Intuitive Interaction in Mobile Application Interfaces and The Role Animation Has on Information Integration: An Empirical User Study.

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DECLARATION

I declare that this thesis is my own unaided work; submitted for the degree of Master of Digital Arts at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination at any other university.

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Date

11 May 2020

ACKNOWLEDGEMENTS

The work contained in this thesis is my own. The inspiration for the work's direction was provided by my supervisor, Edward (Ted) White. His guidance and collaboration are fundamental to the substance of this thesis and he has provided invaluable guidance and large amounts of patience in the process.

Thank you to Professor Dr Gütig, Dr Alethea Blackler and Dr Jörn Hurtienne for their assistance, and a hearty thank you to all the people who took part in my study. Further to that, Joshua P. Britz deserves a massive thank you for helping me develop the trickier aspects of the Angular mobile application used in the experimental portion of the study, and for good taste in gin.

To my mother Carol, my sister Savanna, and my brother Dalton: thank you for having all the patience in the world while I sacrificed weekends and time with you. It is quite an undertaking to do something like this and you've all been there for me, even when you didn't realise it.

To my two wonderful little daughters, my schnauzer-therapists, Maggie and Annie, you girls have kept Daddy sane and he loves you all the more for it.

Finally, I must express my profound gratitude to my husband, my confidante, and my best friend David. My love: you have provided me with unfailing support, steadfast encouragement, been my sounding-board, provided lots of gin, and given me perspective when I needed it most. This accomplishment would not have been possible without you. Avec toi, je suis moi.

ABSTRACT

In the design and development industry, animation in the mobile interface is regarded as making interaction with mobile apps more intuitive. This study investigates the claim from the perspective of intuitive interaction research in Human-Computer Interaction (HCI), and Judgment and Decision making (JDM). The hypothesis is that animation in the mobile interface can influence how individuals integrate information, which is an underlying process of intuition. A wholly between-subjects design was used to test the relationship between animation, information integration, and judgmental evaluation. One hundred and fifty-two (152) participants were randomly assigned to either the experimental or control condition. The control condition is a replication of an experiment in automatic processing (Betsch, Plessner, Schwieren, & Gütig, 2001) and the experimental condition is an extension of this earlier work where animation is introduced as the independent variable. The results suggest that animation has a significant effect on how information is integrated and the resulting judgmental evaluations that were formed by participants.

Key words: *intuitive interaction, judgment and decision-making, information integration, animation, judgmental evaluation.*

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CHAPTER 1: INTRODUCTION

The problem with technological innovations such as those found in mobile applications is that they are becoming ever more complex with an increasing number of functions and uses (Kleinmuntz, 1987; Naumann, 2007; O'Brien, 2010; Hurtienne, 2011; Blackler, Gomez, Popovic & Thompson, 2016 Asikhia, 2016). It is therefore pertinent to better understand how to support the decision making processes that make these complexities more understandable to users (Hurtienne & Blessing, 2007; Hurtienne, 2011; Loeffler, Hess, Maier & Hurtienne, 2013), or else it could culminate in user abandonment of these applications (Hoehle & Venkatesh, 2015; Taba, Keivanloo, Zou, Ng, J., & Ng, T., 2014).

In response to this, design and development professionals in the Information Technology (IT) industry have, in recent years, made the case that animation in mobile interfaces holds not only cognitive benefits such as reducing cognitive load (Babich, 2017; Head, 2016) and attention steering (Carine, 2019; Kraft & Hurtienne, 2017; Yalanska, 2015), but also enables intuitive use of these interfaces (Babich, 2017; Carine, 2019; McLeod, 2019; Head, 2016; Yalanska, 2015). The argument from the professional perspective is that animation enables intuitive use of interfaces in terms of micro-interactions performed (Babich, 2017; Head, 2016). For example, a download button in an interface that when clicked displays an animated loader, gives the user an immediate sense that their action (the button click) has been successful and that a consequential action is being performed by the system without them having to think any further about it (Babich, 2017; Carine, 2019; Head, 2016; Yalanska, 2015). The conclusion reached is often that animation "makes complex software interactions so intuitive that they almost become invisible" (McLeod, 2019, p. 9). The problem, however, is that in a professional space, although the term *intuitive* is frequently used, there is no formal definition of what it means cognitively or how it is generally understood (Blackler, Popovic & Mahar 2003; O'Brien, Rogers & Fisk, 2008). This study therefore hopes to resolve this situation by expanding the cognitive understanding of intuitive interaction through examining the existing definitions and juxtaposing it against understandings and definitions from cognitive research.

The Human-Computer Interaction (HCI) literature posits that intuitive interaction can only occur when an individual is able to transfer knowledge that has been internalised in long-term memory to a new context of technology use (Blackler & Popovic, 2015). However, Still and Still (2019) suggest that currently there is insufficient reflective critique from the domain of cognitive science used in the theoretical development of the concept of intuitive interaction. Even though it is understood that prior experience is necessary for intuitive interaction to occur (Betsch, 2008; Blackler & Popovic, 2016), the underlying cognitive mechanisms are not clearly described since research in cognitive science and HCI have separate goals (Still & Still, 2019b). The proposal that the present study is based on is that an understanding of cognitive principles can lead to a better framework for HCI to work from in order to yield predictive power in intuitive interaction research (O'Brien, 2010; Still & Still, 2019b). Currently, design and cognitive research have different goals when investigating the processes that underlie intuition: "cognitive research emphasises the implicit nature of the knowledge supporting intuition, while the design literature does not" (Still & Still, 2019b, p. 43). Design studies are primarily concerned with assessing how a design works in a specific context, whereas cognitive research focuses on the underlying processes of intuition itself (Still & Still, 2019).

The disconnection between the two is problematic, as it infers that work in intuitive interaction is under-described from a cognitive perspective within HCI (O'Brien, 2010; Still & Still, 2019b). Without a clear understanding of how intuition operates cognitively, it is therefore problematic for a designer to determine when an interaction they are creating could be used intuitively by the people they are creating it for (O'Brien, 2010; Still & Still, 2019b).

Therefore, in order to compensate for the lack of cognitive principles that currently describe intuitive interaction in HCI, this study intends to import an experiment from within the Judgment and Decision Making (JDM) field to extend the research programme into intuitive interaction by combining cognitive research into information integration and value formation with extant design research.

From a JDM perspective, the literature has progressed to the point where decision making is no longer exclusively considered an explicit process that requires effortful working memory (Kahneman, 2011; Kahneman & Frederick, 2005; Simon, 1955), but it is suggested that decision making is largely a process that occurs through both automatic and explicit mechanisms of cognition (Betsch et al., 2001; Glöckner & Betsch, 2012; Thompson, 2014). Thus Badgaiyan (2019) posits that all our decisions are made explicitly and with full conscious awareness, but the evidence points to the fact that decisions are first made non-consciously and only the outcome is made available to the conscious mind.

The intuitive interaction literature has come to the conclusion that prior experience is the leading contributor to intuitive use, i.e. if a feature has been encountered before it will be recognised and used without thought in successive uses (Blackler & Popovic, 2016), but it does not describe how this process works cognitively, which is a major limitation for design (Still & Still, 2019b). In the JDM literature, information integration is a key concept of intuition (Betsch & Roth, 2018) and it is suggested that this automatic process describes the literature gap between prior experience and the intuitive use of an interface. In the course of the current study there will be an emphasis on intuitive interaction as a decision making process (Blackler, 2008; O'Brien, 2010; O'Brien et al., 2008) with specific focus on information integration and judgmental evaluation.

In order to address the inherent limitations of intuitive interaction research, the present study will firstly offer an up-to-date criticism of the theory and evaluate it in terms of current research in JDM. Secondly, the present study aims to replicate and extend a dual-task experiment from cognitive research that demonstrates how intuitive processes operate automatically and are capable of processing information without overloading cognitive systems such as working memory (Betsch et al., 2001; Betsch & Glöckner, 2010; Glöckner & Witteman, 2010). In order to extend the experiment, the present study imports the dual-task procedure into HCI. The experiment investigates if one of the core processes of intuition, information integration, can be influenced by animation in the mobile interface and the potential effect of this on judgment and decision making.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter will provide an overview of the literature that spans a variety of fields including judgment and decision making (JDM), cognitive psychology and intuitive interaction research wherein the current research is situated. This review highlights the most important evidence for the argument of the current study. The structure of the review is centred around key facets of cognitive research into intuitive interaction and formulated in such a way as to demonstrate the importance of the present study and what it may contribute to HCI research in intuitive interaction.

2.1.1 Decision making

Decision making is a fundamental cognitive process and it is apparent in almost every procedure of daily life (Glöckner & Betsch, 2012; Wang & Ruhe, 2007). Essentially it is a process where one belief or course of action is selected from among several options based on the individual's preferences, values and beliefs (Baumeister & Vohs, 2007; Eysenck & Keane, 2015). Individuals therefore make a multitude of decisions of varying levels of importance and complexity every day (Glöckner & Witteman, 2010). Deciding on who to vote for, what to eat, or which button to click in a complex interface are all examples of common decisions that are made on a daily basis (Minda, 2015).

In early theoretical work in JDM, the aim was to provide general and normative theories that predicted the outcomes of decision making rather than describe the processes underlying the decision itself (Bodenhausen & Todd, 2010; Glöckner & Witteman, 2010). The normative view of decision making uses a model that describes how decision making *should* operate in order to be optimal, i.e. the process individuals ought to follow in order to make a decision

(Baron, 2012; Chandler, 2017). As Baron (2012) notes, this view provides standards for the evaluation of decisions. Under this view, it was assumed that individuals were perfectly rational beings and made decisions based on methods found in probability theory and economics (Kahneman, 2002; Nett, T., Nett N., & Glöckner, 2019). These early theories posited that the decision maker equally considered all information available to them (Glöckner & Witteman, 2010; Kahneman, 2002; Simon, 1955). It was believed that decision making was a logical procedure and that an individual would weigh up all information and consider the pros and cons of each until the best choice was arrived at (Bodenhausen & Todd, 2010). The assumption under the normative view is that decision makers are perfectly rational and follow well-defined rules and preferences of behaviour (Beresford & Sloper, 2008; Bodenhausen & Todd, 2010; Glöckner & Witteman, 2010). A deliberate decision making process is considered to be effortful because information is processed in a serial fashion, it is cognitively demanding in terms of resources such as working memory and attention and operates slowly (Evans, 2008; Kahneman & Frederick, 2005; Stanovich, 2011). Further to this, individuals can verbalise the exact process they took to reach the final outcome of their decision (Evans, 2008; Kahneman & Frederick, 2005; Stanovich, 2011).

In JDM research this view of the perfectly rational decision maker has been abandoned in part due to the work by Simon (1955) who put forward that cognition is inherently bounded, i.e. the human cognitive system is constrained by limited knowledge, computational capacity and time (Betsch & Glöckner, 2010; Gigerenzer & Goldstein, 1996; Simon, 1955). Unlike the normative view of decision making, the descriptive view posits that individuals might not rely on deliberate calculation in making decisions because of the cost involved in terms of time and effort (Beresford & Sloper, 2008; Bodenhausen & Todd, 2010; Glöckner & Witteman, 2010; Wang & Ruhe, 2007). Descriptive models of decision making are theories that attempt to explain how judgments and decisions are made based on observation of actual decision behaviours (Baron, 2012; Chandler, 2017). Under the descriptive view, it is understood that decisions are often made through automatic processes which is why an individual cannot introspectively unpack how they arrived at a decision which they made (Bodenhausen & Todd, 2010).

