and Right Edges to Centre of Screen; proposed by 2 participants.
 - Gesture 3 – Trace "X" Across The Screen; proposed by 2 participants.
 - Gesture 4 – Drag Hand Across Screen ("Waving Goodbye"); proposed by 1 participants.
- The agreement score for this referent was 0.515 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 45: Gestures Assigned to Referent 24 – Close web browser

Referent 24 – Close web browser		
Gesture Name	Gesture Summary	Gesture Illustration
Gesture 1 – Single Tap on "Close Button" (Top Right Corner of Screen)	The user closes the web browser by tapping once on a “Close Button” located at the top right corner of the screen.	
Gesture 2 – Drag Hands from Left and Right Edges to Centre of Screen	The user closes the web browser by dragging the lower part of the left hand from the left edge of the screen to the middle of the screen (Phase 1), while simultaneously dragging the lower part of the right hand from the right edge of the screen to the middle (Phase 2).	
Gesture 3 – Trace "X" Across The Screen	The user closes the web browser by tracing an “X” across the screen i.e. dragging a finger diagonally from the top left corner of the screen to the bottom right corner (Phase 1) and then dragging a finger from the top right corner of the screen to the bottom left corner (Phase 2).	

Referent 24 – Close web browser

<i>Gesture Name</i>	<i>Gesture Summary</i>	<i>Gesture Illustration</i>
Gesture 4 – Drag Hand Across Screen ("Waving Goodbye")	The user closes the web browser by dragging the palm of the hand across the screen from right to left.	 The illustration shows a web browser window with a Google search page. A large, semi-transparent grey arrow points from the right edge of the screen towards the left, indicating the direction of the gesture. A black silhouette of a hand is positioned at the right end of this arrow, with its palm facing the screen, representing the user's hand performing the 'Waving Goodbye' gesture to close the browser.

4.7 CONCLUSION

This concludes the Data Analysis chapter which presented the demographics of participants, provided data on the gestures provided by participants and discussed these data in relation to the hypotheses made in the previous chapter. This chapter also presented the final, coherent user-defined gesture set for conducting an informational search, which was the aim of the study. Each gesture that comprises the final gesture set was illustrated graphically, and accompanied by its attributes.

It should be noted that the final gesture is fairly large and comprises a variety of gestures for each function. This diversity in the approaches employed by participants to complete tasks implies that tasks should indeed be designed in a way that enables users to complete them in varying ways – allowing, for example, the use of different gestures for the same task, or differing combinations of gestures for that task.

5. DISCUSSION

This chapter discusses the various considerations for gesture design, emanating from the results presented in the previous chapter and the hypotheses. It explains the significance and implications of these results for the design of tablet web browsing gestures. Important results are highlighted and explanations are provided where there are unexpected results.

5.1 CO-EXISTENCE OF ONE-HAND AND TWO HANDED GESTURES

As illustrated in the previous chapter, data supported Hypothesis 1: when asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, the use of one-handed gestures is more likely to be observed than the use of two-handed gestures. Based on this, the following implications arise:

- The use of two-handed gestures should be limited.
- If two-handed gestures are developed for a specific function, an alternative one-handed gesture should be made available.

It is also worth noting that during the experiments, participants did not actually hold the iPad in their hands – it was placed on the table, facing participants at an incline. It should not be forgotten that tablets are hand-held devices and that in other scenarios the tablet may be held in one hand, while the other hand gestures. This means that although participants had both hands available for gesturing, they still opted to use one-handed gestures. While this adds further credence to the implication above there is, however, an exception to these.

Frisch et al (2009) had noted that two-handed gestures had been preferred for two tasks, these were related to resizing; the *scale node* task (where the size of a single node is either increased or decreased) and the *zoom diagram* task (where the size of the entire diagram is either increased or decreased). Similarly, Hinrichs and Carpendale (2011) had pointed out users had preferred to gesture with one hand instead of two, with the resizing being the only exception. It is therefore noteworthy that the referents for which the most two-handed gestures were elicited were for the gestures relating to resizing; Referent 6 – Make webpage content larger and Referent 7 – Make webpage content smaller. This implies that two-handed gestures should be specifically considered for functions that relate to resizing. For these functions, if a one-handed gesture has been developed, a two-handed gesture should be made available as an alternative.

5.2 INCLUSION OF DESKTOP COMPUTING ADAPTATIONS IN TABLET BROWSING

Three hypotheses addressed desktop computing adaptations;

- Hypothesis 2A: When asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, the majority of participants will use gestures that are adaptations of desktop computing, with single finger taps substituting mouse clicks and single finger drags substituting mouse drags.
- Hypothesis 2B: When asking novice users to simulate tasks related to an informational search on a multi-touch tablet device the majority of participants will provide gestures using their index fingers.
- Hypothesis 2C: When asking novice users to simulate tasks related to an informational search on a multi-touch tablet device, the majority of participants will incorporate the use of menus (main menus and context menus) into their gestures.

The data collected strongly supported Hypothesis 2A and Hypothesis 2B. This suggests that when browsing on tablet devices, users rely heavily on desktop computing as a point of reference for their gestures. As such the following implications arise:

- It is not be advisable to create completely novel gestures for tablet web browsing that do not correspond to any of the ways in which desktop web browsing is performed.
- Should novel gestures be developed for tablet web browsing, gestures that are desktop computing adaptations, including those that require menu access, should be made available as alternatives to users.

A key observation is that users drew upon their experiences of desktop computing despite the removal of graphical elements relating to Windows or Macintosh operating systems; these included menus, title bars and buttons – including the navigation icons / buttons such as “Back”, “Refresh”. Epps et al (2006) had explained that the extensive use of the index finger in their study may have resulted from the “Windows-centric” screen shots presented to the participants. This study, however, also found that participants largely used their index fingers despite the absence of Windows or Macintosh elements. Similar to the findings of Epps et al (2006) for example, most participants (14 out of 20) tapped on an imaginary “X” in the top right-hand corner of the screen for closing the application (Referent 24 – Close web browser). This is despite the fact that none of the referents had the “Minimise”, “Maximise” and “Close” buttons typically found on the top right corner of windows. This reflects the views of Wobbrock et al (2009) who point out that desktop computing is deeply ingrained in users’ minds. As such, it may be prudent to use desktop computing adaptations for web browsing on tablets.

A major disadvantage of using of desktop computing adaptations is that they may not make the best use of multi-touch technology, especially given the predominant use of single finger taps. The advantage of this approach, however, is that users can move between their desktops, which they are familiar with, and their tablet devices without having to learn or memorise new ways with which to interact with the tablet web browser. Micire et al (2009) share a similar view as they suggest that mouse-type interactions should be carried over into the multi-touch domain as this would make gesture sets easier for users to learn.

Adopting this approach, however, introduces certain complexities; scrolling provides a good example of this. Mauney et al (2010) note that in their study, approximately 70% of the participants that owned devices that employed swiping gestures (drags / flicks) for scrolling up or down, dragged / flicked *upwards* on the screen in order to scroll *down*. In contrast, Mauney et al (2010) note that approximately 50% of participants who owned devices that employed arrow keys or scroll bars, dragged / flicked *downwards* to scroll *down*. The fact that Windows and Macintosh operating systems generally employ arrow keys or scroll bars explains why it is that most participants (13 out of 20) in this study dragged or flicked downwards on the screen to scroll down the webpage, and vice versa⁵. The complexity introduced by adopting a desktop computing adaptation in this situation, and allowing users to drag downwards in order to scroll down, means that users that have become accustomed to dragging / flick upwards to scroll down will find this method of scrolling unintuitive.

In this situation, both types of users, those who drag upwards to scroll down (and vice versa) and those who drag downwards to scroll down (and vice versa), cannot both be accommodated, as one gesture (in this case dragging down) cannot produce two different outcomes. The recommendation in such situations would be to allow users to decide which outcomes should be produced when dragging downwards or upwards by allowing users to configure what function should be mapped to which gesture. Although used as an example, it should be noted that scrolling is an action that users perform frequently when web browsing, with users sometimes viewing information that is located at the lower areas on long pages (Budiu and Nielsen, 2010; Budiu and Nielsen, 2011). This highlights another observation; users tended to apply their gestures for scrolling up and down the right edge of the screen or the middle of the screen – as illustrated in the user-defined gesture set. This implies that enough space must be made available on the right edge of the screen to allowing for scrolling gestures, which is a recommendation also provided by Budiu and Nielsen (2011).

⁵ A similar stance may be taken for Referent 2 – Go to previous webpage and Referent 3 – Go to next webpage where participants dragged left to revert to the previous page and dragged right to move to the next page as browsers tend to have an arrow button pointing to the left for reverting to the previous page, and an arrow button pointing to the right for going to the next page.

Budiu and Nielsen (2011) further recommended that designers or developers should avoid covering pages with carousels and other design features that may interfere with scrolling gestures.

The use of desktop computing adaptations should, however, not overshadow the fact that several participants produced novel gestures, such as dragging a finger repeatedly over an item to delete it, as if “rubbing it out” (Referent 18), dragging a browsing tab “off the screen” to close it (Referent 16) and tracing a question mark on the screen to activate the “Help” function (Referent 23), but to mention a few. These should not be excluded from the gestures set, but as previously mentioned designers and developers should try to ensure that such gestures co-exist with gestures that are desktop computing adaptations, including those gestures that require the use of menus.

Micire et al (2009) reported that less than a third of the participants in their study requested menu access. This was contrary to the studies conducted by Wobbrock et al (2009) and Mauney et al (2010). The explanation offered was that the application domain of controlling robot teams, which the study conducted by Micire et al (2009) investigated, was not common in desktop computing. This is not the case, however, with web browsing, and yet even few participants required menu access; 10.082% of all gestures provided required menu access. A possible explanation for this is that the participants in this study use menus sparingly when web browsing on desktops, and as such did not require a great deal of menu access. Another possible explanation is that users had no difficulties in coming up with gestures for the various referents presented to them. Mauney et al (2010) pointed out that participants in their study requested a menu when they had difficulty thinking of a gesture. Given that lack of gestures that require menu access in this study, it may be argued that participants found it easy to create gestures and as such used menus less frequently. Despite the infrequency of gestures that require menu access, it is important for these to be made available to users as an alternative way of carrying out various functions, as noted by Norman and Nielsen (2010).

5.3 ENABLING GESTURE RE-USE

Two hypotheses address gestures re-use

- Hypothesis 3A: When asking novice users to simulate gestures for tasks related to an informational search on a multi-touch tablet device, gesture re-use will be observed i.e. participants will attempt using the same gesture to accomplish different tasks (in different interactive contexts).
- Hypothesis 3B: When asking novice users to simulate gestures for complex tasks related to an informational search on a multi-touch tablet device, participants will sequence gestures but in different combinations based on their judgment of how the task should be decomposed.

The data collected strongly supported Hypothesis 3A and Hypothesis 3B. Based on this, the following implications arise:

- Tasks should be designed in such a way that they may be completed with a variety of gestures.
- Complex tasks should be designed in such a way that they may be achieved through varying combinations of gestures.

The right-most column of Table 12 (Frequency of all Gestures Used) is entitled “Different Gestures Used” and shows the variety of gestures used for each referent. The first thing to note when looking at this column is that all the referents, without exception, elicited different gestures from participants. Referent 4 “Stop loading webpage content” elicited the least variety of gestures with 3 different gestures being used, while Referent 21 “Save image on webpage to memory” elicited the greatest variety of gestures, with 12 gestures in total being used. This reinforces the existing knowledge that users differ in how they go completing various tasks. For designers and developers, it means that gesture re-use is essential and should be maximised, while obviously ensuring that no conflicts occur. There are 5 gestures specifically that need to be taken into account by designers and developers when re-use is being considered, as shown in the data collected; the one finger tap, the one finger drag, the one finger flick, the one finger press and the one finger double-tap. These accounted for 86.065% of all gestures provided by participant across all referents, with the one finger tap and one finger drag jointly accounting for 74.855%.

As would be expected, similar dominance of this pair of gestures was seen when analysing sequential compound gestures, accounting for 87.077% of all sequential compound gestures used. Putting these two gestures aside, however, only 8 of the remaining 36 gestures were re-used in sequential compound gestures. This once more illustrates the limited scope of gestures that participants are readily willing to use, and re-use.

5.4 CONCLUSION

This chapter discussed the key considerations for gestures design, based on the results presented in the previous chapter as well as the hypotheses. It explained the significance and implications of these results for the design of tablet web browsing gestures.

It should be noted that all the above considerations are encapsulated in the user-defined gesture set presented in this study, which serves as a key output of this study.

6. CONCLUSION

This chapter provides conclusions regarding the research problem that was set out at the start of the paper. It provides a brief summary of the research report highlights the limitations of the study and identifies future research directions arising from the study.

6.1 RESEARCH PROBLEM

The research problem this study set out to solve was: what is the most intuitive user-defined gesture set for conducting an informational search on a multi-touch tablet web browser? The gesture set produced by this study answers this question, with the key observation being that users generally attempt to replicate their desktop experience, substituting the mouse pointer with their fingers; typically using one finger taps, that resemble clicks, and one finger drags that resemble mouse drags. This implies that pointer-type gestures should be used in gesture design. It should be noted, however, that there are situations where users prefer to use multi-touch gestures that are not derivatives of desktop computing. These are in the minority, however.

To accommodate users that have strong reliance on desktop computing, as well as those that wish to create a new and different experience, while also trying to best utilise the offerings of multi-touch technology, it is incumbent on designers and developers of tablet web browsers to find ways with which the pointer-based interactions and novel, multi-touch gestures can co-exist.

6.2 AIM OF THE STUDY

The study has achieved its aim of creating a user-defined gesture set for conducting an informational search on a multi-touch tablet web browser based on gestures elicited from participants. This was achieved by utilising the design science research paradigm and employing participatory design methods to elicit gestures from participants. For each of the gestures in the final user-defined gesture set, the following attributes were provided:

- Form; which relates to which, and how many, part(s) of the hand(s) were used and how these part(s) made contact with the screen
- Nature; which relates to whether the gesture was symbolic, physical, metaphorical or arbitrary
- Binding; which relates to whether the gesture was object-centric, world-dependent, world-independent, or had mixed dependencies
- Flow; which relates to whether the gesture was discrete or continuous

These were accompanied by an illustration of the gesture.

6.3 LIMITATIONS

This study had various limitations that need to be taken in consideration. The first of these is that participants were mainly university staff. This means that they may not be representative of the general population. Furthermore all the participants in the study were adults; the average age of the participants was 40 years. Hinrichs and Carpendale (2011) have shown that adults and children tend to differ in their choice of gestures – as such the gesture set may have been different had the participant group constituted children or teenagers. A further limitation, with respect to the participants is that they were mainly right-handed. The participant group was, therefore, not representative of the general population in terms of handedness. The gesture set may have been different had there been greater representation of left-handed people.

No work was done in analysing the gestures provided in relation to the demographics of the participants e.g. identifying whether there were any patterns or tendencies in the gestures provided by male participants in comparison to those provided by female participants, or contrasts in the gestures proposed by participants that use Google frequently and those that use it occasionally. This type of analysis may have revealed some insights in terms of the participants' demographic data influenced their choice of gestures.

The final limitation is with respect to the functions for which gestures were elicited. As previously noted, the study only addressed functions that directly enable or support the activity of conducting an informational search on the front-end; all functions relating to background configurations, preferences and settings were excluded from the analyses of functions. This means that while the user-defined gesture set addressed the key functions for conducting an information search, it does not cover the full complement of web browsing functions.

6.4 FUTURE RESEARCH

There are various implications for future research. The first of these would be to conduct usability studies on the user-defined gesture set, using completely different participant groups, to determine the extent to which the gestures presented in this study are usable in practice. Prospective research questions could include:

- How learnable and memorable are user-defined gestures in comparison to those used in existing multi-touch tablet web browsers?

- What difficulties, if any, would experienced users of multi-touch tablet devices encounter in adopting a user-defined gesture set based on users with limited or no experience of touch screen devices?

Following investigation of these research questions, further studies could determine the extent to which all the gestures provided may be supported by existing multi-touch hardware and gesture recognition software; addressing whether it would be feasible for a tablet web browser to support the large gesture set presented by this study, and if not, how best the gesture set could be reduced without adversely affecting usability. Furthermore, an investigation could be conducted on the reliability of recognising the novel gestures presented.

It would be recommended that other similar studies be conducted for tablet devices, but focusing on a variety of other application contexts, such as word processing, note taking, viewing videos, playing music and gaming. With tablet devices becoming more popular within the public domain, it becomes increasingly important to ensure that usability requirements for the various activities that tablet devices support are well understood by those in practice.

6.5 IMPLICATIONS FOR DESIGNERS AND DEVELOPERS

The results of Research and Development endeavours undertaken by companies involved in designing interfaces or web browsing software for multi-touch tablet devices are generally not made publicly available. When these results are eventually published for public consumptions, it is often after a significant time period has passed since the completion of the research or after the company has already enjoyed first mover advantage based on the knowledge acquired through the research effort. Patents and other proprietary standards that inhibit competitors from using the same gestures generally follow. This would be expected as these companies need to create or maintain a competitive advantage in order to remain profitable. Unlike the research efforts of these companies, the results of this study are made publicly available for general consumption, and fairly quickly upon completion.

This study offers a user-defined gesture set for conducting an informational search on multi-touch tablet web browser. The gestures were elicited from a study of inexperienced tablet users who served as the participants.. This user-defined gesture set may be used as it currently exists by gesture designers or developers who to use it in new versions of web browsing software for multi-touch tablet devices (if feasible to do so). As the gesture set is fairly large, designers may decide only to use certain gestures, or to modify certain gestures, as they deem fit for their applications. Furthermore, while these gestures have been created specifically for conducting an informational search on a multi-touch tablet web browser, it is not

inconceivable that designers may employ some of the gestures presented in this study in various other application contexts as functions such as “searching for text” or “request help” are not limited to web browsing application context.

In addition to the user-defined gesture set, this study provided various insights for multi-touch tablet browsing more especially the gestures related to this activity; as presented in the previous chapter. These enhanced the understanding or appreciation of what users, specifically those have had limited or no prior experience with touch screen devices, consider to be intuitive. This understanding will enable designers to design gestures that are aligned to the naïve or natural expectations of their users, and would therefore results in satisfactory or enjoyable experiences for these users – potentially attracting such other users, or non-users, to their applications.

6.6 CONCLUSION

As noted by Bruno and Muzzupappa (2010): the design of the interface is a critical task in the product development process, because it directly influences the customers’ satisfaction and, consequently, the success of the product on the market. The importance of usability in today’s fiercely competitive tablet market can, therefore, not be overstated. In such an aggressive market, each contribution made, regardless of its magnitude, becomes invaluable. The contribution of this study to current practice is a coherent, user-defined gesture set for conducting an informational search on a multi-touch tablet device – as was initially set out in aims of the study. In addition to this, the study provided insights that relate to gesture design. Both these contributions may prove beneficial not only to those designing and developing multi-touch tablet interfaces, but also to their users.

7. REFERENCES

- Adikari, S., McDonald, C., Collings, P. (2006). A Design Science Approach to an HCI Research Project. In Proceedings of the 2006 Australasian Computer-Human Interaction Conference, OZCHI 2006, Sydney, Australia, 20–24 November.
- Apple (2012). Technical Specifications [Online]. Available: <http://www.apple.com/ipad/specs/> [1 March 2012]
- Ashbrook, D., and Starner, T. (2010). MAGIC: A Motion Gesture Design Tool. In Proceedings of the 28th International Conference on Human Factors in Computing Systems - CHI '10, Atlanta, USA, 10 – 15 April.
- Bachl, S., Tomitsch, M., Wimmer, C., and Grechenig, T. (2010). Challenges for Designing the User Experience of Multi-touch Interfaces. Engineering Patterns for Multi-Touch Interfaces 2010, a workshop of the ACM SIGCHI Symposium on Engineering Interactive Computing Systems 2010, Berlin, Germany, 19 – 23 June.
- Bhattacharjee, A. (2011). Social Science Research: Principles, Methods and Practises [Online]. http://dl.dropbox.com/u/31779972/Social_Science_Research.pdf [20 April 2012]
- Broder, A. A Taxonomy of Web Search. SIGIR Forum 36(2):3–10, 2002.
- Bruno, F., and Muzzupappa, M. (2010). Product interface design: A participatory approach based on virtual reality. International Journal of Human-Computer Studies, 68 (2010): 254–269.
- Budiu, R., and Nielsen, J. (2010). Usability of iPad Apps and Websites [Online]. Available: http://www.nngroup.com/reports/mobile/ipad/ipad-usability_1st-edition.pdf [28 June 2011]
- Budiu, R., and Nielsen, J. (2011). Usability of iPad Apps and Websites 2nd Edition [Online]. Available: http://www.nngroup.com/reports/mobile/ipad/ipad-usability_2nd-edition.pdf [28 June 2011]
- Cechanowicz, J., Irani, P., and Subramanian, S. (2007). Augmenting the Mouse with Pressure Sensitive Input. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems – CHI 2007, San Jose, California, USA, 28 April – 3 May.
- Chung, P., Fang, B., and Quek, F. (2008). MirrorTrack – A Vision Based Multi-Touch System for Glossy Display Surfaces. Stevenage, Hertfordshire: The Institution of Engineering and Technology.
- Clicky Web Analytics (2012). Search engines (Global marketshare) [Online]. <http://www.getclicky.com/marketshare/global/search-engines/> [June 2012]
- Downey, D., Dumas, S., Liebling, D., and Horvitz, E. (2008). In Proceedings of the 17th Conference on Information and Knowledge Management – CIKM '08, Napa Valley, California, USA, 26 – 30 October.
- Epps, J., Lichman, S., and Wu, M. (2006). A Study of Hand Shape Use in Tabletop Gesture Interaction. In Proceedings of the 2006 Annual Conference on Human Factors in Computing Systems – CHI '06, Montreal, Canada, 22 – 27 April.

Fleischmann, K. R. (2006). Do-It-Yourself Information Technology: Role Hybridization and the Design–Use Interface. *Journal of the American Society for Information Science and Technology*, 57(1):87–95.

Freeman, D., Benko, H., Morris, M. R., and Wigdor, D. (2009). ShadowGuides: Visualizations for In-Situ Learning of Multi-touch and Whole-Hand Gestures. In *Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces - ITS '09*, Banff, Alberta, Canada, 23 – 25 November.

Frisch, M., Heydekorn, J., and Dachzelt, R. (2009). Investigating Multi-touch and Pen Gestures for Diagram Editing on Interactive Surfaces. In *Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces – ITS '09*, Calgary, AB, Canada, 23 – 25 November.

Han, J. Y. (2005). Low-Cost Multi-Touch Sensing through Frustrated Total Internal Reflection. In *Proceedings of the 18th annual ACM symposium on User Interface Software and Technology – UIST '05*, Seattle, Washington, USA, 23 – 27 October.

Harrison, N., and Barrios, J. (2010). Apple Sells Three Million iPads in 80 Days [Online]. Available: <http://www.apple.com/pr/library/2010/06/22ipad.html> [19 February 2011]

Hevner, A. R., and March, S. T. (2003). The Information Systems Research Cycle. *IT Systems Perspective* 36(11): 111–113.

Hevner, A., March, S., Park, J. and Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, 28(1): 75-105.

Heydekorn, J., Frisch, M., and Dachzelt, R. (2011). Evaluating a User-Elicited Gesture Set for Interactive Displays. In *Proceedings of Mensch und Computer 2011*, Duisburg, Germany, 12–15 September.

Hinckley, K., Yatani, K., Pahud, M., Coddington, N., Rodenhouse, J., Wilson, A., Benko, H., Buxton, B. (2010). Manual Deskterity: An Exploration of Simultaneous Pen + Touch Direct Input. In *Proceedings of the 28th International Conference on Human Factors in Computing Systems - CHI '10*, Atlanta, USA, 10 – 15 April.

Hinrichs, U., and Carpendale, S. (2011). Gestures in The Wild: Studying Multi-Touch Gesture Sequences on Interactive Tabletop Exhibits. In *Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems – CHI '11*, Vancouver , Canada, 7 – 12 May.

Howcroft, D., and Wilson, M. (2003). Paradoxes of participatory practices: the Janus role of the systems developer, *Information and Organization*, 13 (2003):1–24

Iivari, N. (2006). ‘Representing the User’ in software development—a cultural analysis of usability work in the product development context. *Interacting with Computers* (18): 635–664

Jiao, X., Deng, H., and Wang, F. (2010). An Investigation of Two-Handed Manipulation and Related Techniques in Multi-touch Interaction. In *Proceedings of the International Conference on Machine Vision and Human-Machine Interface - MVHI*, Kaifeng, China, 24-25 April.

Kane, S. K., Wobbrock, J. O., and Ladner, R. E. (2011). Usable Gestures for Blind People: Understanding Preference and Performance. In *Proceedings of the 2011 Annual Conference on Human Factors in Computing Systems – CHI '11*, Vancouver , Canada, 7 – 12 May.

Lao, S., Heng, X., Zhang, G., Ling, Y., and Wang, P. (2009). A Gestural Interaction Design Model for Multi-touch Displays. In Proceedings of the 23rd British HCI Group Annual Conference on People and Computers: Celebrating People and Technology – BCS-HCI '09, Cambridge, United Kingdom, 1 – 5 September.

Llaurens, V., Raymond, M., and Faurie C. (2009). Why are some people left-handed? An evolutionary perspective. *Philosophical Transactions of The Royal Society*, 364(1519): 881–894.

Mauney, D., Howarth, J., Wirtanen, A., and Capra, M. (2010). Cultural Similarities and Differences in User-Defined Gestures for Touchscreen User Interfaces. In Proceedings of the 28th ACM CHI Conference on Human Factors in Computing Systems, Atlanta, USA, 10 – 15 April.

Micire, M., Desai, M., Courtemanche, A., Tsui K. M., and Yanco, H. A. (2009). Analysis of Natural Gestures for Controlling Robot Teams on Multi-touch Tabletop Surfaces. In Proceedings of the ACM International Conference on Interactive Tabletops and Surfaces – ITS '09, Calgary, AB, Canada, 23 – 25 November.

Morris, M. R., Wobbrock, J. O., and Wilson, A. D. (2010). Understanding Users' Preferences for Surface Gestures. In Proceedings of Graphics Interface 2010 – GI '10, Toronto, Ontario, Canada, 31 May – 2 June.

Muller, M. (2009). Participatory Design: The Third Space in HCI [Online]. Available: http://watsonweb.watson.ibm.com/cambridge/Technical_Reports/2010/TR2010.10%20Participatory%20Design%20The%20Third%20Space%20in%20HCI.pdf [13 March 2012]

Muller, T., and Kerris, N. (2012). New iPad Tops Three Million [Online]. Available: <http://www.apple.com/pr/library/2012/03/19New-iPad-Tops-Three-Million.html> [29 May 2012]

NetMarketShare (2012). Search Engine Market Share [Online]. <http://marketshare.hitslink.com/report.aspx?qprid=4> [June 2012]

Nguyen B., and Chaparro, B. (2010). Survey Results: iPad is Best for Reading, Communicating, and Gaming [Online]. <http://psychology.wichita.edu/surl/usabilitynews/122/ipadsurvey.asp> [19 February 2011]

Nielsen, M., Störring, M., Moeslund, T.B., and Granum, E. (2003). A procedure for developing intuitive and ergonomic gesture interfaces for HCI. In Proceedings of the 5th International Gesture Workshop 2003, Genova, Italy, 15–17 April.

Norman, D. A., and Nielsen, J. (2010). Gestural Interfaces: A Step Backward in Usability. *Interactions*, 17 (5): 46 – 49.

Olsson, E. (2004). What active users and designers contribute in the design process. *Interacting with Computers* (16): 377–401.

Piirainen, K., Gonzalez, R. A., and Kolfshoten, G. (2010). Quo Vadis, Design Science? – A Survey of Literature. In Proceedings of the Global Perspectives on Design Science Research, 5th International Conference, DESRIST 2010, St. Gallen, Switzerland, 4–5 June.

Rose, D. E., and Levinson, D. (2004). Understanding User Goals in Web Search. In Proceedings of the 13th International World Wide Web Conference – WWW 2004, New York, USA, 17–22 May.

Saffer, D. (2009). *Designing Gestural Interfaces: Touchscreens and Interactive Devices*. California, Sebastopol: O'Reilly Media, Inc.

Sax, C., and Lawrence, E. (2009). Tangible Information: Gestures for a Portable e-Nursing Touch Screen Interface. In Proceedings of the 11th International Conference on e-Health Networking, Applications and Services – Healthcom 2009, Sydney, 16 – 18 December.

Schoeffmann, K., Ahlström, D., and Beecks, C. (2011). 3D Image Browsing on Mobile Devices. In Proceedings of the IEEE International Symposium on Multimedia, 2011 – ISM 2011, Dana Point, California, USA, 5 – 7 Dec.

StatCounter (2012). Top 5 Search Engines from Jun 2011 to Jun 2012 [Online]. http://gs.statcounter.com/?PHPSESSID=t1p3fqfeuimnrdpgigmmff1q3#search_engine-ww-monthly-201106-201206 [June 2012]

StatOwl (2012). Search Engine Market Share [Online]. http://www.statowl.com/search_engine_market_share.php [June 2012]

Stern, H. I., and Wachs, J. P., and Edan, Y. (2008). Designing hand gesture vocabularies for natural interaction by combining psycho-physiological and recognition Factors. *International Journal of Semantic Computing*, 2(1): 137–160.

Tan, F. B. and Hunter, M. G. (2002). The Repertory Grid Technique: A method for the study of cognition in Information Systems. *MIS Quarterly*, 26(1), 39–57.

Vaishnavi, V., and Kuechler, B. (2011). Design Science Research in Information Systems [Online]. <http://desrist.org/design-research-in-information-systems/> [15 May 2012]

Wang, F., Cao, X., Ren, X., and Irani, P. (2009). Detecting and Leveraging Finger Orientation for Interaction with Direct-Touch Surfaces. In Proceedings of the 22nd annual ACM symposium on User Interface Software and Technology – UIST '09, British Columbia, Canada, 4–7 October.

Wastell, D., Sauer, J., and Schmeink, C. (2009) Time for a “design turn” in IS innovation research? A practice report from the home front. *Information Technology & People*, 22(4), 335–350

Wobbrock, J. O., Morris, M. R., and Wilson, A. D. (2009). User-defined gestures for surface computing. In Proceedings of the 27th international conference on human factors in computing systems – CHI 2009, Boston, Massachusetts, USA, 4 – 9 April

Wobbrock, J.O., Aung, H.H., Rothrock, B., and Myers, B.A. (2005). Maximizing the guessability of symbolic input. . In Proceedings of the 2005 Annual Conference on Human Factors in Computing Systems–CHI '05, Portland, Oregon, 2–7 April.

Wu, M., Shen, C., Ryall, K., Forlines, C., and Balakrishnan, R. (2006). Gesture Registration, Relaxation, and Reuse for Multi-Point Direct-Touch Surfaces. *First IEEE International Workshop on Horizontal Interactive Human-Computer Systems – TableTop '06*: 183 – 190.

APPENDIX A – PARTICIPATORY GESTURE DESIGN VS GESTURE VALIDATION

The section below provides a contrast between participatory gesture design (wherein users are actively involved the design of gestures from the start) and gesture validation (wherein users are involved only in the validation of gestures that have already been developed).

THE ARGUMENT FOR PARTICIPATORY GESTURE DESIGN – AN ILLUSTRATION

Norman and Nielsen (2010) point the finger at manufacturers such as Apple, Google and Microsoft, as well as the general developer community, for ignoring longstanding conventions and introducing ill-conceived ones when it comes to the design of gestural interfaces. They call for all manufacturers and developers to apply the principles and conventions that have been proven through HCI research when designing gestural interfaces. HCI research, however, does not provide practitioners with an all-encompassing manual of how to create gestures that appeal to users, and the stringent application of HCI principles and conventions cannot guarantee that practitioners will be able to design gestures that are intuitive to users. This is illustrated by the study conducted by Morris et al (2010).

In their study Morris et al (2010) asked twenty-two participants to rate a set of 81 gestures on Microsoft Surface. The gestures in this gesture set did not relate to any specific application context; they were a set of gestures for basic interactions with 2D shapes (circles, triangles, squares etc.) such a rotating them or changing their sizes. This gesture set consisted of user-defined gestures and gestures designed by 3 HCI researchers; all 3 of which have received formal, academic tuition in both computer science and HCI, all 3 of which are experts in the field of HCI and specifically gesture interaction and all 3 of which have designed and evaluated various gestural interfaces. The participants, who were uninformed as to which gestures were user-defined and which were designed by the researchers, rated the suitability of gestures for the actions they were designed to perform. The results of the study indicated that users preferred the user-defined gestures over those who created by the researchers or experts.

Morris et al (2010) report that the gestures defined by the researchers tended to be more complex, physically and conceptually, than those defined by the users. Morris et al (2010) also note that the user-defined gestures were also more likely to use a single finger than those defined by the researchers and point out that that while users found the researcher-defined gestures “clever”, they ultimately preferred simplicity. This would suggest that when users, who are the intended beneficiaries of HCI principles and conventions, are the ones

who design how a gestural interface should work, what they put forward should supersede existing HCI principles and conventions if ever there is a conflict between what research stipulates and what they require.

Morris et al (2010) acknowledge that usability and design professionals complete extensive training to become experts, and that it is such experts that typically design interaction techniques. These are then refined via user testing and iterative design. Their findings suggest, however, that participatory design methodologies should be used for gesture *creation* and not merely in gesture *validation* and refinement. They specifically single out the user-centred gesture elicitation methodology used by Wobbrock et al (2009) as being exemplary. It should be noted, however, that the study conducted by Morris et al (2010), which is an extension to the study completed by Wobbrock et al (2009), measured users' preferences in the absence of a specific application context. Morris et al (2010) point out that such an approach is appropriate for understanding general differences between user-defined gestures and those authored by researchers, as well as for evaluating cross-application gesture sets, but understanding how a specific application context influences gesture preference is a valuable area for further study. This validates the need for this research, which will be addressing gesture preference for the web browsing application context, and will be identifying how this application context influences the user-defined gestures proposed by users.

THE SHORTCOMINGS OF GESTURE VALIDATION APPROACH – AN ILLUSTRATION

As previously pointed out, users are generally involved after a design solution has been created and merely serve a validation role (Olsson, 2004; Iivari, 2006). This is what was done by Sax and Lawrence (2009).

Sax and Lawrence (2009) conducted usability tests for the browsing of Hypertext Mark-up Language (HTML) web pages on a touch screen tablet device and they report on some of the differences between the gestures designed by professionals and those preferred by users. These usability tests were specifically for browsing on a prototype of the Portable Medical Monitoring Computer (PMMC), a medical information system with its own in-built gestural browser that supports registered nurses in nursing homes. For the usability tests, the users were introduced to the available gestures on the PMMC, but were not told where the gestures could be performed. These gestures are shown in Figure 7 below.

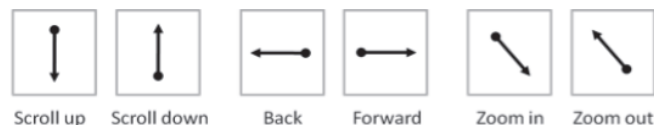


Figure 7: The available gestures on the PMMC; the dot indicates the starting point of a gesture and arrow indicates its path

These gestures had been designed to perform specific actions by the designers of the system, with moving backwards and forwards between pages and scrolling upwards and downwards on a page, being the only gestures designed for browsing. As the participants were not told which actions the gestures were intended to perform, the participants' instinctive use of these gestures would either validate or invalidate their suitability for the actions they were designed to perform.

The study by Sax and Lawrence (2009) indicates significant differences between what had been designed and what the users preferred in terms of navigating backwards and forwards between pages;

- for navigating from the current page to the previous page, users generally preferred to swipe from left to right, which was in direct contrast to the way the designers had designed the “back” gesture (swiping from right to left)
- for navigating from the current page to the next page, users generally preferred to swipe from right to left, which was in direct contrast to the way the designers had designed the “forward” gesture (swiping from left to right)
- for scrolling upwards, some users preferred to move their finger downwards in order to scroll up the page, which was in direct contrast to the way the designers had designed the “scroll up” gesture (moving the finger upwards),
- for scrolling downwards, some users preferred to move their finger upwards in order to scroll down the page, which was in direct contrast to the way the designers had designed the “scroll down” gesture (moving the finger downwards).