In general terms, when cognition is discussed, most people have the concept that it is a controlled, deliberate process which consumes cognitive resources such as attention and working memory (Kihlstrom, 2018). This conception of decision making, however, is not consistent with individuals' everyday experience where choices are often made without explicitly weighing up all the relevant information available in the environment (Bodenhausen & Todd, 2010; Hogarth, 2010; Kahneman, 2002; Plessner, Betsch & Betsch, 2008). This experience has been described by many dual-process theories of cognition that propose there are two distinct cognitive systems which underlie decision making (Evans, 2003; Kahneman & Frederick, 2005; Miles, Charron-Chénier & Schleifer, 2019) and dual-process theories are ubiquitous in psychology (see Barrett, Tugade & Engle, 2004) because it helps describe human performance in decision making (Plessner, Betsch & Betsch, 2008). For the purposes of the present study it is important to have a deeper understanding of how the two systems differ, because although the study focuses on automatic or intuitive processes, these are most often described in opposition to the explicit or deliberative process of decision making (Creighton & Gawronski, 2013; Epstein, 1994).

2.2 Dual-process theory of cognition

According to the literature, dual-process theories of cognition all work from the same assumption that there is a Type 1 system and a Type 2 system of cognition (Evans, 2008; Kahneman, 2011). The Type 1 system is characterised as being automatic, fast and has a high capacity, i.e. it can handle large amounts of information and relies on associative memory (Betsch et al., 2001; Betsch & Glöckner, 2010; Evans, 2008; Kahneman, 2011). By contrast the Type 2 system cannot handle large amounts of information (low capacity) as it is limited by working memory and performs its operations in a serial manner, i.e. it is slow and deliberative (Evans & Stanovich, 2013a; Evans, 2008; Kahneman, 2011).

The characterisation of two separate cognitive processes, Type 1 and Type 2, can be seen across several areas of research (Epstein, 1994; Evans & Stanovich, 2013a; Kahneman, 2011; Kahneman & Frederick, 2005; Sloman, 1996) and this is what is generally known as a dual-process theory of cognition (Hodgkinson, Langan-Fox & Sadler-Smith, 2008). It is generally accepted in JDM that these two modes are different methods of information processing (Horstmann, Ahlgrimm & Glöckner, 2009; Maldei, Koole & Baumann, 2019). The fundamental ways in which Type 1 and Type 2 differ are further explained in the next paragraphs.

Researchers tend to use different names for the two processes mentioned above, such as associative vs. rule-based (Sloman, 1996), fast vs. slow (Kahneman, 2011), associative vs. tacit (Hogarth, 2010), or analytic vs. experiential (Epstein, 1994). A more comprehensive list of the different labels used to describe the two systems, can be found in Evan's article titled "Dual-Processing Accounts of Reasoning, Judgment, and Social Cognition" (2008, p. 257).

Most dual-process theories of cognition suggest that human behaviour is controlled by both deliberate and automatic processes of cognition (Kahneman, 2011, pp. 15-16; Kihlstrom, 2018). Kahneman (2011) used the following example to demonstrate the difference between Type 1 and Type 2 systems.

Figure 2.1 Woman’s angry face (Kahneman, 2011, p. 15)

In Figure 2.1 above, the woman’s face is immediately interpreted as emotional and Kahneman suggests that as quickly as one perceives that the woman in the image has dark hair, one also apprehends that she is angry (Kahneman, 2011). Kahneman (2011) argues that this is an instance of automatic (Type 1) process, which he calls a System 1 process, where the interpretation of the woman’s emotional state occurs with little to no cognitive effort and without voluntary control on our part. We have no direct experience of the information processing that has to have happened for us to come to the conclusion that the woman is angry (Evans, 2010; Kahneman, 2011).

By contrast, if you give someone the mathematical problem “17 × 24” (Kahneman, 2011, p. 16) to solve, most people do not instantaneously know what the answer is or should be (Kahneman, 2011). Kahneman (2011) suggests that while a person may have a vague notion of the range of possible results for this problem, a solution does not immediately come to mind.

In order to solve this problem a person has to follow a serial procedure of steps and this is a cognitively effortful process as one has to recall the rules of multiplication from long-term memory and then deliberately follow the procedure until a result is obtained while it is all held in working memory (Kahneman, 2011). The effort required when engaging in Type 2 processing, labelled a System 2 process by Kahneman (2011), can be seen in other activities such as turning into heavy traffic, navigating a tight parking spot and completing a tax return (Kahneman & Klein, 2009). What the dual-process view suggests is that there is more to cognition than only deliberative or Type 2 processing (Brandimonte, Bruno & Collina, 2006; Evans, 2003; Gronchi & Giovannelli, 2018).

The traditional view of decision making, as explained by classic models of decision making, such as the subjective expected utility model, focuses almost exclusively on Type 2 processing (Glöckner & Witteman, 2010). This model assumes that people are rational decision makers in that they have full knowledge of the environment they are in (i.e. aware of all information available in the environment), they are efficiently organised and have clear preferences that would allow them to compute courses of action to reach the most optimal solution (Simon, 1955). Figure 2.2 by Sadler-Smith (2007) demonstrates the course of a perfectly rational decision tree where the goal would be to optimise the outcome of a choice through a logical sequence of steps. In this rationalist model a person buying convenience foods, for example, may weigh up all aspects such as cost, nutrition, portion size and anticipated satisfaction as attributes in making their choice (Sadler-Smith, 2007). The components of the decision are mapped out in a decision tree (Figure 2.2) where the subjective probability and what the value to the decision maker is, i.e. the utility, is set out in a step by step fashion with the outcome of a subjective expected utility or a valued decision.

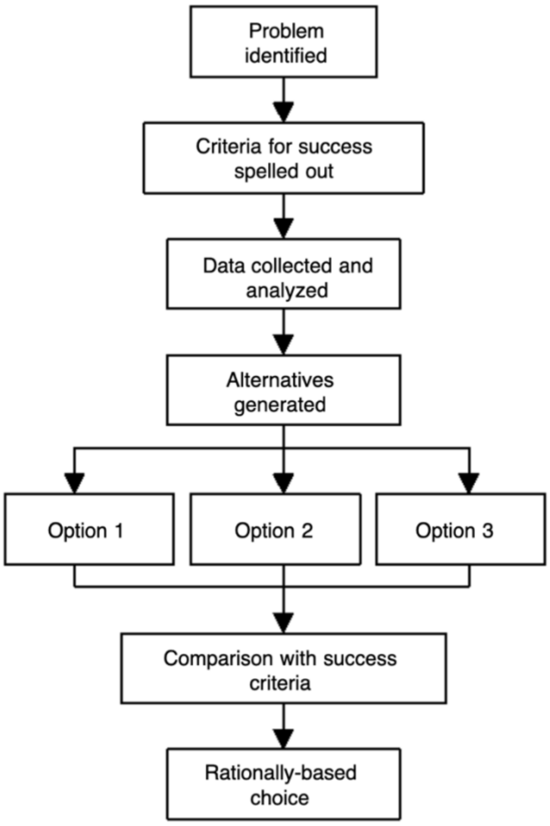

Figure 2.2 A rational choice model (Sadler-Smith, 2007)

The subjective expected utility model of decision making assumes that people make decisions in a considered manner where the choice made is the option with the highest expected value, i.e. a person selects the best choice from a number of options based on supposed rational behaviour (Baumeister & Vohs, 2007; Sadler-Smith, 2007; Simon, 1955). This model is problematic as it relies on a person being fully aware of all relevant information in the environment (Baumeister & Vohs, 2007; Sadler-Smith, 2007). For example, the customer in the grocery store must hold information about all aspects of nutrition, cost, satisfaction and portion size in their minds (in the convenience foods example) and then assess the importance of every piece of information (Shah & Oppenheimer, 2008) when making decisions about which convenience foods to purchase. Thus, the person making the decision must also then assign a weight or relative importance to each piece of information being assessed (Shah & Oppenheimer, 2008) about each convenience food under consideration, e.g. what relative weight does cost have when considered against nutritional value, etc.

In this model all alternatives must be considered, compared along all attributes, all the information must be given psychological weight and integrated and then the product holding the highest value is selected (Shah & Oppenheimer, 2008). However, the model fails on a practical level, because an individual does not have the mental capacity to perform all these analyses sequentially bearing all the information in mind (Kahneman, 2011; Shah & Oppenheimer, 2008; Simon, 1955). This step by step deliberation requires great mental effort because people have limited cognitive resources (Cohen, Dennett & Kanwisher, 2016) especially in the form of working memory which is a limited capacity system (Baddeley, 2003).

Due to these considerations, Simon (1955) was the first to acknowledge that people have "limited knowledge and ability" (p. 114) when it comes to decision making and they operate within constraints that are imposed both by the environment they find themselves in and the constraints of their own cognitive resources (Shah & Oppenheimer, 2008). This concept is known as bounded rationality (Simon, 1955, 1996). The essential tenet of the bounded rationality approach is that people cannot focus attention and integrate all relevant pieces of information at the same time (Sadler-Smith, 2007; Simon, 1955). It is suggested that this is the case because of the innate capacity constraints of working memory and attention (Betsch, 2008; Sadler-Smith, 2007). What this means is that deliberative thinking is necessarily a step by step process where information is considered sequentially (Simon, 1955).

Due to these constraints people will naturally tend to minimise the amount of mental effort and information considered when making a decision through the use of cognitive shortcuts commonly referred to as heuristic processing (Brusovansky, Glickman & Usher, 2018; Glöckner & Betsch, 2008; Shah & Oppenheimer, 2008).

2.3 Heuristic processing

Heuristic processing can be explained as a decision made, based on simple rules of information search and/or output (Betsch & Glöckner, 2010; Tversky, 1974). It is a strategy used to reduce the cognitive effort needed when making a decision, especially when there is a large amount of information to process (Fiedler & Sydow, 2015; Kahneman & Frederick, 2005; Shah & Oppenheimer, 2008; Tversky, 1974).

A seminal example of heuristic processing that Kahneman and Tversky (1974) put forward is found in their exercise of giving people an occupation list to choose from (e.g. farmer, salesman, airline pilot, librarian, or physician) and asking them to arrange this list in order of probability based on a personality sketch of a target person described with key words such as shy, withdrawn, helpful, meek and tidy (p. 1124). The target person is frequently described as a librarian because the key words are assessed on the nearest stereotype that they conform to, i.e. a librarian. Individuals often make this judgment even though statistically in the world there are many more farmers than librarians who could potentially fit this description (Kahneman, 2011, p. 1124). This is an example of the representativeness decision strategy where the judgment is made in a probabilistic fashion, i.e. the probability that the person described is a librarian compared to the statistical base-rate of the number of librarians that actually exist in a population (Tversky, 1974).