While these results highlight the difference between the gestures designed by professionals and those that users would prefer to use, specific to the application context of browsing, it is important to note that the PMMC prototype used by Sax and Lawrence (2009) did not use multi-touch technology, which many current tablet devices use. Furthermore, the PMMC prototype's browser was not a general-purpose browser (unlike Google Chrome or Safari for example) and had very simple and limited functionality; navigating backwards and forwards between pages and scrolling up and down on those pages, and yet the designers were not able to meet their users' expectations.

APPENDIX B – EXPERIMENT PROCEDURE AND CONSENT FORM

Invitation to Participate in the Study: Participatory Gesture Design – An Investigation of User-Defined Gestures for Conducting an Informational Search on a Tablet Device

Introduction

Good day, my name is Tsele Rakubutu and I am currently completing my Master of Commerce degree in Information Systems at the University of the Witwatersrand, in collaboration with the University of South Africa. I thank you for considering to participate in this study.

Should you choose to participate, you will be requested to carry out experimental tasks which require you to propose touch screen gestures for various web browsing functions. During this process, video and audio recordings of you will be captured. You will also be requested to rate each gesture you suggest in terms of its suitability for the function presented and the ease with which it can be performed. It is envisaged that the experimental tasks, including ratings will collectively last approximately 45 minutes.

Please note that the video and audio recordings as well as information you provide will only be used for the purposes of this specific research. Your name, or any information that you could uniquely identify you, will not be associated with any data that are collected during the experiment and will not be used in the research report or any documents related to this study. Should you choose to participate, you should also be aware that you will be free to withdraw from the experimental tasks at any stage, and for any reason.

Declaration

I _____ have chosen to participate in this study, and as a participant:

- I am participating freely without being forced in any way to do so.
- I understand that I can withdraw from the experimental tasks at any point should I wish to.
- I will do my best to provide honest and accurate information.

- I give consent to the research team to capture video and audio recordings of me while I am doing the experimental tasks as I understand that this is required in order to analyse the gestures and information I provide.

As you carry out the experimental tasks, we humbly request to take pictures of you, which we would insert in the research report or related documents, such as presentations on this research. You are free to either grant or deny us permission to do so.

I ☐ give / ☐ do not give (please tick the correct option) consent to the researchers to take pictures of me during the experimental tasks for the research report and related documents.

Signature: _____

Demographic Information

Age: _____

Please tick the appropriate box for the statements below.

Gender: ☐ Male ☐ Female

Handedness: ☐ Right ☐ Left

I generally use Google to search for information:

☐ Never ☐ Rarely ☐ Occasionally ☐ Frequently

I have used touch screen devices (such as touch screen phones, or tablets):

☐ Never ☐ Rarely ☐ Occasionally ☐ Frequently

Experiment Procedure

For each of the experimental tasks, you will be presented with a short video recording (on an iPad) illustrating one web browsing function. This video will show the output of the function. You will be required to propose any gesture of your liking that would produce the output displayed.

The steps that will be taken during the experimental tasks are explained below. Please note that you can stop to ask questions **at any point** during the experiment, and that there are no time limits imposed on you during any of these steps.

The experimental tasks will be done as follows:

1. The researcher explain the function that will be presented to you
2. The research will play a video of the function on an iPad, and if necessary re-played as many times as required until you understand what the function is
3. You will be requested to confirm that you understand the function
4. If you require, you can take some time to think about which gesture you would like to propose; as previously mentioned, there are no time limits and you can take as much time as you need
5. The video will be played once again, but with a glass sheet covering the iPad
6. You will be requested to
 - a. perform the gesture(s) that you have in mind for the function on the glass sheet, and to
 - b. “think aloud” as you perform the gesture(s) and verbalise any thoughts or reasoning for the gesture(s) you are proposing.

Please note that if you are unsatisfied with the gesture(s) you have proposed for the function, you will be allowed to redo it/them immediately after your proposal i.e. before proceeding to the next gesture. You should also note that you will not be permitted to use the same gesture(s) for different functions. The researcher will assist you in this regard.

When performing the gesture (Step 6.a.), if you feel that you require an additional widget (i.e. any control or mechanism that you feel is useful or necessary for carrying out the gesture) you will be allowed to assume it was present – provided you explained in detail what the widget is, the form you expected it to take and how you expected it to work.

Preference Ratings

You will be required to rate each gesture you propose in terms of how well you think it suits the function and how easy it is to perform. You will be requested to rate each gesture immediately after you perform it.

Please indicate the extent to which you agree with each of the following statements about the gestures you proposed, where 1 represents that you strongly disagree with the statement and 5 represents that you strongly agree.

Gesture 1: Input search query

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 2: Go to previous page

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 3: Go to next page

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 4: Stop loading page content

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 5: Refresh/reload page content

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 6: Make content of the page larger

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 7: Make content of the page smaller

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 8: Pan down the page

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 9: Pan up the page

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 10: Pan across the page

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 11: Find text on the page

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 12: Copy section of text on the page

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 13: Paste section of text into search engine

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 14: Open link on the web page in new tab

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 15: Create a new browsing tab

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 16: Close a browsing tab

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 17: View record of visited pages

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 18: Delete record of visited pages

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 19: Save current page address within the browser for viewing the same page later

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 20: Open saved page address

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 21: Save image on page to memory

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 22: Save webpage to memory

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 23: Request help

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

Gesture 24: Close web browser

The gesture I picked is a good match for its intended purpose

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

The gesture I picked is easy to perform

	1	2	3	4	5	
Strongly Disagree	☐	☐	☐	☐	☐	Strongly Agree

APPENDIX C – DETAILED INFORMATION ON USER-DEFINED GESTURE SET

This section provides detailed information for all the gestures in the final user-defined gesture set for conducting an informational search on a multi-touch tablet web browser. Illustrations⁶ for each of the gestures assigned to a referent are provided, a summary of the what the gesture entails is presented, as well as the gesture's attributes (Gesture Complexity, Gesture Nature, Gesture Binding, Gesture Flow, Pointer-Type).

1. REFERENT 1 – INPUT SEARCH QUERY

The key points relating to this referent are as follows:

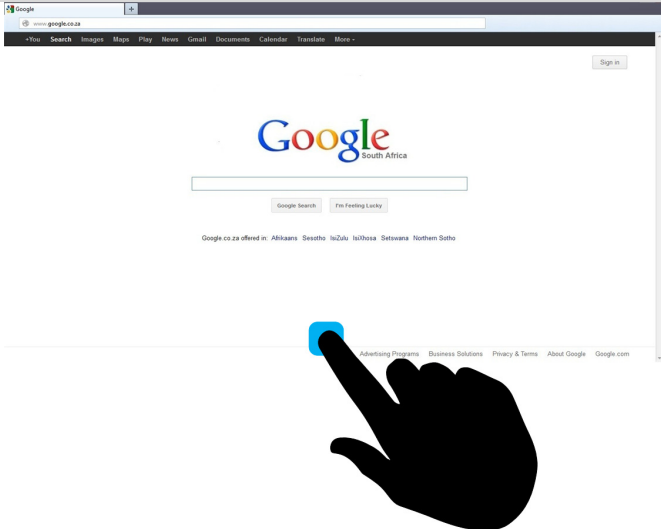
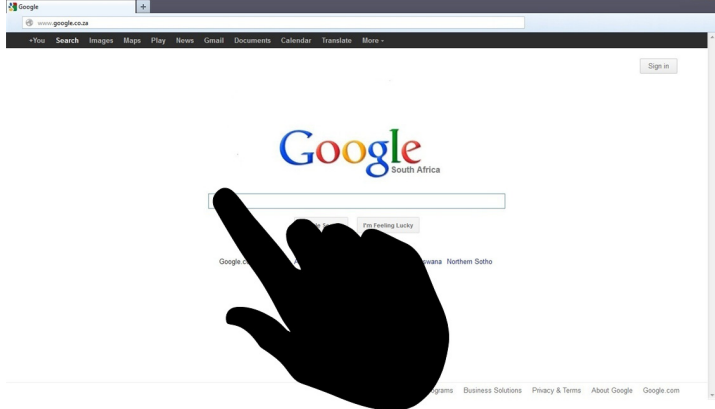
- 20 gestures were elicited.
- 1 gesture was excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Keyboard Button”; proposed by 9 participants.
 - Gesture 2 – Single Tap on Google Textbox; proposed by 5 participants.
 - Gesture 3 – Flick Keyboard Up; proposed by 1 participant.
 - Gesture 4 – Write in Google Textbox with a Fingertip; proposed by 1 participant.
 - Gesture 5 – Write in Google Textbox with a Stylus; proposed by 1 participant.
 - Gesture 6 – Simulate Typing Action; proposed by 1 participant.
- The agreement score for this referent was 0.310 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

⁶ Some of the images used in creating the illustrations below were used courtesy of the following websites:

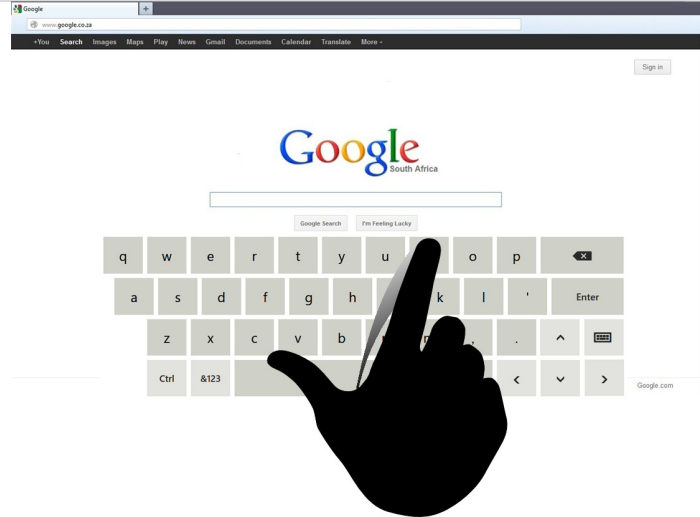
- <http://www.kickerstudio.com/blog/2008/12/touchscreen-stencils/>
- <http://www.clker.com/>
- <http://commons.wikimedia.org/>
- <http://openclipart.org/>
- <http://footage.shutterstock.com/>

Table 46: Gestures Assigned to Referent 1 – Input Search Query

Gesture Illustration		Gesture Information	
Gesture 1 – Single Tap on “Keyboard Button”			
		Summary	The user calls up a keyboard by tapping once on a “keyboard button”.
		Gesture Complexity	Simple
		Gesture Nature	Metaphorical
		Gesture Binding	Object-centric
		Gesture Flow	Discrete
Pointer-Type	Yes		
Gesture 2 – Single Tap on Google Textbox			
		Summary	The user calls up a keyboard by tapping once on the Google textbox.
		Gesture Complexity	Simple
		Gesture Nature	Metaphorical
		Gesture Binding	Object-centric
		Gesture Flow	Discrete
Pointer-Type	Yes		

Gesture Illustration

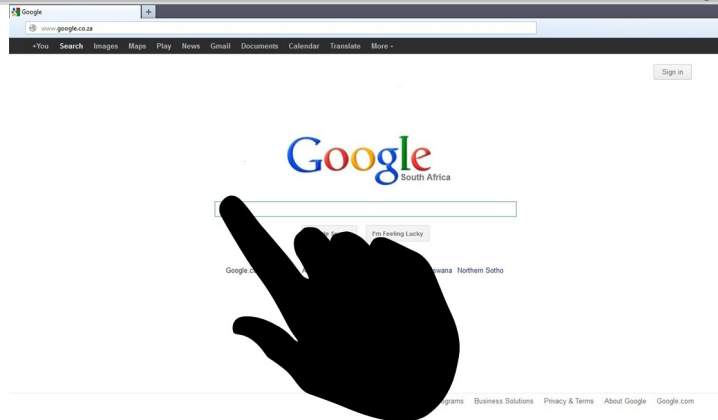
Gesture 3 – Flick Keyboard Up



Gesture Information

Summary	The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen.
Gesture Complexity	Simple
Gesture Nature	Physical
Gesture Binding	World-dependent
Gesture Flow	Discrete
Pointer-Type	No

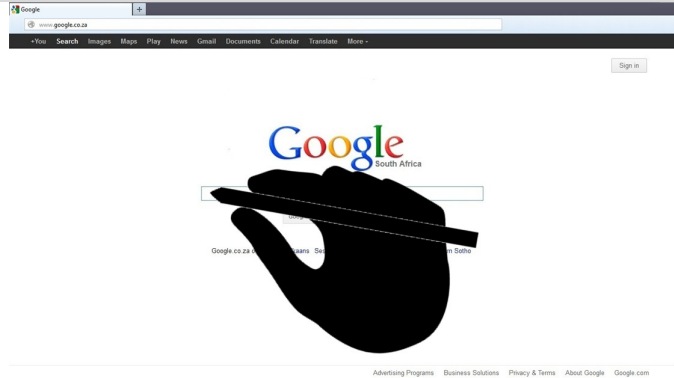
Gesture 4 – Write in Google Textbox with a Fingertip



Summary	The user uses his / her fingertip as if it is a pen to “write” the search query in the Google textbox.
Gesture Complexity	Complex – Sequential: Each letter is considered to be a phase of the gesture; phases are sequential
Gesture Nature	Metaphorical: The finger is used as if it was a pen and the webpage as if it was a sheet of paper
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture Illustration

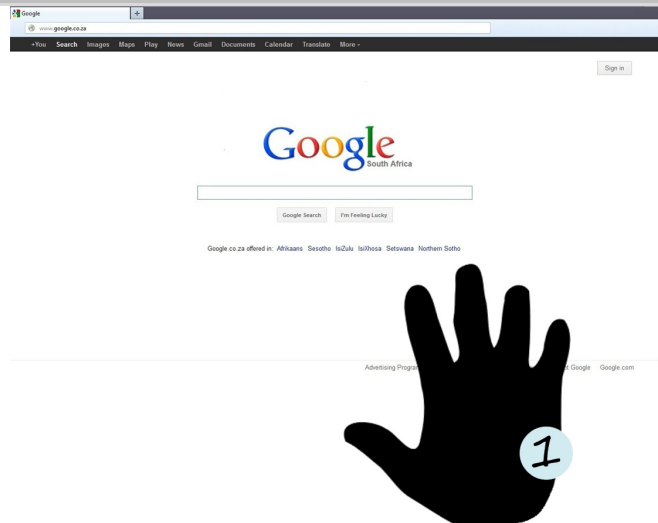
Gesture 5 – Write in Google Textbox with a Stylus



Gesture Information

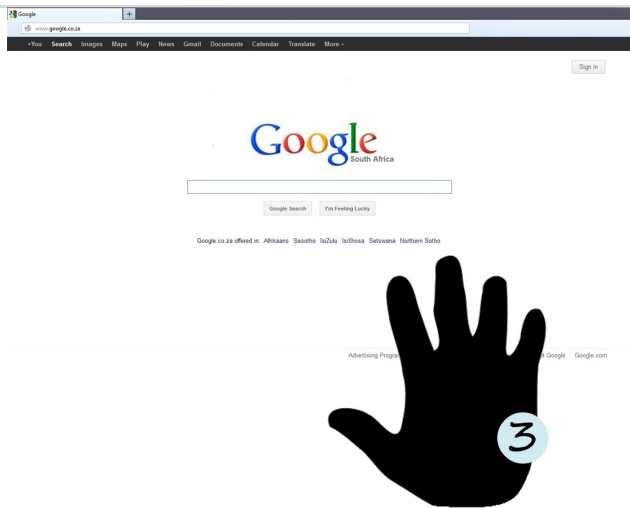
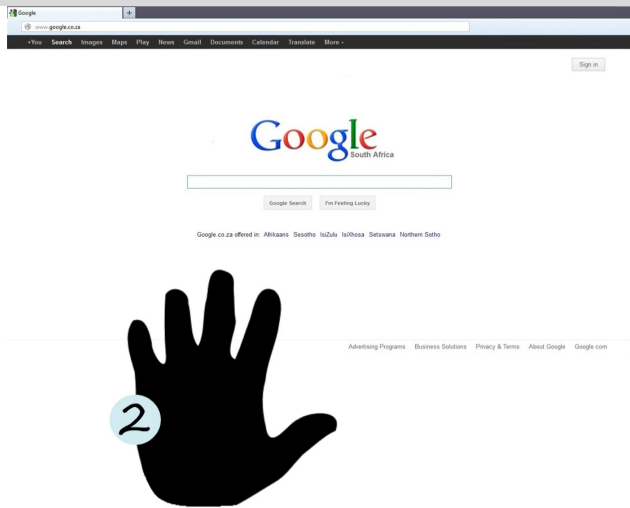
Summary	The user uses a stylus to “write” the search query in the Google textbox.
Gesture Complexity	Complex – Sequential: Each letter is considered to be a phase of the gesture; phases are sequential
Gesture Nature	Metaphorical: The webpage is used as if it was an actual sheet of paper
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	No

Gesture 6 – Simulate Typing Action



Summary	To bring up a keyboard, the participant pretends that he / she is typing on the screen. This gesture begins with a tap of the right index, right middle, right ring and right pinkie finger (in any order) in quick succession.
---------	---

Gesture Illustration



Summary

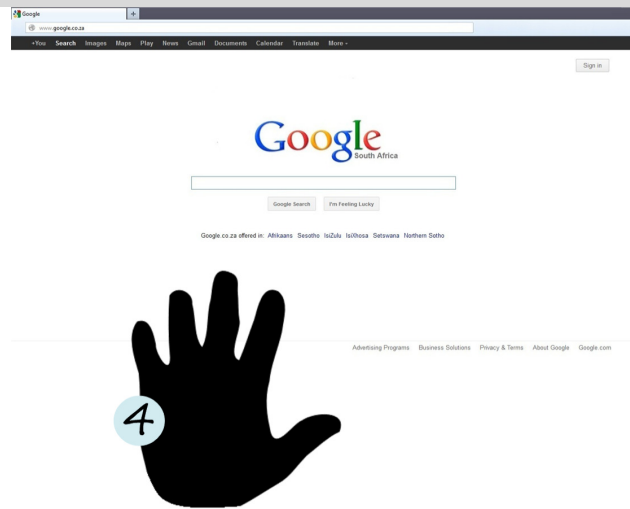
Gesture Information

This is followed by with a tap of the left index, left middle, left ring and left pinkie finger (in any order) in quick succession.

Summary

This is followed with a tap of the right index, right middle, right ring and right pinkie finger (in any order) in quick succession.

Gesture Illustration



Gesture Information

Summary	This is followed by with a tap of the left index, left middle, left ring and left pinkie finger (in any order) in quick succession.
Gesture Complexity	Complex – Sequential: Each tap, on either hand, is a phase of the gesture; phases are sequential
Gesture Nature	Metaphorical: The user types as if there are keyboard keys at the bottom of the screen
Gesture Binding	World-dependent
Gesture Flow	Discrete
Pointer-Type	No

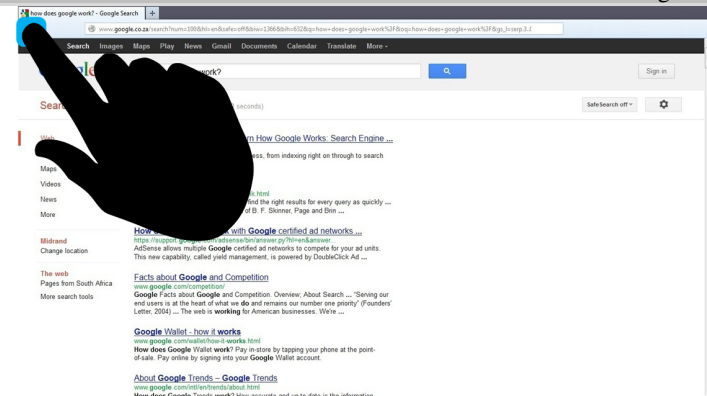
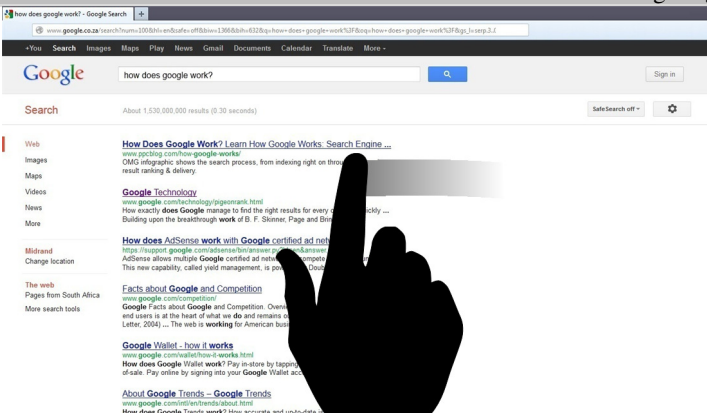
2. REFERENT 2 – GO TO PREVIOUS WEBPAGE

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 2 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 2 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Back Button”; proposed by 13 participants.
 - Gesture 2 – Drag Finger from Right to Left; proposed by 4 participants.
- The agreement score for this referent was 0.475 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 47: Gestures Assigned to Referent 2 – Go To Previous Webpage

Gesture Illustration	Gesture Information																			
	Gesture 1 – Single Tap on “Back Button” <table border="1"> <tr> <td>Summary</td><td colspan="2">The user taps on the “Back” button.</td></tr> <tr> <td>Gesture Complexity</td><td colspan="2">Simple</td></tr> <tr> <td>Gesture Nature</td><td colspan="2">Metaphorical</td></tr> <tr> <td>Gesture Binding</td><td colspan="2">Object-centric</td></tr> <tr> <td>Gesture Flow</td><td colspan="2">Discrete</td></tr> <tr> <td>Pointer-Type</td><td colspan="2">Yes</td></tr> </table>		Summary	The user taps on the “Back” button.		Gesture Complexity	Simple		Gesture Nature	Metaphorical		Gesture Binding	Object-centric		Gesture Flow	Discrete		Pointer-Type	Yes	
Summary	The user taps on the “Back” button.																			
Gesture Complexity	Simple																			
Gesture Nature	Metaphorical																			
Gesture Binding	Object-centric																			
Gesture Flow	Discrete																			
Pointer-Type	Yes																			
	Gesture 2 – Drag Finger from Right to Left <table border="1"> <tr> <td>Summary</td><td colspan="2">The user performs a drag gesture from right to left.</td></tr> <tr> <td>Gesture Complexity</td><td colspan="2">Simple</td></tr> <tr> <td>Gesture Nature</td><td colspan="2">Metaphorical</td></tr> <tr> <td>Gesture Binding</td><td colspan="2">World-independent</td></tr> <tr> <td>Gesture Flow</td><td colspan="2">Discrete</td></tr> <tr> <td>Pointer-Type</td><td colspan="2">No</td></tr> </table>		Summary	The user performs a drag gesture from right to left.		Gesture Complexity	Simple		Gesture Nature	Metaphorical		Gesture Binding	World-independent		Gesture Flow	Discrete		Pointer-Type	No	
Summary	The user performs a drag gesture from right to left.																			
Gesture Complexity	Simple																			
Gesture Nature	Metaphorical																			
Gesture Binding	World-independent																			
Gesture Flow	Discrete																			
Pointer-Type	No																			

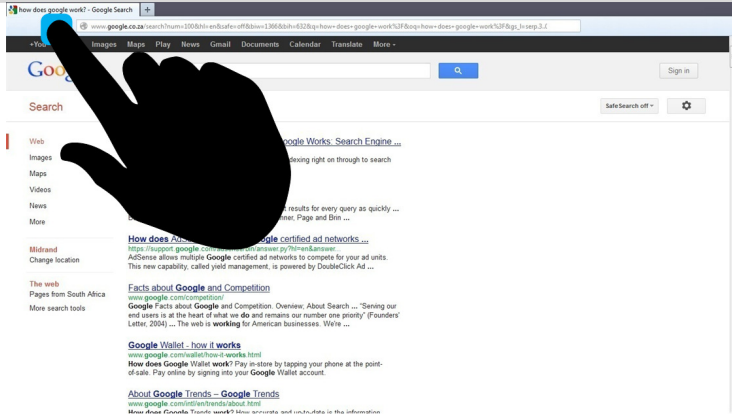
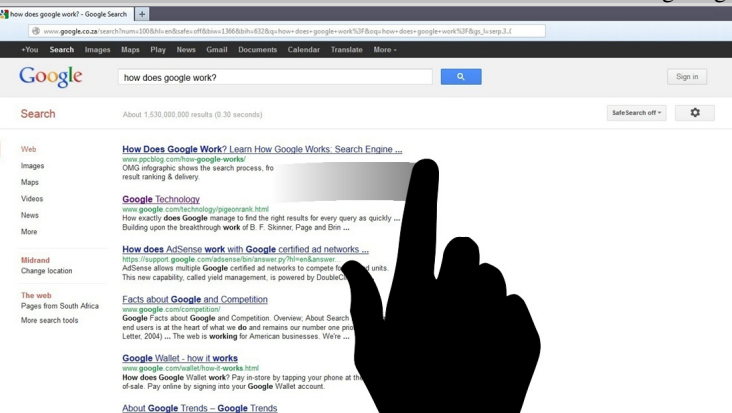
3. REFERENT 3 – GO TO NEXT WEBPAGE

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 4 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 2 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Forward Button”; proposed by 12 participants.
 - Gesture 2 – Drag Finger from Left to Right; proposed by 4 participants.
- The agreement score for this referent was 0.425 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 48: Gestures Assigned to Referent 3 – Go To Next Webpage

Gesture Illustration		Gesture Information	
Gesture 1 – Single Tap on “Forward Button”			
		Summary	The user taps on the “Forward” button.
Gesture Complexity		Simple	
Gesture Nature		Metaphorical	
Gesture Binding		Object-centric	
Gesture Flow		Discrete	
Pointer-Type		Yes	
Gesture 2 – Drag Finger from Left to Right			
		Summary	The user performs a drag gesture from left to right.
Gesture Complexity		Simple	
Gesture Nature		Metaphorical	
Gesture Binding		World-independent	
Gesture Flow		Discrete	
Pointer-Type		No	

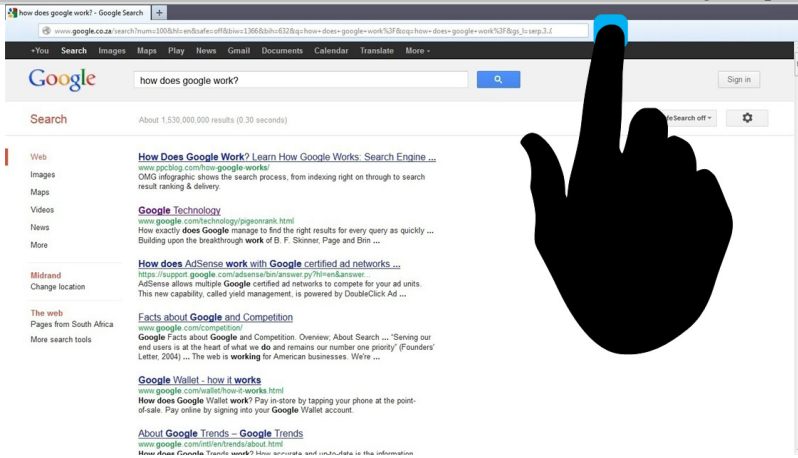
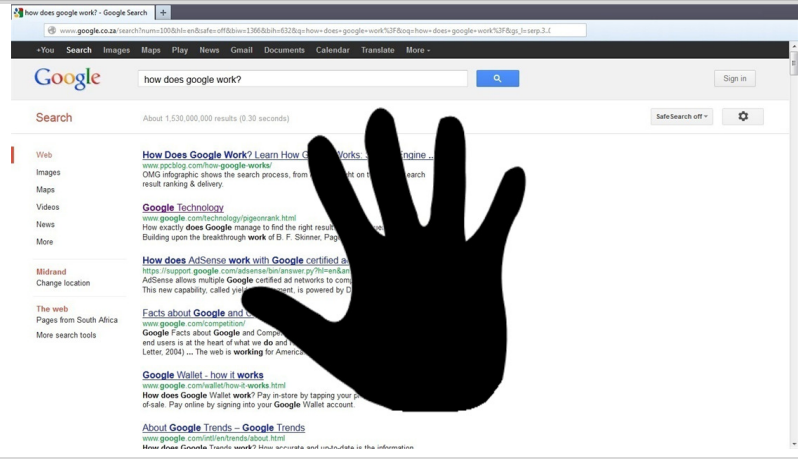
4. REFERENT 4 – STOP LOADING WEBPAGE CONTENT

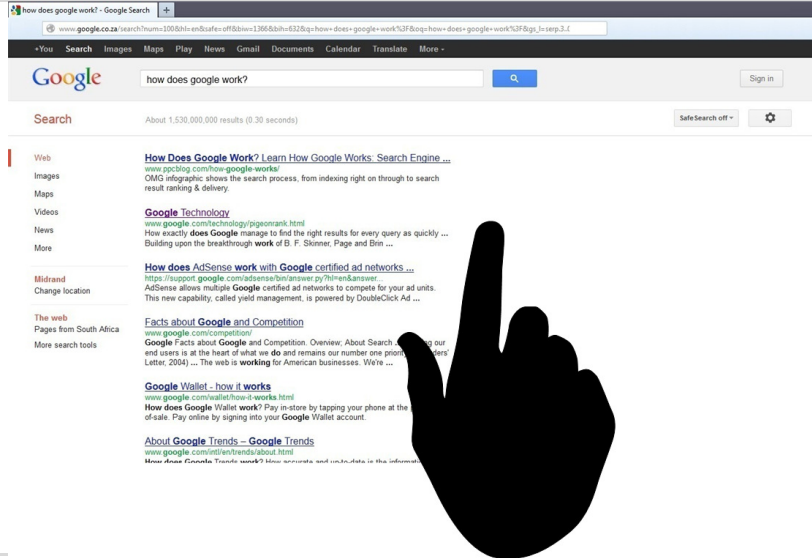
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 3 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Stop Button”; proposed by 15 participants.
 - Gesture 2 – Palm Tap; proposed by 2 participants.
 - Gesture 3 – Single Tap on Screen; proposed by 2 participants.
- The agreement score for this referent was 0.585 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 49: Gestures Assigned to Referent 4 – Stop loading webpage content

Gesture Illustration		Gesture Information	
Gesture 1 – Single Tap on “Stop Button” 		Summary The user stops the webpage from loading by tapping once on a “stop button”.	
		Gesture Complexity	Simple
		Gesture Nature	Metaphorical
		Gesture Binding	Object-centric
		Gesture Flow	Discrete
		Pointer-Type	Yes
Gesture 2 – Palm Tap 		Summary The user stops the webpage from loading by tapping once on the screen with the palm of the hand.	
		Gesture Complexity	Complex – Parallel: Gesture comprises a tap of all 5 fingers simultaneously
		Gesture Nature	Physical: The user stops the webpage like how one would physically stop a moving object
		Gesture Binding	World-independent
		Gesture Flow	Discrete
		Pointer-Type	No



Summary

The user stops the webpage from loading by tapping once on the screen with a single finger.

Gesture Complexity	Simple
Gesture Nature	Arbitrary
Gesture Binding	World-independent
Gesture Flow	Discrete
Pointer-Type	No

5. REFERENT 5 – REFRESH / RELOAD WEBPAGE CONTENT

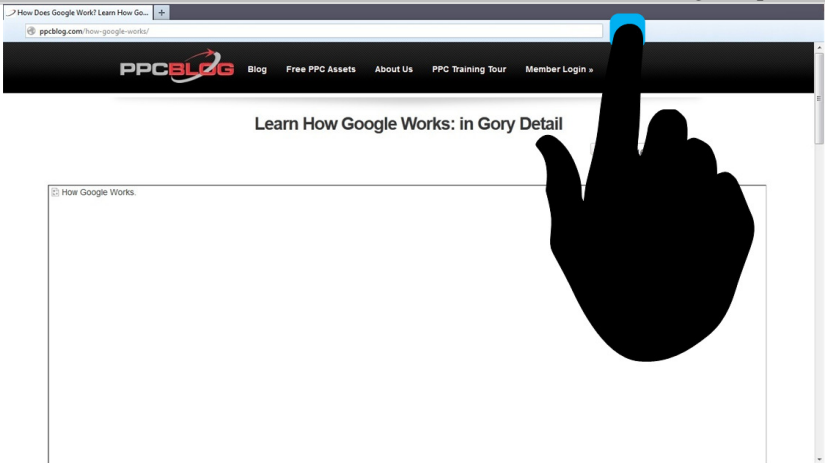
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 3 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 2 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Refresh Button”; proposed by 16 participants.
 - Gesture 2 – Trace Circle; proposed by 1 participant.

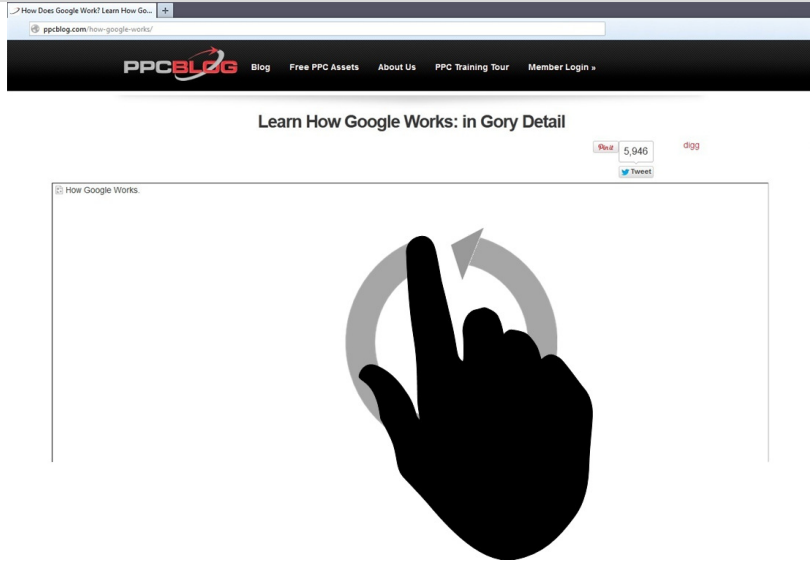
- The agreement score for this referent was 0.650 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 50: Gestures Assigned to Referent 5 – Refresh / reload webpage content

<i>Gesture Illustration</i>	<i>Gesture Information</i>	
Gesture 1 – Single Tap on “Refresh Button” 	Summary	The user refreshes / reloads the webpage by tapping once on a “refresh button”.
		Gesture Complexity Simple
		Gesture Nature Metaphorical
		Gesture Binding Object-centric
		Gesture Flow Discrete
		Pointer-Type Yes

Gesture 2 – Trace Circle



Summary

The user refreshes / reloads the webpage by tracing a circle (in an anti-clockwise direction) on the screen.

Gesture Complexity	Simple
Gesture Nature	Symbolic
Gesture Binding	World-independent
Gesture Flow	Discrete
Pointer-Type	No

6. REFERENT 6 – MAKE WEBPAGE CONTENT LARGER

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 1 gesture was excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 3 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 7 gestures were assigned to this referent:

- Gesture 1 – Drag Two Fingers Apart; proposed by 5 participants.
 - Gesture 2 – Single Tap on “Magnify Button”; proposed by 4 participants.
 - Gesture 3 – Drag Five Fingers Apart; proposed by 3 participants.
 - Gesture 4 – Drag Finger to Corner of Screen; proposed by 1 participant.
 - Gesture 5 – Drag Two Palms Apart; proposed by 1 participant.
 - Gesture 6 – Drag Two Fingers Apart - Using Both Hands; proposed by 1 participant.
 - Gesture 7 – “Magnifying Scale” Widget; proposed by 1 participants.
- The agreement score for this referent was 0.145 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 51: Gestures Assigned to Referent6 – Make webpage content larger

Gesture Illustration		Gesture Information	
Gesture 1 – Drag Two Fingers Apart			
		Summary	The user makes the webpage content larger by dragging his / her thumb and index finger apart.
		Gesture Complexity	Complex – Parallel: Gesture comprises a drag with the thumb and index finger simultaneously
		Gesture Nature	Metaphorical
		Gesture Binding	World-independent
		Gesture Flow	Continuous
		Pointer-Type	No

Gesture Illustration



Gesture 2 – Single Tap on “Magnify Button”



Gesture Information

Summary

The user may also use fingers on different hands.