Although the heuristic processing approach has been influential (Fiedler & Sydow, 2015), it has not been without serious critique (Fiedler & Sydow, 2015; Thompson, 2014). Chief among these criticisms is that the approach mostly demonstrates how automatic processing, in the form of heuristic shortcuts, leads to only a subset of information being considered (Betsch & Glöckner, 2010; Thompson, 2014) and not how these processes might be able to innately integrate large amounts of information (Betsch, 2008). For example, the lexicographic strategy in decision making is a mental shortcut used when an individual makes a choice between alternatives based on only one piece of information (Betsch & Roth, 2018; Horstmann, Ahlgrimm, & Glöckner, 2009). For example, an individual that only cares about minimising the cost of buying detergent could use a lexicographic strategy to sort through options and come to a decision quite quickly based on the cost attribute alone (Betsch & Roth, 2018). Essentially the lexicographic strategy selects one attribute as the most important and the decision is made on this singular piece of information (Beresford & Sloper, 2008; Betsch & Roth, 2018).

In the literature, intuition has been equated with heuristic processing because judgments and decisions are reached quickly without making much of an impact on working memory (Gigerenzer, 2007; Kahneman & Frederick, 2005). This view has been challenged by several researchers as heuristics are shortcuts for deliberate processing, i.e. they use only a subset of information to come to a decision or judgment. The heuristic processing method itself, where a piece of information is consciously compared to others, is still deliberative (Betsch, 2008; Evans, 2010; Thompson, 2014; Shah & Oppenheimer, 2008). The problem is that many heuristics involve deliberate reasoning and only reduce the information processing load required to come to a decision and as such do not match the criteria of intuitive processing (Betsch, 2008; Evans, 2010; Thompson, 2014; Shah & Oppenheimer, 2008).

Heuristic processing is not necessarily intuitive or automatic processing as it works on a condensed subset of information (Betsch & Glöckner, 2010; Thompson, 2014) and as such are more effort reducing than a change of processing mode (Hilbig, Scholl & Pohl, 2010; Shah & Oppenheimer, 2008). Further to this, heuristic processing is based on simplistic rules that allow decisions to be reached quickly, but just because a decision is fast does not necessarily imply that it is an intuitive one (Betsch, 2008; Evans, 2010).

In contrast to the heuristic processing perspective of intuition, Betsch and Glöckner (2010) have proposed that intuitive processing is not merely a simplification of task complexity, but rather it is capable of dealing with complex tasks and information processing under the correct conditions (Betsch & Glöckner, 2010; Thompson, 2014). This conceptualisation of intuitive processing is what will be used for this study as a key understanding of how the cognitive process operates. The focus for purposes of the present study is that automatic or Type 1 processes do not require working memory to function (Evans, 2008; Evans & Stanovich, 2013b; Thompson, 2014) and the suggestion that Type 1 processes are considered instrumental to how people make choices and decisions (Betsch & Glöckner, 2010).

2.4 Automatic processing in JDM

Historically, decision making has been considered a process of conscious control and reasoning (Simon, 1955) and the automatic processes of intuition have been neglected in JDM studies (Glöckner & Betsch, 2008). The topic has not been taken as seriously as deliberate or analytic decision making research, nor has it been held in high regard (Betsch, 2008; Hogarth, 2010). In recent years, however, the concept of automatic or intuitive information processing has gained more interest in JDM research, and this research is in marked contrast to the work conducted in the heuristic processing tradition (Betsch & Glöckner, 2010).

From a heuristic processing perspective, intuition uses a subset of information for processing and often comes to a non-optimal decision outcome in a range of contexts (Evans & Stanovich, 2013a; Tversky & Kahneman, 1974). For example, the hospital problem below offers a sample of the type of questions heuristics researchers use in experiments:

> A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower. For a period of 1 year, each hospital recorded the days on which more than 60 percent of the babies born were boys. Which hospital do you think recorded more such days?
>
> 1. The larger hospital (21)
> 2. The smaller hospital (21)
> 3. About the same (that is, within 5 percent of each other) (53)
>
> (Tversky & Kahneman, 1974, p. 1125)

The correct answer, according to sampling theory and the law of large numbers, is that the smaller hospital is likely to record more days with babies being born that are boys (Tversky & Kahneman, 1974). In the example above, the numbers next to the multiple choice answers indicate the number of participants who chose each option. What this result, and others of its type, suggested was that intuition is flawed even when presented with evidence in the form of sample size (Kahneman, 2011; Tversky & Kahneman, 1974). For similar examples of how intuitive decisions, in this tradition of research, come to incorrect answers, please see the bat and ball base-rate problem and the mammography problem (Kahneman, 2011; Shea & Frith, 2016; Tversky & Kahneman, 1974).

Questions such as the hospital problem are meant to be a demonstration of how automatic processing is insensitive to the fundamentals of statistics such as sample size, base-rate calculations, and regression (Tversky & Kahneman, 1974). From a heuristic processing tradition it also suggests that even when prior information is supplied, people are not able to correctly predict outcomes when thinking intuitively (Tversky & Kahneman, 1974). The conclusion reached from within this tradition is that intuition leads to suboptimal decisions that are inferior to decisions that are made through deliberate processes (Betsch, 2008; Evans, 2010; Patterson & Eggleston, 2017).

The main criticism levelled at this conclusion is that the task type is not suited to automatic processing and that the statistical nature of the questions used are more likely to induce analysis and deliberative thinking than automatic or intuitive thinking (Patterson & Eggleston, 2017). Thus the conclusion that intuition is inferior to deliberate processing is frequently based on decision tasks that are novel or abstract which in turn prompts deliberative or Type 2 processing (Betsch & Glöckner, 2010; Evans, 2010; Hilbig et al., 2010; Thompson, 2014). The statistical questions used in heuristic processing research often require training in Bayesian reasoning to solve and this is not the correct method to induce automatic processing, as it requires specialist training and understanding. Heuristic processing researchers use probabilistic problems (Betsch, 2008, p. 15; Gigerenzer & Hoffrage, 1995, p. 685; Kahneman, 2011; Kahneman & Frederick, 2005, p. 273; Kahneman & Klein, 2009, p. 521) and come to the conclusion that intuition is systematically error prone (Betsch, 2008). However the real distinction, as Betsch (2008) points out, is that people are just bad intuitive statisticians without the necessary training (Evans, 2010). The problems used within this tradition are not suitable to the study of intuition because they induce heuristic strategies of decision making and these are essentially deliberative shortcuts (Betsch, 2008). The only reason heuristic processing is regarded as intuitive is because it differs from formal logic where hypothetically all information is used to come to a decision and heuristic processing uses only a subset of information (Betsch, 2008).

Further to this criticism, Haberstroh (2008) has suggested that the contextual situation in which decisions are made can have an influence on the decision strategy selected (p. 267). In their experiments to illustrate this, Haberstroh and Betsch (2002) instructed participants to either guess spontaneously or to think carefully about their answer. In controlling for the decision mode, the experiment revealed that participants in the intuitive judgment (spontaneous guess) condition were able to come to correct estimates about the frequency estimate under study in the experiment, while participants in the deliberation condition were strongly biased (Haberstroh, 2008). Based on this, Betsch (2008) has argued that the focus on heuristics, a cognitive shortcut, can naturally lead to errors in judgment because in most of these studies the researchers did not control for judgment mode, i.e. participants could choose to answer spontaneously or deliberate about the answer (Betsch, 2008).

In opposition to findings in heuristics research where the decision problem (such as the hospital problem) is novel and abstract to participants, Betsch (2008) argues that a pre-requisite for people to be sensitive to probabilistic type questions is that they need to be exposed to consolidated knowledge, i.e. information stored in long-term memory (Betsch, 2008; Dane & Pratt, 2007; Hogarth, 2001, 2010; Sloman, 1996). This argument is made on the basis that intuition and intuitive processes operate on knowledge that has already been implicitly consolidated in long-term memory (Betsch, 2008; Hogarth, 2001; Lieberman, 2000; Reber, 1989). What this infers is that intuitive processes can only be accurate with the types of knowledge that are already consolidated (Betsch, 2008). The types of experimental questions used by Kahneman and Tversky (1974) and other researchers in the field are generally not based on an individual’s long-term knowledge and as such they do not fulfil a necessary condition for automatic processing to occur (Betsch, 2008; Patterson & Eggleston, 2017). Essentially the argument that Betsch (2008) makes is that most people are not high-level users of mathematics and probability, therefore they have no prior experience to draw upon and consequently rely on deliberate processing.

2.4.1 Automatic processing and information integration

Contrary to the heuristic processing perspective of intuition, Betsch (2008) has argued that intuitive processes are capable of yielding judgments that are both correct and accurate. In addition to this, a significant percentage of research has been conducted to demonstrate that automatic processes of cognition can integrate large amounts of information without impacting cognitive resources such as working memory (Betsch & Roth, 2018; Betsch, 2008; Betsch & Glöckner, 2010; Betsch et al., 2006; Betsch et al., 2001; Glöckner & Betsch, 2012).

It is widely accepted that information integration occurs in a near optimal manner in categorisation, perception and speech comprehension studies (Betsch & Roth, 2018; Hotaling, Cohen, Shiffrin, & Busemeyer, 2015). In these cases individuals can integrate information from multiple sources without having a negative impact on cognitive resources such as working memory (Hotaling et al., 2015). In contrast to this, the literature on decision making often implies that integrating information from multiple sources does not occur in an optimal way (Betsch & Roth, 2018; Hotaling et al., 2015). In the literature, several key arguments have been made in JDM about automatic processing. Primary among these arguments is that automatic processes can integrate large amounts of information from multiple sources in a near optimal fashion without noticeable cognitive effort (Betsch & Roth, 2018; Betsch & Glöckner, 2010; Glöckner & Betsch, 2012). This is markedly different to the heuristic processing view where intuitive processes are conceptualised as a reduction in task complexity (Betsch & Roth, 2018; Betsch & Glöckner, 2010; Glöckner & Betsch, 2012; Shah & Oppenheimer, 2008).

Information integration has been called a fundamental intuitive process that is central to how intuition operates (Betsch & Roth, 2018). It is the process whereby multiple sources of stimuli are perceived, internalised and combined which results in a response that is quantifiable (Foster, 2014). Information integration can either operate on a perceptual level, e.g. depth perception is made up of depth, colour, triangulation, shadow and size cues (Foster, 2014) or it can operate as a psychological process such as a decision concerning what type of pizza to choose based on size, toppings and cost variables (Foster, 2014; Hotaling et al., 2015). In general, there are three stages to information integration: valuation, integration and response (Foster, 2014). Valuation is the process of a stimulus being accorded psychological weight, e.g. perceived sound intensity is a valuation of pitch and tone (Anderson, 2014; Foster, 2014). Integration refers to how an individual associates multiple sources of information and accords each psychological weight to come to a response or outcome (Anderson, 2014; Foster, 2014). These three stages have been called the problem of the three unobservables as it is not yet possible to directly see how information is evaluated and integrated in the cognitive system (Anderson, 2014).

Even though the three processes of information integration cannot be directly observed, the operation of the system can be investigated. For example, a modified Mouselab experiment has been used to show that automatic processes allow people to quickly integrate all pieces of information shown to them and come to a decision based on all these pieces of information and not only a single attribute (Glöckner & Betsch, 2008).

In general, the Mouselab method is used to trace what strategies are used in decision making processes, e.g. it can help researchers distinguish if a weighted additive rule or lexicographic rule has been used and it is a standard tool for strategy classification (Glöckner & Betsch, 2008; Wedell, 2015). In a traditional Mouselab experiment, a covered matrix is presented to participants and they have to use the computer mouse to hover the cursor over boxes to reveal information (see Figure 2.3). The participant is put under time pressure to collect information by sequentially moving the mouse over the covered blocks and then making a decision based on the information they have seen (Glöckner & Betsch, 2008). For example, a participant may be shown a simple covered matrix where they need to make a decision between buying Camera A or Camera B (Figure 2.3) (Willemsen & Johnson, 2004). As an individual moves the mouse over the covered blocks, hidden information is revealed, i.e. in Figure 2.4 the mouse has revealed the information hidden behind the *Price Option B* block shown in Figure 2.3.

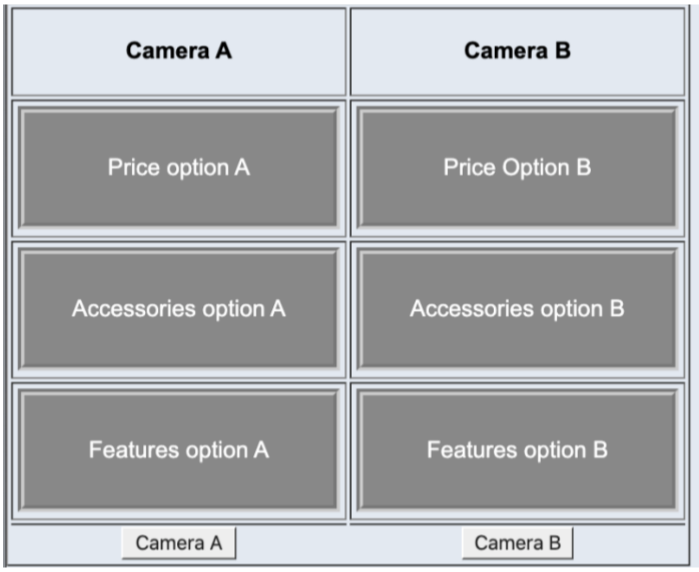

Figure 2.3 Mouselab camera choice experiment (covered) (Willemsen & Johnson, 2004)

Figure 2.4 Mouselab camera choice experiment (uncovered) (Willemsen & Johnson, 2004)

In the above example (Figures 2.3 & 2.4) an individual would be given a time limit to complete the task and make a decision between which camera they would buy (Glöckner & Betsch, 2008; Payne, Bettman & Johnson, 1988). The original Mouselab experiments (Payne et al., 1988) suggested that individuals minimise the amount of information considered as a decision strategy and in so doing reduce the mental effort needed to come to a decision (Glöckner & Betsch, 2008; Payne et al., 1988). Contrary to this, in a modified Mouselab experiment, Glöckner and Betsch (2008) found that if all pieces of information were kept uncovered then they would all be used in coming to a decision in what appeared to be a WADD (weighted additive decision) fashion.

The WADD rule is a decision strategy where each piece of information is considered individually and assigned a relative level of importance by the decision maker, and these are used to arrive at an overall evaluation of each option in the matrix (Brusovansky et al., 2018; Glöckner & Betsch, 2008; Payne et al., 1988). The WADD rule requires considerable computational effort because each option in the decision has to be considered and accorded a relative weight (Glöckner & Betsch, 2008). The WADD strategy is often used as the benchmark strategy to which heuristic strategies are compared and is generally considered to be a Type 2 (System 2) process (Wedell, 2015). The finding that information could be integrated in the modified Mouselab experiment seems counter to the general understanding of how decision strategies are made because WADD is considered an effortful Type 2 process and too complex for individuals to perform unassisted by external aids (Brusovansky et al., 2018; Wedell, 2015).

In the Mouselab experiments conducted by Payne, Bettman and Johnson (1988), the decision strategies used by participants were made using heuristic strategies, i.e. not all information was considered. If participants were given no time constraint in the original experiment, then participants employed a WADD strategy to come to a decision (Wedell, 2015). However, in the open matrix experiment (Glöckner & Betsch, 2008), it was found that participants made decisions that did not conform to heuristic strategies but rather employed weighted additive procedures in a limited space of time (Betsch & Roth, 2018). What this suggests is that Type 1 processes are able to integrate large amounts of information even under time pressure but without the need for deliberately calculating the relative weight of each attribute in the process (Glöckner & Betsch, 2008).

Glöckner and Betsch (2008) have suggested that the original Mouselab method of process tracing is itself problematic as the procedure forces participants to undergo a serial method of information search. Participants have to uncover each block one by one and, by default, this restriction encourages more deliberative step-by-step strategies (Glöckner & Betsch, 2008). In the traditional Mouselab method it has been shown that under time constraints individuals employ heuristic strategies for decision making that minimise mental effort by not considering all the available information (Payne et al., 1988). In contrast to this, the open Mouselab experiments demonstrate that individuals are able to employ automatic processes to process information and come to decisions based on the WADD rule, but without expending the mental effort that this rule implies (Glöckner & Betsch, 2008). In essence, what Glöckner and Betsch (2008) conclude, is that the Mouselab method restricts the operation and observation of automatic processing because it enforces serial search through the available information and is not a suitable method for uncovering the operation of automatic processes on information.

The suggestion that automatic processes can in effect work to integrate large amounts of information without effortful use of working memory (Betsch & Glöckner, 2010) is an important one because, as Kahneman (2011) indicates, "anything that occupies your working memory reduces your ability to think" (p. 25). Of course, this statement cannot be read out of context to mean that working memory is inherently not thinking, but rather that the use of working memory is fundamentally a Type 2 process, that its capability is limited and thus there are limits on computation when making deliberative decisions (Kahneman, 2002; Stanovich & West, 2000). Individuals are guarded with their cognitive resources precisely because it is effortful and working memory is a low capacity system that can only be applied to one task at a time (Evans, 2010). Intuitive processing however, as Evans (2010) suggests, is based on experiential learning and when dealing with real-world situations that are familiar to us, we can rely on these stored experiences to guide decision making.

Many researchers in JDM agree that intuition as a process draws on associations from environmental stimuli, matched to prior experience, and this results in an intuitive judgment that then becomes available to conscious processes (Betsch, Hoffmann, Hoffrage, & Plessner, 2003; Dane & Pratt, 2007; Hogarth, 2001, 2010). The implication is that intuitive processes operate automatically and have an influence on behaviour, and it is the default approach especially in situations that are easy to process (Kahneman, 2011).

2.4.2 The parallel constraint satisfaction model

In contrast to classic theories of decision making where information is consciously deliberated to come to a decision (cf. Simon, 1955), the heuristics and biases research has shown that individuals do not necessarily make optimal decisions based on all the available information (e.g. Kahneman, 2011; Tversky, 1972; Tversky & Kahneman, 1974).

Current heuristic processing models of decision making assume that a number of different information integration strategies are used when coming to a decision, for example the weighted additive rule, the Take The Best rule (TTB) and the lexicographic rule (LEX), depending on the context of the decision, e.g. the environment or the effort versus accuracy required for the decision (Herbig & Glöckner, 2009).

In contrast to this perspective, Glöckner and Betsch (2008) have proposed the Parallel Constraint Satisfaction (PCS) model, where automatic processes are accorded more importance and deliberate processes only act on the outputs of intuition as a supporting process that optimises decisions (Glöckner & Betsch, 2008; Herbig & Glöckner, 2009).

Under the PCS model, when a decision problem is perceived, an automatic network is activated that contains all the associated information existing in memory and this is matched against the available cues to establish consistency between the stored information and the cues presented by the decision problem (Glöckner & Betsch, 2008; Herbig & Glöckner, 2009). Thus, the most probable interpretation is highlighted through a process of automatically weighting all the cues and valuing/devaluing aspects of the information that do and do not support the dominant interpretation.

The key to this model is that it proceeds automatically and unconsciously as soon as an individual is confronted with a decision task. Conceptually all pieces of information are weighed against each other and the best interpretation creates an emergent mental representation that is used to make a decision (Glöckner & Betsch, 2008; Herbig & Glöckner, 2009).

2.4.3 The role of working memory in decision making

In the literature most contemporary studies of dual-process theories specify that Type 2 processes (deliberative) are constrained by the limits of working memory (Baddeley, 2003; Cohen et al., 2016; Evans & Stanovich, 2013a; Kahneman, 2002, 2011; Maldei et al., 2019; Patterson & Eggleston, 2017; Stanovich & West, 2000). The operational definition of working memory is that it is a limited capacity system that is able to temporarily store and manipulate stimuli representations that are no longer available to the senses, i.e. it allows an individual to use knowledge from past experience to solve a current task (Mendoza-Halliday, Torres & Martinez-Trujillo, 2015).

It is a limited capacity system because the number of items that can be recalled and manipulated during a complex working memory task such as a mental arithmetic calculation is constrained (Barrett et al., 2004; Eysenck & Keane, 2015). The tasks involved are complex because an individual has to maintain information ready to be accessed while simultaneously processing information computationally (Barrett et al., 2004; Eysenck & Keane, 2015). For example, when multiplying 17 by 24 an individual following the long multiplication process would first need to follow a step by step process to derive the two partial products 68 and 340, which ultimately have to be added together to reach the correct answer of 408. This type of processing is often mentally taxing and the effort is demonstrated through physiological signals such as dilated pupils and accelerated heart rate (Dane & Pratt, 2009; Hodgkinson et al., 2008; Kahneman, 2011).

Recent experimental research has shown that even if working memory is loaded, it has no effect on intuitive judgments of coherence (Maldei et al., 2019). What this suggests is that the dual-process theory of cognition is correct in the assumption that Type 2 processing does not rely on working memory (Evans, 2003; Hogarth, 2001; Stanovich & West, 2000) and by extension, automatic processes of decision making deserve greater attention (Betsch & Roth, 2018; Betsch, 2008).

In decision science it has become important to understand how automatic Type 1 processes seem to be able to consider multiple pieces of information simultaneously and process large amounts of information and still come to accurate judgments and decisions (Betsch, 2008). If automatic processing does indeed operate unconstrained by cognitive capacity (e.g. working memory), then it can be inferred that these processes are more powerful than has previously been assumed (Betsch, 2008). It is now generally accepted in the literature that decisions are largely an automatic process, but they are supplemented by processes in the deliberate mode as needed (Badgaiyan, 2019; Betsch, 2008; Horstmann et al., 2009).

2.4.4 Automatic processing has a value account

Numerous studies have suggested that automatic or intuitive processes are dedicated to integrating information and the formation of judgmental or choice tendencies (Betsch & Glöckner, 2010; Betsch, et al., 2003; Betsch et al., 2001; Plessner et al., 2008). In order to differentiate between automatic and deliberative processes, Betsch and colleagues (2001) developed a dual-task procedure where participants were required to memorise advert information presented on a TV screen while reading, out loud, return values of shares appearing on a ticker tape below the adverts (Figure 2.5) (Betsch et al., 2001).