Summary

The user makes the webpage content larger by tapping on a “magnify button”.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

Object-centric

Gesture Flow

Discrete

Pointer-Type

Yes

Gesture Illustration

Gesture 3 – Drag Five Fingers Apart



Gesture Information

Summary	The user makes the webpage content larger by placing all 5 fingers on the screen and dragging them all apart from each other.
Gesture Complexity	Complex – Parallel: Gesture comprises 5 drags done simultaneously
Gesture Nature	Metaphorical
Gesture Binding	World-independent
Gesture Flow	Continuous
Pointer-Type	No

Gesture 4 – Drag Finger to Corner of Screen



Summary	The user makes the webpage content larger by dragging with a single finger an inner section of the screen to the corner of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 5 – Drag Two Palms Apart



Gesture Information

Summary

The user makes the webpage content larger by placing the sides of both hands on the screen (towards the centre of the page) and dragging them apart (the left hand towards the left edge of the screen, and the right hand towards the right edge of the screen).

Gesture Complexity

Complex – Parallel: Gesture comprises a drag with each hand done simultaneously

Gesture Nature

Metaphorical: The drags with both hands are metaphorical

Gesture Binding

World-dependent: Both phases are world-dependent

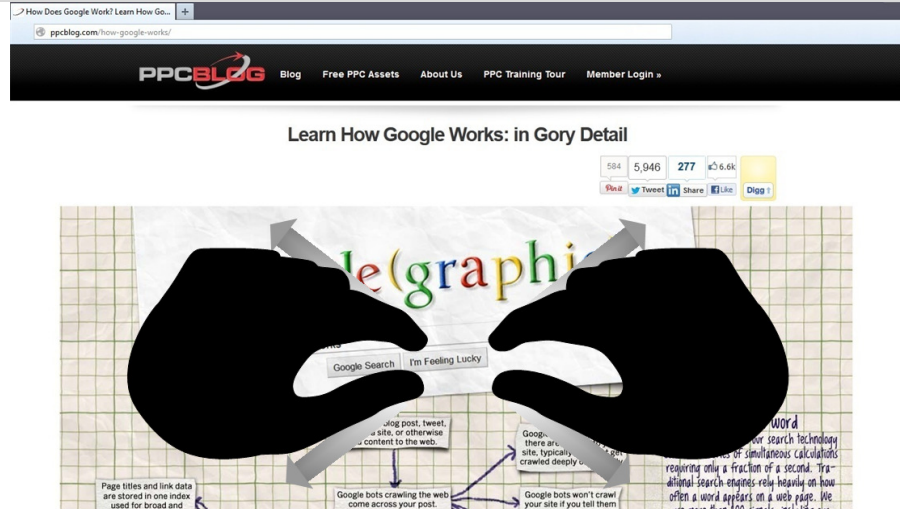
Gesture Flow

Continuous

Pointer-Type

No

Gesture 6 – Drag Two Fingers Apart - Using Both Hands



Summary

The user makes the webpage content larger by dragging his / her right thumb and index finger from the centre of the screen towards the bottom right and top right corners of the screen respectively. This is done while simultaneously dragging the left thumb and index finger from the centre of the screen to the bottom left and top left corners of the screen respectively.

Gesture Complexity

Complex – Parallel: Each drag done with each finger is a phase of the gesture; all phases are done simultaneously

Gesture Nature

Metaphorical: The drags with both hands are metaphorical

Gesture Binding

World-dependent: All phases are world-dependent

Gesture Flow

Continuous

Pointer-Type

No



Summary

The user makes the webpage content larger using a scale at the bottom of the screen. Dragging the arrow rightwards enlarges the size of the content.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

Object-centric

Gesture Flow

Continuous

Pointer-Type

Yes

7. REFERENT 7 – MAKE WEBPAGE CONTENT SMALLER

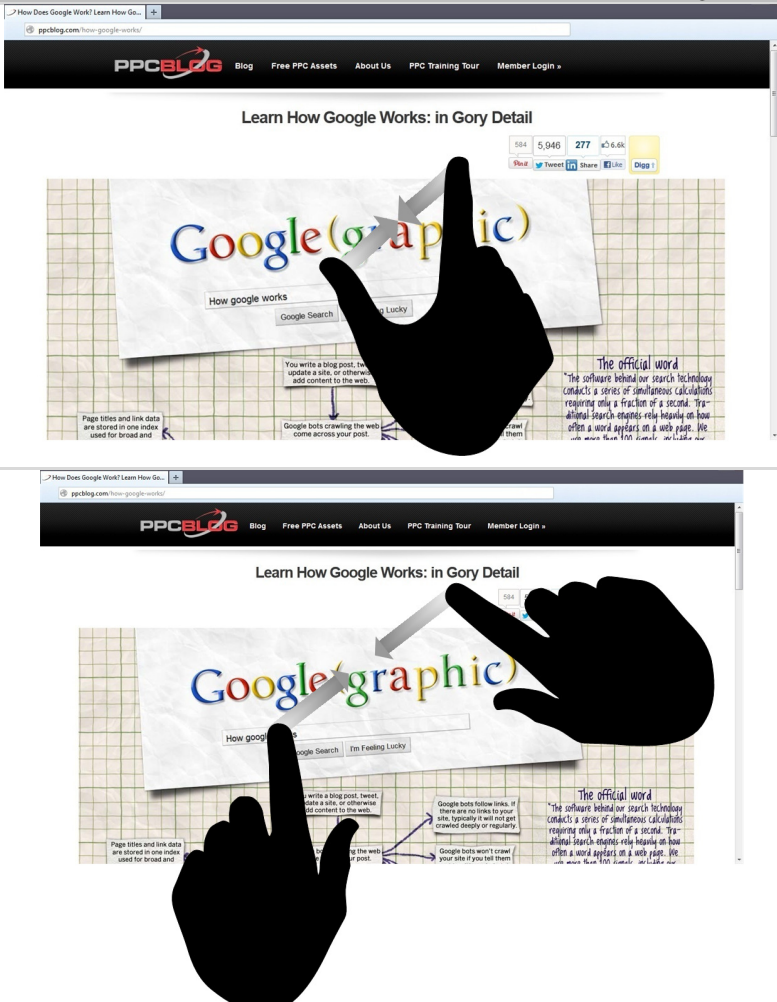
The key points relating to this referent are as follows:

- 20 gestures were elicited.

- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 4 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Drag Two Fingers Together; proposed by 5 participants.
 - Gesture 2 – Single Tap on “Minify Button”; proposed by 4 participants.
 - Gesture 3 – Drag Five Fingers Together; proposed by 2 participants.
 - Gesture 4 – Drag Finger from Corner of Screen; proposed by 1 participant.
 - Gesture 5 – Drag Two Fingers Together - Using Both Hands; proposed by 1 participant.
 - Gesture 6 – “Magnifying Scale” Widget; proposed by 1 participant.
- The agreement score for this referent was 0.145 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 52: Gestures Assigned to Referent7 – Make webpage content smaller

Gesture Illustration	Gesture Information														
Gesture 1 – Drag Two Fingers Together 	<table border="1"> <tr> <td>Summary</td><td>The user makes the webpage content smaller by dragging his / her thumb and index finger together.</td></tr> <tr> <td>Gesture Complexity</td><td>Complex – Parallel: Gesture comprises a drag with the thumb and index finger simultaneously</td></tr> <tr> <td>Gesture Nature</td><td>Metaphorical</td></tr> <tr> <td>Gesture Binding</td><td>World-independent</td></tr> <tr> <td>Gesture Flow</td><td>Continuous</td></tr> <tr> <td>Pointer-Type Summary</td><td>No</td></tr> <tr> <td></td><td>The user may also use fingers on different hands.</td></tr> </table>	Summary	The user makes the webpage content smaller by dragging his / her thumb and index finger together.	Gesture Complexity	Complex – Parallel: Gesture comprises a drag with the thumb and index finger simultaneously	Gesture Nature	Metaphorical	Gesture Binding	World-independent	Gesture Flow	Continuous	Pointer-Type Summary	No		The user may also use fingers on different hands.
Summary	The user makes the webpage content smaller by dragging his / her thumb and index finger together.														
Gesture Complexity	Complex – Parallel: Gesture comprises a drag with the thumb and index finger simultaneously														
Gesture Nature	Metaphorical														
Gesture Binding	World-independent														
Gesture Flow	Continuous														
Pointer-Type Summary	No														
	The user may also use fingers on different hands.														

Gesture Illustration

Gesture 2 – Single Tap on “Minify Button”



Gesture Information

Summary	The user makes the webpage content smaller by tapping on a “minify button”.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	Object-centric
Gesture Flow	Discrete
Pointer-Type	Yes

Gesture 3 – Drag Five Fingers Together



Summary	The user makes the webpage content smaller by sprawling all 5 fingers on the screen and dragging them towards from each other.
Gesture Complexity	Complex – Parallel: Gesture comprises 5 drags done simultaneously
Gesture Nature	Metaphorical
Gesture Binding	World-independent
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 4 – Drag Finger from Corner of Screen



Gesture Information

Summary

The user makes the webpage content smaller by dragging with a single finger from the corner of the screen to the inner section of the screen.

Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 5 – Drag Two Fingers Together - Using Both Hands



Gesture Information

Summary

The user makes the webpage content smaller by dragging his / her right thumb and index finger from the bottom right and top right corners of the screen respectively towards the centre of the screen. This is done while simultaneously dragging the left thumb and index finger from the bottom left and top left corners of the screen respectively towards the centre of the screen.

Gesture Complexity

Complex – Parallel: Each drag done with each finger is a phase of the gesture; all phases are done simultaneously

Gesture Nature

Metaphorical: The drags with both hands are metaphorical

Gesture Binding

World-dependent: All phases are world-dependent

Gesture Flow

Continuous

Pointer-Type

No

Gesture 6 – “Magnifying Scale” Widget



Summary

The user makes the webpage content larger using a scale at the bottom of the screen. Dragging the arrow leftwards decreases the size of the content.

Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	Yes

8. REFERENT 8 – PAN DOWN THE WEBPAGE

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).

- 5 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 8 gestures were assigned to this referent:
 - Gesture 1 – Drag Finger Downward (Right Edge of Screen); proposed by 4 participants.
 - Gesture 2 – Drag Finger Downward (Scrollbar); proposed by 4 participants.
 - Gesture 3 – Flick Finger Downward (Right Edge of Screen); proposed by 2 participants.
 - Gesture 4 – Drag Finger Downward (Middle of Screen); proposed by 1 participant.
 - Gesture 5 – Drag Multiple Fingers Downward; proposed by 1 participant.
 - Gesture 6 – Flick Finger Downward (Bottom Edge of Screen); proposed by 1 participant.
 - Gesture 7 – Flick Finger Downward (Scrollbar Arrow); proposed by 1 participant.
 - Gesture 8 – Drag Half-Closed Palm Down; proposed by 1 participant.
- The agreement score for this referent was 0.490 (the average agreement score was 0.327).

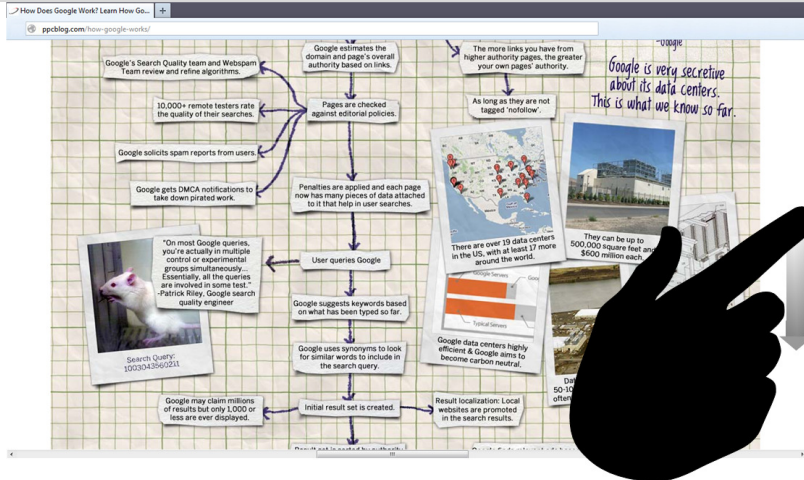
The gestures assigned to this referent are tabulated below.

Table 53: Gestures Assigned to Referent8 – Pan down the webpage

Gesture Illustration		Gesture Information	
Gesture 1 – Drag Finger Downward (Right Edge of Screen)			
		Summary The user drags a single finger downwards on the right edge of the screen.	
		Gesture Complexity	Simple
		Gesture Nature	Metaphorical
		Gesture Binding	World-dependent
		Gesture Flow	Continuous
		Pointer-Type	Yes

Gesture Illustration

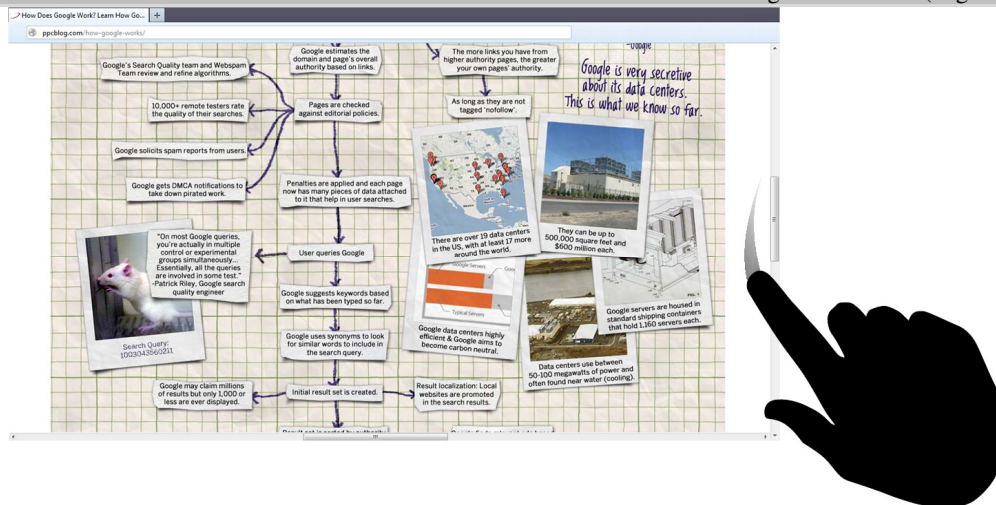
Gesture 2 – Drag Finger Downward (Scrollbar)



Gesture Information

Summary	The user drags a single finger downwards on the scrollbar.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	Yes

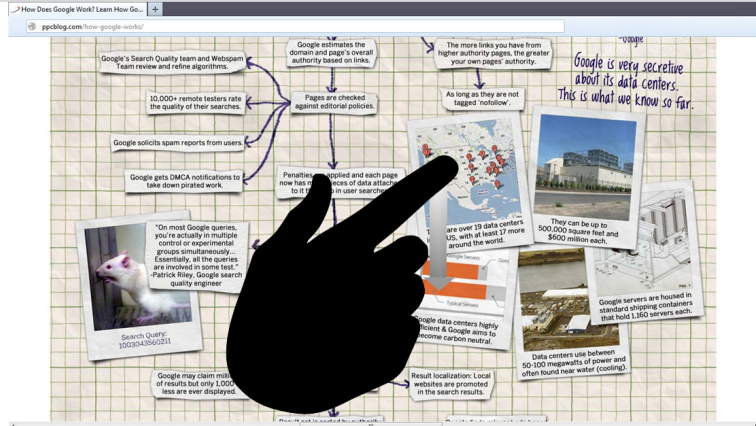
Gesture 3 – Flick Finger Downward (Right Edge of Screen)



Summary	The user flicks a single finger downwards on the right edge of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 4 – Drag Finger Downward (Middle of Screen)



Summary

The user drags a single finger downwards in the middle of the screen.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

World-dependent

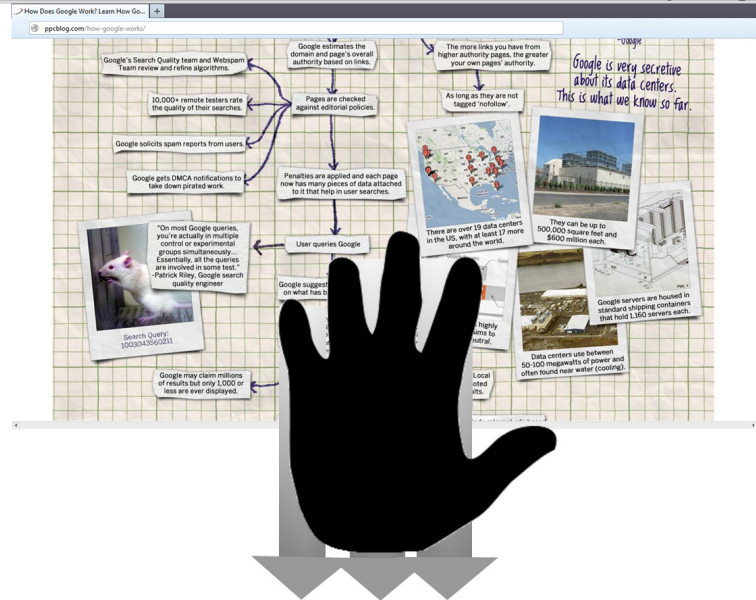
Gesture Flow

Continuous

Pointer-Type

No

Gesture 5 – Drag Multiple Fingers Downward



Summary

The user drags with the pinkie, ring, middle and index fingers from the top to the bottom of the screen.

Gesture Complexity

Complex – Parallel: Gesture comprises a drag with each finger done simultaneously

Gesture Nature

Metaphorical: The drags are metaphorical; they “direct” the screen in the required direction

Gesture Binding

World-independent

Gesture Flow

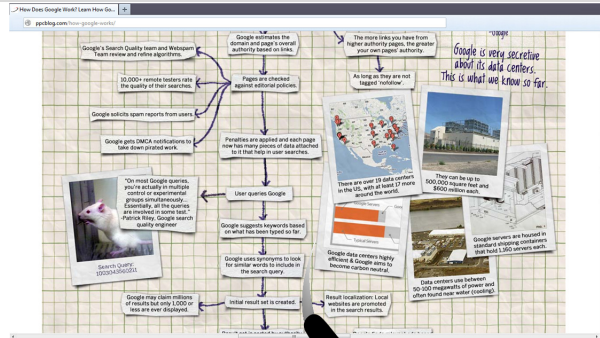
Continuous

Pointer-Type

No

Gesture Illustration

Gesture 6 – Flick Finger Downward (Bottom Edge of Screen)



Summary

The user flicks a single finger downwards at the bottom edge of the screen.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

World-dependent

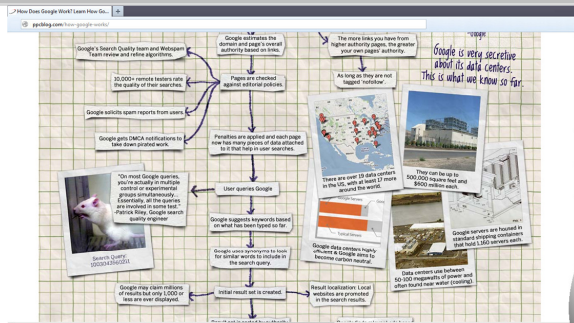
Gesture Flow

Continuous

Pointer-Type

No

Gesture 7 – Flick Finger Downward (Scrollbar Arrow)



Summary

The user flicks a single finger downwards on the scrollbar arrow that points down.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

Object-centric

Gesture Flow

Continuous

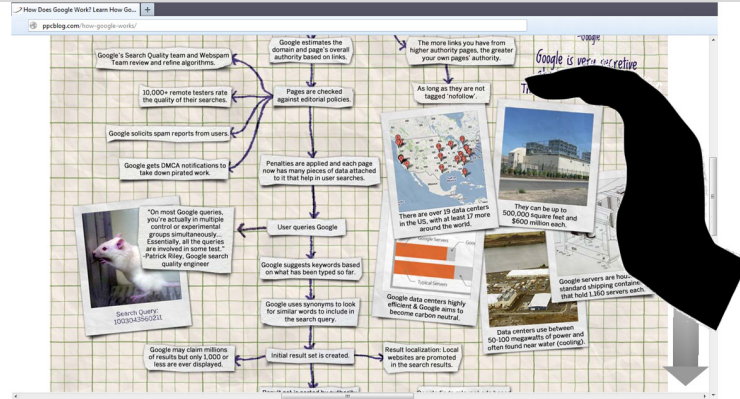
Pointer-Type

No

Gesture Information

Gesture Illustration

Gesture 8 – Drag Half-Closed Palm Down



Gesture Information

Summary	The user drags a half-closed palm from the top to the bottom on the right edge of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

9. REFERENT 9 – PAN UP THE WEBPAGE

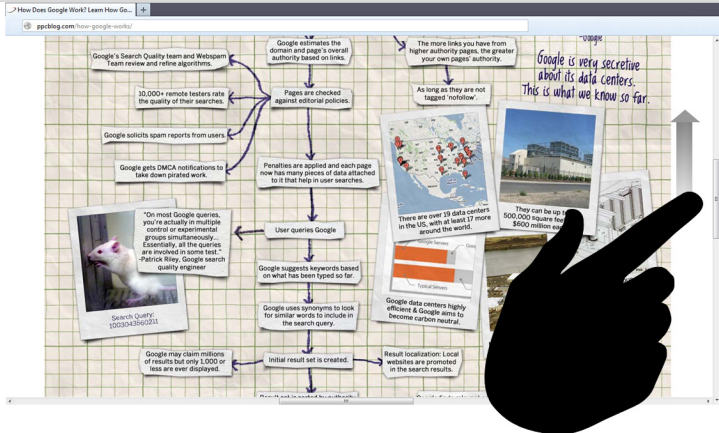
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 5 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 8 gestures were assigned to this referent:
 - Gesture 1 – Drag Finger Upward (Right Edge of Screen); proposed by 4 participants.
 - Gesture 2 – Drag Finger Upward (Scrollbar); proposed by 4 participants.
 - Gesture 3 – Flick Finger Upward (Right Edge of Screen); proposed by 2 participants.
 - Gesture 4 – Drag Finger Upward (Middle of Screen); proposed by 1 participant.

- Gesture 5 – Drag Multiple Fingers Upward; proposed by 1 participant.
- Gesture 6 – Flick Finger Upward (Top Edge of Screen); proposed by 1 participant.
- Gesture 7 – Flick Finger Upward (Scrollbar Arrow); proposed by 1 participant.
- Gesture 8 – Drag Half-Closed Palm Up; proposed by 1 participant.
- The agreement score for this referent was 0.490 (the average agreement score was 0.327).

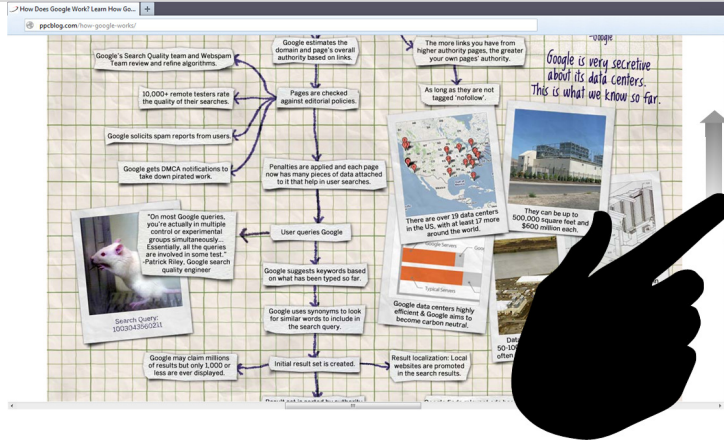
The gestures assigned to this referent are tabulated below.

Table 54: Gestures Assigned to Referent9 – Pan up the webpage

Gesture Illustration		Gesture Information
Gesture 1 – Drag Finger Upward (Right Edge of Screen)		
		Summary The user drags a single finger upwards on the right edge of the screen.
Gesture Complexity		Simple
Gesture Nature		Metaphorical
Gesture Binding		World-dependent
Gesture Flow		Continuous
Pointer-Type		Yes

Gesture Illustration

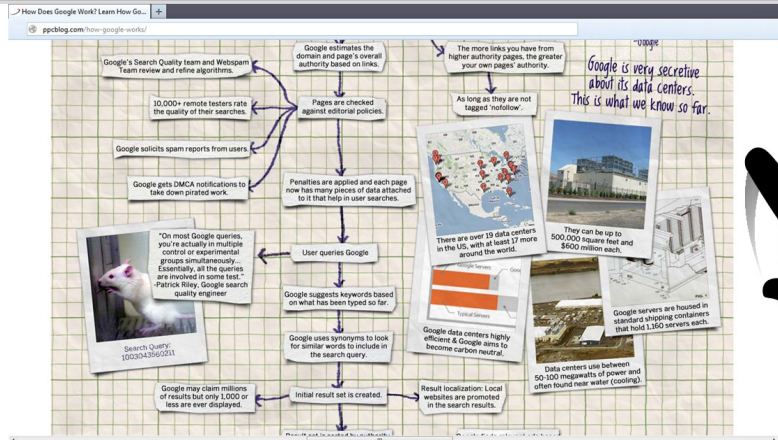
Gesture 2 – Drag Finger Upward (Scrollbar)



Gesture Information

Summary	The user drags a single finger upwards on the scrollbar.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	Yes

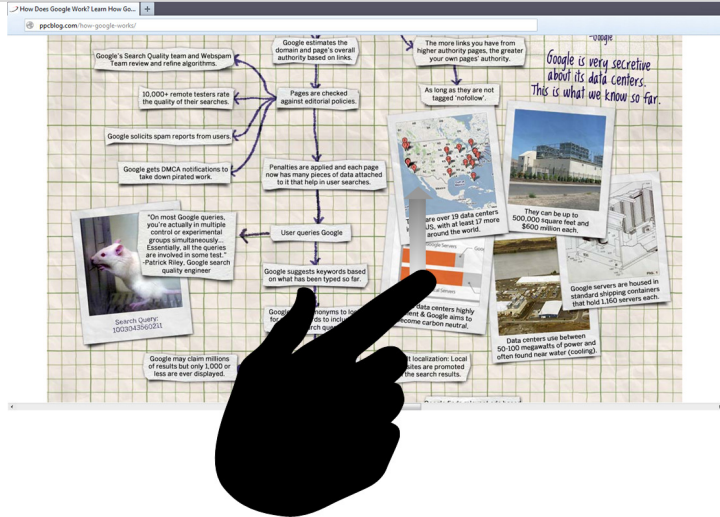
Gesture 3 – Flick Finger Upward (Right Edge of Screen)



Summary	The user flicks a single finger upwards on the right edge of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 4 – Drag Finger Upward (Middle of Screen)



Summary

The user drags a single finger upwards in the middle of the screen.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

World-dependent

Gesture Flow

Continuous

Pointer-Type

No

Gesture 5 – Drag Multiple Fingers Upward



Summary

The user drags from the bottom to the top of the screen with the pinkie, ring, middle and index fingers.

Gesture Complexity

Complex – Parallel: Gesture comprises a drag with each finger done simultaneously

Gesture Nature

Metaphorical: The drags are metaphorical; they “direct” the screen in the required direction

Gesture Binding

World-independent

Gesture Flow

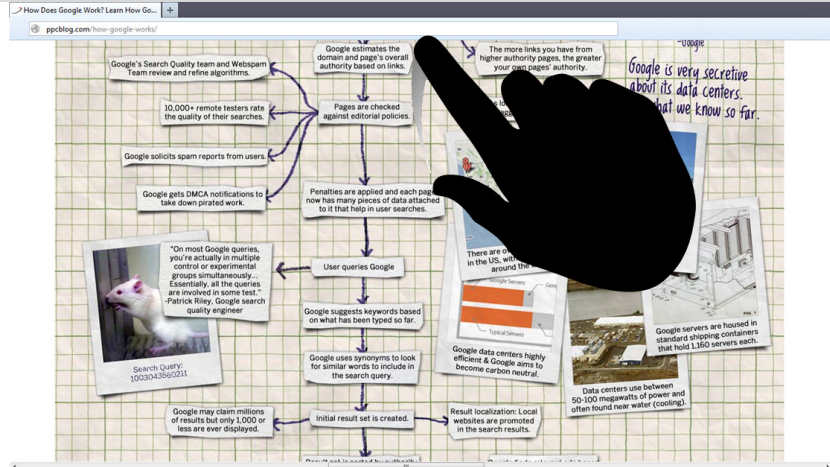
Continuous

Pointer-Type

No

Gesture Illustration

Gesture 6 – Flick Finger Upward (Top Edge of Screen)



Summary

The user flicks a single finger upwards at the top edge of the screen.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

World-dependent

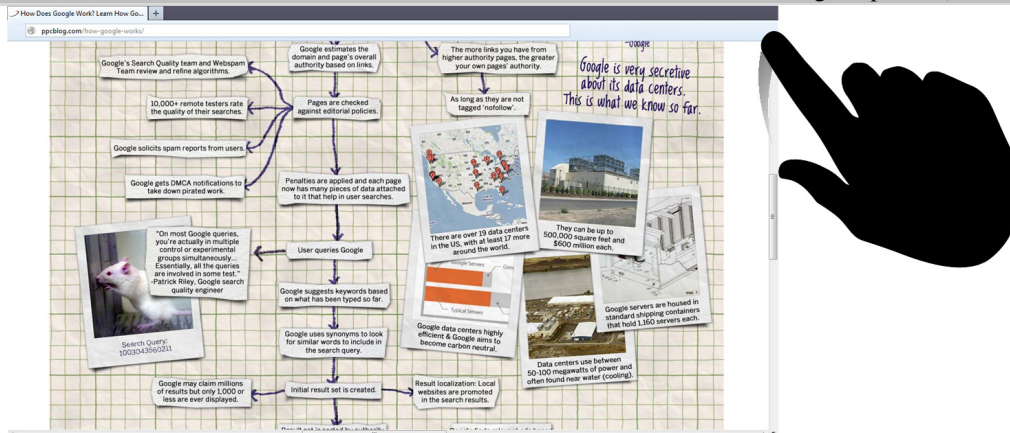
Gesture Flow

Continuous

Pointer-Type

No

Gesture 7 – Flick Finger Upward (Scrollbar Arrow)



Summary

The user flicks a single finger upwards on the scrollbar arrow that points up.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

Object-centric

Gesture Flow

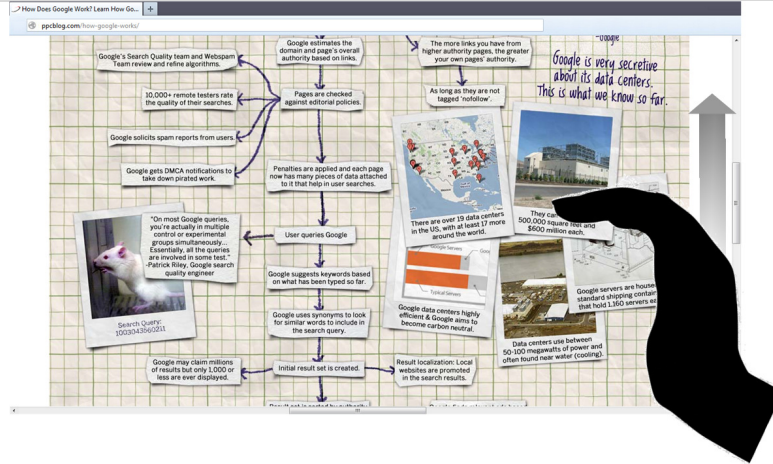
Continuous

Pointer-Type

No

Gesture Illustration

Gesture 8 – Drag Half-Closed Palm Up



Gesture Information

Summary	The user drags a half-closed palm from the bottom to the top on the right edge of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

10. REFERENT 10 – PAN ACROSS THE WEBPAGE

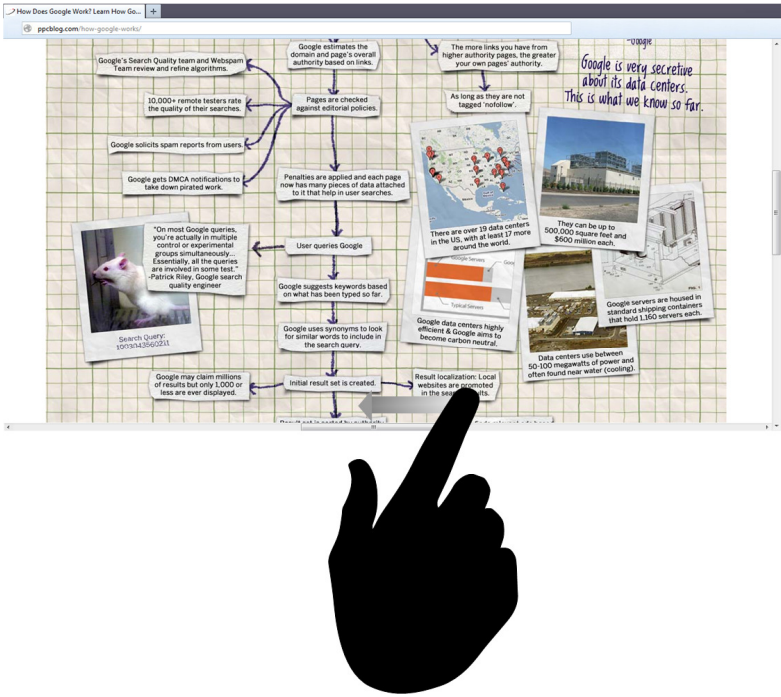
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 3 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 8 gestures were assigned to this referent:
 - Gesture 1 – Drag Finger Left (Bottom Edge of Screen); proposed by 4 participants.
 - Gesture 2 – Drag Finger Left (Middle of Screen); proposed by 3 participants.

- Gesture 3 – Flick Finger Left (Bottom Edge of Screen); proposed by 2 participants.
- Gesture 4 – Flick Finger Left (Middle of Screen); proposed by 1 participant.
- Gesture 5 – Flick Finger Left (Right Edge of Screen); proposed by 1 participant.
- Gesture 6 – Flick Finger Left (Scrollbar Arrow); proposed by 1 participant.
- Gesture 7 – Drag Multiple Fingers Left; proposed by 1 participant.
- Gesture 8 – Drag Vertical Hand Right; proposed by 1 participant.
- The agreement score for this referent was 0.590 (the average agreement score was 0.327).

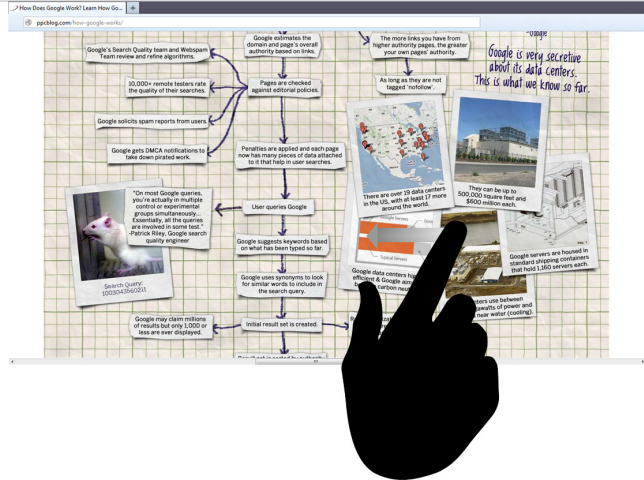
The gestures assigned to this referent are tabulated below.

Table 55: Gestures Assigned to Referent10 – Pan across the webpage

Gesture Illustration		Gesture Information	
Gesture 1 – Drag Finger Left (Bottom Edge of Screen)			
		Summary	The user drags a single finger from right to left at the bottom edge of the screen.
		Gesture Complexity	Simple
		Gesture Nature	Metaphorical
		Gesture Binding	World-dependent
		Gesture Flow	Continuous
		Pointer-Type	No

Gesture Illustration

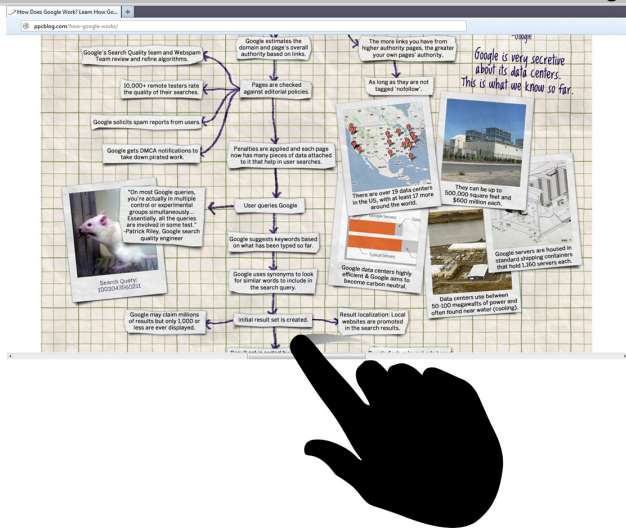
Gesture 2 – Drag Finger Left (Middle of Screen)



Gesture Information

Summary	The user drags a single finger from right to left in the middle of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

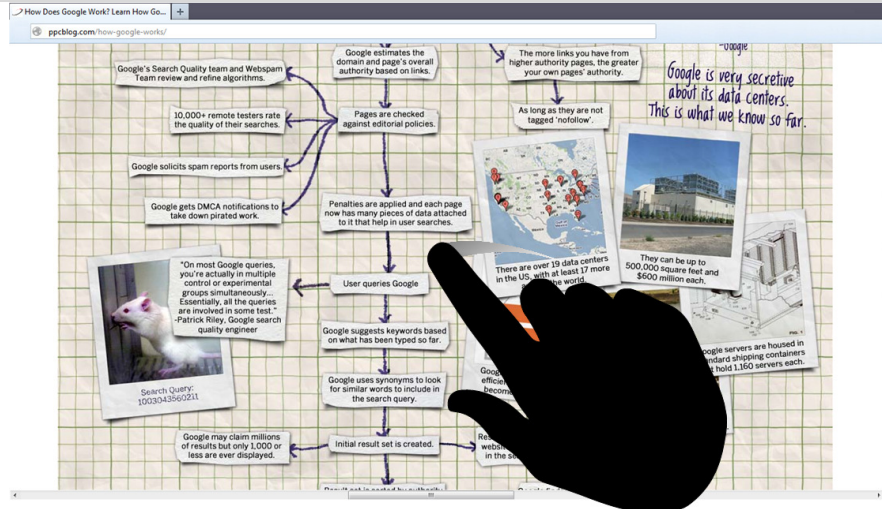
Gesture 3 – Flick Finger Left (Bottom Edge of Screen)



Summary	The user flicks a single finger from right to left at the bottom of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

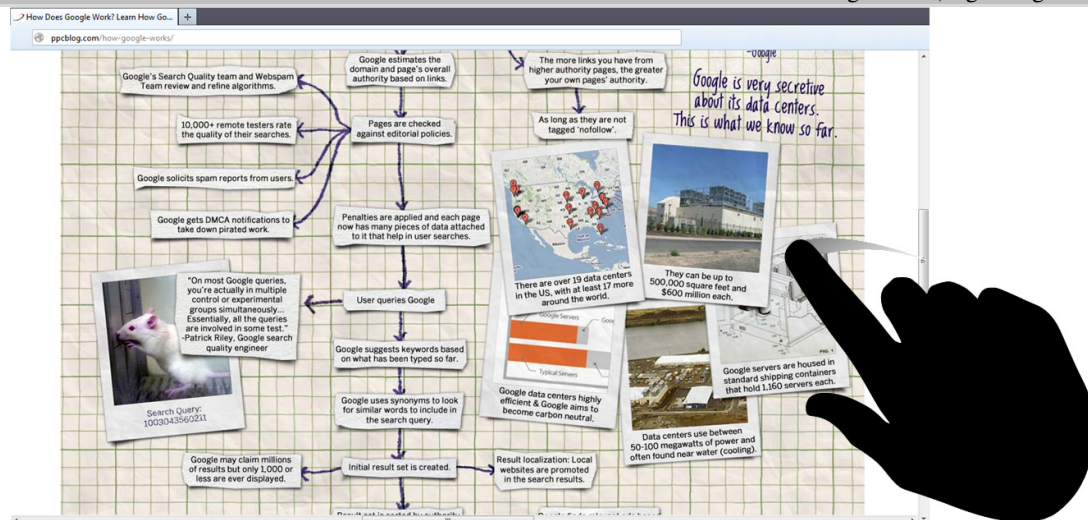
Gesture 4 – Flick Finger Left (Middle of Screen)



Gesture Information

Summary	The user flicks a single finger from right to left in the middle of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

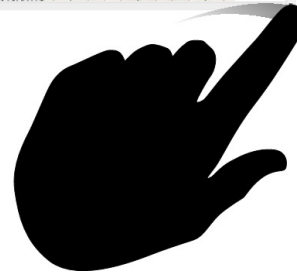
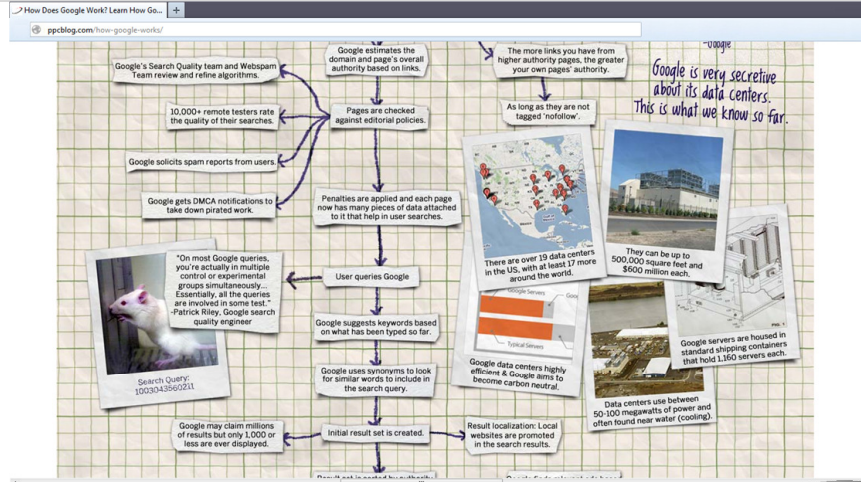
Gesture 5 – Flick Finger Left (Right Edge of Screen)



Summary	The user flicks a single finger from right to left at the right edge of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 6 – Flick Finger Left (Scrollbar Arrow)



Gesture Information

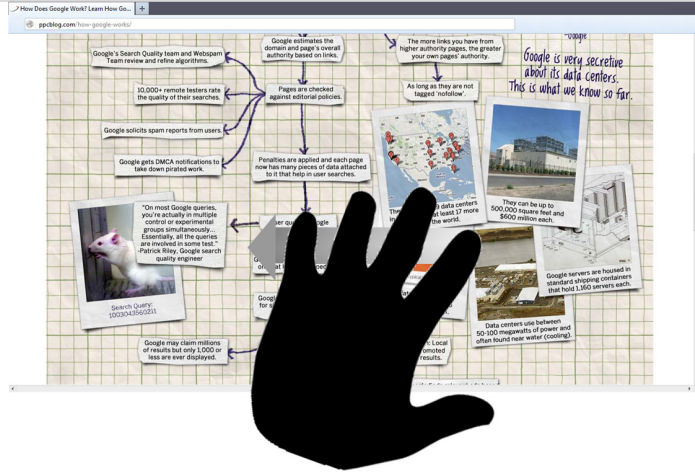
Summary

The user flicks a single finger left to right on the scrollbar arrow that points right.

Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

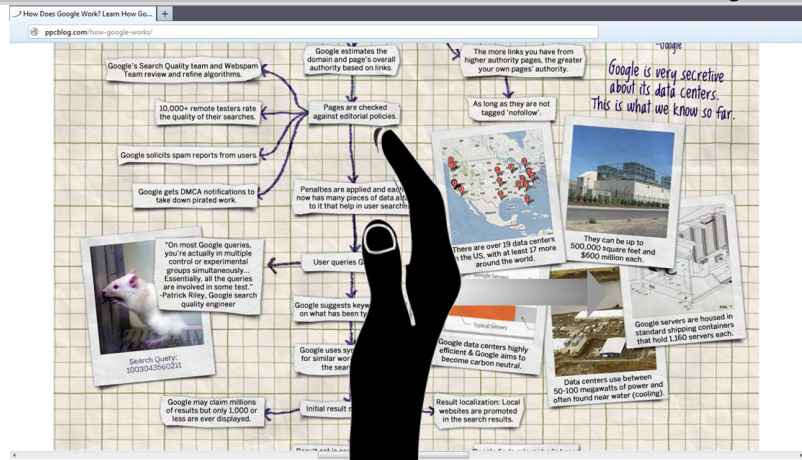
Gesture 7 – Drag Multiple Fingers Left



Gesture Information

Summary	The user drags from the right to the left of the screen with the pinkie, ring, middle and index fingers.
Gesture Complexity	Complex – Parallel: Gesture comprises a drag with each finger done simultaneously
Gesture Nature	Metaphorical: The drags are metaphorical; they “direct” the screen in the required direction
Gesture Binding	World-independent
Gesture Flow	Continuous
Pointer-Type	No

Gesture 8 – Drag Vertical Hand Right



Summary	The user drags the side of 1 hand from the right to the left in the middle of the screen.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

11. REFERENT 11 – SEARCH FOR TEXT ON THE WEBPAGE

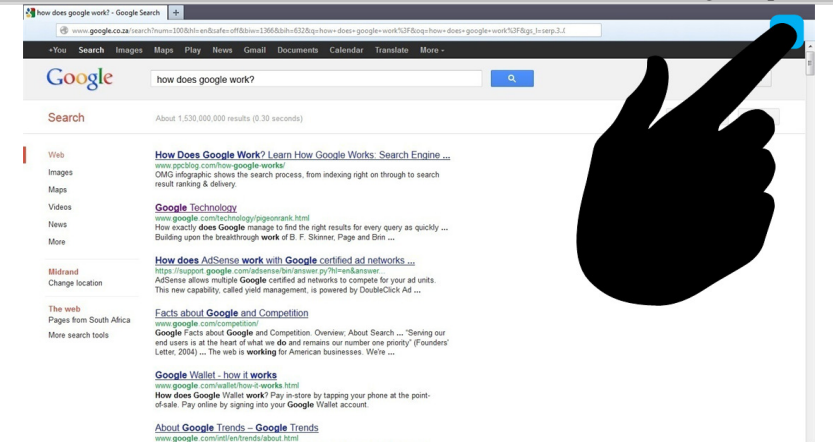
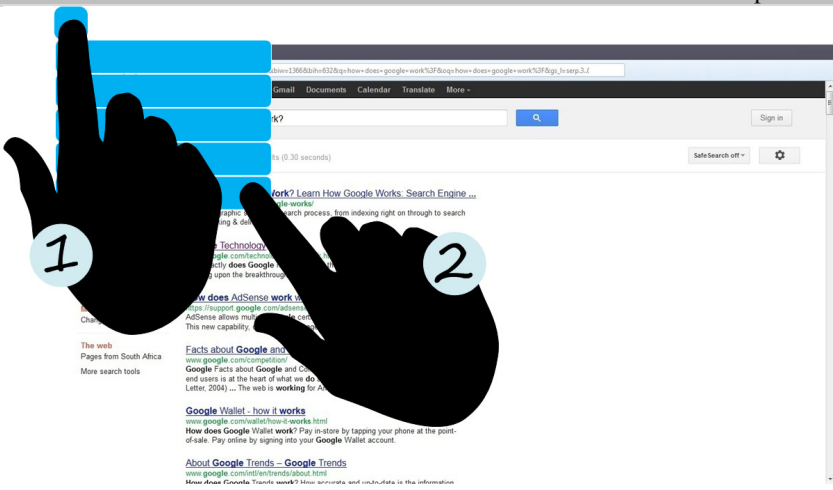
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 2 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Search Button”; proposed by 12 participants.
 - Gesture 2 – Select Option from Main Menu; proposed by 2 participants.
 - Gesture 3 – Use Keyboard Shortcut (Alt + F); proposed by 1 participant.
 - Gesture 4 – Trace “Search Box”; proposed by 1 participant.
 - Gesture 5 – Tap with Both Palms; proposed by 1 participant.
 - Gesture 6 – “Search Circle”; proposed by 1 participant.
- The agreement score for this referent was 0.390 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

It should be noted that the participants were requested to provide gestures that would call up a textbox into which they could provide their search queries. The gestures for providing this search query were not elicited as these were addressed in Referent 1 – Input Search Query.

Table 56: Gestures Assigned to Referent11 – Search for text on the webpage

Gesture Illustration	Gesture Information												
Gesture 1 – Single Tap on “Search Button” 	<table border="1"> <tr> <td>Summary</td><td>The user calls up a textbox into which he / she can provide the search query by tapping on a “search button”.</td></tr> <tr> <td>Gesture Complexity</td><td>Simple</td></tr> <tr> <td>Gesture Nature</td><td>Metaphorical</td></tr> <tr> <td>Gesture Binding</td><td>Object-centric</td></tr> <tr> <td>Gesture Flow</td><td>Discrete</td></tr> <tr> <td>Pointer-Type</td><td>Yes</td></tr> </table>	Summary	The user calls up a textbox into which he / she can provide the search query by tapping on a “search button”.	Gesture Complexity	Simple	Gesture Nature	Metaphorical	Gesture Binding	Object-centric	Gesture Flow	Discrete	Pointer-Type	Yes
Summary	The user calls up a textbox into which he / she can provide the search query by tapping on a “search button”.												
Gesture Complexity	Simple												
Gesture Nature	Metaphorical												
Gesture Binding	Object-centric												
Gesture Flow	Discrete												
Pointer-Type	Yes												
Gesture 2 – Select Option from Main Menu 	<table border="1"> <tr> <td>Summary</td><td>The user calls up a textbox into which he / she can provide the search query by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to provide a search query (Phase 2).</td></tr> <tr> <td>Gesture Complexity</td><td>Complex – Sequential: Gesture comprises 2 taps done sequentially.</td></tr> <tr> <td>Gesture Nature</td><td>Metaphorical: Phase 1 and 2</td></tr> <tr> <td>Gesture Binding</td><td>Object-centric: Phase 1 and 2</td></tr> <tr> <td>Gesture Flow</td><td>Continuous</td></tr> <tr> <td>Pointer-Type</td><td>Yes</td></tr> </table>	Summary	The user calls up a textbox into which he / she can provide the search query by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to provide a search query (Phase 2).	Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.	Gesture Nature	Metaphorical: Phase 1 and 2	Gesture Binding	Object-centric: Phase 1 and 2	Gesture Flow	Continuous	Pointer-Type	Yes
Summary	The user calls up a textbox into which he / she can provide the search query by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to provide a search query (Phase 2).												
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.												
Gesture Nature	Metaphorical: Phase 1 and 2												
Gesture Binding	Object-centric: Phase 1 and 2												
Gesture Flow	Continuous												
Pointer-Type	Yes												

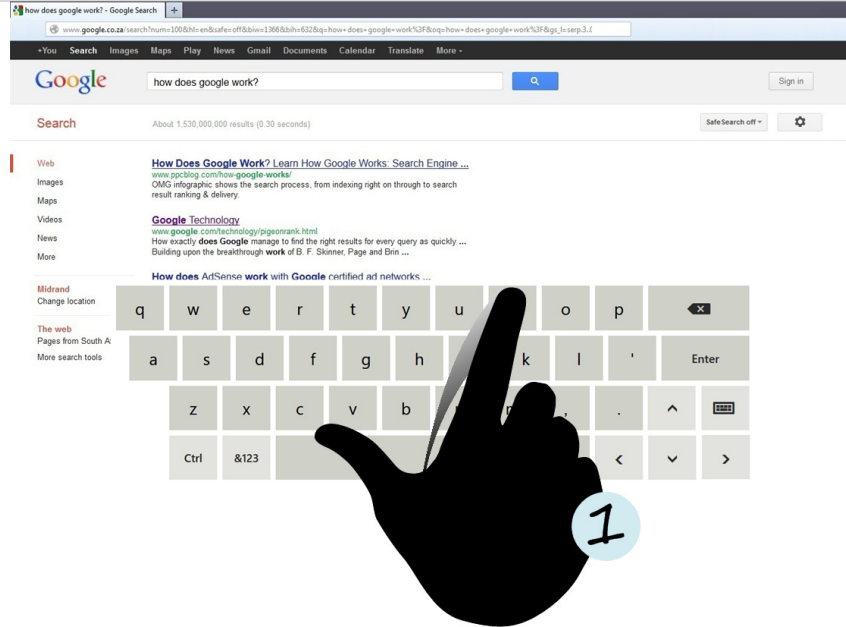
Gesture Illustration

Gesture 3 – Use Keyboard Shortcut (Alt + F)

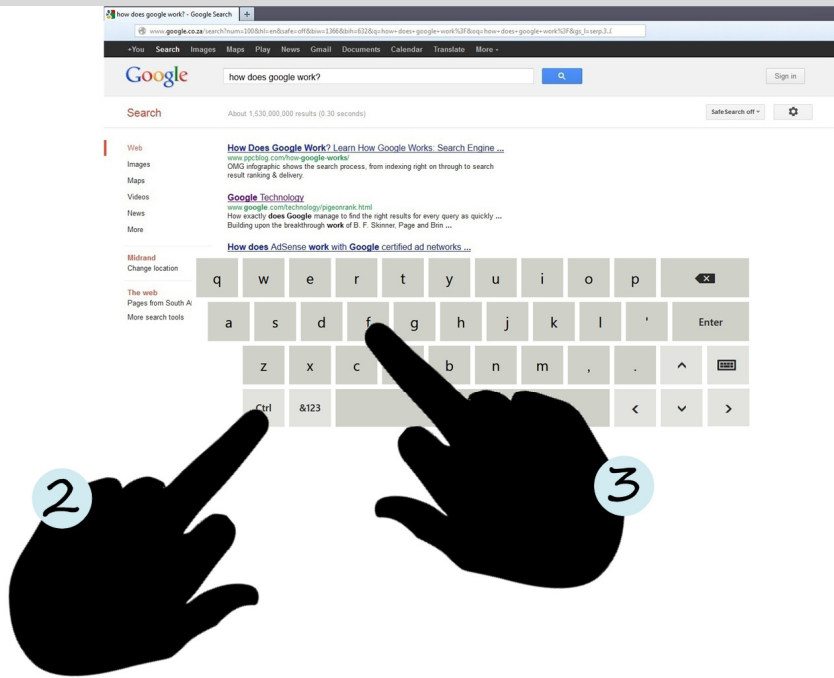
Gesture Information

Summary

The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen (Phase 1).



Gesture Illustration



Gesture Information

Summary

The user calls up a textbox into which he / she can provide the search query by using a keyboard shortcut – the user presses the “Ctrl” key (Phase 2) and taps the “F” key (Phase 3) while pressing it.

Gesture Complexity

Complex – Sequential: Phase 1 and the first part of Phase 2 are done sequentially.
Complex – Parallel: The second part of Phase 2 and Phase 3 are done in parallel.

Gesture Nature

Physical: Phase 1
Metaphorical: Phase 2 and 3

Gesture Binding

World-dependent: Phase 1
Object-centric: Phase 2 and 3

Gesture Flow

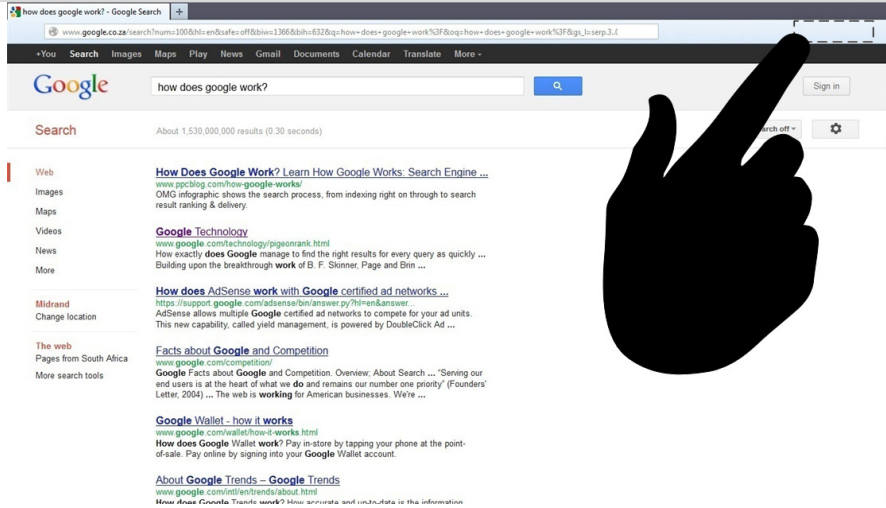
Continuous

Pointer-Type

No

Gesture Illustration

Gesture 4 – Trace “Search Box”



Summary

The user calls up a textbox into which he / she can provide the search query by tracing a box to the right of the address bar.

Gesture Complexity

Complex – Parallel: Gesture comprises 4 drags to trace the sides of the box.

Gesture Nature

Symbolic

Gesture Binding

World-dependent

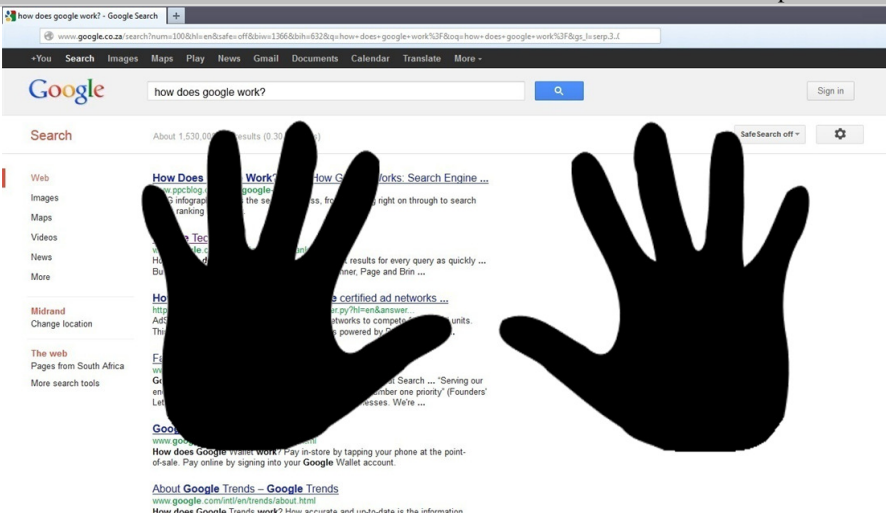
Gesture Flow

Discrete

Pointer-Type

No

Gesture 5 –Tap with Both Palms



Summary

The user calls up a textbox into which he / she can provide the search query by tapping on the screen with both palms a couple of times. The palms taps are done in quick succession.

Gesture Complexity

Complex – Parallel: Gesture comprises palms taps done simultaneously (both hands tap at the same time).
Complex – Sequential: Gesture comprises palms taps done sequentially (the taps of each hand are sequential)

Gesture Nature

Arbitrary: all phases of the gesture are arbitrary.

Gesture Binding

World-independent

Gesture Flow

Discrete

Pointer-Type

No

Gesture Information

Gesture Illustration

Gesture 6 – “Search Circle”

Gesture Information

Summary

The user calls up a textbox into which he / she can provide the search query by “making a circle” with the right thumb and right index finger, and placing these on the screen. This is achieved by twisting the wrist so that the length of the thumb and index finger are in contact with the touch screen.

Gesture Complexity

Complex – Parallel: Gesture comprises a tap with the thumb and index finger simultaneously.

Gesture Nature

Arbitrary

Gesture Binding

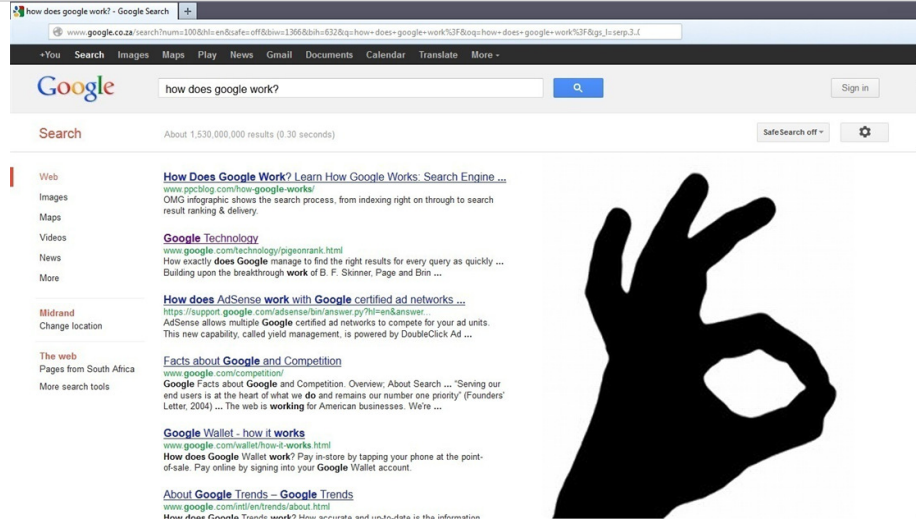
World-independent

Gesture Flow

Discrete

Pointer-Type

No



12. REFERENT 12 – COPY A SECTION OF TEXT ON THE WEBPAGE

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 17 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 2 gestures were assigned to this referent:
 - Gesture 1 – Press and Drag Finger Over Text; proposed by 2 participants.
 - Gesture 2 – Single Tap on Words, Highlight and Copy; proposed by 1 participants.

- The agreement score for this referent was 0.110 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 57: Gestures Assigned to Referent12 – Copy a section of text on the webpage

Gesture Illustration		Gesture Information	
Gesture 1 – Press and Drag Finger Over Text			
		Summary	The user copies a section of text pressing with a single finger where the text begins, and dragging the finger over the text (from left to right).
		Gesture Complexity	Complex – Sequential: Gesture comprises a press and a drag done sequentially.
		Gesture Nature	Metaphorical
		Gesture Binding	Object-centric
		Gesture Flow	Continuous
		Pointer-Type	Yes

Gesture Illustration

Gesture 2 – Single Tap on Words, Highlight and Copy

Gesture Information



Summary	The user copies a section of text by tapping on each of the words to be copied (Phase 1), tapping once on a “Highlight Button” – which highlights the words which were tapped (Phase 2), tapping once on a “Copy Button” – which copies the highlighted words (Phase 3).
Gesture Complexity	Complex – Sequential: Phase 1 (which comprises single finger taps done sequentially), Phase 2 and Phase 3 are done sequentially.
Gesture Nature	Physical: Phase 1; words are pointed out as one would point words in a book or document. Metaphorical: Phase 2 and 3
Gesture Binding	Object-centric: All phases are object-centric
Gesture Flow	Continuous
Pointer-Type	Yes

13. REFERENT 13 – PASTE SECTION OF TEXT INTO SEARCH ENGINE

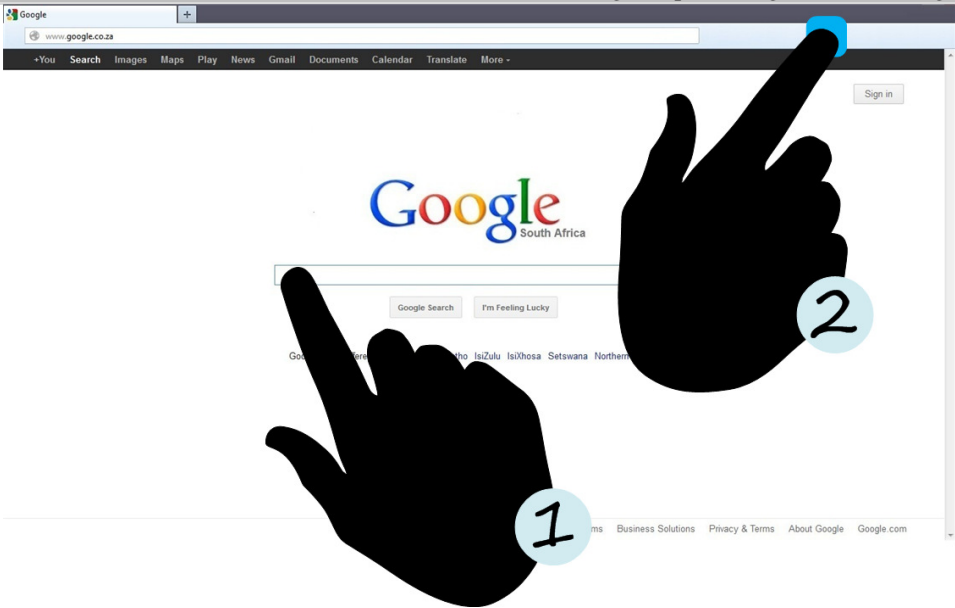
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 7 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).

- Following the exclusions of conflicts, 7 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on Google Textbox, Single Tap on “Paste Button”; proposed by 3 participants.
 - Gesture 2 – Use Keyboard Shortcut (Ctrl + V); proposed by 1 participant.
 - Gesture 3 – Select Option from Context Menu on Google Textbox; proposed by 2 participants.
 - Gesture 4 – Single Tap with Finger, Drag Finger Right; proposed by 1 participants.
 - Gesture 5 – Drag Finger Left on Google Textbox; proposed by 1 participant.
 - Gesture 6 – Two Finger Tap; proposed by 1 participant.
 - Gesture 7 – Drag Text from “Easel Button” or “Paste Button”; proposed by 1 participant.
- The agreement score for this referent was 0.105 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 58: Gestures Assigned to Referent13 – Paste section of text into search engine

Gesture Illustration		Gesture Information	
Gesture 1 – Single Tap on Google Textbox, Single Tap on “Paste Button”			
		Summary	The user pastes a section of text into Google by tapping once on the Google textbox (Phase 1), and tapping once on the “Paste Button”.
		Gesture Complexity	Complex – Parallel: Gesture comprises 2 taps done sequentially.
		Gesture Nature	Metaphorical: Phase 1 and 2
		Gesture Binding	Object-centric: Both phases are object-centric.
		Gesture Flow	Continuous
		Pointer-Type	Yes

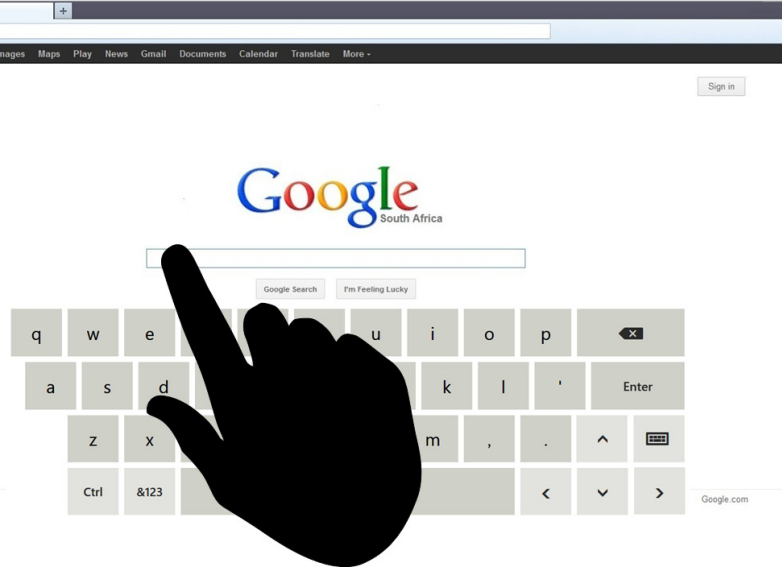
Gesture Illustration

Gesture 2 – Use Keyboard Shortcut (Ctrl + V)

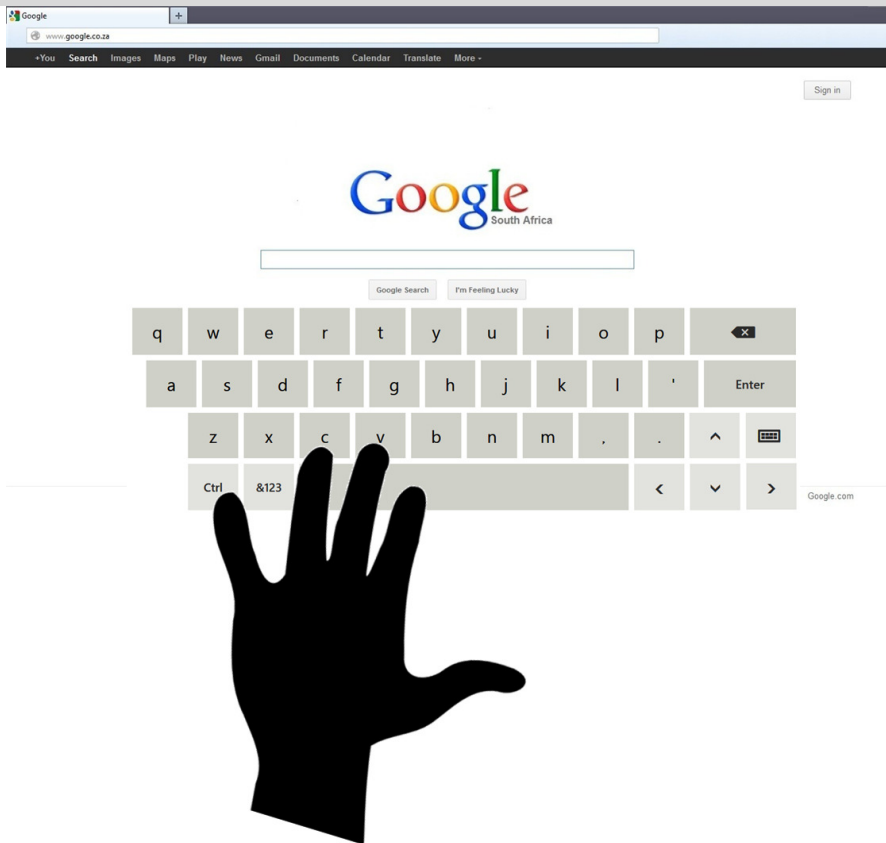
Gesture Information

Summary

The user taps once on the Google text box to bring up the keyboard (Phase 1).



Gesture Illustration



Gesture Information

Summary

The user uses a keyboard shortcut to paste the text – this comprises of pressing the “Ctrl” key (Phase 2) and tapping the “C” key (Phase 3) while pressing it.

Gesture Complexity

Complex – Sequential: Phase 1 and the first part of Phase 2 are done sequentially.
Complex – Parallel: The second part of Phase 2 and Phase 3 are done in parallel.

Gesture Nature

Metaphorical: Phase 1, 2 and 3

Gesture Binding

Object-centric: Phase 1, 2 and 3

Gesture Flow

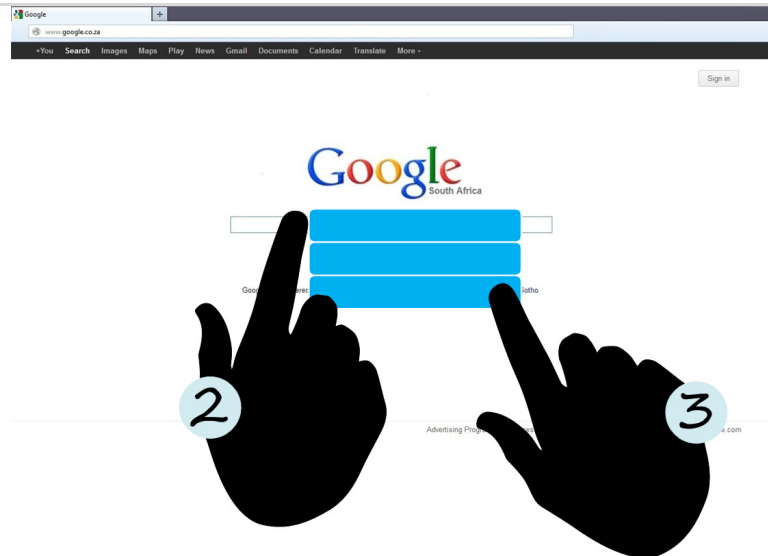
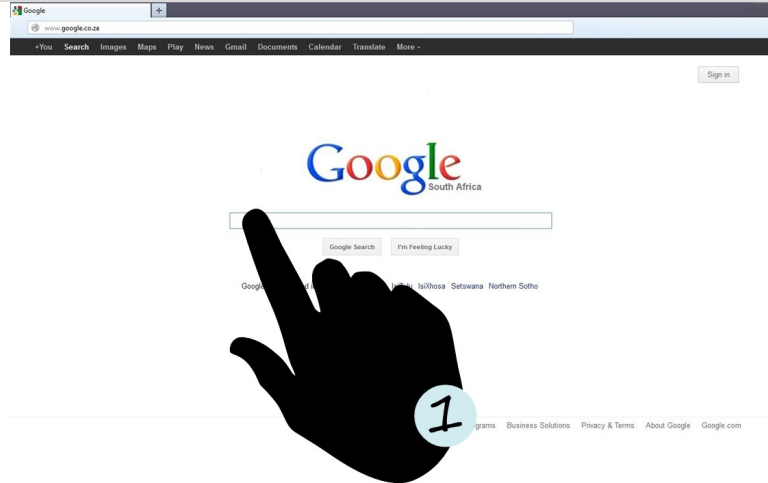
Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 3 – Select Option from Context Menu on Google Textbox



Gesture Information

Summary	The user taps once on the Google textbox (Phase 1).
Summary	The user taps again on the Google textbox – to the right of where the initial tap was done (Phase 2). Doing so bring up a context menu. The user taps once on the “Paste” menu item (Phase 3) to paste the text.
Gesture Complexity	Complex – Sequential: Phase 1, 2 and 3 are done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 3 Arbitrary: Phase 2
Gesture Binding	Object-centric: Phase 1, 2 and 3
Gesture Flow	Continuous
Pointer-Type	Yes

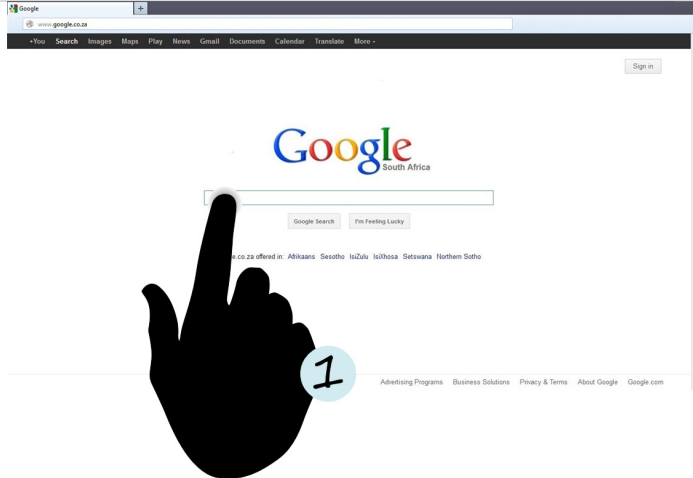
Gesture Illustration

Gesture 4 – Single Tap with Finger, Drag Finger Right

Gesture Information

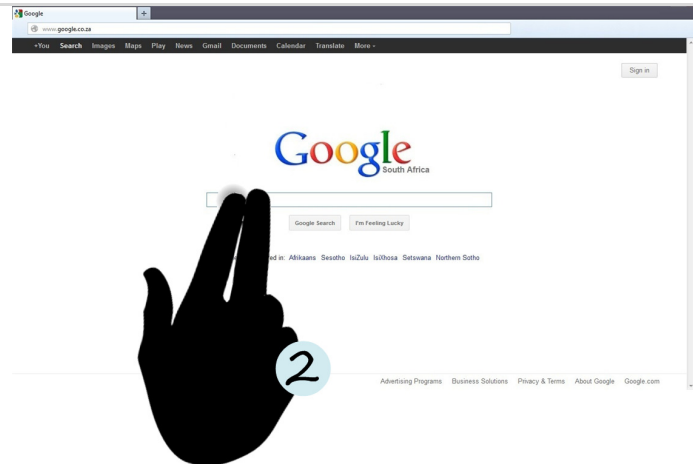
Summary

The user presses on the Google textbox with the index finger (Phase 1).