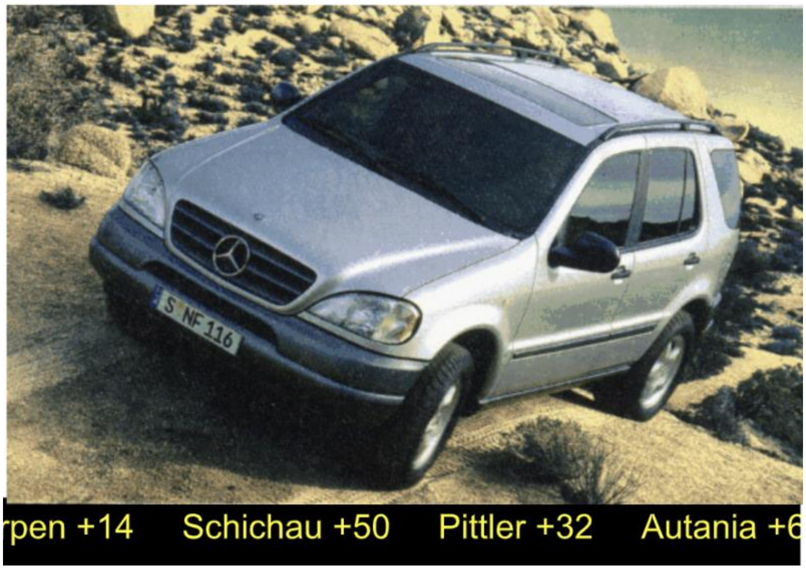

Figure 2.5 Information integration experiment showing share returns (Betsch & Glöckner, 2010, p. 282). Reprinted with permission.

In their experiment, the primary task (share information) was framed as a distractor, while the real distractor (memorising advert information) was framed as the primary task (Betsch et al., 2001). The reason for this framing was so that participants focused their attention on the intensive memorisation task and not explicitly on the share information (Betsch & Glöckner, 2010; Betsch et al., 2006; Betsch et al., 2001; Betsch, Plessner & Schallies, 2004). Participants were told they would be assessed on their recall of the adverts and as a distraction they needed to read the share returns presented on the tickertape out loud.

Share returns were presented as if they were share values over several days of trading and that each number was not an absolute value of the share, but the gain of that share in the market, i.e. Schichau +50 in Figure 2.5 represents what that share gained in value on that trading day (50 Euro cents in this case) and not the total value of that particular share.

At the end of the experiment, participants were asked to evaluate the shares in terms of how they felt about them i.e. “what do you think of share X?” (Betsch et al., 2001, p. 894). Participants were presented with a scroll bar and were able to judgmentally evaluate each share using a slider that the participant was able to move between very bad (sehr schlecht) and very good (sehr gut) (see Figure 2.6).

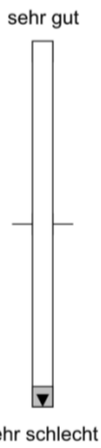

Figure 2.6 Share evaluation slider used in Betsch et al’s. (2001) study.

In post interviews it was established that participants had not intended to form attitudes towards the shares and that the share return information was implicitly integrated without intention or deliberate control (Betsch et al., 2006; Betsch & Glöckner, 2010).

The main outcome of the experiment was that participants were able to aggregate large amounts of information under conditions of information overload even when they had not intended to do so (Betsch et al., 2006). Figure 2.7 shows how participants rated the shares shown to them, with the y-axis indicating intensity of liking, while the x-axis shows the total share values for each share (summed up) (Betsch & Glöckner, 2010).

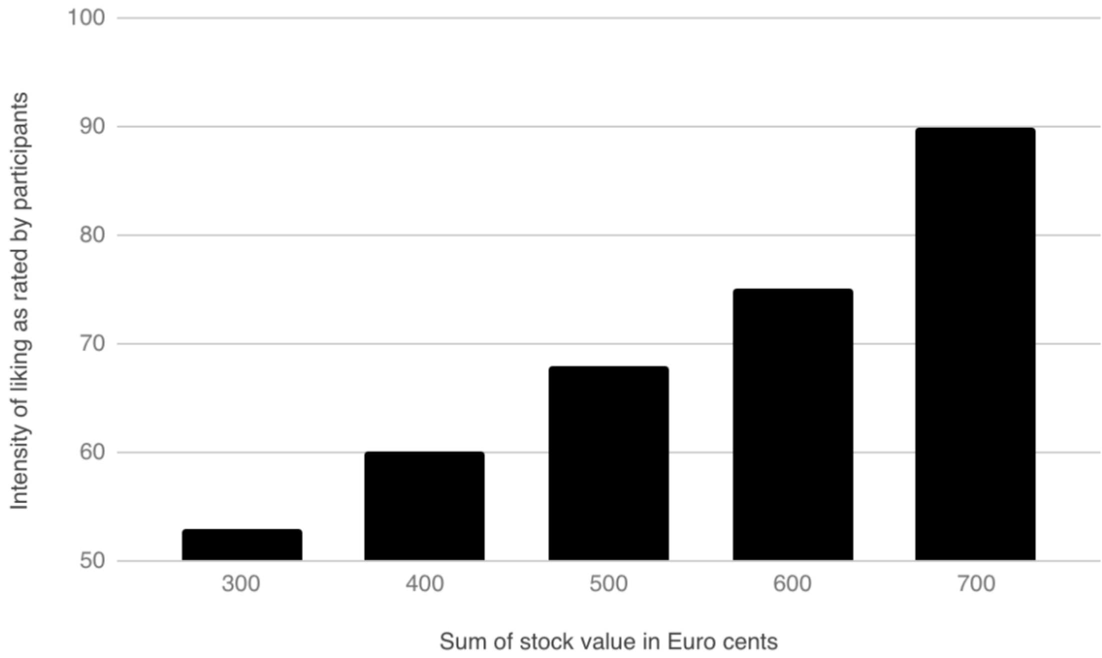

Figure 2.7 Participants' rating of share returns, with higher numbers indicating more intense liking (Betsch et al., 2001). Reprinted with permission.

What this study, and subsequent studies found (Betsch, Hoffmann et al., 2003; Plessner, Betsch, Schallies, & Schwieren, 2008), was that evaluative judgments of the shares perfectly displayed the actual variation of the summed values (Betsch & Glöckner, 2010). For instance, participants could rate which of the five shares presented were better and which were worse, without explicitly knowing what the actual shares added up to. Figure 2.7 shows that the share with a 300 sum was rated least positively and the share with a 700 sum was rated most positively (Betsch & Glöckner, 2010). The participants' evaluative judgments perfectly reproduced the actual differences between the shares without being able to explicitly recall any of the share value distributions.

The attitude judgments that Betsch et al. (2001) recorded were sensitive to the actual share distributions (Table 2.1). While participants could evaluate the shares judgmentally, they could not provide reasons why they rated the shares in this way, nor provide accurate sum or average values for the shares. Participants could also not remember any concrete values for the returns shown to them. The mean values and standard deviations of the share ratings are shown in Table 2.1.

Table 2.1

Attitude Judgments made by Participants (Betsch et al., 2001, p. 245)

Sum of returns	**300**		**400**		**500**		**600**		**700**	
	M	SD	M	SD	M	SD	M	SD	M	SD
Attitude judgment	0.05	2.83	0.44	1.46	0.77	1.93	1.25	2.30	2.20	1.69

According to Betsch and Glöckner (2010) as well as Dane and Pratt (2007) measuring intuitive processes directly is a complex methodological process to define because these processes are non-conscious. The result of these processes, however, in the form of an intuitive judgment, outcome or choice is a measurable phenomenon. In their dual-task experiment, Betsch et al. (2001) measured the outcome in terms of the judgmental evaluation participants made of the shares.

Betsch et al. (2001) stated that the subjective evaluations of the shares should follow a more-is-better principle. For example, the more a share adds up to in terms of the sum of their return values, the more participants should like them. First participants were asked to rate the shares in terms of liking and this measure represented the intuitive ranking of each share. Then participants were asked to deliberatively estimate both the sum and the average value for each share. These estimates were then checked for correlation against the true sums and averages of the shares. The Pearson correlation coefficients for each of these variables were calculated and they found that no coefficient involving the attitude judgment was significantly different from a zero correlation as the coefficient was ps > 0.25 (Betsch et al., 2001, p. 245). This indicated that participants were not able to tell the difference between the shares with regards to the estimated sums and averages of the returns (Betsch et al., 2001).

These findings suggest, firstly, that automatic processing can integrate large amounts of information without affecting working memory; and secondly that these processes deliver accurate results (Betsch et al., 2001; Betsch et al., 2003; Betsch & Glöckner, 2010; Plessner et al., 2008). Therefore, this is unlike the examples found in the heuristic processing research which illustrate how intuitive processes come to incorrect conclusions (Betsch, 2008; Betsch & Glöckner, 2010; Kahneman & Frederick, 2005; Patterson & Eggleston, 2017; Tversky & Kahneman, 1974). This research suggests that there are multiple processes involved in judgment and decision making which occur automatically (Betsch et al., 2001), and which have not been thoroughly investigated in intuitive interaction research within HCI. For this reason, the present study will attempt to replicate and extend the work by Betsch et al. (2001). This study not only replicates the cognitive experiment but extends it by considering animation as an independent variable and the influence this has on how people process mobile interface information. Further to this, the present study will be conducted outside of laboratory conditions and instead of using a TV as a display, the study will use a mobile phone.

The present research is considered an important contribution because in recent years psychology has found itself in a reproducibility crisis where large-scale reproduction studies found that only half of the studies could be replicated (Yong, 2012). Replication is also a concern within the HCI community (Greiffenhagen & Reeves, 2013) where the debate centres on why replication is not a core part of the discipline, as it is in many others. The prevailing conclusion is that replication in HCI requires a more evolved understanding of the purpose for reproducing work (Greiffenhagen & Reeves, 2013; Wilson, Reeves, & Coyle, 2014). Adopting the approach directly from science and technology studies is problematic as these studies are often conducted for motivated and sometimes controversial reasons (Greiffenhagen & Reeves, 2013). Further to this, it has been argued that if specific work is revisited for replication, then it is important to not only validate the findings, but to also make a significant contribution based on that work (Wilson et al., 2014). In accordance with this principle, the current study will attempt to replicate and extend prior work to contribute incrementally to the body of knowledge.

The original dual-task study by Betsch et al. (2001) did not focus on what potential impact manipulation in terms of design could have on information integration and the resulting judgmental evaluations made. The only interface manipulation attempted by Betsch et al. (2001) was in making two share returns more salient and presenting them in a red colour. This iteration of their experiment did not yield a positive result as only 12 of the 62 participants could choose the correct returns for both those shares.

According to Woldeamanuel and Geta (2018), this outcome is not surprising as colour vision deficiency is a frequently occurring vision disorder (Woldeamanuel & Geta, 2018) and congenital red-green colour vision deficiency is a common abnormality within human populations (Birch, 2012). Colour vision deficiency does vary from population to population, but in Germany, where Betsch et al. (2001) conducted their experiments, the prevalence in men is 8% and this may have potentially skewed their results. This therefore further validates the need to investigate how information integration, and the resulting judgmental evaluation, can be influenced in the interface through manipulating the processing fluency and form factor of the information.

2.4.5 Automatic processing and presentation format

Kahneman (2011) suggested that in certain situations people will employ an automatic decision strategy, i.e. an individual will think, choose and act using Type 1 processing rather than Type 2 processing (Gronchi & Giovannelli, 2018). For example, Kahneman (2011) conducted an experiment where participants were presented with two false statements:

"**Adolf Hitler was born in 1892.**

Adolf Hitler was born in 1887." (p. 64).