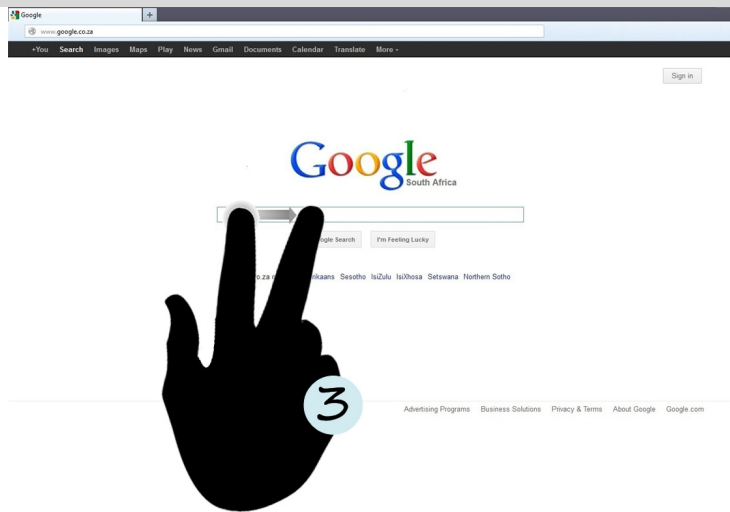


Summary

The user then taps with on the Google textbox with the middle finger (Phase 2), while still pressing with the index finger.



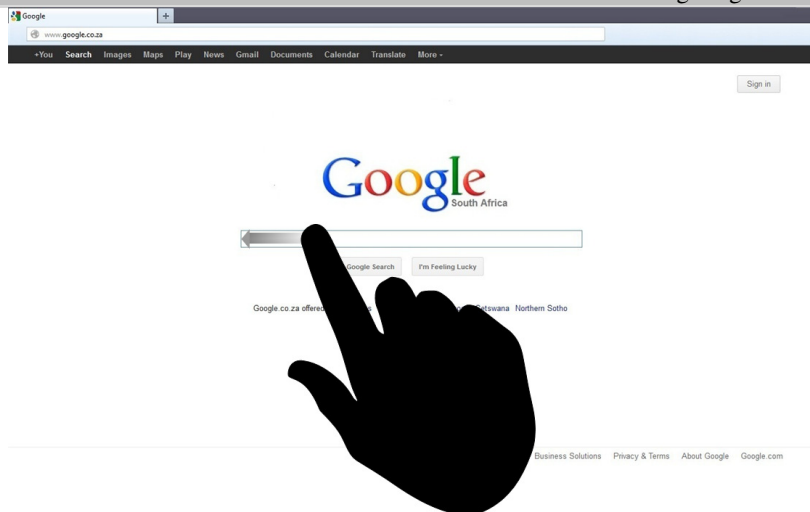
Gesture Illustration



Gesture Information

Summary	The user then drags the middle finger to the right on the Google textbox (Phase 3) to paste the text.
Gesture Complexity	Complex – Sequential: Phase 1, 2 and 3 are done sequentially Complex – Parallel: Phase 2 and 3 are done in parallel with Phase 1
Gesture Nature	Metaphorical: Phase 1 and 3 Arbitrary: Phase 2
Gesture Binding	Object-centric: Phase 1, 2 and 3
Gesture Flow	Continuous
Pointer-Type	Yes

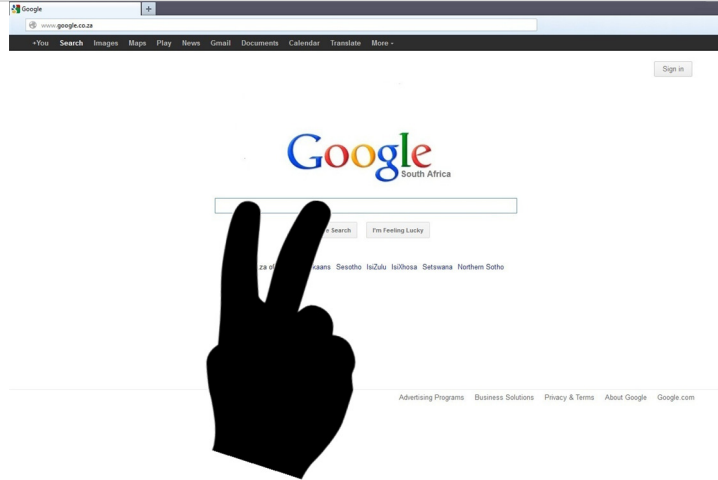
Gesture 5 – Drag Finger Left on Google Textbox



Summary	The user pastes a section of text into Google by dragging a finger from right to left on the Google textbox. This is not done along the entire length of the textbox, but towards the left edge of the textbox.
Gesture Complexity	Simple
Gesture Nature	Arbitrary
Gesture Binding	Object-centric
Gesture Flow	Discrete
Pointer-Type	No

Gesture Illustration

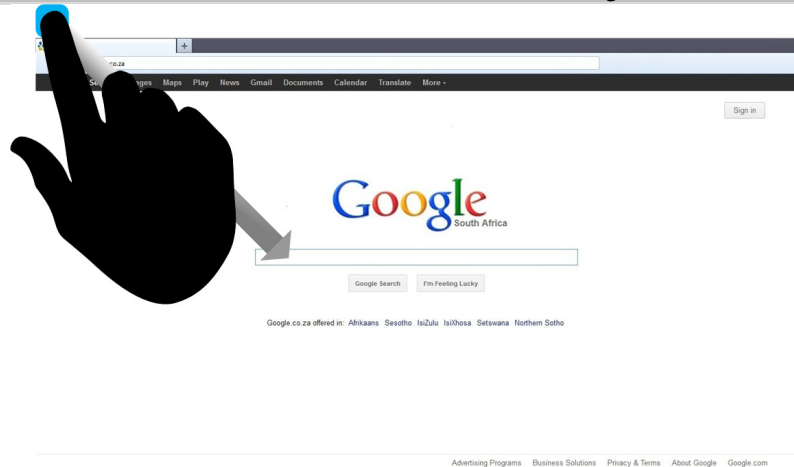
Gesture 6 – Two Finger Tap



Gesture Information

Summary	The user pastes a section of text into Google by tapping once on the Google textbox with both the index and middle fingers.
Gesture Complexity	Complex – Parallel: Gestures comprises 2 taps done simultaneously
Gesture Nature	Arbitrary
Gesture Binding	Object-centric
Gesture Flow	Discrete
Pointer-Type	No

Gesture 7 – Drag Text from “Easel Button” or “Paste Button”



Summary	The user pastes a section of text into Google by dragging a finger from the “Easel Button” or “Paste Button” to the Google textbox.
Gesture Complexity	Simple
Gesture Nature	Physical
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	Yes

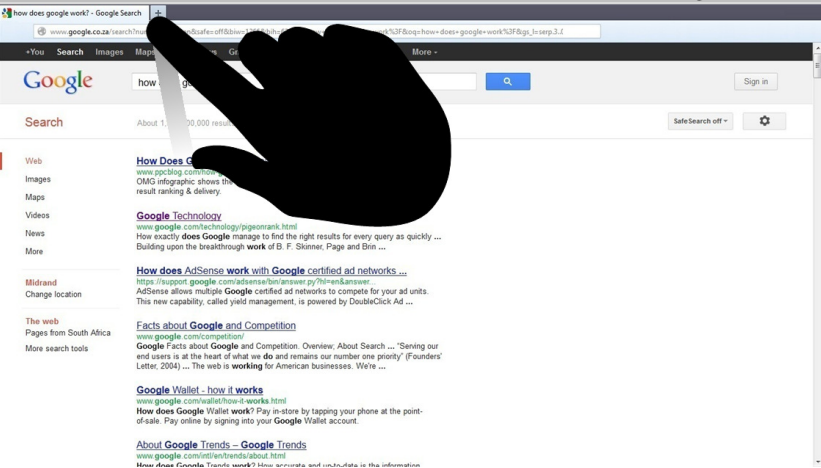
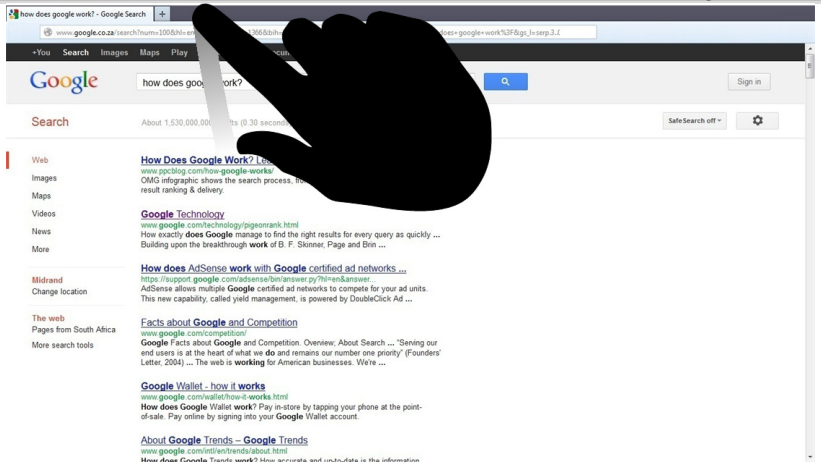
14. REFERENT 14 – OPEN LINK ON THE WEBPAGE IN A NEW TAB

The key points relating to this referent are as follows:

- 19 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 8 gestures were assigned to this referent:
 - Gesture 1 – Drag Link to “New Tab Button”; proposed by 4 participants.
 - Gesture 2 – Drag Link to “New Tab Area”; proposed by 4 participants.
 - Gesture 3 – Double Tap Link; proposed by 4 participants.
 - Gesture 4 – Single Tap on Link, Quickly Tap on “New Tab Button” (Jump); proposed by 2 participants.
 - Gesture 5 – Drag Link to “New Tab Area” with Two Fingers; proposed by 1 participant.
 - Gesture 6 – Press Link, Select Option From Context Menu; proposed by 1 participants.
 - Gesture 7 – Drag Finger Over Link, Select Option from Context Menu; proposed by 1 participants.
 - Gesture 8 – Draw “Tab” on Link; proposed by 1 participant.
- The agreement score for this referent was 0.247 (the average agreement score was 0.327).

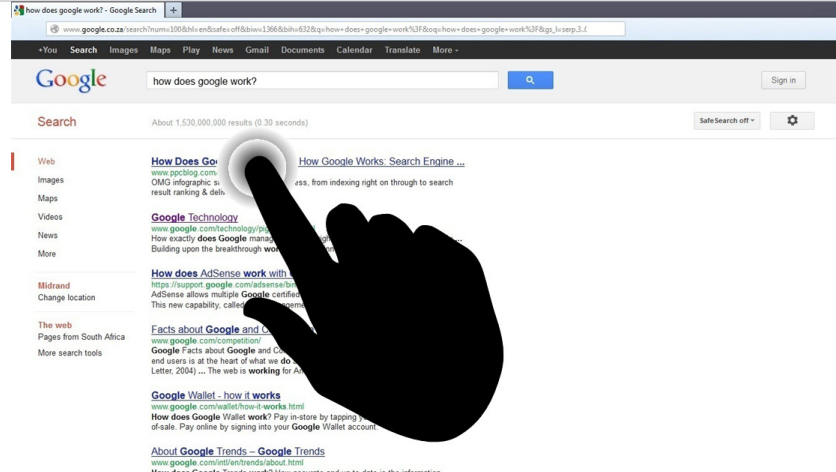
The gestures assigned to this referent are tabulated below.

Table 59: Gestures Assigned to Referent14 – Open link on the webpage in a new tab

Gesture Illustration	Gesture Information												
Gesture 1 – Drag Link to “New Tab Button” 	<table border="1"> <tr> <td>Summary</td><td>The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Button”.</td></tr> <tr> <td>Gesture Complexity</td><td>Simple</td></tr> <tr> <td>Gesture Nature</td><td>Physical</td></tr> <tr> <td>Gesture Binding</td><td>Object-centric</td></tr> <tr> <td>Gesture Flow</td><td>Continuous</td></tr> <tr> <td>Pointer-Type</td><td>Yes</td></tr> </table>	Summary	The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Button”.	Gesture Complexity	Simple	Gesture Nature	Physical	Gesture Binding	Object-centric	Gesture Flow	Continuous	Pointer-Type	Yes
Summary	The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Button”.												
Gesture Complexity	Simple												
Gesture Nature	Physical												
Gesture Binding	Object-centric												
Gesture Flow	Continuous												
Pointer-Type	Yes												
Gesture 2 – Drag Link to “New Tab Area” 	<table border="1"> <tr> <td>Summary</td><td>The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”).</td></tr> <tr> <td>Gesture Complexity</td><td>Simple</td></tr> <tr> <td>Gesture Nature</td><td>Physical</td></tr> <tr> <td>Gesture Binding</td><td>Object-centric</td></tr> <tr> <td>Gesture Flow</td><td>Continuous</td></tr> <tr> <td>Pointer-Type</td><td>Yes</td></tr> </table>	Summary	The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”).	Gesture Complexity	Simple	Gesture Nature	Physical	Gesture Binding	Object-centric	Gesture Flow	Continuous	Pointer-Type	Yes
Summary	The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”).												
Gesture Complexity	Simple												
Gesture Nature	Physical												
Gesture Binding	Object-centric												
Gesture Flow	Continuous												
Pointer-Type	Yes												

Gesture Illustration

Gesture 3 – Double Tap Link



Summary

The user opens a link on the webpage in a new tab by double tapping on the link.

Gesture Complexity

Complex – Sequential: Gesture comprises 2 taps done in quick succession

Gesture Nature

Arbitrary

Gesture Binding

Object-centric

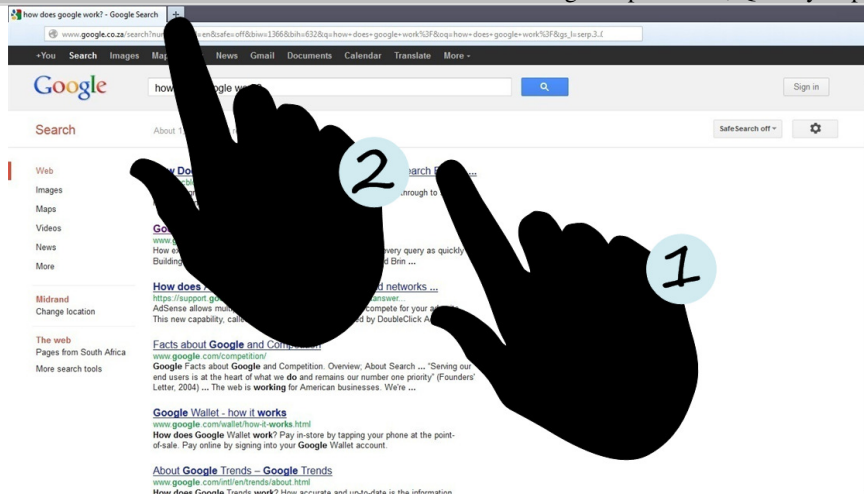
Gesture Flow

Discrete

Pointer-Type

Yes

Gesture 4 – Single Tap on Link, Quickly Tap on “New Tab Button” (Jump)



Summary

The user opens a link on the webpage in a new tab tapping on the link (Phase 1) and quickly tapping on the “New Tab Button” immediately afterwards (Phase 2).

Gesture Complexity

Complex – Sequential: Gesture comprises 2 taps done in quick succession.

Gesture Nature

Metaphorical

Gesture Binding

Object-centric

Gesture Flow

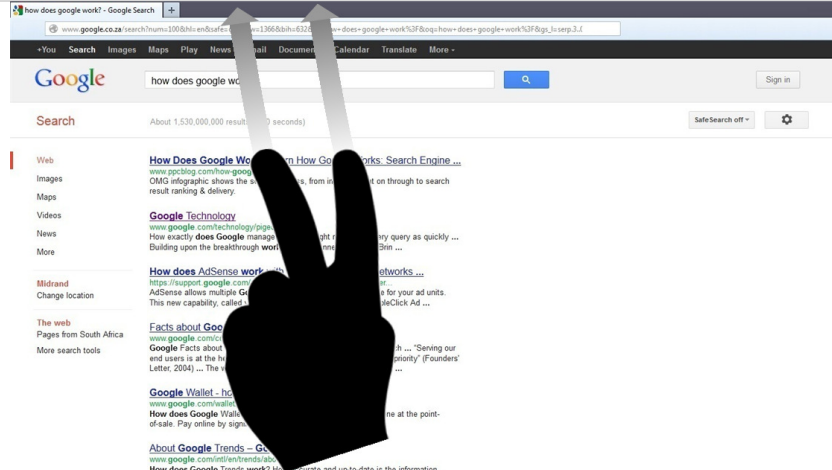
Continuous

Pointer-Type

No

Gesture Illustration

Gesture 5 – Drag Link to “New Tab Area” with Two Fingers



Gesture Information

Summary	The user opens a link on the webpage in a new tab by dragging the link to the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”) with 2 fingers.
Gesture Complexity	Complex – Parallel: Gesture comprises 2 drags done simultaneously
Gesture Nature	Physical
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	No

Gesture 6 – Press Link, Select Option From Context Menu



Summary	The user opens a link on the webpage in a new tab by pressing on the link with 1 finger (Phase 1) – this brings up a context menu. The user then taps once on the relevant menu item (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises a press and a tap done sequentially.
Gesture Nature	Arbitrary: Phase 1 Metaphoric: Phase 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture Illustration

Gesture 7 – Drag Finger Over Link, Select Option from Context Menu

Gesture Information

Summary

The user drags 1 finger over the link to be opened in a new tab (Phase 1) – this highlights the link.

Summary

The user taps on the link to bring up a context menu (Phase 2). The user then taps on the relevant menu item (Phase 3).

Gesture Complexity

Complex – Sequential: Gesture comprises a drag and 2 taps done sequentially.

Gesture Nature

Metaphorical: Phase 1 and 3
Arbitrary: Phase 3

Gesture Binding

Object-centric: Phase 1, 2 and 3

Gesture Flow

Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 8 – Draw “Tab” on Link

Gesture Information

Summary

The user opens a link on the webpage in a new tab by drawing a “tab” on the link. This consists of a short drag to the right, a short drag up, another short drag to the right, a short drag down and a final drag to the right.

Gesture Complexity

Complex – Sequential: Gesture comprises 5 drags done sequentially.

Gesture Nature

Symbolic

Gesture Binding

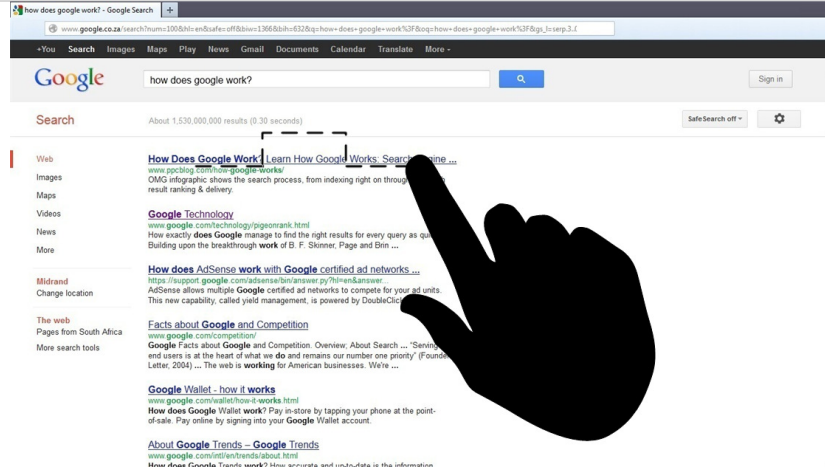
Object-centric: All phases

Gesture Flow

Discrete

Pointer-Type

No



15. REFERENT 15 – OPEN A NEW BROWSING TAB

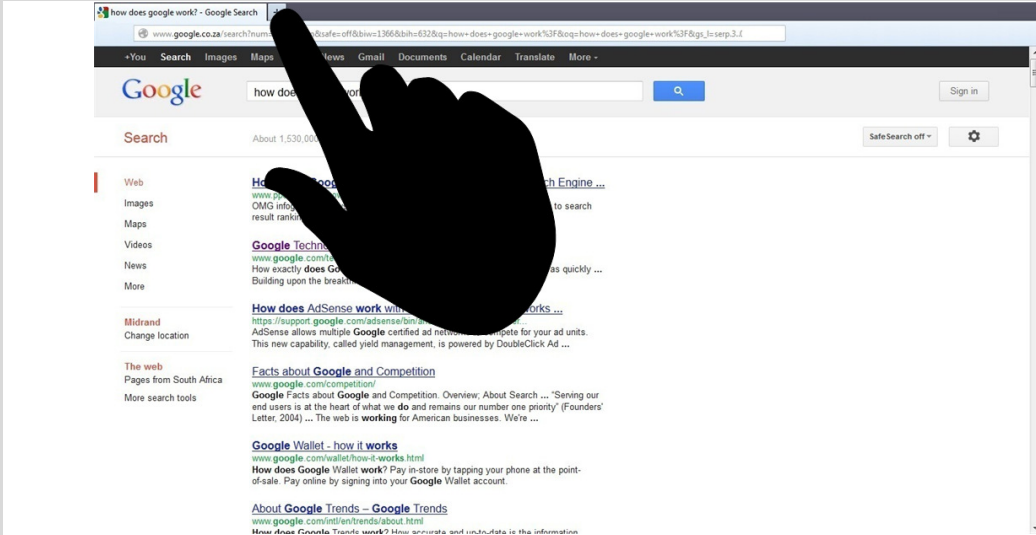
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “New Tab Button”; proposed by 11 participants.
 - Gesture 2 – Single Tap on “New Tab Area”; proposed by 3 participants.
 - Gesture 3 – Double Tap on Whitespace; proposed by 2 participants.

- Gesture 4 – Select Option from Main Menu; proposed by 1 participant.
- Gesture 5 – Draw “Tab” on “New Tab Area”; proposed by 1 participant.
- Gesture 6 – Palm Taps While Moving Hands Apart; proposed by 1 participant.
- The agreement score for this referent was 0.345 (the average agreement score was 0.327).

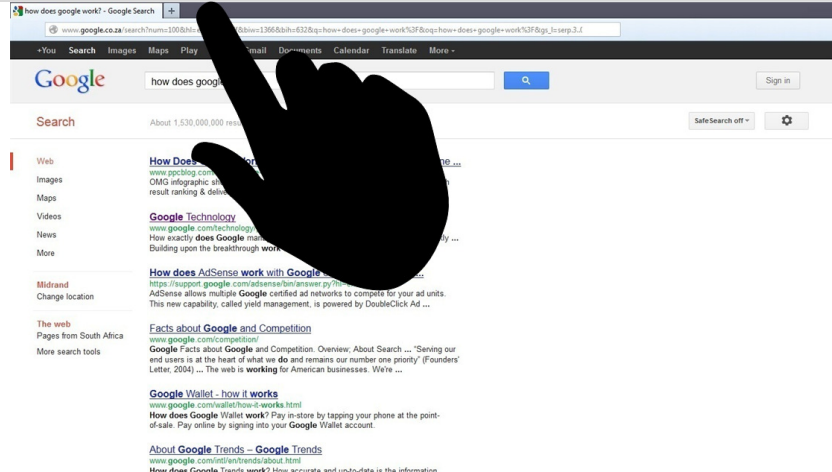
The gestures assigned to this referent are tabulated below.

Table 60: Gestures Assigned to Referent15 – Open a new browsing tab

Gesture Illustration		Gesture Information	
Gesture 1 – Single Tap on “New Tab Button”		Summary	The user opens a new browsing tab by tapping once on the “New Tab Button”.
		Gesture Complexity	Simple
		Gesture Nature	Metaphorical
		Gesture Binding	Object-centric
		Gesture Flow	Discrete
		Pointer-Type	Yes

Gesture Illustration

Gesture 2 – Single Tap on “New Tab Area”



Summary

The user opens a new browsing tab by tapping once on the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”).

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

Object-centric

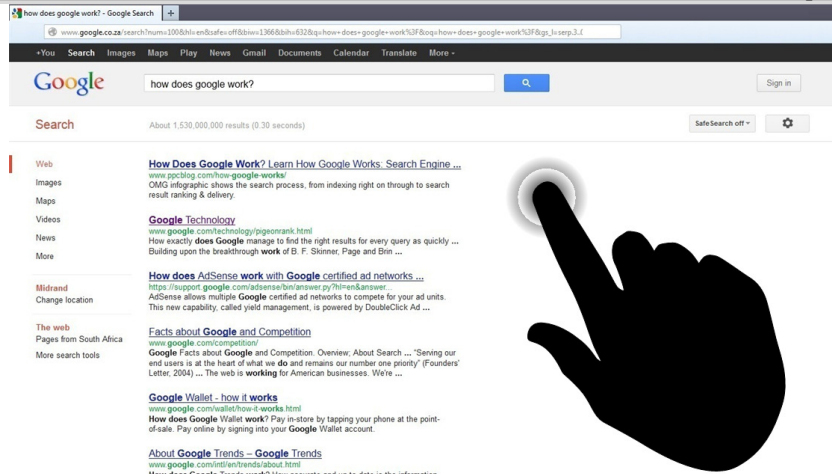
Gesture Flow

Discrete

Pointer-Type

No

Gesture 3 – Double Tap on Whitespace



Summary

The user opens a new browsing tab by double tapping with 1 finger on whitespace.

Gesture Complexity

Complex – Parallel: Gesture comprises 2 taps done in quick succession.

Gesture Nature

Arbitrary

Gesture Binding

World-independent

Gesture Flow

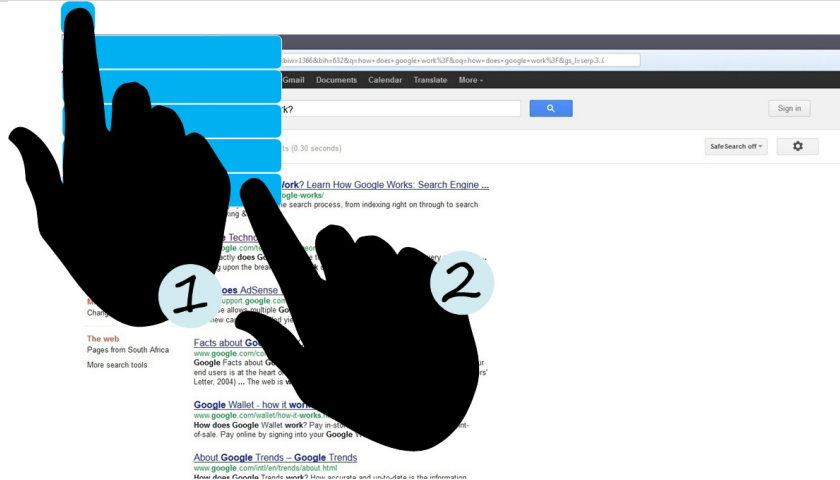
Discrete

Pointer-Type

No

Gesture Illustration

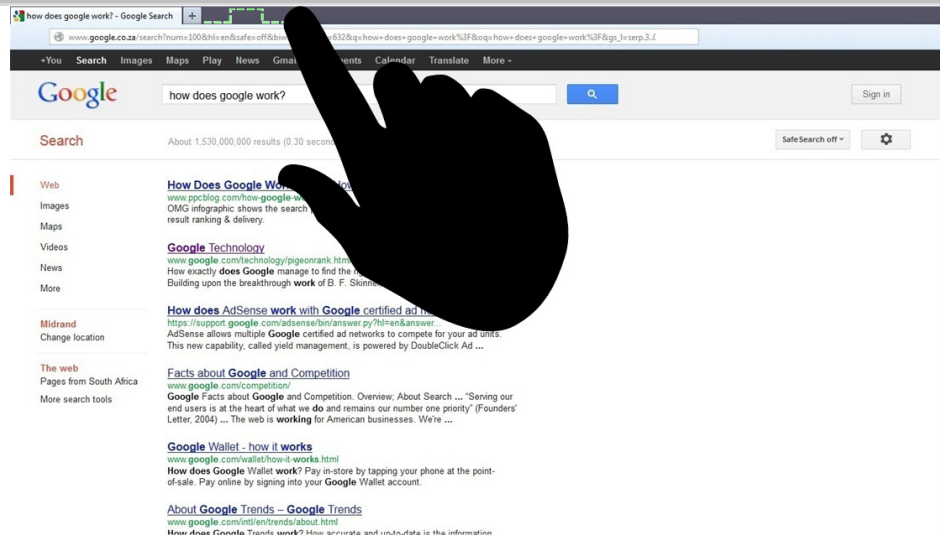
Gesture 4 – Select Option from Main Menu



Gesture Information

Summary	The user opens a new browsing tab by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1) and tapping once on a menu item that enables him / her to open a new browsing tab.
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture 5 – Draw “Tab” on “New Tab Area”

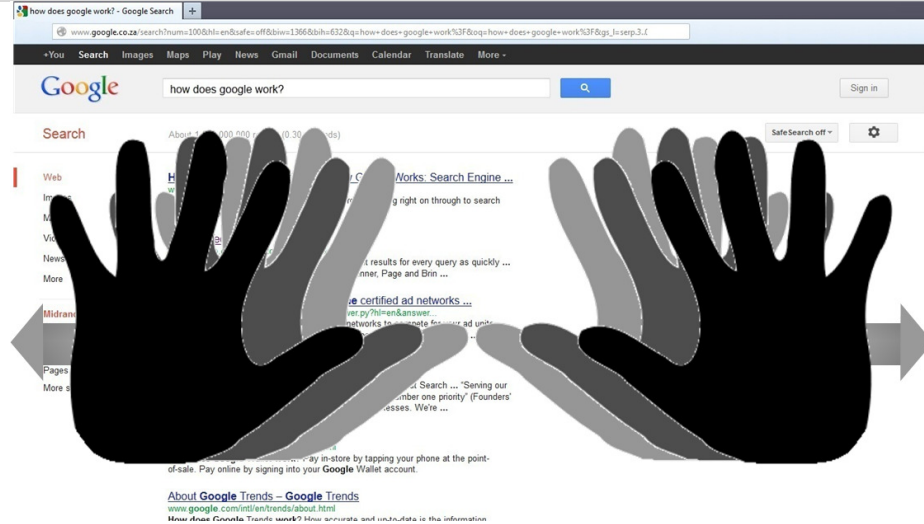


Summary	The user opens a new browsing tab by drawing a “tab” on the “New Tab Area” (which is the grey area towards the right of the “New Tab Button”). This consists of a short drag to the right, a short drag up, another short drag to the right, a short drag down and a final drag to the right.
Gesture Complexity	Complex – Sequential: Gesture comprises 5 drags done sequentially.
Gesture Nature	Symbolic
Gesture Binding	Object-centric: All phases
Gesture Flow	Discrete
Pointer-Type	No

Gesture Illustration

Gesture 6 – Palm Taps While Moving Hands Apart

Gesture Information



Summary	The user opens a new browsing tab by tapping with the palms while moving the palms towards the edges of the screen; the left hand moves towards the left edge of the screen while the right hand moves towards the right edge.
Gesture Complexity	Complex – Parallel: Gestures comprises palms taps with both hands done simultaneously.
Gesture Nature	Arbitrary
Gesture Binding	World-dependent
Gesture Flow	Discrete
Pointer-Type	No

16. REFERENT 16 – CLOSE A BROWSING TAB

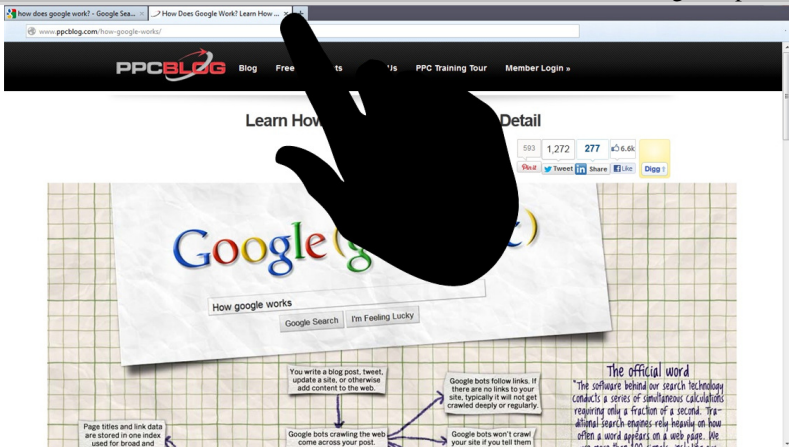
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 0 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Close Tab” Cross; proposed by 15 participants.
 - Gesture 2 – Flick Tab “Off The Screen” With Multiple Fingers (Downward); proposed by 1 participant.

- Gesture 3 – Drag Tab “Off The Screen” with Two Fingers; proposed by 1 participant.
- Gesture 4 – Trace “X” on Tab; proposed by 1 participant.
- Gesture 5 – Push Tab Beneath Adjacent Tab; proposed by 1 participant.
- Gesture 6 – Single Tap on Tab; proposed by 1 participant.
- The agreement score for this referent was 0.575 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 61: Gestures Assigned to Referent 16 – Close a browsing tab

Gesture Illustration	Gesture Information	
Gesture 1 – Single Tap on “Close Tab” Cross  The illustration shows a browser window with a tab bar at the top. A hand is shown tapping the 'Close Tab' cross on the right side of the tab bar. The browser window displays a page titled 'Learn How Google Works' with a Google logo and search bar. Below the search bar, there is a diagram explaining how Google works, including a section titled 'The official word'.	Summary The user closes a browsing tab by tapping once on the “Close Tab” cross (“x”).	
	Gesture Complexity	Simple
	Gesture Nature	Metaphorical
	Gesture Binding	Object-centric
	Gesture Flow	Discrete
	Pointer-Type	Yes

Gesture Illustration

Gesture 2 – Flick Tab “Off The Screen” With Multiple Fingers (Downward)



Gesture Information

Summary	The user closes a browsing tab by flicking the tab directly downwards using the index, middle, ring and pinkie fingers.
Gesture Complexity	Complex – Parallel: Gesture comprises 4 flicks (with the above-mentioned fingers) done simultaneously.
Gesture Nature	Physical
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	No

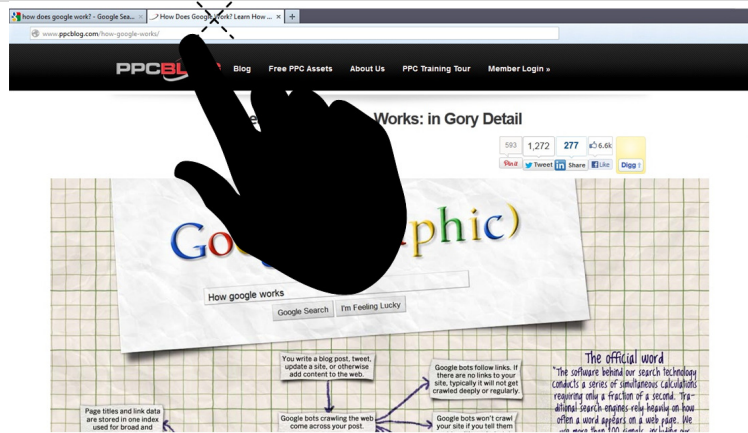
Gesture 3 – Drag Tab “Off The Screen” with Two Fingers



Summary	The user closes a browsing tab by dragging the tab towards the left edge of the screen in a downward motion with 2 fingers.
Gesture Complexity	Complex – Parallel: Gesture comprises 2 drags done simultaneously.
Gesture Nature	Physical
Gesture Binding	Object-centric
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 4 – Trace “X” on Tab



Summary

The user closes a browsing tab by tracing an “X” on the tab i.e. dragging a finger diagonally from left to right, and then dragging the finger diagonally from right to left.

Gesture Complexity

Complex – Sequential: Gesture comprises 2 drags done sequentially.

Gesture Nature

Symbolic

Gesture Binding

Object-centric

Gesture Flow

Discrete

Pointer-Type

No

Gesture 5 – Push Tab Beneath Adjacent Tab



Summary

The user closes a browsing tab by “pushing it beneath” an adjacent tab. This is done by dragging a finger from right to left over the tab.

Gesture Complexity

Simple

Gesture Nature

Physical

Gesture Binding

Object-centric

Gesture Flow

Continuous

Pointer-Type

No

Gesture Illustration

Gesture 6 – Single Tap on Tab

Gesture Information

Summary

The user closes a browsing tab by tapping on it once with 1 finger.

Gesture Complexity

Simple

Gesture Nature

Arbitrary

Gesture Binding

Object-centric

Gesture Flow

Discrete

Pointer-Type

No

17. REFERENT 17 – VIEW RECORD OF VISITED WEBPAGES

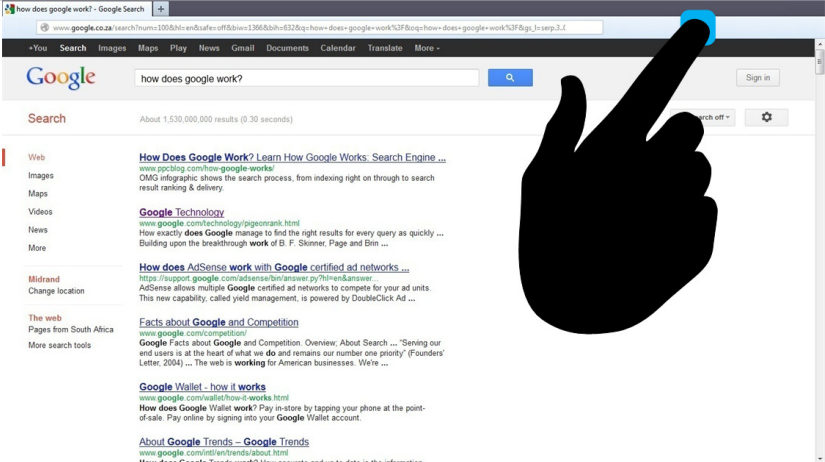
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 7 gestures were assigned to this referent:
 - Gesture 1 – Single Tap On “History Button”; proposed by 8 participants.

- Gesture 2 – Select Option From Main Menu; proposed by 3 participants.
- Gesture 3 – Flick History “Out Of Address Bar”; proposed by 3 participants.
- Gesture 4 – Use Keyboard Shortcut (Ctrl + H); proposed by 2 participants.
- Gesture 5 – Drag History Bar Out From Left Edge of Screen; proposed by 1 participant.
- Gesture 6 – Trace Triangle at Top of Screen; proposed by 1 participant.
- Gesture 7 – Double Tap with Vertical Side of Hand; proposed by 1 participant.
- The agreement score for this referent was 0.225 (the average agreement score was 0.327).

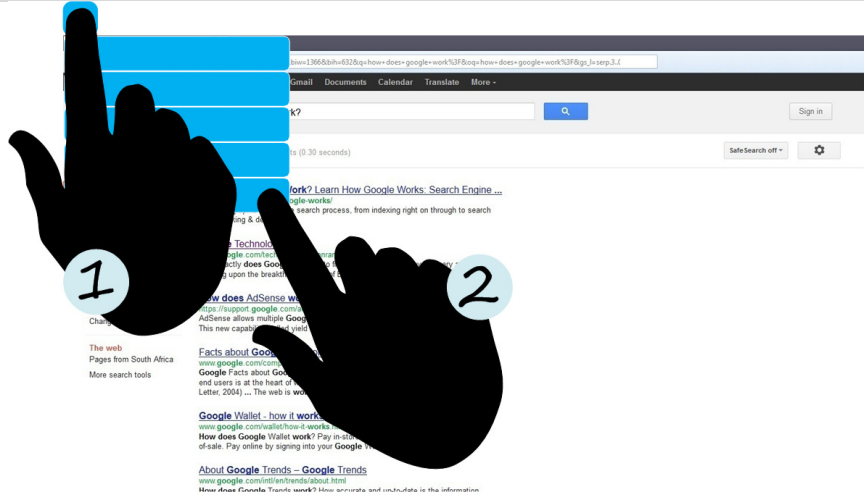
The gestures assigned to this referent are tabulated below.

Table 62: Gestures Assigned to Referent 17 – View record of visited webpages

Gesture Illustration	Gesture Information	
Gesture 1 – Single Tap On “History Button” 	Summary	The user views a record of visited webpages by tapping once on a “History Button”
	Gesture Complexity	Simple
	Gesture Nature	Metaphorical
	Gesture Binding	Object-centric
	Gesture Flow	Discrete
	Pointer-Type	Yes

Gesture Illustration

Gesture 2 – Select Option From Main Menu



Gesture Information

Summary

The user views a record of visited webpages by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to view a record of visited pages (Phase 2).

Gesture Complexity	Complex – Sequential: Gesture comprises 2 gestures done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture Illustration

Gesture 3 – Flick History “Out Of Address Bar”

Gesture Information

Summary

The user views a record of visited webpages by flicking the history record “out of the address bar”. This is done downwards on the address bar.

Gesture Complexity

Simple

Gesture Nature

Metaphorical

Gesture Binding

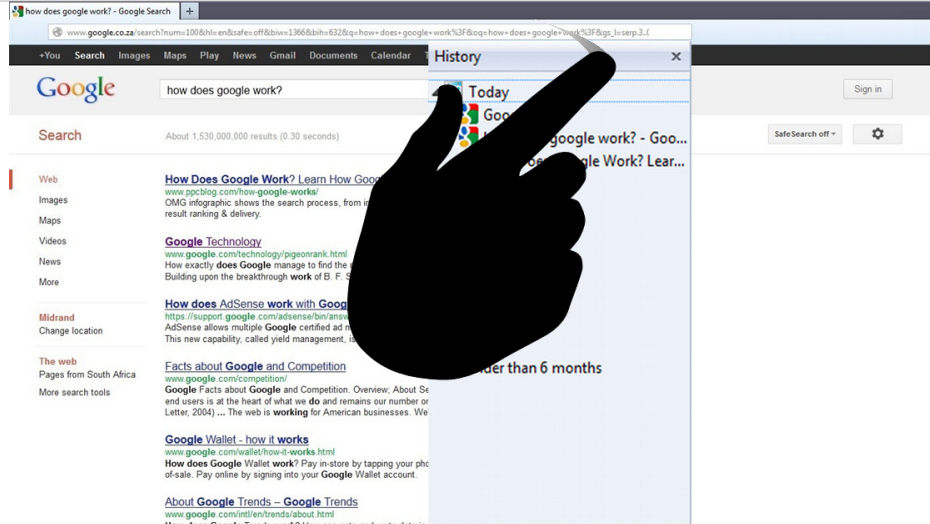
Object-centric

Gesture Flow

Discrete

Pointer-Type

No



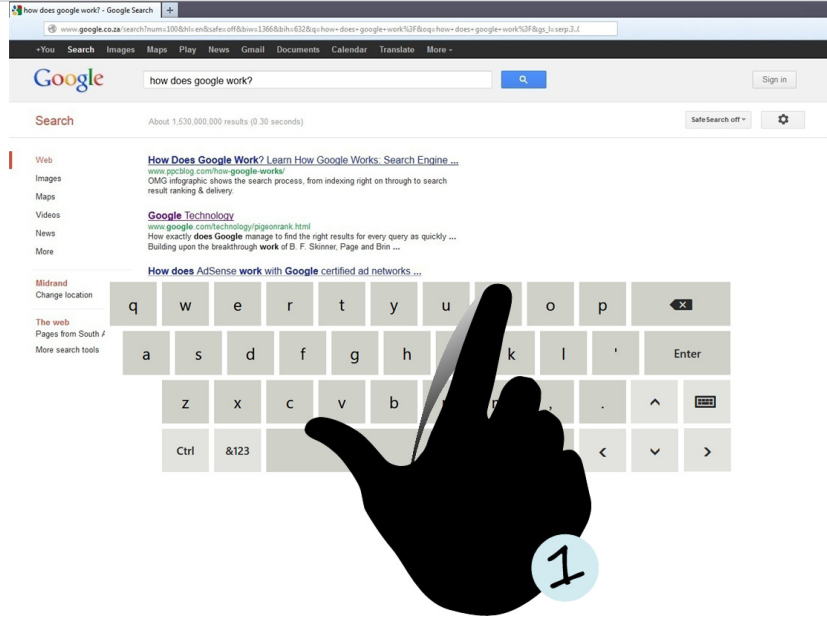
Gesture Illustration

Gesture 4 – Use Keyboard Shortcut (Ctrl + H)

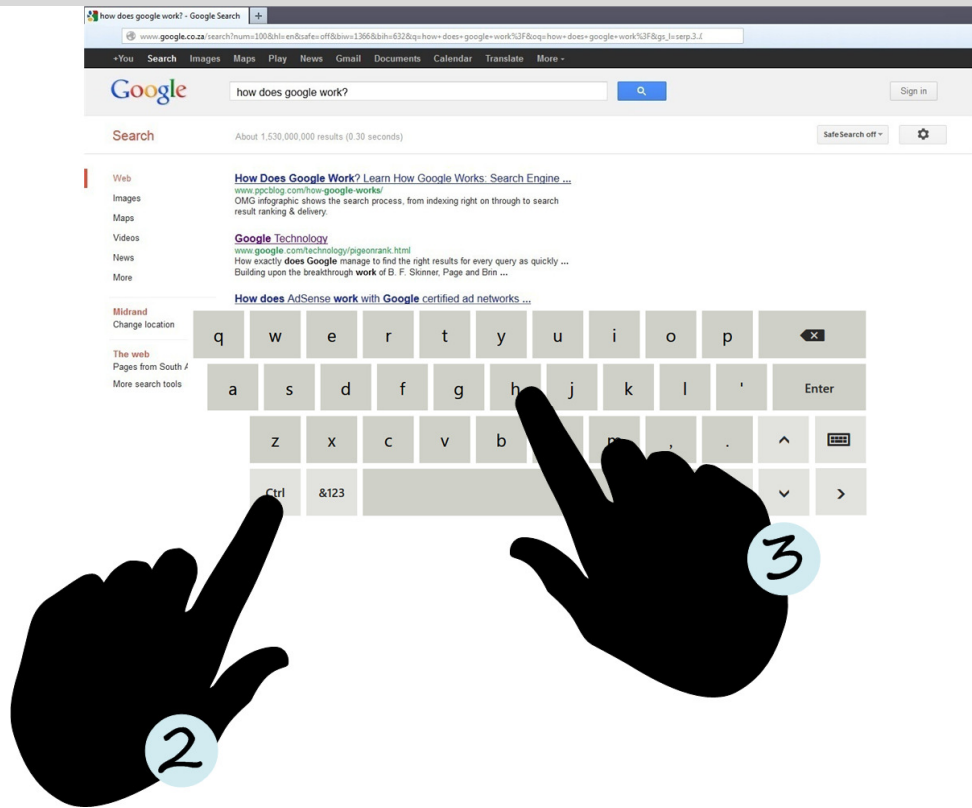
Gesture Information

Summary

The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen (Phase 1).



Gesture Illustration

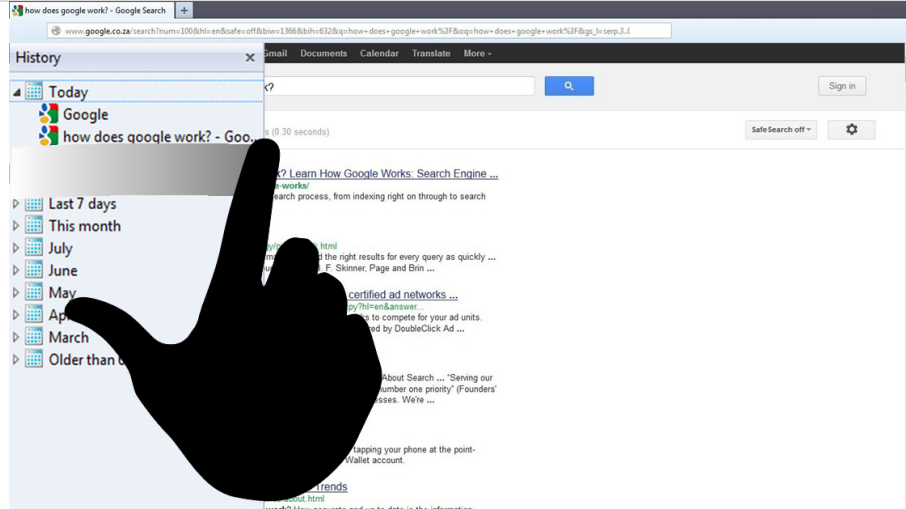


Gesture Information

Summary	The user views a record of visited webpages by using a keyboard shortcut – the user presses the “Ctrl” key (Phase 2) and taps the “H” key (Phase 3) while pressing it.
Gesture Complexity	Complex – Sequential: Phase 1 and the first part of Phase 2 are done sequentially. Complex – Parallel: The second part of Phase 2 and Phase 3 are done in parallel.
Gesture Nature	Physical: Phase 1 Metaphorical: Phase 2 and 3
Gesture Binding	World-dependent: Phase 1 Object-centric: Phase 2 and 3
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

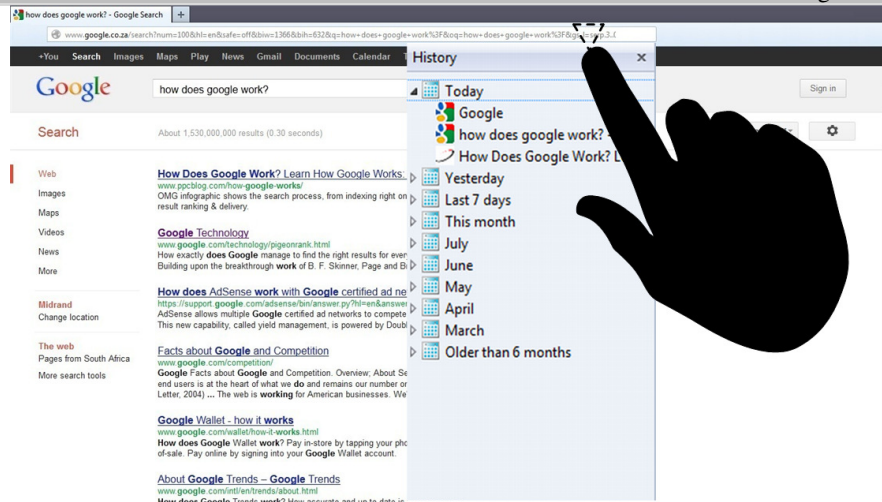
Gesture 5 – Drag History Bar Out From Left Edge of Screen



Gesture Information

Summary	The user views a record of visited webpages by dragging the record out from left edge of the screen with a single finger drag from left to right.
Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	World-dependent
Gesture Flow	Continuous
Pointer-Type	No

Gesture 6 – Trace Triangle at Top of Screen



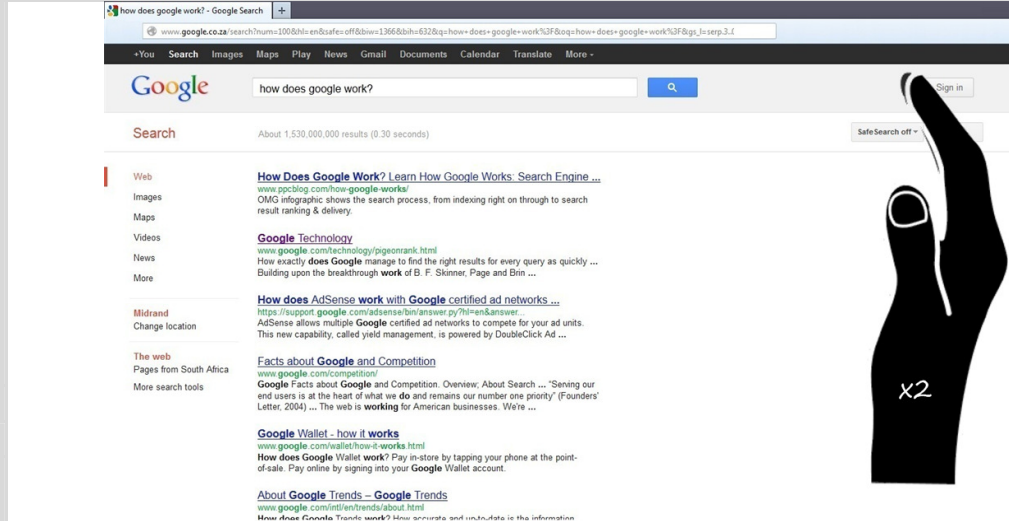
Summary	The user views a record of visited webpages by tracing a triangle (upside down) on at the top of screen – around the region of the address bar. This done by performing 3 short drags from each of the sides.
Gesture Complexity	Complex – Sequential: Gesture comprises 3 drags done sequentially.
Gesture Nature	Symbolic: All phases make up a symbolic gesture
Gesture Binding	World-dependent
Gesture Flow	Discrete
Pointer-Type	No

Gesture Illustration

Gesture 7 – Double Tap with Vertical Side of Hand

Gesture Information

Summary	The user views a record of visited webpages by performing a double tap with the vertical side of the hand. This is done on the right edge of the screen.
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
Gesture Nature	Arbitrary
Gesture Binding	World-dependent
Gesture Flow	Discrete
Pointer-Type	No



18. REFERENT 18 – DELETE ENTRY FROM RECORD OF VISITED PAGES

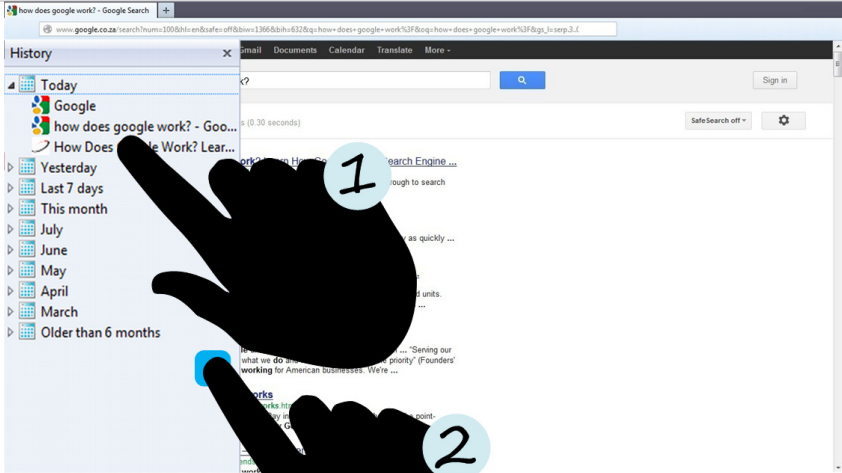
The key points relating to this referent are as follows:

- 19 gestures were elicited.
- 5 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 9 gestures were assigned to this referent:
 - Gesture 1 – Single Tap On History Item, Single Tap on “Delete Button”; proposed by 4 participants.
 - Gesture 2 – Drag Finger Over History Item, Single Tap on “Delete Button”; proposed by 1 participants.

- Gesture 3 – Trace “X” on History Item; proposed by 1 participants.
- Gesture 4 – Select Checkbox, Single Tap on “Delete Button”; proposed by 1 participant.
- Gesture 5 – Single Tap And Drag Finger Over History Item, Trace “X” on History Item; proposed by 1 participant.
- Gesture 6 – Select Option From Context Menu; proposed by 1 participant.
- Gesture 7 – Drag Finger Over History Item to “Rub It Out”; proposed by 1 participant.
- Gesture 8 – Select History Item and Delete Using Keyboard Button; proposed by 1 participant.
- Gesture 9 – Select History Item and “Rub It Out” With Hand; proposed by 1 participant.
- The agreement score for this referent was 0.108 (the average agreement score was 0.327).

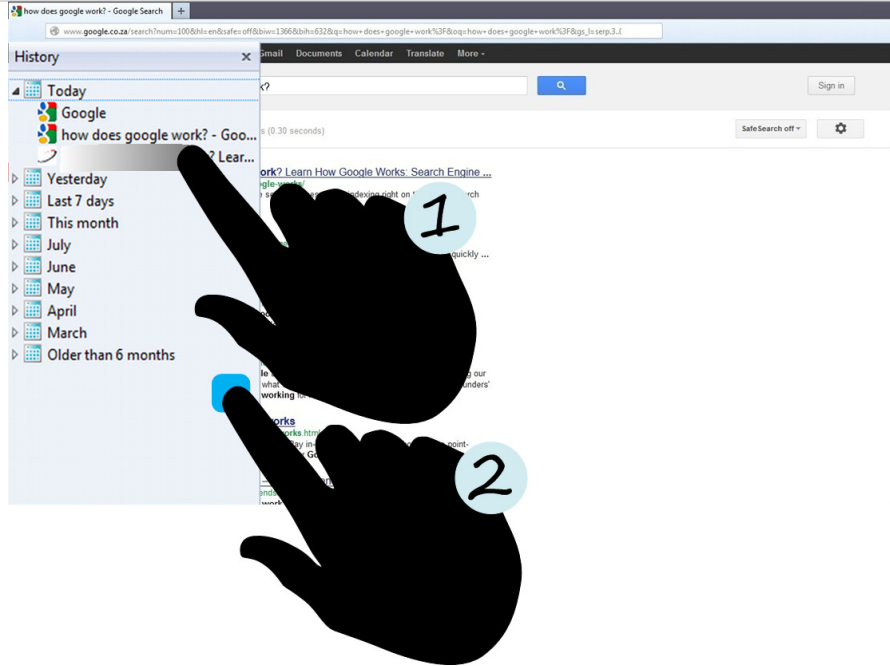
The gestures assigned to this referent are tabulated below.

Table 63: Gestures Assigned to Referent 18 – Delete entry from record of visited pages

Gesture Illustration		Gesture Information
Gesture 1 – Single Tap On History Item, Single Tap on “Delete Button”		
		Summary The user deletes an item from the record of visited pages by tapping once on the item (Phase1) and tapping once on a “Delete Button”.
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.	
Gesture Nature	Physical: Phase 1 Metaphorical: Phase 2	
Gesture Binding	Object-centric: Phase 1 and 2	
Gesture Flow	Continuous	
Pointer-Type	Yes	

Gesture Illustration

Gesture 2 – Drag Finger Over History Item, Single Tap on “Delete Button”



Gesture Information

Summary

The user deletes an item from the record of visited pages by dragging a finger over the item from left to right (Phase 1) and tapping once on a “Delete Button”.

Gesture Complexity

Complex – Sequential: Gesture comprises a drag and a tap done sequentially.

Gesture Nature

Metaphorical: Phase 1 and 2

Gesture Binding

Object-centric: Phase 1 and 2

Gesture Flow

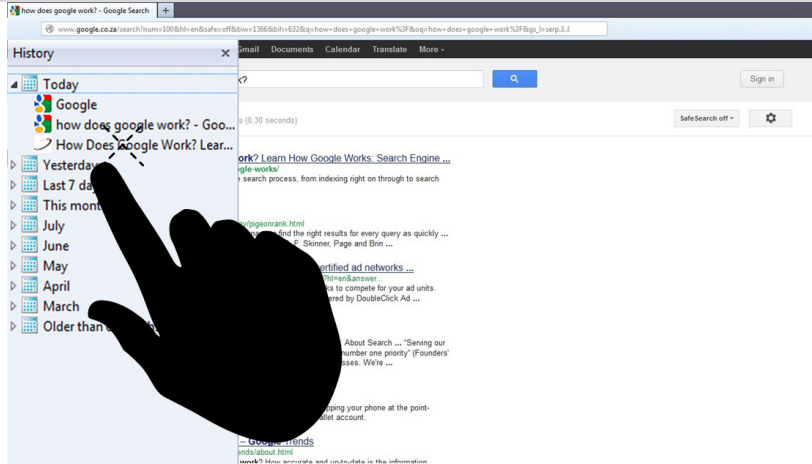
Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 3 – Trace “X” on History Item



Gesture Information

Summary

The user deletes an item from the record of visited pages by tracing an “X” over the item i.e. dragging a finger diagonally from left to right (Phase 1), and then dragging the finger diagonally from right to left (Phase 2).

Gesture Complexity

Complex – Sequential: Gesture comprises 2 drags done sequentially.

Gesture Nature

Symbolic: Phases make up a symbolic gesture

Gesture Binding

Object-centric: Phase 1 and 2

Gesture Flow

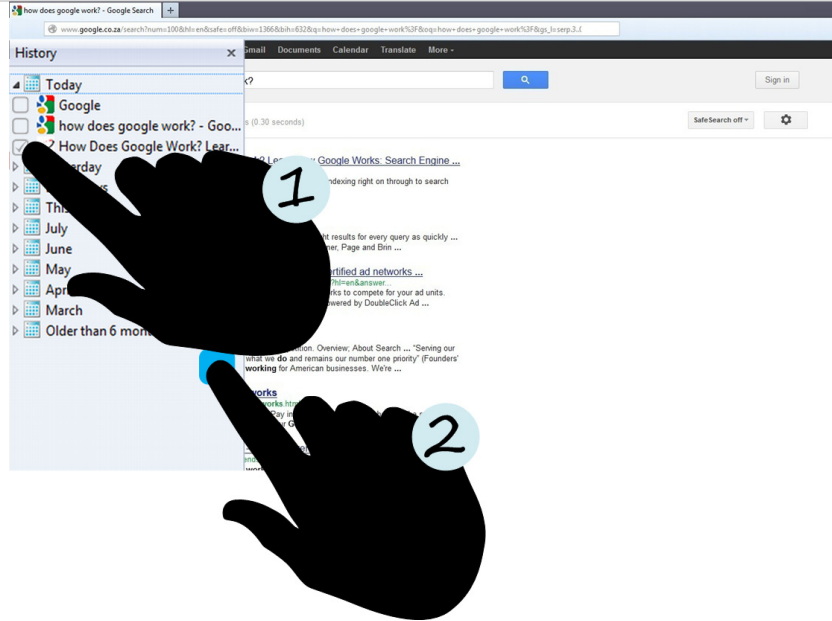
Discrete

Pointer-Type

No

Gesture Illustration

Gesture 4 – Select Checkbox, Single Tap on “Delete Button”



Gesture Information

Summary

The user deletes an entry from the record of visited pages by tapping on a checkbox alongside the item (Phase 1) and tapping on the “Delete Button”.

Gesture Complexity

Complex – Sequential: Gesture comprises 2 taps done sequentially.

Gesture Nature

Metaphorical: Phase 1 and 2

Gesture Binding

Object-centric: Phase 1 and 2

Gesture Flow

Continuous

Pointer-Type

Yes

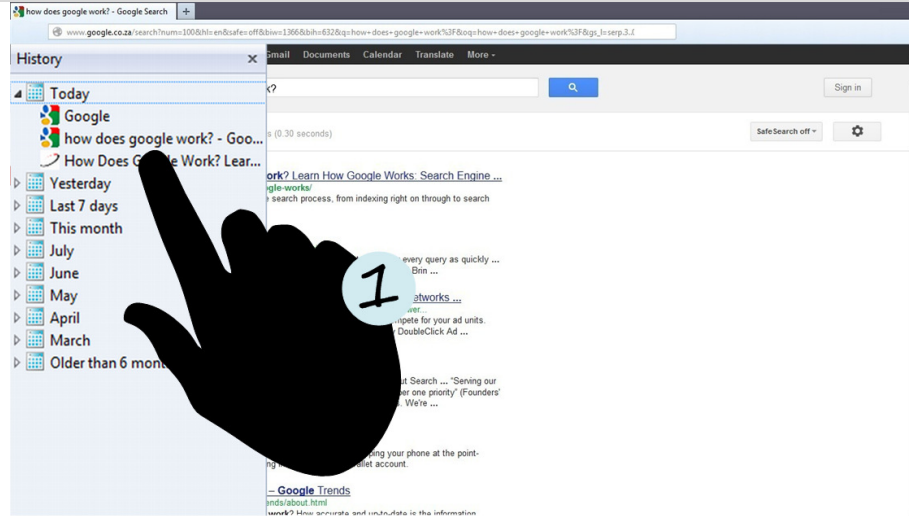
Gesture Illustration

Gesture 5 – Single Tap And Drag Finger Over History Item, Trace “X” on History Item

Gesture Information

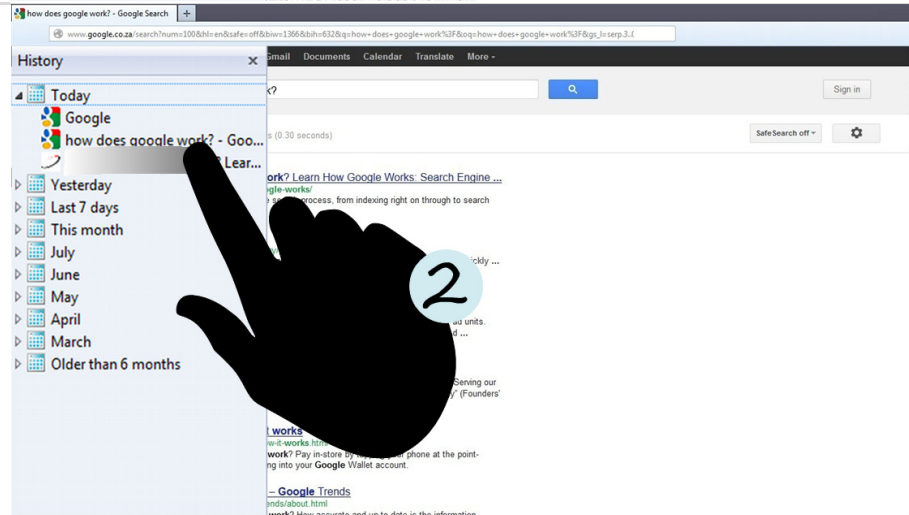
Summary

The user taps once on the item to be deleted (Phase 1).

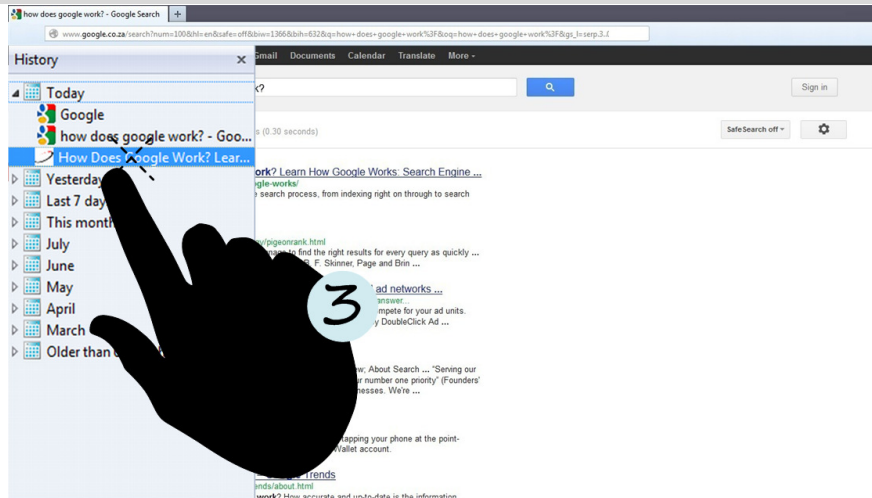


Summary

The user then drags a finger from left to right over the item (Phase 2).



Gesture Illustration



Gesture Information

Summary

The user then traces an “X” over the item i.e. dragging a finger diagonally from left to right (Phase 3), and then dragging the finger diagonally from right to left (Phase 4) to delete it from the record of visited pages.

Gesture Complexity

Complex – Sequential: Gesture comprises a tap and 3 drags done sequentially.

Gesture Nature

Physical: Phase 1
Metaphorical: Phase 2
Symbolic: Phase 3 and 4

Gesture Binding

Object-centric: All phases

Gesture Flow

Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 6 – Select Option From Context Menu

Gesture Information

Summary

The user taps once on a button that calls up a context menu (Phase 1). The user then taps once on the menu item that activates the delete function (Phase 2).

Summary

The user then taps once on the time period during which the item to be deleted exists (Phase 3) – in the illustration, the time period is “Today”. The user taps once on the item to delete it from the record of visited pages (Phase 4).

Gesture Complexity

Complex – Sequential: Gesture comprises 4 taps done sequentially.