The only difference between the two statements, aside from the differing year, is that one statement is in bold text and the other is not. Participants were found to be more likely to choose the statement in bold type as being the correct one even though both statements are factually incorrect. Kahneman (2011) suggests that individuals focus on the statement in **bold** because it is perceived to be easier to process because the bolding gives it prominence and therefore more psychological salience. It is suggested that Type 1 thinking assumes control in this case because the bold text is easier to focus on and process because past experience with text elements that are bold indicated to the reader that it is more important and probably the correct answer (Kahneman, 2011). Kahneman calls this cognitive ease or processing fluency (Kahneman, 2011).

Processing fluency can be defined as a form of associative processing based on prior experience which culminates from a perceived stimulus (Sloman, 1996). For example, a towel hanging on a rack near a shower would more likely be inferred to be a bath towel than if that same towel lying flat on sand near an umbrella, which would be associatively processed as a beach towel (Aminoff & Tarr, 2015). If a person has only ever had experience of a towel in the context of a bathroom, they would not as easily process it as a beach towel. Key to understanding how prior experience relates to this form of processing is that associative processing is structured by associations of objects or events that co-occur over time either through similarity or contiguity (Creighton & Gawronski, 2013). Stimuli are defined as coming from multiple sources such as self, person, group, object, behaviour or abstract concepts (Betsch et al., 2003; Hogarth, 2001, 2010). Stimuli are encoded based on their statistical regularities and stimuli such as objects could be treated the same depending on how correlated they are in terms of features or temporal contiguity (Sloman, 1996).

Processing fluency is important in terms of the present study because it suggests that the way in which information is presented has an influence on how people react to it (Kahneman, 2011). Through prior experience, individuals associate the bolding of the text with importance and thus conclude that the bolded statement is the correct one (Kahneman, 2011). There is an automatic associative process that occurs between how the text is understood and the prior experience that an individual has with this type of presentation (Kahneman, 2011; Still, 2017).

This type of automatic association (Kahneman, 2011; Still, 2017) where the presentation format that individuals are exposed to can, without their explicit awareness, affect decision making (Balcetis & Granot, 2015), is pertinent to this study. This is because the presentation of information is an important design concern to resolve complex interactions between technology and the user (Dix, 2004). The goal is to determine if the way in which information is presented in the mobile interface can influence how it is processed and integrated. The argument is essentially that non-conscious associations such as processing fluency may control how we perceive and react to both objects and situations in everyday life (Gigerenzer, 2007; Kahneman, 2002; Klein, 2008; Myers, 2004). The implication for design of mobile interfaces is that an understanding of processing fluency may lead to interfaces that are easier to understand because they exploit cognitive inclinations that already exist.

There is evidence that suggests that the manner in which information is presented has an effect on the way it is processed by Type 1 processes (Bolte & Goschke, 2005; Kahneman, 2011; Lieberman, 2000; Topolinski & Strack, 2009). In principle it is a demonstration of the impact that presentation factors have on information integration (Duke, Fiacconi & Köhler, 2014; Wänke & Hansen, 2015). For example, Topolinski and Strack (2009) demonstrated experimentally that manipulating the contrast value of a font, the colour and how often a stimulus is shown, will successfully influence judgments. Further to this, Glöckner and Betsch (2012) have also demonstrated with modified Mouselab experiments (section 2.4.1), that even with an increase in information presented in an interface, decision time will decrease if the information displayed is coherent, i.e. if the information points provided do not conflict with each other (Glöckner & Betsch, 2008, 2012).

Broadly speaking the research suggests that intuition has the ability to make judgments on the basis of matching cues from a perceptual stimulus to implicitly stored information that is unconsciously activated in memory (Betsch & Glöckner, 2010; Bolte & Goschke, 2005; Patterson & Eggleston, 2017). This implicit recognition process results in an evaluation or judgment that can be used by explicit cognitive processes to make a decision (Dane & Pratt, 2007; Gore & Sadler-Smith, 2011; Lieberman, 2000).

Even though the concept of intuition has often been criticised for a lack of definition and being largely unquantifiable (Dane & Pratt, 2009), an increasing number of studies have shown that implicit forms of information processing (associated with intuition) can influence perception, memory and judgment (Betsch et al., 2001; Lieberman, 2000; Reber, 1993). This infers that perception and intuitive processes are inextricably linked and have a role to play in the interpretation of perceptual content (Seth, 2017). This notion of a link between intuition and perception has long been discussed. For example, James (1981) states that:

> whilst part of what we perceive comes through our senses from the object before us, another part (and it may be the larger part) always comes... out of our own head (p. 747).

What this view reinforces is the notion that human behaviour is shaped by both intuitive (Type 1) and more deliberate or analytic processes (Type 2). Further to this it underscores the importance of implicit knowledge and the influence that it can exert on decision making processes (Evans & Stanovich, 2013a; Simon, 1992; Kahneman, 2011; Patterson & Eggleston, 2017; Zander, Öllinger & Volz, 2016).

Söllner, Bröder and Hilbig (2013) demonstrated that the way individuals integrate information is directly influenced by the level of search that is needed to gather the relevant information from the interface. Information search is the process by which an individual seeks out the available information when trying to make a decision (Söllner, et al., 2013). Similarly to Glöckner and Betsch (2008), Söllner et al. (2013) found that the less information search is required, the more information is integrated through automatic Type 1 processes which is consistent with the PCS model. PCS-consistent behaviour is a model that describes where information integration is not limited by cognitive resources and automatic processing is able to conduct a quick weighted addition of all the available information (Glöckner, 2010; Glöckner & Betsch, 2008; Herbig & Glöckner, 2009). The suggestion is that the accessibility of information, how it is organised, presented and whether or not participants have to search the interface, might influence decision making (Söllner et al., 2013).

Figure 2.8 Matrix, map and complex map presentation. (Söllner et al., 2013, p. 282)

To demonstrate this effect, Söllner and colleagues (2013) conducted a within-subjects study where they used open matrix presentations (similar to Mouselab), simple maps and complex maps (Figure 2.8). Söllner et al. (2013) found that even a moderate increase in information search in the interface hindered the use of automatic processing (Söllner et al., 2013). In the experiment participants had to choose which of two cities had more inhabitants and then give a confidence judgment for their decision in 70 random decision trials (Söllner et al., 2013). The key decision information was provided as letters A, B, C, D with the relevant cue validities on top of each presentation format (Figure 2.8) (Söllner et al., 2013). In the open matrix format the plus and minus signs indicated the presence or absence of each cue (A,B,C,D) (Söllner et al., 2013).

In the open matrix presentation (Figure 2.8), Söllner et al. (2013) found that PCS-consistent behaviour was significantly more prevalent ($p < .001$) in this condition than either of the map conditions. What this suggests is that participants were able to integrate the information in the open matrix format in an automatic fashion without switching strategy to heuristic processing (Söllner et al., 2013). Even moderate information search meant that decision makers switched to a sequential or analytic information processing approach rather than a PCS-consistent one (Söllner et al., 2013). What this indicates is that if information is immediately accessible and unhampered by information search then it will be integrated automatically using all available cues in the interface (Glöckner & Betsch, 2008; Söllner et al., 2013). The key argument therefore being made is that serial or deliberative processes are increasingly used when the extent of information search is great and the corollary to this is that when information is presented in an accessible manner, then it can be captured by a perception-like process (Söllner et al., 2013).

These findings are pertinent to the present study because the presentation of information in an interface, and how it is understood, is also a key software usability concern. Referring to the International Standards Organization principles of information presentation in computer interfaces it states that principled presentation of information has benefits such as a reduction in mental effort and improvements in speed, accuracy and user experience of a product or service (International Organization for Standardization, 2017). The key implication around information search and integration as put forward by Söllner et al. (2013) could have a positive impact on interface design if information presentation is considered as influencing how the interface is understood, rather than for mere aesthetic effect.

2.5 Interface animation and cognition

In recent years there is a growing understanding in design research that animation in the interface acts to either provide feedback to the user in terms of the task they are trying to complete, or provide information about the system itself (Novick, Rhodes, & Wert, 2011).

Animation has become extensively used in interfaces, and the design approach has changed from using it as a demonstration of process, to the fundamental idea that it can work as a functional element to make the interface more understandable (Chevalier et al., 2016; Liddle, 2016). There is a growing body of evidence that animation in the interface can influence how a person processes information. For instance, Gonzalez (1996) showed experimentally that users made decisions more accurately and faster if elements in the interface were animated smoothly versus abruptly, and her conclusion was that animation offers more than a presentation technique. While simultaneously showing that decision making performance is contingent on animation style, it provides a valuable interactive technique which can be used to influence how users engage with an interface (Gonzalez, 1996). Even though animations are commonly used in interface design (Alvre, 2017; Chang & Ungar, 1993; Chevalier et al., 2016; Head, 2016), there is not a lot of empirical evidence to suggest that decision making can be influenced by animation.

Despite this lack of evidence, it has been suggested that animation in the interface does have various cognitive effects. For example, studies have shown that motion onset in the interface is able to capture attention and that it is prioritised by the visual system (Abrams & Christ, 2002; Pratt, Radulescu, Guo, & Abrams, 2010). The onset of motion is when an object begins to move in an interface and Abrams and Christ (2002) found that attention is particularly focused on this type of movement because of historically relevant biological imperatives such as survival in the detection of prey and predators (Abrams & Christ, 2002).

Further to this, Pratt, Radulescu and Guo (2010) showed that animacy captured participants' visual attention involuntarily and that humans process animate objects over inanimate ones. Furthermore, additional studies (Abrams & Christ, 2002; Franconeri & Simons, 2005; Von Mühlenen & Lleras, 2013) have suggested that different types of motion in an interface capture attention in different ways. For instance, looming motion (a dynamic increase in object size) (Franconeri & Simons, 2005) has been experimentally shown to attract attention faster than receding motion (Rossini, 2014). Calvillo and Jackson (2014) also found that under conditions of low perceptual load, animate objects in an interface capture attention more frequently than inanimate ones.

These study outcomes therefore suggest that motion in the interface has cognitive effects, whether it is to focus attention (Abrams & Christ, 2002) or to induce cognitive processing (Pratt et al., 2010) but no studies have yet determined the link between decision making and animation. Typically, interface animation is predominately either studied in terms of attentional control or entertainment and aesthetics (Abrams & Christ, 2002; Alvre, 2017; Chang & Ungar, 1993; Calvillo & Jackson, 2014; Franconeri & Simons, 2005; Von Mühlenen & Lleras, 2013; Pratt et al., 2010; Rossini, 2014) and not in terms of how they might influence decision making (Alvre, 2017).

The present study will therefore investigate how interface animation influences information integration, a core cognitive process of decision making, and the judgments that are formed as a result. In order to do this, the present study will replicate and extend the cognitive experiment conducted by Betsch et al. (2001). To date, no comparative studies have utilised the research design of this study in HCI or looked at the effect that animate motion has on intuitive information processing. The potential value for this study is that it extends intuitive interaction research by investigating the cognitive aspects of design and it looks at interface animation from the perspective of processing fluency and the impact that this has on information integration.