Gesture Nature

Metaphorical: Phase 1 and 2
Physical: Phase 3 and 4

Gesture Binding

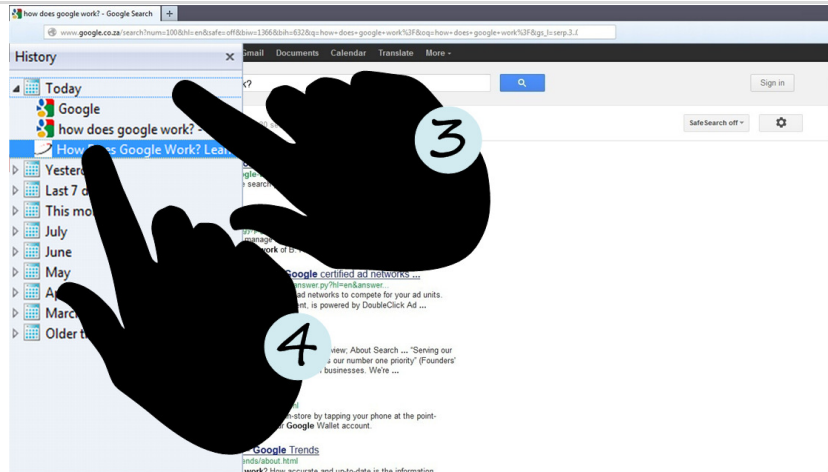
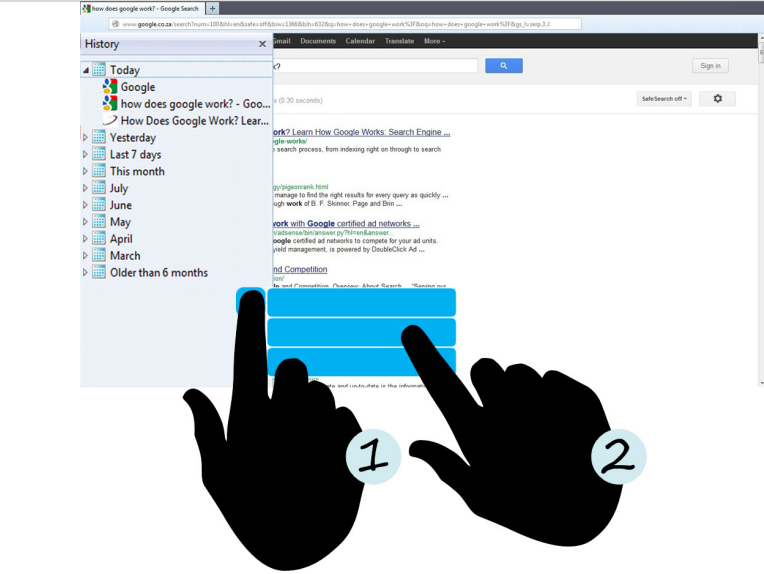
Object-centric: All phases

Gesture Flow

Continuous

Pointer-Type

Yes



Gesture Illustration

Gesture 7 – Drag Finger Over History Item to “Rub It Out”

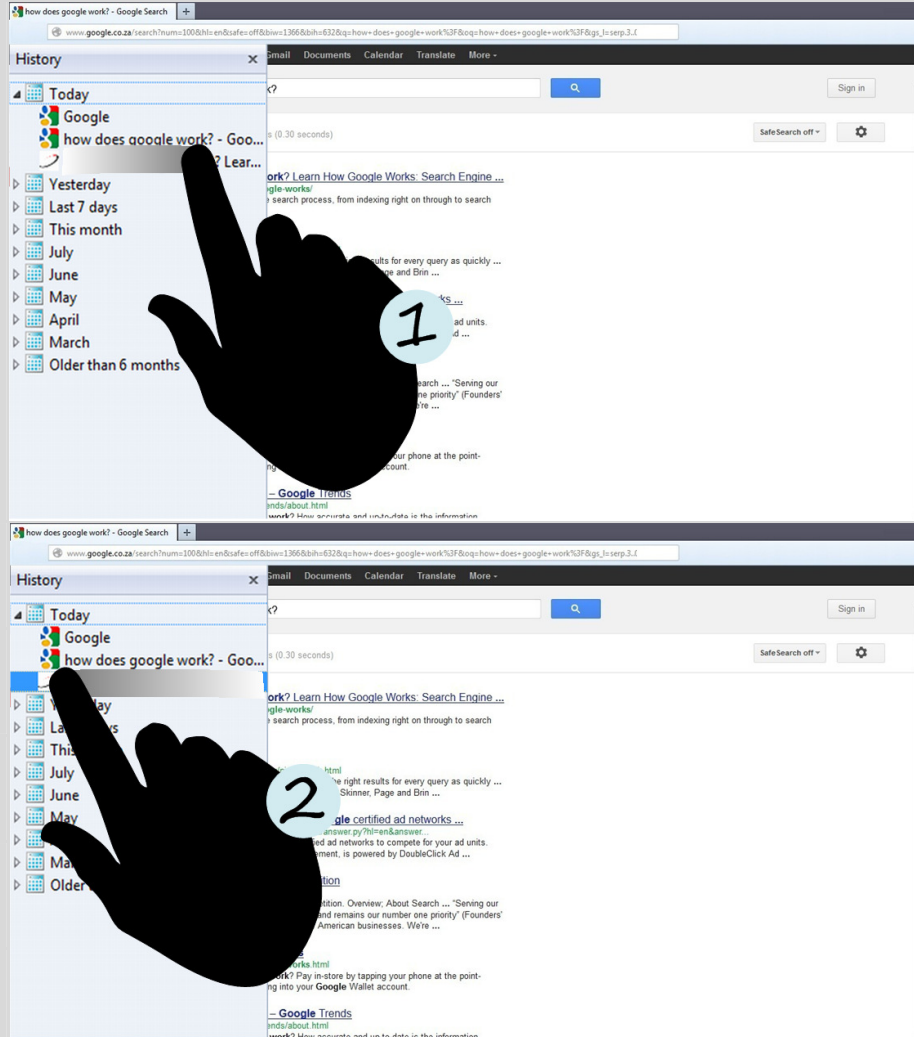
Gesture Information

Summary

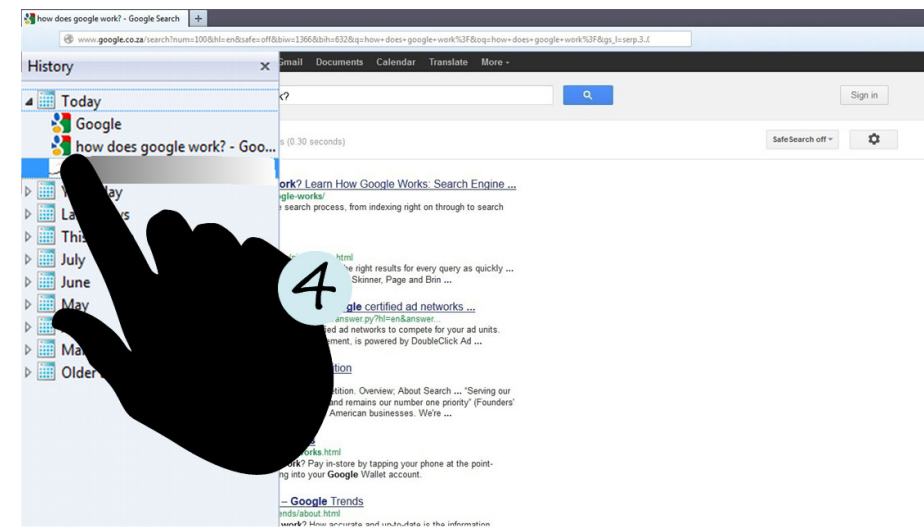
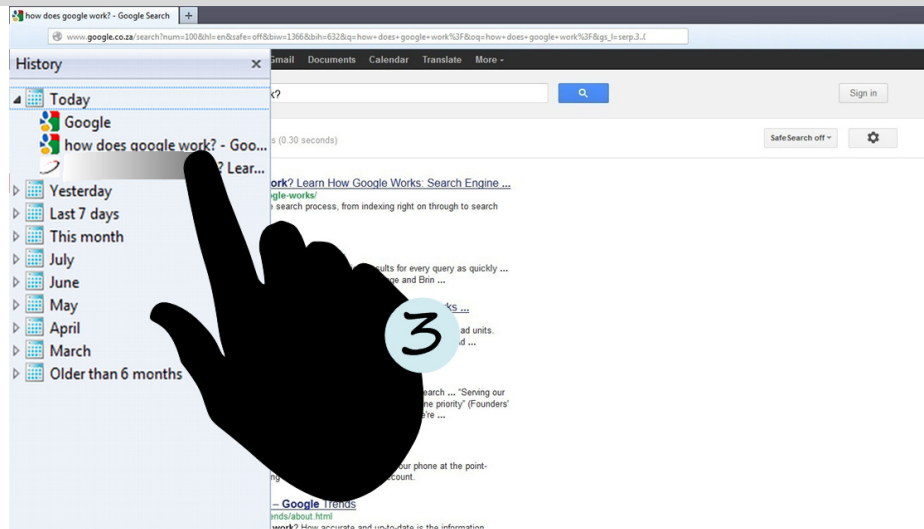
The user deletes an item of the record of visited pages by “rubbing out” the entry. This is done by dragging the finger from left to right over the item (Phase 1).

Summary

The user then drags the finger from right to left over the item (Phase 2).



Gesture Illustration

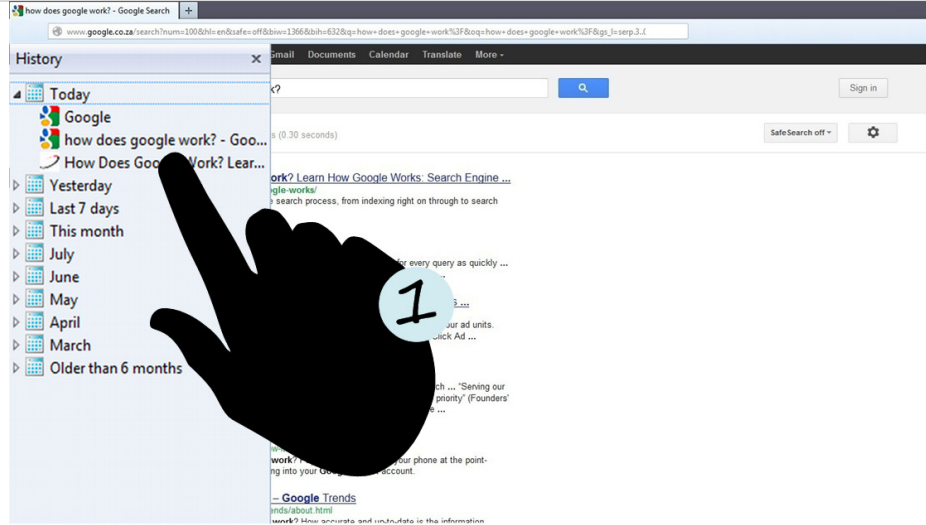


Gesture Information

Summary	The user then drags the finger from left to right over the item (Phase 3).
Summary	The user then drags the finger from right to left over the item (Phase 4).
Gesture Complexity	Complex – Sequential: Gesture comprises 4 drags done sequentially.
Gesture Nature	Metaphorical: The finger is used as if it were an eraser
Gesture Binding	Object-centric: All phases
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 8 – Select History Item and Delete Using Keyboard Button

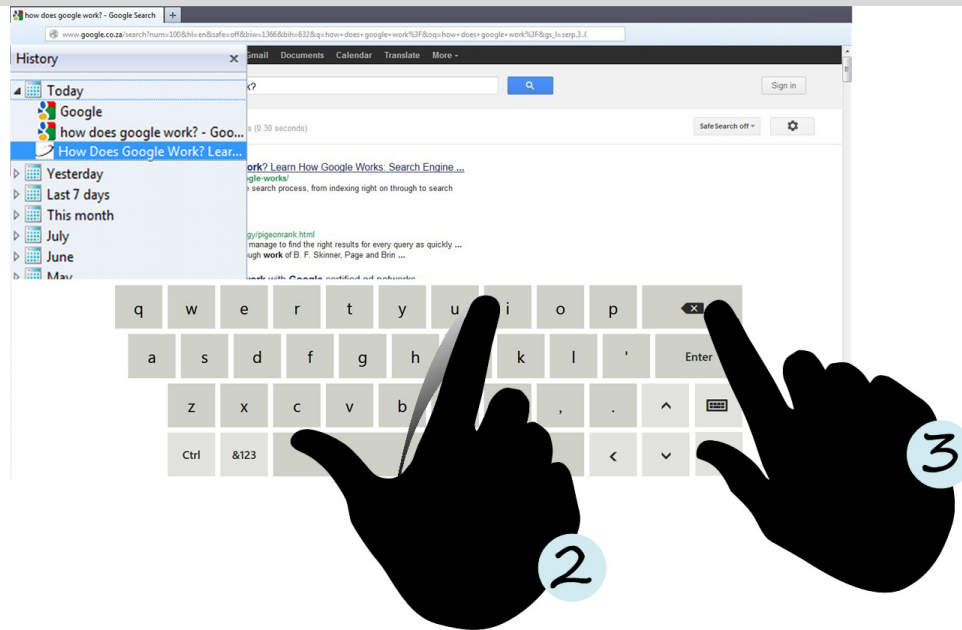


Gesture Information

Summary

The user deletes an item from the record of visited pages using a keyboard shortcut. The user taps once on the item to be deleted (Phase 1).

Gesture Illustration



Gesture Information

Summary

The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen (Phase 2). The user then deletes the item by tapping once on a “Delete” button on the keyboard.

Gesture Complexity

Complex – Sequential: Gesture comprises a tap, flick and another tap, all done sequentially.

Gesture Nature

Physical: Phase 1 and 2
Metaphorical: Phase 3

Gesture Binding

Object-centric: Phase 1 and 3
World-dependent: Phase 2

Gesture Flow

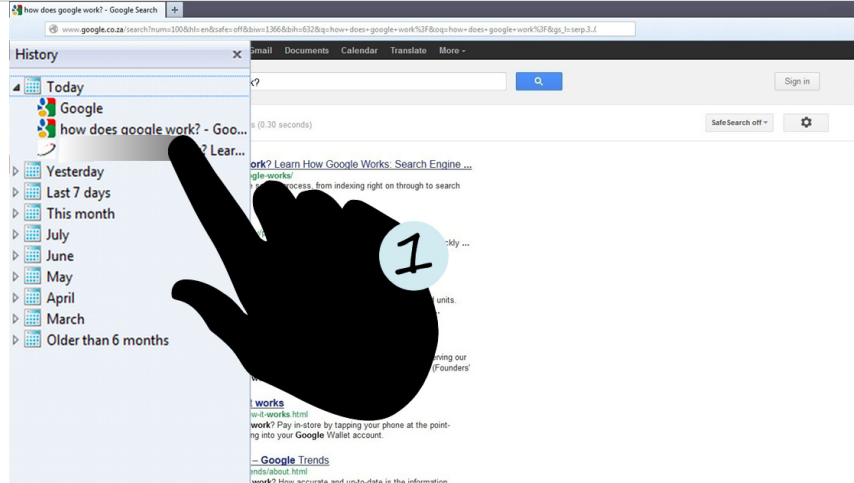
Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 9 – Select History Item and “Rub It Out” With Hand

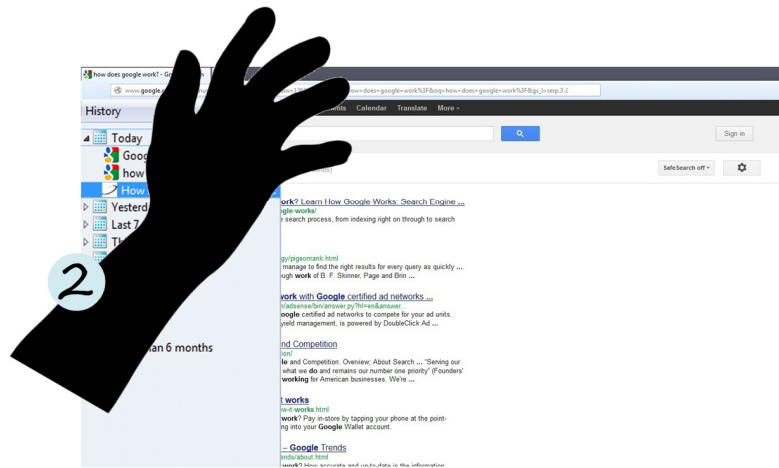


Gesture Information

Summary

The user drags a finger from left to right over the item to be deleted (Phase 1).

Gesture Illustration



Gesture Information

Summary	The user then “rubs it out” by tapping on it with the lower part of the palm (Phase 2). This is the only gesture during this part of the hand was used.
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2 – Finger used as a highlighter and lower part of palm used as if it were an eraser
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	No

19. REFERENT 19 – SAVE CURRENT WEBPAGE ADDRESS WITHIN THE BROWSER FOR VIEWING AT A LATER STAGE

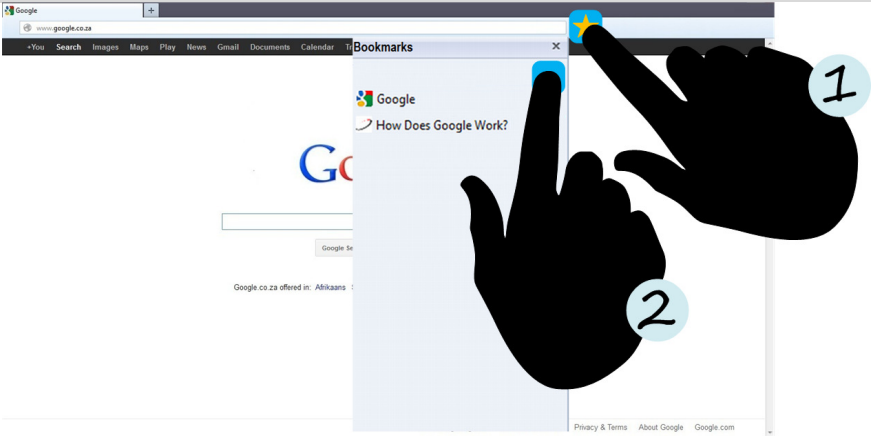
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 5 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 4 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Favourites Button”, Single Tap on “Add Button”; proposed by 5 participants.

- Gesture 2 – Press on Webpage, Drag Webpage to “Favourites Button”; proposed by 1 participant.
- Gesture 3 – Single Tap on Webpage, Quickly Tap on “Favourites Button” (Jump); proposed by 1 participants.
- Gesture 4 – Select Option from Main Menu; proposed by 2 participants.
- Gesture 5 – Drag Webpage with Two Fingers to Address Bar; proposed by 1 participant.
- Gesture 6 – Drag Finger Over Address Bar Twice; proposed by 1 participant.
- The agreement score for this referent was 0.140 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 64: Gestures Assigned to Referent 19 – Save current webpage address within the browser for viewing at a later stage

Gesture Illustration	Gesture Information	
Gesture 1 – Single Tap on “Favourites Button”, Single Tap on “Add Button” 	Summary	The user saves the address of the current webpage within the browser by tapping once on the “Favourites Button” (Phase 1) – this calls up a list of webpages that has been saved, “Favourites”. The user taps once on the “Add Button” to save it.
	Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
	Gesture Nature	Metaphorical: Phase 1 and 2
	Gesture Binding	Object-centric: Phase 1 and 2
	Gesture Flow	Continuous
	Pointer-Type	Yes

Gesture Illustration

Gesture 2 – Press on Webpage, Drag Webpage to “Favourites Button”



Gesture Information

Summary	The user saves the address of the current webpage within the browser by pressing on the webpage (Phase 1), and dragging it to the “Favourites Button” (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises a press and a drag done sequentially.
Gesture Nature	Physical: Webpage handled like it was an actual sheet of paper
Gesture Binding	Mixed Dependencies: Phase 1 - the press may be world-independent or world dependent. Object-centric: Phase 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture Illustration

Gesture 3 – Single Tap on Webpage, Quickly Tap on “Favourites Button” (Jump)



Gesture Information

Summary	The user saves the address of the current webpage within the browser by tapping on the page (Phase 1) and quickly tapping on the “Favourites Button”.
Gesture Complexity	Complex – Sequential: Gesture comprises 2 gestures done sequentially.
Gesture Nature	Physical: Phase 1 Metaphorical: Phase 2
Gesture Binding	World-independent: Phase 1 Object-centric: Phase 2
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 4 – Select Option from Main Menu



Gesture Information

Summary

The user saves the address of the current webpage within the browser by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to save the webpage within the browser (Phase 2).

Gesture Complexity

Complex – Sequential: Gesture comprises 2 taps done sequentially.

Gesture Nature

Metaphorical: Phase 1 and 2

Gesture Binding

Object-centric: Phase 1 and 2

Gesture Flow

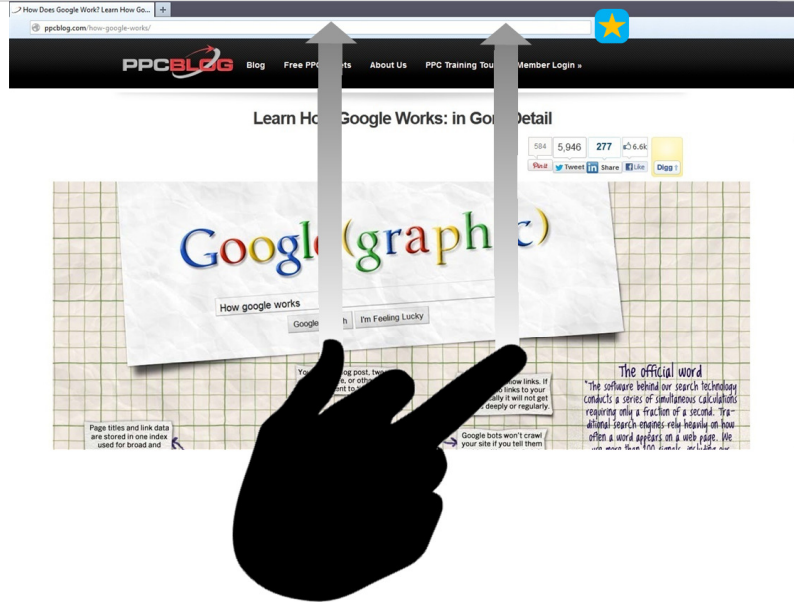
Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 5 – Drag Webpage with Two Fingers to Address Bar



Gesture Information

Summary

The user saves the address of the current webpage within the browser by dragging the webpage to the address bar with 2 fingers.

Gesture Complexity

Complex – Parallel: Gesture comprises 2 drags done in parallel.

Gesture Nature

Physical

Gesture Binding

World-independent

Gesture Flow

Discrete

Pointer-Type

No

Gesture Illustration

Gesture 6 – Drag Finger Over Address Bar Twice



Gesture Information

Summary	The user saves the address of the current webpage within the browser by dragging a finger over the address bar from left to right (Phase 1).
Summary	The user then drags the finger from right to left (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 2 drags done sequentially.
Gesture Nature	Arbitrary: Phase 1 and 2
Gesture Binding	Object-centric
Gesture Flow	Discrete
Pointer-Type	No

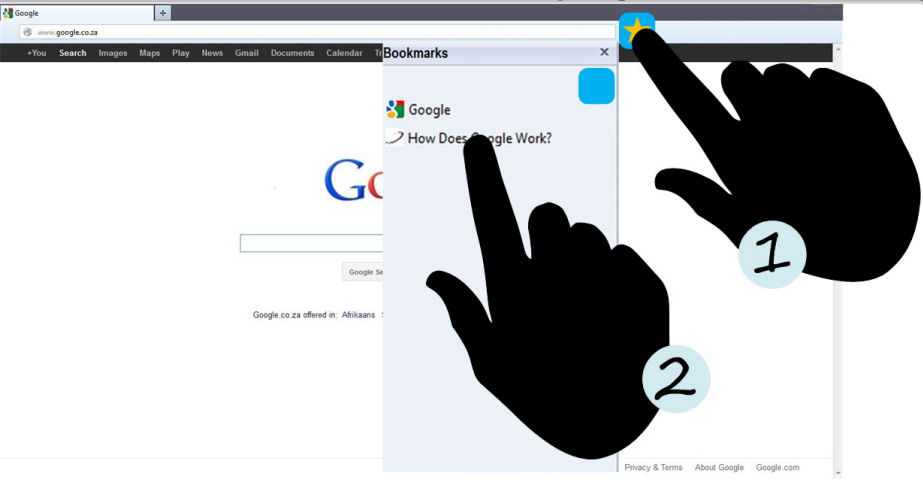
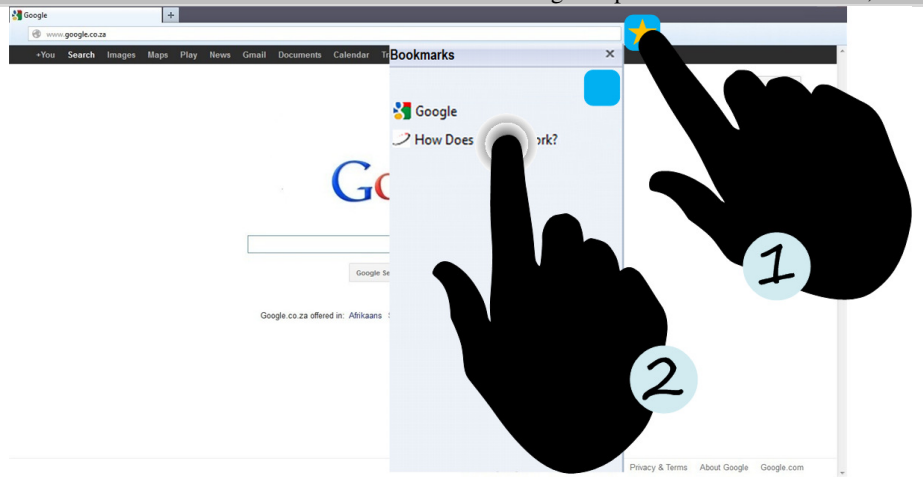
20. REFERENT 20 – CALL UP SAVED WEBPAGE ADDRESS

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 4 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 3 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 5 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Favourites Button”, Single Tap on “Saved Webpage”; proposed by 9 participants.
 - Gesture 2 – Single Tap on “Favourites Button”, Double Tap on “Saved Webpage”; proposed by 1 participant.
 - Gesture 3 – Select Option from Menu; proposed by 1 participant.
 - Gesture 4 – Drag Finger Over Address Bar, Single Tap on “Saved Webpage”; proposed by 1 participant.
 - Gesture 5 – Double Tap on Address Bar With Two Fingers, Drag Finger Over “Saved Webpage”; proposed by 1 participant.
- The agreement score for this referent was 0.235 (the average agreement score was 0.327).

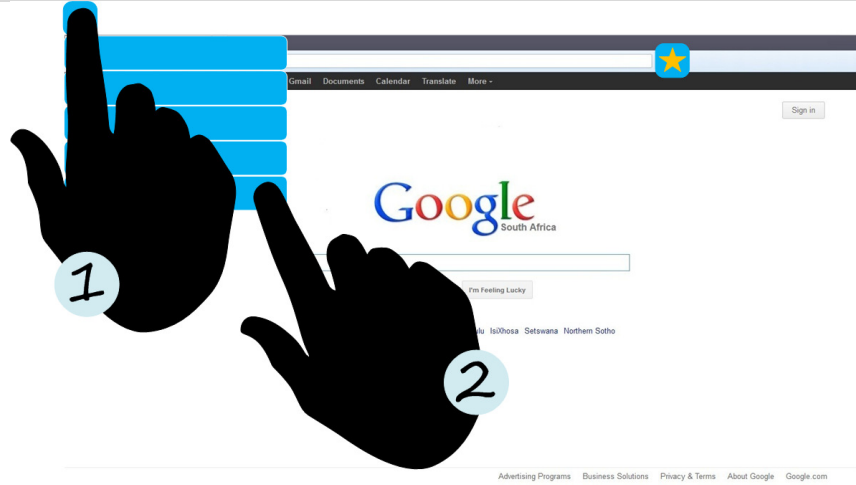
The gestures assigned to this referent are tabulated below.

Table 65: Gestures Assigned to Referent 20 – Call up saved webpage address

Gesture Illustration	Gesture Information												
Gesture 1 – Single Tap on “Favourites Button”, Single Tap on “Saved Webpage” 	<table border="1"> <tr> <td>Summary</td><td>The user calls up a saved webpage address by tapping once on the “Favourites Button” (Phase 1) – this lists all the saved webpages. The user then taps once on the one he / she wants opened (Phase 2).</td></tr> <tr> <td>Gesture Complexity</td><td>Complex – Sequential: Gesture comprises 2 taps done sequentially.</td></tr> <tr> <td>Gesture Nature</td><td>Metaphorical: Phase 1 and 2</td></tr> <tr> <td>Gesture Binding</td><td>Object-centric: Phase 1 and 2</td></tr> <tr> <td>Gesture Flow</td><td>Continuous</td></tr> <tr> <td>Pointer-Type</td><td>Yes</td></tr> </table>	Summary	The user calls up a saved webpage address by tapping once on the “Favourites Button” (Phase 1) – this lists all the saved webpages. The user then taps once on the one he / she wants opened (Phase 2).	Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.	Gesture Nature	Metaphorical: Phase 1 and 2	Gesture Binding	Object-centric: Phase 1 and 2	Gesture Flow	Continuous	Pointer-Type	Yes
Summary	The user calls up a saved webpage address by tapping once on the “Favourites Button” (Phase 1) – this lists all the saved webpages. The user then taps once on the one he / she wants opened (Phase 2).												
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.												
Gesture Nature	Metaphorical: Phase 1 and 2												
Gesture Binding	Object-centric: Phase 1 and 2												
Gesture Flow	Continuous												
Pointer-Type	Yes												
Gesture 2 – Single Tap on “Favourites Button”, Double Tap on “Saved Webpage” 	<table border="1"> <tr> <td>Summary</td><td>The user calls up a saved webpage address by tapping once on the “Favourites Button” (Phase 1) – this lists all the saved webpage addresses. The user then double taps on the one he / she wants opened (Phase 2).</td></tr> <tr> <td>Gesture Complexity</td><td>Complex – Sequential: Gesture comprises 3 taps done sequentially.</td></tr> <tr> <td>Gesture Nature</td><td>Metaphorical: Phase 1 and 2</td></tr> <tr> <td>Gesture Binding</td><td>Object-centric: Phase 1 and 2</td></tr> <tr> <td>Gesture Flow</td><td>Continuous</td></tr> <tr> <td>Pointer-Type</td><td>Yes</td></tr> </table>	Summary	The user calls up a saved webpage address by tapping once on the “Favourites Button” (Phase 1) – this lists all the saved webpage addresses. The user then double taps on the one he / she wants opened (Phase 2).	Gesture Complexity	Complex – Sequential: Gesture comprises 3 taps done sequentially.	Gesture Nature	Metaphorical: Phase 1 and 2	Gesture Binding	Object-centric: Phase 1 and 2	Gesture Flow	Continuous	Pointer-Type	Yes
Summary	The user calls up a saved webpage address by tapping once on the “Favourites Button” (Phase 1) – this lists all the saved webpage addresses. The user then double taps on the one he / she wants opened (Phase 2).												
Gesture Complexity	Complex – Sequential: Gesture comprises 3 taps done sequentially.												
Gesture Nature	Metaphorical: Phase 1 and 2												
Gesture Binding	Object-centric: Phase 1 and 2												
Gesture Flow	Continuous												
Pointer-Type	Yes												

Gesture Illustration

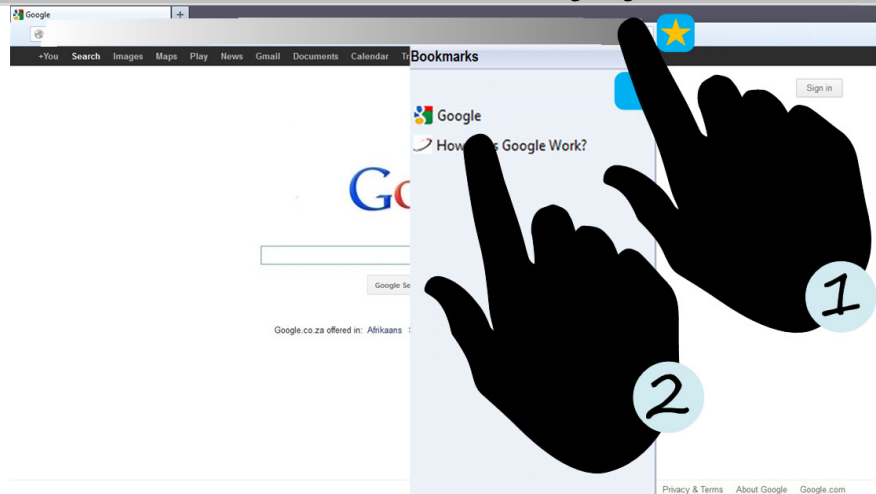
Gesture 3 – Select Option from Menu



Gesture Information

Summary	The user calls up a saved webpage address by calling up a menu that lists all saved webpage addresses and selecting the appropriate option. This is done by tapping once on a button that calls up a menu of saved webpage addresses (Phase 1), and tapping once on the one he / she wants opened (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture 4 – Drag Finger Over Address Bar, Single Tap on “Saved Webpage”



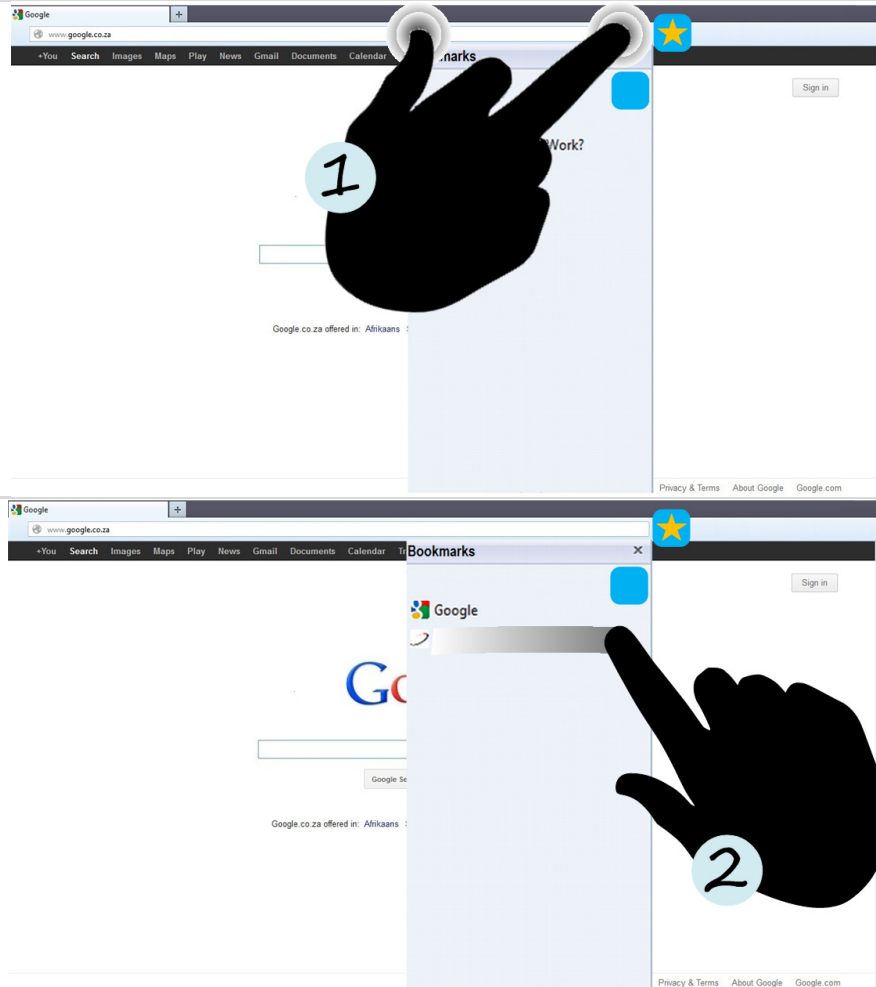
Summary	The user calls up a saved webpage address by dragging a finger from left to right over the address bar (Phase 1) – this lists all the saved webpage addresses. The user then taps once on the one he / she wants opened (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture Illustration

Gesture 5 – Double Tap on Address Bar With Two Fingers, Drag Finger Over “Saved Webpage”

Gesture Information

Summary	The user calls up a saved webpage address by double tapping on the address bar with 2 fingers (Phase 1) – this lists all the saved webpage addresses.
Summary	The user then drags a finger from left to right on the one he / she wants opened (Phase 2).
Gesture Complexity	Complex – Parallel: Phase 1 consists of tapping with 2 fingers simultaneously. This is done twice. Complex – Sequential: Gesture comprises a 2 double taps and a drag done sequentially.
Gesture Nature	Arbitrary: Phase 1 Metaphorical: Phase 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	No



21. REFERENT 21 – SAVE IMAGE ON WEBPAGE TO MEMORY

The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 2 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 5 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 10 gestures were assigned to this referent:
 - Gesture 1 – Lasso Image, Single Tap on “Save Button”; proposed by 1 participant.
 - Gesture 2 – Trace Box Around Image, Single Tap on “Save Button”; proposed by 2 participants.
 - Gesture 3 – Lasso Image, Select Option from Context Menu; proposed by 1 participant.
 - Gesture 4 – Trace Box Around Image, Double Tap Image; proposed by 1 participant.
 - Gesture 5 – Drag Finger Over Upper and Right Edge of Image, Single Tap on “Save Button”; proposed by 2 participants.
 - Gesture 6 – Single Tap on Image, Place Both Hands on Image; proposed by 1 participant.
 - Gesture 7 – Select “Snipping Tool” from Main Menu, Drag Fingers Along Boundary of Image; proposed by 1 participant.
 - Gesture 8 – Lasso Image, Double Tapping Image With Three Fingers; proposed by 1 participants.
 - Gesture 9 –Tapping on Image with Two Fingers; proposed by 1 participant.
 - Gesture 10 – Select Option from Special Image Context Menu; proposed by 1 participant.
- The agreement score for this referent was 0.060 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 66: Gestures Assigned to Referent 21 – Save image on webpage to memory

Gesture Illustration	Gesture Information
Gesture 1 – Lasso Image, Single Tap on “Save Button” 	
Summary	The user saves an image on the webpage to memory by lassoing the image i.e. dragging the finger in an ellipse around the image (Phase 1), and tapping once on the “Save Button” (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises a drag and a tap done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2; in Phase 1 the finger is used as if it is a utility knife, to cut out the image.
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture Illustration

Gesture 2 – Trace Box Around Image, Single Tap on “Save Button”



Gesture Information

Summary	The user saves an image on the webpage to memory by drawing a box around the image i.e. dragging the finger in a rectangle around the image (Phase 1), and tapping once on the “Save Button” (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 4 drags (for each side of the box) and a tap, done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2; in Phase 1 the finger is used as if it is a utility knife, to cut out the image.
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture Illustration

Gesture 3 – Lasso Image, Select Option from Context Menu



Gesture Information

Summary	The user saves an image on the webpage to memory by lassoing the image i.e. dragging the finger in an ellipse around the image (Phase 1), pressing on the image (Phase 2) to call up a context menu, and tapping once on the option that enables the user to save the image (Phase 3).
Gesture Complexity	Complex – Sequential: Gesture comprises a drag, a press and a tap done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 3; in Phase 1 the finger is used as if it is a utility knife, to cut out the image. Arbitrary: Phase 2
Gesture Binding	Object-centric: Phase 1, 2 and 3
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture Illustration

Gesture 4 – Trace Box Around Image, Double Tap Image



Gesture Information

Summary	The user saves an image on the webpage to memory by drawing a box around the image i.e. dragging the finger in a rectangle around the image (Phase 1), and double tapping with 1 finger (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 4 drags (for each side of the box) and 2 taps, done sequentially.
Gesture Nature	Metaphorical: Phase 1; finger is used as if it is a utility knife, to cut out the image. Arbitrary: Phase 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 5 – Drag Finger Over Upper and Right Edge of Image, Single Tap on “Save Button”



Gesture Information

Summary

The user saves an image on the webpage to memory by dragging the finger along the upper and right edge of the image (Phase 1), and tapping once on the “Save Button” (Phase 2).

Gesture Complexity

Complex – Sequential: Gesture comprises 2 drags and a tap done sequentially.

Gesture Nature

Arbitrary: Phase 1
Metaphorical: Phase 2

Gesture Binding

Object-centric: Phase 1 and 2

Gesture Flow

Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 6 – Single Tap on Image, Place Both Hands on Image

Gesture Information

Summary

The user saves an image on the webpage to memory by tapping once on the image (Phase 1).

Summary

The user then places both hands on the image to save it (Phase 2).

Gesture Complexity

Complex – Sequential: Phase 1 and Phase 2 are done sequentially.
Complex – Parallel: Phase 2 comprises 2 palm taps done simultaneously

Gesture Nature

Physical: Phase 1
Arbitrary: Phase 2

Gesture Binding

Object-centric: Phase 1 and 2

Gesture Flow

Continuous

Pointer-Type

Yes



Gesture Illustration

Gesture 7 – Select “Snipping Tool” from Main Menu, Drag Fingers Along Boundary of Image



Gesture Information

Summary

The user saves an image on the webpage to memory by selecting a “Snipping Tool” from the main menu and “cutting out” the image to be saved. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the “Snipping Tool” option (Phase 1).

Gesture Illustration



Gesture Information

Summary

The user then “cuts out” the image by tracing a box around the image. To trace the left side of the box, the user drags the thumb and index apart (Phase 3). To trace the upper and lower sides of the box, the user drags the thumb and index finger, simultaneously from left to right along the length of the image (Phase 4). To trace the right side of the box, the user drags the thumb and index finger together (Phase 5).

Gesture Complexity

Complex – Sequential: Gesture comprises 2 taps and first part of Phase 3 done sequentially.
Complex – Parallel: Phase 3, 4 and 5 comprise 3 drags with the thumb and 3 with the index finger, done simultaneously.

Gesture Nature

Metaphorical: All phases

Gesture Binding

Object-centric: All phases

Gesture Flow

Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 8 – Lasso Image, Double Tapping Image With Three Fingers



Gesture Information

Summary

The user saves an image on the webpage to memory by lassoing the image i.e. dragging the finger in an ellipse around the image (Phase 1), and double tapping with 3 fingers on the image (Phase 2).

Gesture Complexity

Complex – Sequential: Gesture comprises a drag and 3 finger double tap done sequentially.

Gesture Nature

Metaphorical: Phase 1; the finger is used as if it is a utility knife, to cut out the image.
Arbitrary: Phase 2

Gesture Binding

Object-centric: Phase 1 and 2

Gesture Flow

Continuous

Pointer-Type

No

Gesture Illustration

Gesture 9 –Tapping on Image with Two Fingers



Gesture Information

Summary

The user saves an image on the webpage to memory by tapping on the image with 2 fingers.

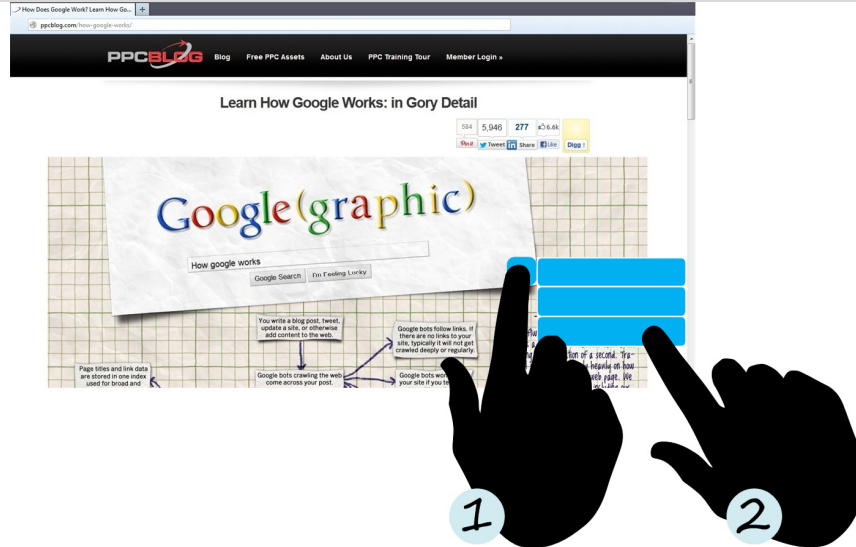
Gesture Complexity	Complex – Parallel: Gesture comprises 2 taps done simultaneously.
Gesture Nature	Arbitrary
Gesture Binding	Object-centric
Gesture Flow	Discrete
Pointer-Type	No

Gesture Illustration

Gesture 10 – Select Option from Special Image Context Menu

Gesture Information

Summary	The user saves an image on the webpage to memory by tapping on a special widget that is present on all images on webpages (Phase 1). When tapped, this widget calls up a context menu. The user then taps once on the option that enables him / her to save the image (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes



22. REFERENT 22 – SAVE CURRENT WEBPAGE TO MEMORY

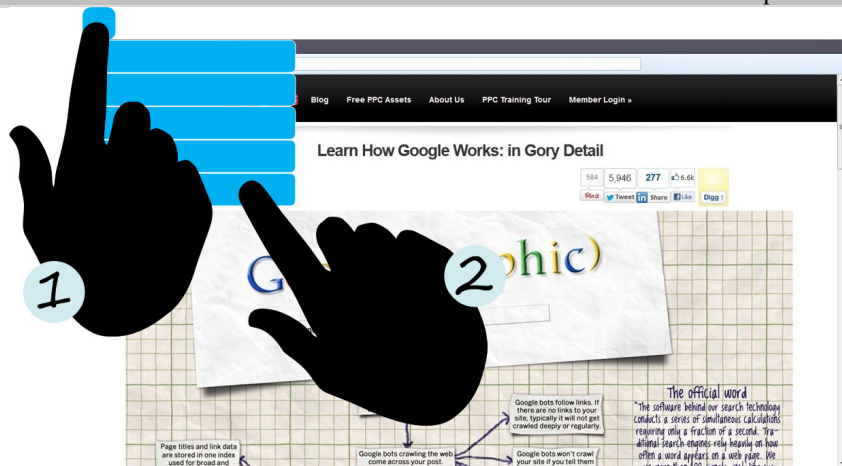
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 1 gesture was excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 7 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 6 gestures were assigned to this referent:
 - Gesture 1 – Select Option from Main Menu; proposed by 3 participants.

- Gesture 2 – Single Tap on “Save Button”; proposed by 4 participants.
 - Gesture 3 – Trace Boundary Box on Webpage, Double Tap Webpage; proposed by 1 participant.
 - Gesture 4 – Drag Finger Over Upper and Right Edge of Webpage, Single Tap on “Save Button”; proposed by 1 participant.
 - Gesture 5 – Use Keyboard “Save Button”; proposed by 1 participant.
 - Gesture 6 – Select Option from Special Webpage Context Menu; proposed by 1 participant.
- The agreement score for this referent was 0.105 (the average agreement score was 0.327).

The gestures assigned to this referent are tabulated below.

Table 67: Gestures Assigned to Referent 22 – Save current webpage to memory

Gesture Illustration	Gesture 1 – Select Option from Main Menu		Gesture Information
	Summary	The user saves the current webpage to memory by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that enables him / her to provide a search query (Phase 2).	
	Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.	
	Gesture Nature	Metaphorical: Phase 1 and 2	
	Gesture Binding	Object-centric: Phase 1 and 2	
	Gesture Flow	Continuous	
	Pointer-Type	Yes	

Gesture Illustration

Gesture 2 – Single Tap on “Save Button”



Gesture Information

Summary

The user saves the current webpage to memory by tapping once on a “Save Button”.

Gesture Complexity	Simple
Gesture Nature	Metaphorical
Gesture Binding	Object-centric
Gesture Flow	Discrete
Pointer-Type	Yes

Gesture Illustration

Gesture 3 – Trace Boundary Box on Webpage, Double Tap Webpage

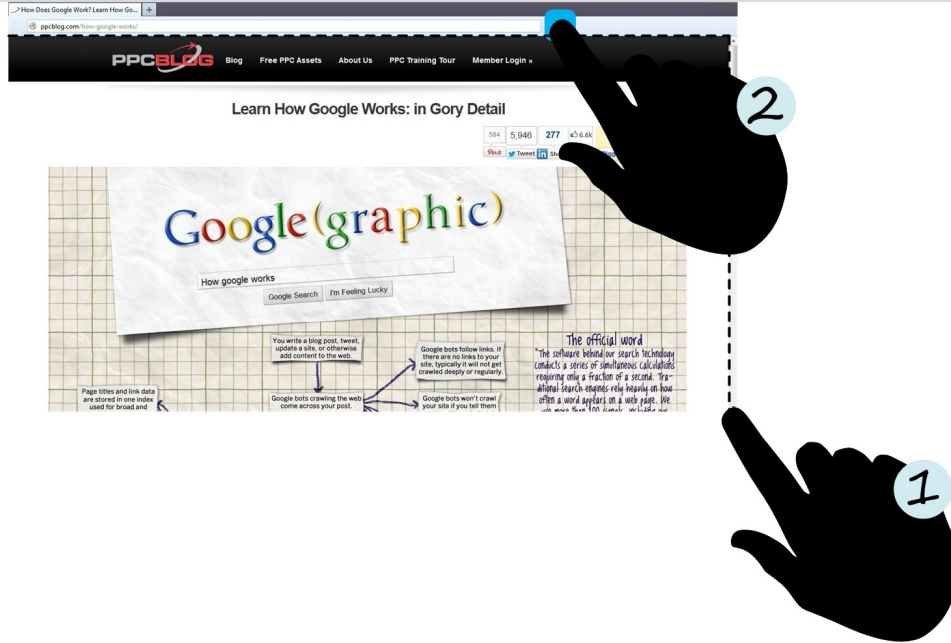


Gesture Information

Summary	The user saves the current webpage to memory by drawing a box around the frame of the webpage i.e. dragging the finger in a rectangle around the current frame of the webpage (Phase 1), and double tapping with 1 finger (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 4 drags (for each side of the box) and 2 taps, done sequentially.
Gesture Nature	Metaphorical: Phase 1; finger is used as if it is a utility knife, to cut out the webpage. Arbitrary: Phase 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 4 – Drag Finger Over Upper and Right Edge of Webpage, Single Tap on “Save Button”



Gesture Information

Summary

The user saves the current webpage to memory by dragging the finger along the upper and right edge of the webpage (Phase 1), and tapping once on the “Save Button” (Phase 2).

Gesture Complexity

Complex – Sequential: Gesture comprises 2 drags and a tap done sequentially.

Gesture Nature

Arbitrary: Phase 1
Metaphorical: Phase 2

Gesture Binding

Object-centric: Phase 1 and 2

Gesture Flow

Continuous

Pointer-Type

Yes

Gesture Illustration

Gesture 5 – Use Keyboard “Save Button”



Gesture Information

Summary

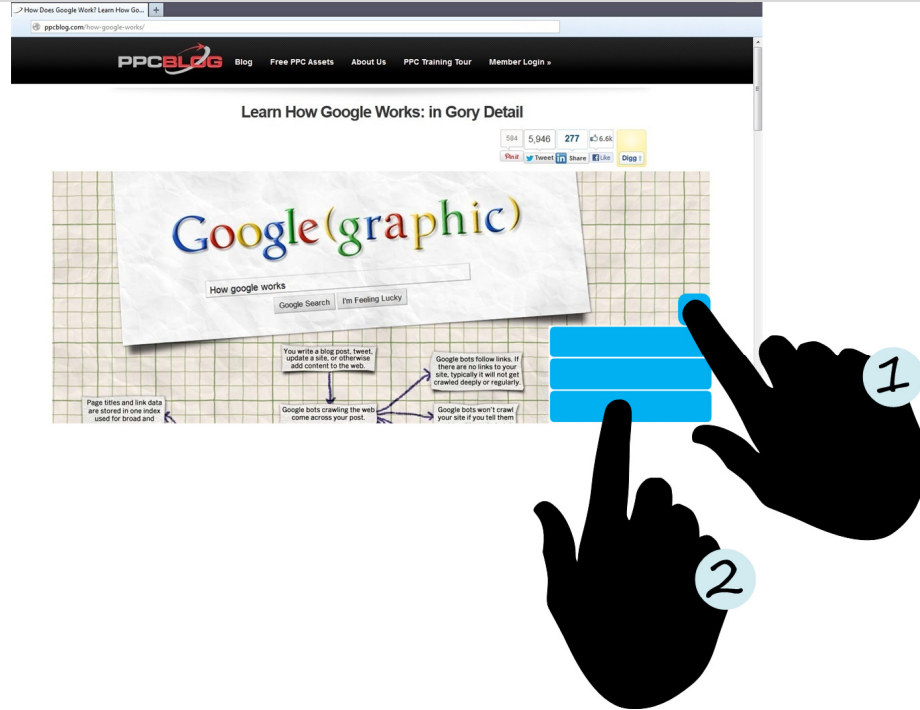
The user calls up a keyboard by “flicking it up” from the lower edge of the screen by performing a single finger flick at the lower edge of the screen (Phase 1). The user then taps once on “Save Button” on the keyboard.

Gesture Complexity	Complex – Sequential: Gesture comprises a flick and tap done sequentially.
Gesture Nature	Physical: Phase 1 Metaphorical: Phase 2
Gesture Binding	World-dependent: Phase 1 Object-centric: Phase 2
Gesture Flow	Continuous
Pointer-Type	No

Gesture Illustration

Gesture 6 – Select Option from Special Webpage Context Menu

Gesture Information



Summary	The user saves the current webpage to memory by tapping on a special widget that is present on all on webpages (Phase 1). When tapped, this widget calls up a context menu. The user then taps once on the option that enables him / her to save the webpage (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

23. REFERENT 23 – REQUEST HELP

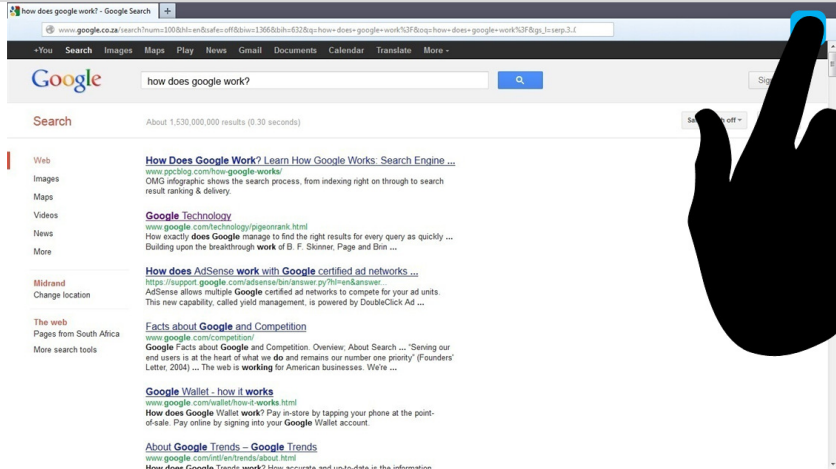
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).

- 4 gestures were excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 5 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on “Help Button”; proposed by 12 participants.
 - Gesture 2 – Trace a Question Mark in Middle of Screen; proposed by 1 participant.
 - Gesture 3 – Select Option from Main Menu; proposed by 1 participant.
 - Gesture 4 – Triple Tap on Screen; proposed by 1 participant.
 - Gesture 5 – Two Finger Press on Screen; proposed by 1 participant.
- The agreement score for this referent was 0.380 (the average agreement score was 0.327).

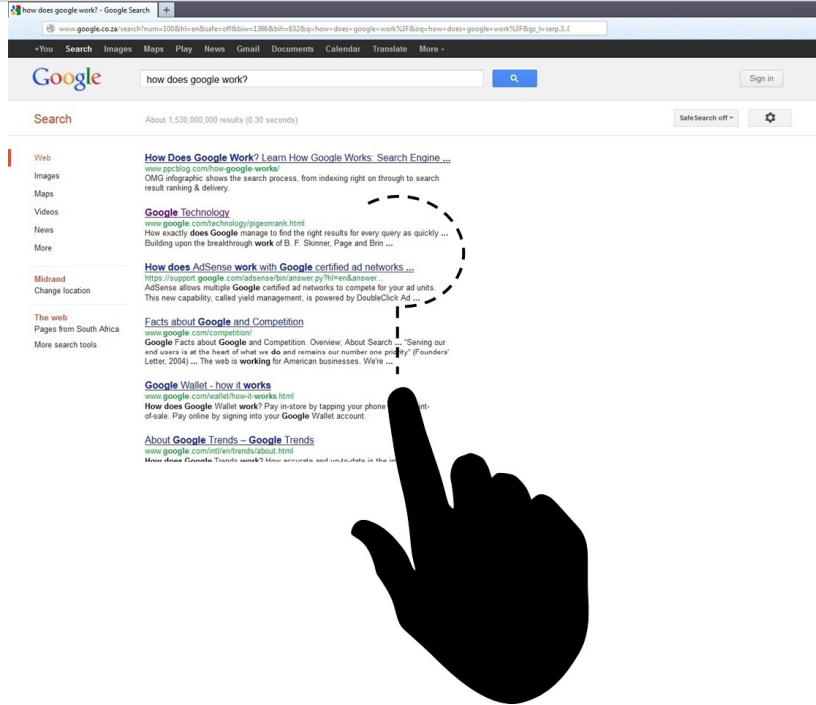
The gestures assigned to this referent are tabulated below.

Table 68: Gestures Assigned to Referent 23 – Request help

Gesture Illustration		Gesture Information	
Gesture 1 – Single Tap on “Help Button”			
			
		Summary	The user requests help by tapping once on a “Help Button”.
		Gesture Complexity	Simple
		Gesture Nature	Metaphorical
		Gesture Binding	Object-centric
		Gesture Flow	Discrete
		Pointer-Type	Yes

Gesture Illustration

Gesture 2 – Trace a Question Mark in Middle of Screen



Gesture Information

Summary

The user requests help by tracing a question mark in the middle of the screen. This consists of a curved drag (denoting the curved part of the question mark) and a tap (denoting the dot below the curved part).

Gesture Complexity

Complex – Sequential: Gesture comprises a drag and a tap done sequentially.

Gesture Nature

Symbolic

Gesture Binding

World-dependent

Gesture Flow

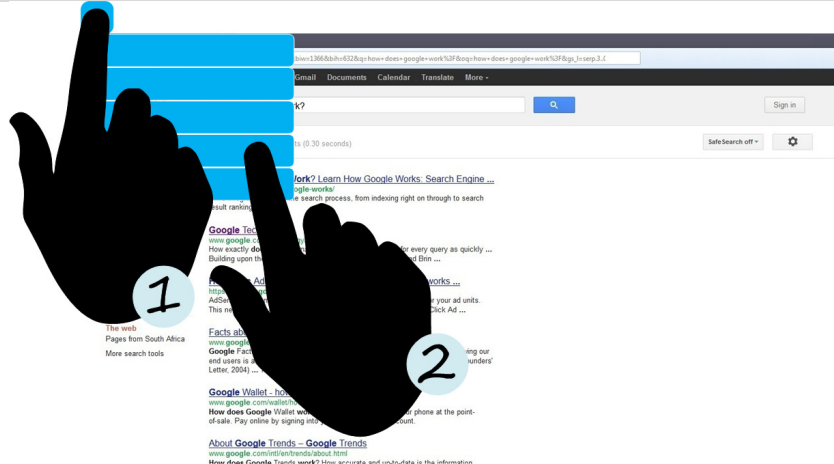
Discrete

Pointer-Type

No

Gesture Illustration

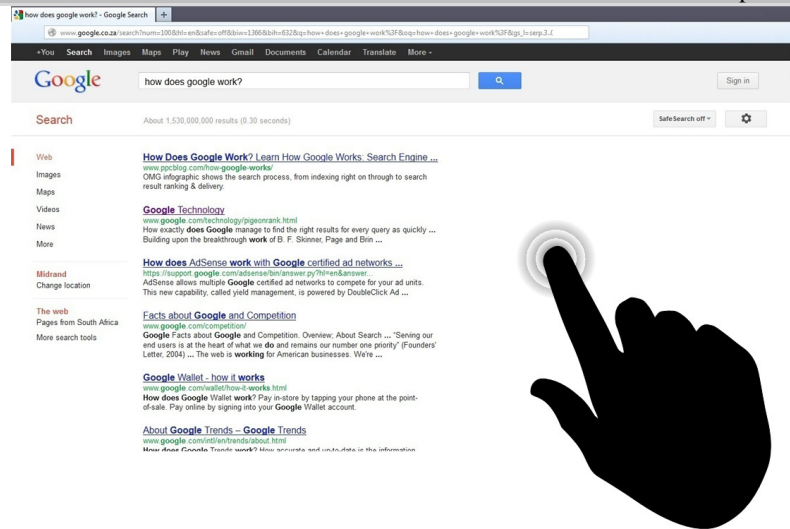
Gesture 3 – Select Option from Main Menu



Gesture Information

Summary	The user requests help by calling up a main menu and selecting the appropriate option. This is done by tapping once on a button that calls up the main menu (Phase 1), and tapping once on the menu item that provides help (Phase 2).
Gesture Complexity	Complex – Sequential: Gesture comprises 2 taps done sequentially.
Gesture Nature	Metaphorical: Phase 1 and 2
Gesture Binding	Object-centric: Phase 1 and 2
Gesture Flow	Continuous
Pointer-Type	Yes

Gesture 4 – Triple Tap on Screen



Summary	The user requests help by tapping three times in quick succession with one finger.
Gesture Complexity	Complex – Sequential: Gesture comprises 3 taps done sequentially in quick succession.
Gesture Nature	Arbitrary
Gesture Binding	World-independent
Gesture Flow	Discrete
Pointer-Type	No

Gesture Illustration

Gesture 5 – Two Finger Press on Screen

Gesture Information

Summary

The user requests help by pressing on the screen with two fingers.

Gesture Complexity

Complex – Parallel: Gesture comprises 2 presses done in parallel.

Gesture Nature

Arbitrary

Gesture Binding

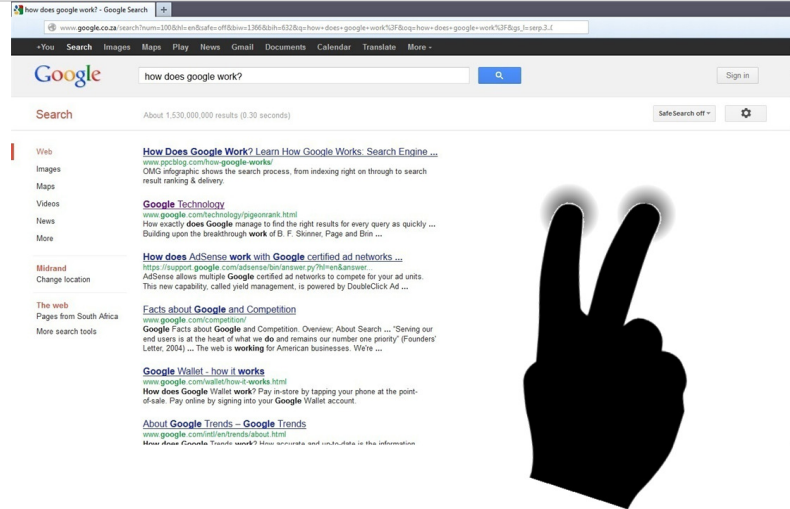
World-independent

Gesture Flow

Discrete

Pointer-Type

No



24. REFERENT 24 – CLOSE WEB BROWSER

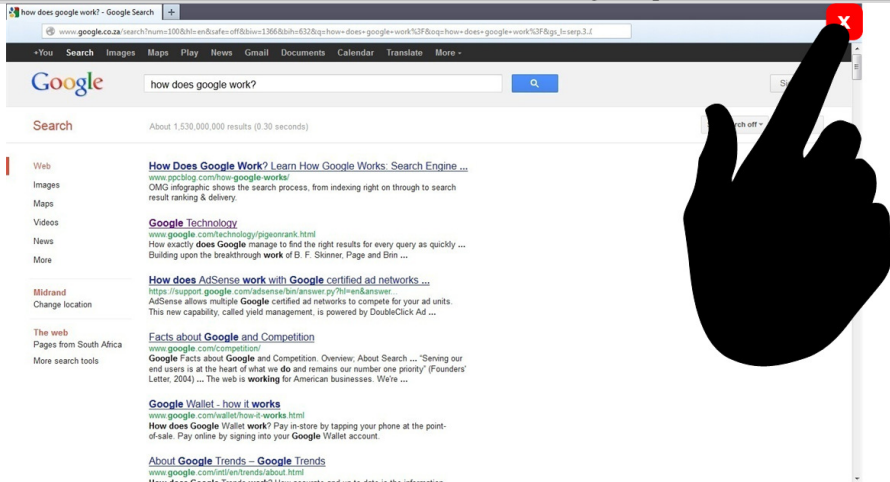
The key points relating to this referent are as follows:

- 20 gestures were elicited.
- 0 gestures were excluded due to internal conflicts (conflicts between the gestures for a single referent, as previously explained in the Methodology chapter).
- 1 gesture was excluded due to external conflicts (conflicts between gestures for different referents, as previously explained in the Methodology chapter).
- Following the exclusions of conflicts, 4 gestures were assigned to this referent:
 - Gesture 1 – Single Tap on "Close Button" (Top Right Corner of Screen); proposed by 14 participants.
 - Gesture 2 – Drag Hands from Left and Right Edges to Centre of Screen; proposed by 2 participants.

- Gesture 3 – Trace "X" Across The Screen; proposed by 2 participants.
- Gesture 4 – Drag Hand Across Screen ("Waving Goodbye"); proposed by 1 participant.
- The agreement score for this referent was 0.515 (the average agreement score was 0.327).

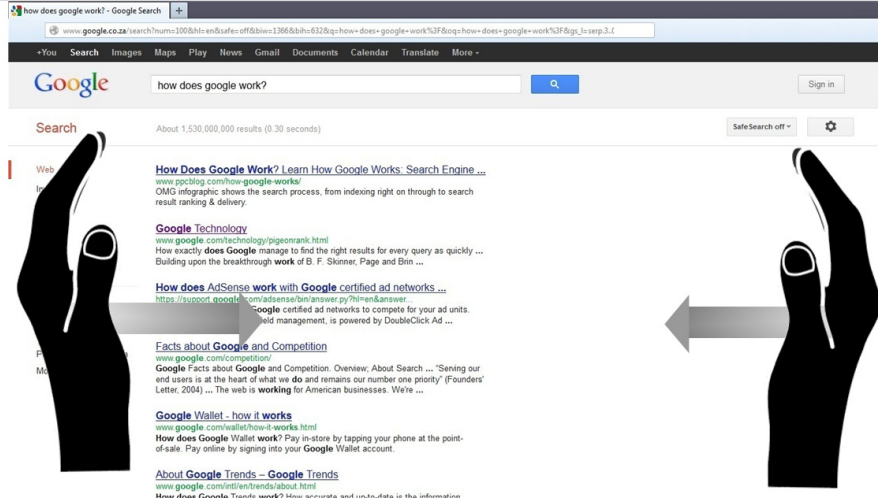
The gestures assigned to this referent are tabulated below.

Table 69: Gestures Assigned to Referent 24 – Close web browser

Gesture Illustration		Gesture Information
Gesture 1 – Single Tap on "Close Button" (Top Right Corner of Screen)		
	Summary The user closes the web browser by tapping once on a “Close Button” located at the top right corner of the screen.	
Gesture Complexity	Simple	
Gesture Nature	Metaphorical	
Gesture Binding	Object-centric	
Gesture Flow	Discrete	
Pointer-Type	Yes	

Gesture Illustration

Gesture 2 – Drag Hands from Left and Right Edges to Centre of Screen



Gesture Information

Summary

The user closes the web browser by dragging the lower part of the left hand from the left edge of the screen to the middle of the screen (Phase 1), while simultaneously dragging the lower part of the right hand from the right edge of the screen to the middle (Phase 2).

Gesture Complexity

Complex – Parallel: Gesture comprises 2 drags done simultaneously.

Gesture Nature

Metaphorical: Phase 1 and 2. The user makes as if he / she is closing a book.

Gesture Binding

World-dependent: Phase 1 and 2

Gesture Flow

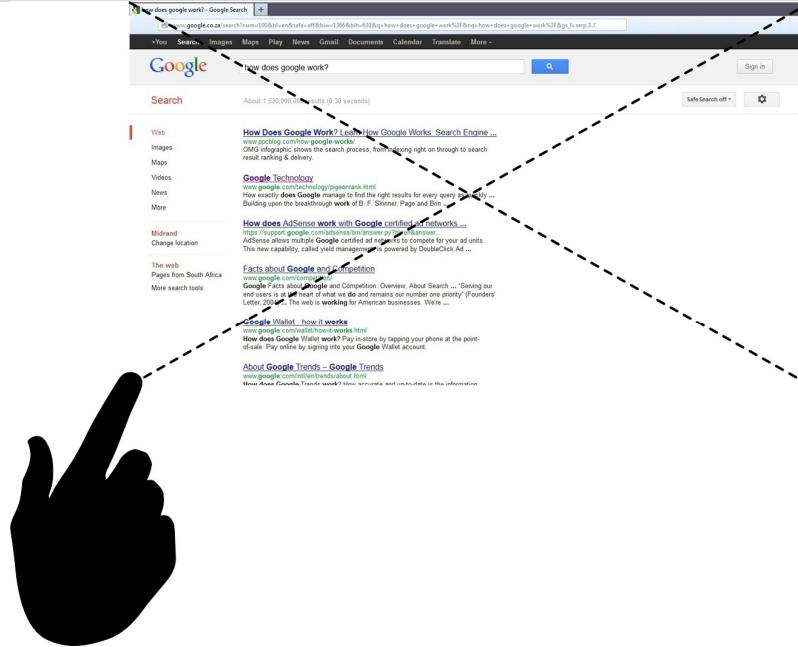
Discrete

Pointer-Type

No

Gesture Illustration

Gesture 3 – Trace "X" Across The Screen



Gesture Information

Summary

The user closes the web browser by tracing an “X” across the screen i.e. dragging a finger diagonally from the top left corner of the screen to the bottom right corner (Phase 1) and then dragging a finger from the top right corner of the screen to the bottom left corner (Phase 2).

Gesture Complexity

Complex – Sequential: Gesture comprises 2 drags done sequentially.

Gesture Nature

Symbolic: Phases make up a symbolic gesture

Gesture Binding

Mixed dependencies: The phases may either be object-centric or world-dependent.

Gesture Flow

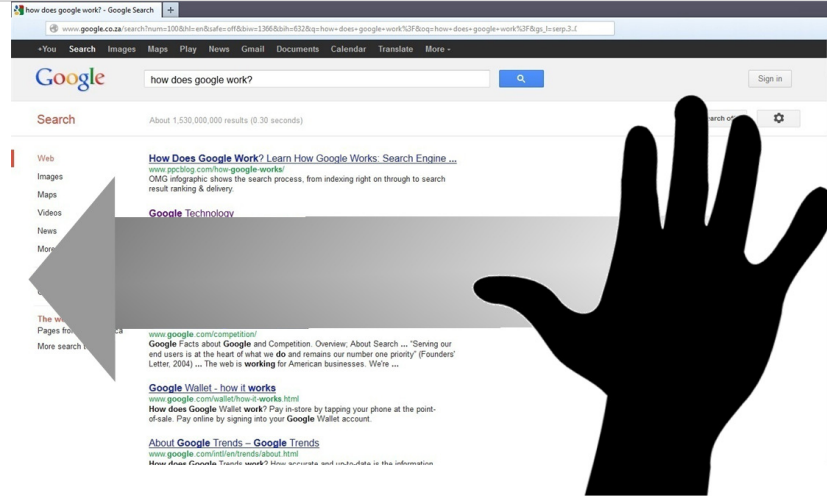
Discrete

Pointer-Type

No

Gesture Illustration

Gesture 4 – Drag Hand Across Screen ("Waving Goodbye")



Gesture Information

Summary	The user closes the web browser by dragging the palm of the hand across the screen from right to left.
Gesture Complexity	Simple
Gesture Nature	Metaphorical: The user makes as if he / she is waving goodbye.
Gesture Binding	World-dependent
Gesture Flow	Discrete
Pointer-Type	No

APPENDIX D – APPROVAL OF RESEARCH REPORT TITLE AND CHANGE OF RESEARCH REPORT TITLE

Below are scanned versions of the:

- School of Economic and Business Science (SEBS) Post Graduate Degrees Committee's approval of this research report's initial title. This document also contains the Ethics Number (CINFO/1002) for this research report.
- Approval for changing the title of this research report to the one it currently has.



Faculty of Commerce, Law & Management
UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

✉ Private Bag 3, WITS, 2050 South Africa

☎ +27 11 717 8005
FAX +27 11 717 8175

21 July 2011

Mr T Rakubutu
BSG Mettle Building
33 Fricker Road
Illovo
2196

Student Number: 512306

Dear Mr Rakubutu

I have pleasure in informing you that the **SEBS Post Graduate Degrees Committee** has approved the following title for your Research Report:

A few pointers on Gesture Design- an investigation of Touch Screen Tablet Web browsing

Furthermore the committee has appointed the following supervisor: **Mr T Addison**, with whom you should maintain regular contact. Please ensure that the title on the bound copies of your research report is the same as that approved by the Post Graduate Committee.

You will be required to submit to the Faculty Office on submission of the report:

- Two spiral bound copies of the Research Report with a signed declaration
- one copy of the abstract
- one copy of the title page
- the Supervisor's Clearance Form

The ethics number for your research report is **CINFO/1002**. It is very IMPORTANT that you ensure that this number appears on the cover page of your research report when you submit.

Please note that you need to be registered every year until your graduation.

Please note: After confirmation of the final Research Report mark, you will be required to submit two unbound final corrected copies signed and dated, an electronic copy (in PDF format), a signed library clearance form and have completed the full ETD form.

We wish you success with your research.

Kind Regards

Ms Ntshepeng Tshabalala
Senior Faculty Officer
Faculty of Commerce, Law & Management

CC Supervisor: Mr T Addison



Faculty of Commerce, Law & Management
Private Bag 3, WITS, 2050
Fax: +27 (01) 11 717-8175
Tel: +27 (01) 11 717-8390

Reference: Ms Kamogelo Dube
E-mail: Kamogelo.Dube@wits.ac.za
28 September 2012
Person No: 512306
TAA

Mr TJ Rakubutu
BSG Mettle Building
33 Fricker Road
Illovo
2196
South Africa

Dear Mr Rakubutu

Master of Commerce in Information Systems: Change of title of research

I am pleased to inform you that the following change in the title of your Research Report for the degree of has been approved:

From:

To **Participatory gesture design: an investigation of user-defined gestures for conducting an informational search using a tablet device**

Yours sincerely

A handwritten signature in black ink, appearing to read "M Bosman".

Mrs Marike Bosman
Faculty Registrar
Faculty of Commerce, Law & Management