2.6 Intuitive interaction within HCI

Although HCI has developed models and methods to subjectively measure intuitive interaction, this is not the main focus of the present study. What is relevant to this study is how intuitive interaction is defined and what concepts from cognitive science could add to the understanding of intuitive interaction. In particular, the present study interrogates the definition of prior experience and what cognitive processes underlie this concept, how it is defined and used in a design context. HCI uses its own definitions of intuition in an applied context, such as Hurtienne (2011) who places emphasis on participants' subjective experience of an interaction with technology, but not on how the underlying processes of intuition operate to achieve this type of interaction. The extant definitions of intuition in HCI fail to incorporate a clear understanding of processes such as information integration and decision making that are suggested to underlie intuitive processing (Betsch, 2008; Betsch et al., 2006; Betsch & Glöckner, 2010). The approaches, definitions and limitations within HCI are discussed with reference to how they are currently used within cognitive research.

As technology becomes more complex and ubiquitous (Hurtienne, 2011), intuitive interaction researchers believe it is important to understand how to design interfaces that are easy to use from a more fundamental perspective (Hurtienne & Blessing, 2007; Loeffler et al., 2013; Naumann et al., 2007). For example, what principles can designers use to create an interface that many different types of people can immediately operate without the need for learning how to do so (Blackler, 2019)? Intuitive interaction research has primarily been driven by software abandonment and user frustration with interfaces and devices, in the hope to alleviate the inherent problems of interacting with technology (Blackler & Popovic, 2015; Blackler & Hurtienne, 2007; Diefenbach & Ullrich, 2015; O'Brien et al., 2008). In recent years the research programme into intuitive interaction has included work on video games, consumer products, eCommerce websites, mixed reality systems and medical record systems (Blackler, Popovic & Mahar, 2010; Desai, Blackler & Popovic, 2016; Ilie, Turel & Witman, 2012; McEwan, Blackler, Johnson, & Wyeth, 2014; Mohan, Blackler & Popovic, 2017).

Within the HCI literature, intuitive interaction is a concept where interfaces and devices can be easily used without the need to learn them and therefore impacting cognitive resources such as working memory (Still & Still, 2019b). The specific area under study in intuitive interaction concerns how interfaces and devices can be designed to be immediately usable through association (Blackler & Hurtienne, 2007; Blackler & Popovic, 2016; Diefenbach & Ullrich, 2015). The association that is suggested to occur in an intuitive interaction is between the stimulus presented to an individual (the interface), and repeated experiences stored in long-term memory (prior experiences) (Blackler & Hurtienne, 2007; Blackler & Popovic, 2016; Diefenbach & Ullrich, 2015).

2.6.1 Definitions of Intuitive Interaction

Fischer, Itoh and Inagaki (2009) identify two main groups within HCI whose definitions of intuitive interaction are primarily used; Blackler and colleagues in Australia and the Intuitive Use of User Interfaces (IUUI) Research Group in Germany. Both of these groups describe intuitive interaction as occurring unconsciously and posit that it is based on prior experience or knowledge which is applied to a new task or environment (Blackler & Popovic, 2016; Blackler et al., 2010; Diefenbach & Ullrich, 2015; Fischer et al., 2009; McAran, 2016).

The IUUI's current definition reads as follows:

> ... the extent to which a product can be used by subconsciously applying prior knowledge, resulting in an effective and satisfying interaction using a minimum of cognitive resources (Hurtienne, 2011, p. 15).

This definition places a strong emphasis on prior knowledge being used subconsciously, but it does not specify what form this knowledge takes. The definition also specifies that the interaction with a product should be satisfying but at the same time it should not unnecessarily tax cognition, i.e. people should not have to explicitly think about how to use an interface or device (Hurtienne, 2011). Although the definition above details that intuitive processes occur subconsciously, it does not expand on how these processes operate.

In a similar vein to the IUUI's definition, Blackler, Popovic and Mahar (2006) state that intuitive interaction relies on knowledge gained through experience of *technological* products. The full definition that the Australian group developed for intuitive interaction reads as follows:

> a type of cognitive processing that is often unconscious and utilises stored experiential knowledge. Intuitive use of products involves utilising knowledge gained through other products or experience(s). Therefore, products that people use intuitively should be those with features they have encountered before. (Blackler, Popovic, & Mahar., 2003, p. 1).

In contrast to the IUUI's definition, Blackler et al. (2003) place greater emphasis specifically on prior experience with *technological* products. Thus, a product is far more likely to be interpreted as intuitive if it has specific features that the user has encountered before (Blackler et al., 2003). For example, the ubiquitous play button found on many consumer devices and interfaces is commonly understood to initiate a start to a process and this interaction concept is the same on different devices ranging from cameras, DVD players, mobile phone interfaces and even washing machines or dishwashers (Blackler et al., 2010).

This function is considered an example of intuitive interaction because it uses knowledge gained from other technology experiences, the function is familiar and transferable between different contexts (Blackler et al., 2010; Fischer, Itoh & Inagaki, 2015), and it can be used without explicitly considering what it does (Blackler, Popovic & Mahar, 2007). Simply put, the argument is that familiarity with features of products and interfaces is a source of prior experience that intuition can draw on to facilitate interaction (Blackler et al., 2010). The key understanding that can be drawn from this perspective is that familiar features are used more intuitively and therefore people with greater familiarity with technology will be able to complete tasks quicker and with fewer errors (Blackler & Popovic, 2015).

From the definitions of intuitive interaction above, the key concept is first, that prior experience is applied when using a new interface (Blackler & Popovic, 2015; Hurtienne & Blessing, 2007) and secondly, the interaction is only considered to be intuitive if the user does not have to explicitly consider how to use the product (Blackler & Popovic, 2015; Hurtienne & Blessing, 2007). For example, if a user has experience with products and interfaces from other domains then generally their interactions will be more intuitive when encountering a new interface that has similar features (Blackler, 2008).

As an example of this, Figure 2.9 shows the remote control interface used by Blackler (2008) to investigate if individuals' intuitive interaction is based on past experience with interfaces and if this knowledge is transferred from known products to new ones (Blackler, 2008; Blackler et al., 2010). The universal remote control has a sophisticated interface with many functions readily displayed and participants had to perform several everyday functions such as turn on the television, play the VCR and reset the clock on the VCR (Blackler et al., 2010). In this experiment Blackler (2008) established that prior experience does transfer to new product use, but it was dependent on the level of familiarity with similar technologies and participants' age.

Figure 2.9 Remote control interface (Blackler et al., 2010)

Different researchers in intuitive interaction have synonymously labelled prior knowledge as familiarity (Blackler & Popovic, 2016; Raskin, 1994), prior experience (Blackler, 2008; Langdon & Hurtienne, 2009; O'Brien, 2010), prior knowledge (Blackler & Hurtienne, 2007; Fischer et al., 2009; Hurtienne et al., 2009) or experiential knowledge (Blackler & Popovic, 2016; Britton, Setchi & Marsh, 2013).

Blackler and Popovic (2016) concluded that the evidence from the last 18 years of research in HCI suggests that "prior experience is the leading contributor to intuitive use" (Blackler & Popovic, 2016, p. 2). The immediate question that gets raised is what constitutes prior experience? From the HCI perspective, Blackler et al. (2010) posit that it is specific product knowledge stored within long-term memory (Blackler et al., 2003, 2010). From this perspective the more experience an individual has with a particular function or feature, the more intuitively they will be able to use it when it appears in unfamiliar domains (Blackler et al., 2003). From this perspective of intuitive use, if an individual repeatedly encounters and uses features, such as a physical play button on a camera, then this knowledge can be transferred. For example, when they encounter the same play button in different scenarios of usage they are therefore more likely to know how to use the device or interface and the functionality provided by the button (Blackler, 2019; Blackler et al., 2010, 2006; Fischer et al., 2015).

Since the present study investigates intuitive interaction from a specific cognitive perspective, it is pertinent to look at how Betsch (2008) defines it:

> Intuition is a process of thinking. The input to this process is mostly provided by knowledge stored in long-term memory that has been primarily acquired via associative learning. The input is processed automatically and without conscious awareness. The output of the process is a feeling that can serve as a basis for judgments and decisions. (Betsch, 2008, p. 4)

When comparing this definition to those of the previous two, it can be seen that the focus in HCI is on subjective and specific product experience. In contrast to this, Betsch (2008) suggests that intuition is a process governed by both environmental and mental inputs that culminates in an output that can be used to form a judgment or make a decision. This is the key differentiation from the HCI perspective in that it emphasises an understanding of the core processes of intuition, including how information is processed and more specifically, the outcome that arises from these processes (Betsch, Plessner & Schallies, 2004; Dane & Pratt, 2007). This suggests that judgmental choices or preferences come about from information that is integrated through intuitive processes (Betsch & Glöckner, 2010). Further to this, it is also suggested that there is an interplay between both intuitive and analytic processes where the resulting judgment based on information integration is handed over to more explicit processes (Betsch & Glöckner, 2010) and this distinction is not made apparent in the HCI literature.

Blackler (2008) developed the Technology Familiarity Questionnaire (TFQ) to establish participants' prior experience and behaviour with different interfaces. The questionnaire determines if participants use certain technology products and the frequency with which they use them and a score is calculated based on these two factors (Blackler, 2008; Blackler & Popovic, 2015). Experimental results suggested that individuals with a higher technology familiarity score took less time in performing tasks and that there was a positive correlation with first time correct use of interface features (Blackler, 2008).

The TFQ asks users to grade their personal experience with various items such as web browsers, mobile phones and devices with touchscreens, asking them to rate their use of tech product features on a scale from "all the features" to "none of the features" (Blackler, 2008, p. 278) and then assigns a score based on the selection. Blackler (2008) has suggested that there is a correlation between the use of products and the intuitive use of new tech products, i.e. people with a higher technology familiarity will be able to complete tasks more quickly and with fewer errors because they have prior experience with that interface feature from other contexts (Blackler, 2008; Blackler et al., 2010).

In order to ascertain this, participants had to fill in a subjective questionnaire, and researchers had to code, from video, which interactions were: intuitive and correct; intuitive but inappropriate; intuitive and incorrect; and not intuitive (Blackler, 2008; Blackler et al., 2003, 2010). Disregarding the subjectivity and the time needed to conduct this kind of analysis (Fischer et al., 2015), in the four groups that the TFQ divided people into (i.e. Expert, Intermediate, Novice and Naïve), there was no significant difference in the time taken to complete operations with an increase in expertise among the participants (Blackler, 2008). Blackler (2008) acknowledges that the power for this calculation was low (0.23) with a relatively high effect size (E_2 = .16), so there was a possibility of a Type II error. Table 2.2

shows the differences between the four groups and time taken on tasks (in seconds). It is interesting to note that there is not much difference in time taken between Expert and Novice, but Intermediate users took longer than both.

Table 2.2

Time Taken vs Technology Familiarity Score (Blackler, 2008, p. 140)

Variable	Expert		Intermediate		Novice		Naïve		Total	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
TF (%)	43.4	7.5	50.2	6.6	43.2	5.2	36.8	11.1	43.4	8.7
Time (secs)	573	564.6	657	216.9	581	386.5	1031	638.9	710.5	481.2

Further to this, in the interview section participants were asked to indicate their level of agreement with statements like “I use my knowledge of products that I am familiar with to guide me in using a new product of the same type” (Blackler, 2008, p. 144) and even though, according to Blackler (2008), 65% of participants strongly agreed with this statement, the subjectivity of this question calls the results into question.

Blackler et al. (2010) specify that people with a high technology familiarity score, which is an indicator of prior experience with technology products, will perform better on tasks through a process of knowledge transfer (Blackler et al., 2010). Specifically, the type of knowledge under discussion is “interface knowledge” (Blackler et al., 2010, p. 76), which is regarded as prior knowledge that a person has about how to control a software application or hardware device (Blackler et al., 2010; Christensson, 2009). Although Blackler et al. (2010) have created an instrument that is able to correlate technology familiarity of interface features with intuitive use of these features in new scenarios and environments, the results do not place certainty on this and it does not describe how the underlying cognitive processes function to achieve this knowledge transfer (Still & Still, 2019b).

2.6.2 Image schemas as prior experience

Another approach to prior experience within intuitive interaction research uses image schemas which are regarded as one of the major perspectives in understanding what constitutes prior experience (Blackler, 2019). Johnson and Lakoff (1987) invented the term image schema to describe their view in which cognitive concepts are analog products of sensorimotor experience (Mandler & Cánovas, 2014). What this means is that bodily interactions in the world, over time, build up schemas that people unconsciously use to frame more abstract concepts (Johnson, 1989, 1992, 2005; Mandler & Cánovas, 2014; Hedblom & Kutz, 2015).

The claim is that prior embodied experience builds up through repetitive bodily interaction with the world and forms abstract, multimodal patterns that are encoded in memory (Loeffler et al., 2013).

Hurtienne (2011) states that:

> Image schemas are sensorimotor and subconscious forms of knowledge representation. Thus, they fulfil the preconditions of intuitive use and hold great promise for user interface design. (Hurtienne, 2011, p. ii)

For example, Hurtienne (2015) describes how a CONTAINMENT image schema [small caps are used by convention when referring to image schemas] is formed from everyday experience. It comes from repeated experience of containment “such as seeing objects being inside or outside of containers” (Hurtienne et al., 2015). These types of experiences are not only encoded into words such as “in, out, high, low, central, peripheral” (Hurtienne et al., 2015), but they describe abstract concepts, so that, for example, linguistically “we would use expressions such as to fall in love, spirits are up, or that's of peripheral concern" (Hurtienne et al., 2015). These are abstract uses of the spatial words and what Hurtienne (2015) calls metaphorical extension.

On an empirical level, Hurtienne and Blessing (2007) assessed image schematic implementations in simplistic interfaces. In their early experiments they presented participants with volume sliders, one designed to represent image schematic understanding of MORE IS UP, LESS IS DOWN and the other showing a representation that violates this schema (Hurtienne & Blessing, 2007). Hurtienne's hypothesis was that if the buttons are arranged in a way that is incompatible with the metaphor, then it should lead to more user errors than when the buttons are arranged to be compatible with the metaphor (Hurtienne & Blessing, 2007). Figure 2.10 shows the sliders designed to be compatible with the MORE IS UP and LESS IS DOWN image schematic metaphor. The left slider is compatible with the metaphor while the right slider is incompatible (Hurtienne & Blessing, 2007, p. 8):

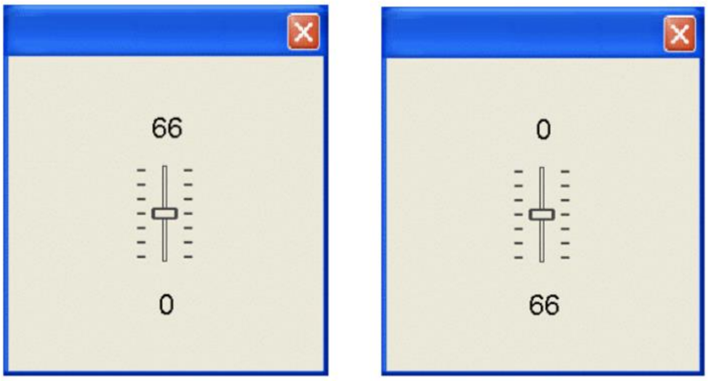

Figure 2.10 Vertical sliders used to assess the MORE IS UP, LESS IS DOWN metaphor

Even though Hurtienne's results indicate that designing in accordance with the image schema (Figure 2.10 - left slider) culminates in faster response times, error rates could not be established as the interface was too simple and in their first version of the experiment there was no statistical difference between the compatible and incompatible version of the design (Hurtienne & Blessing, 2007). Subsequent studies (Hurtienne, 2011; Hurtienne et al., 2009; Stößel et al., 2010) established that image schemas could principally be used in designing for intuitive use, but this was not validated in actual design projects (Hurtienne et al., 2015).

2.6.3 Cognitively describing intuitive interaction

As discussed in the preceding section, several methods (such as the TFQ) have been developed to measure how intuitive an interaction is (Blackler et al., 2019). As yet, however, no consensus has been reached among researchers on how to measure whether or not a design will be intuitive to use (Still & Still, 2019b). This problem still exists despite the fact that instruments such as the Questionnaire for the Subjective Consequences of Intuitive Use (QUESI) (Naumann & Hurtienne, 2010), the INTUI questionnaire (Ullrich & Diefenbach, 2010) and the TFQ have all been developed for this purpose. These instruments primarily suffer from two main failures. First, the observational analyses required are time consuming to conduct (Fischer et al., 2015). Secondly, all the instruments rely on participants' perceived experience with technology and this subjectivity is a major disadvantage because there is no empirical measure for intuitive interaction (Fischer et al., 2015).

Intuitive interaction research overwhelmingly suggests that prior experience is a key contributor to the intuitive use of a product, but it does not coherently explain the cognitive process(es) that underlie this (Still & Still, 2019b). Historically, intuitive interaction research has focused on prior experience and technology familiarity, but the literature has not given much consideration to this type of interaction from a decision making perspective. It is clear, however, that decision making is a crucial part of intuitive interaction. In the literature Blackler (2008) states that "decisions that are quick and relatively automatic are often termed intuitive decision-making" (pp. 28-29), and Diefenbach and Ullrich (2015) regard intuition acting as an unconscious decision making process. While O'Brien, Rogers and Fisk (2008) argue that any "user selection of an action on technology is fundamentally a decision" (p. 2). Intuition in terms of the underlying cognitive processes and the impact that they have on decision making is crucial to a better understanding of intuitive interaction, as it is precisely what a user intends to do with an interface (O'Brien, 2010).

Blackler (2008) states that "fast (or intuitive) decision making uses various heuristics…" (p. 29) and thus further acknowledges the integral role of decision making in intuition and intuitive interaction. This understanding of intuition then culminates in a definition of intuitive interaction that deems it to be "fast and generally non-conscious, so that people would often be unable to explain how they made decisions during intuitive interaction" (Blackler, 2008, p. 107). What this suggests is that decision making is of fundamental importance to intuitive interaction research.

The majority of the literature in HCI, by and large, fails to acknowledge the underlying processes that support intuitive interaction and without this understanding it makes prediction of what interfaces will be used intuitively by people an implausible task (Still & Still, 2019b). Further to this, Still and Still (2019) highlight that the current research into intuitive interaction is problematic because even though it emphasises prior experience as a key feature, it does not specify the implicit nature of this experience or how it works as a cognitive process. For example, Blackler et al. (2010) state that "intuitive use of products involves utilising knowledge gained through other experience(s). Therefore, products that people use intuitively are those with features they have encountered before" (p. 75). While this statement underscores the importance of prior experience with technology, the literature does not investigate the most critical aspect – the intuitive processing mechanisms themselves and how they function together with prior experience to create interactions that are intuitive (Volz & Zander, 2014).

In general terms there is definitional overlap between the concept of intuitive interaction in HCI and the concept of automatic processing in JDM. For example, in intuitive interaction research, intuition is regarded as a process that occurs non-consciously (Blackler et al., 2003; Diefenbach & Ullrich, 2015; Hurtienne, 2011; Naumann et al., 2007). In this paradigm, if an individual is not aware of the underlying processing that produces their behaviour then it is considered to be intuitive (Blackler, 2019; Diefenbach & Ullrich, 2015). Similarly, in JDM research the consensus is that automatic processes are not available to reflective interrogation, i.e. an individual cannot answer why a judgment was made if it has been processed through automatic systems (Betsch et al., 2004).

In JDM the consensus is that intuition operates automatically, and it is a non-conscious process (Evans, 2010). The general view of cognition in JDM is that it consists of two separate processes, alternatively known as automatic and deliberative (e.g. Betsch & Glöckner, 2010; Betsch et al., 2006; Evans, 2010; Horstmann et al., 2009; Kahneman, 2011). By contrast, within intuitive interaction research the focus is almost exclusively on intuition which is often characterised as somewhat non-conscious (Blackler et al., 2010, 2019). This definition is vague and intuitive interaction is conceived of as sitting on a continuum between controlled and automatic processes (Blackler et al., 2010; Still & Still, 2019b). An understanding of dual-process theories of cognition are not explicitly mentioned or demonstrated in the IUUI definition. There are, however, indications that researchers are fully aware of the two separate systems and the proposed characteristics of each (Antle, Corness & Droumeva, 2009; Desai, 2017).

Based on the definitions of intuitive interaction provided (section 2.6.1), it is not clear how intuitive interaction is supposed to work from a process perspective and as Still and Still (2019) suggest, it is difficult to predict what interfaces will be used intuitively if the underlying intuitive processes are not understood. Neither definition offers a clear understanding of the process that underlies intuitive interaction beyond the suggestion that interfaces that match prior experience and do not strain cognitive resources are considered to be intuitive (Blackler et al., 2010; Naumann et al., 2007; O'Brien et al., 2008).

From the literature it seems that HCI researchers believe intuitive interaction to be a process where information that is perceived in a graphical user interface or on a device is integrated or matched against prior experiences stored in long-term memory and this results in an outcome of either recognition, judgment or answer (Blackler et al., 2010).

Although not overtly mentioned in the HCI literature, this process is similar to how decision making processes are described in the JDM literature. For instance, it is well described in the JDM literature that decisions are largely an automatic process where information in the environment is automatically matched against stored information in long-term memory (Betsch, 2008; Betsch et al., 2006; Hogarth, 2001, 2010; Kahneman, 2011). The key difference is that the JDM literature is cognisant of the handoff between Type 1 and Type 2 processes, whereas the literature in HCI is focused on prior knowledge or experience (Blackler & Popovic, 2016).

2.6.4 Addressing a gap in intuitive interaction research

Still and Still (2019) suggest that the intuitive interaction research programme would benefit from a better understanding of principles and methods in cognitive science. They specifically identify a critical area to understanding how intuitive interactions are supported (Still & Still, 2019b). The implication that Still and Still (2019) make is that intuitive interaction research in HCI is theoretically under-described from a cognitive perspective and needs to incorporate methods and theory from cognitive research.

In order to address this ambiguity, and counter to the inherent subjectivity of the existing instruments in intuitive interaction research, the present study imports a paradigm from cognitive psychology proposed by Betsch et al. (2001) into intuitive interaction research to address the current gaps within the literature.

2.6.5 Integration of large amounts of information

There are key insights from the JDM literature that are important for the present study. First, the automatic processes of intuition can integrate large amounts of information and enable decision making through the formation of choice tendencies and judgments without impacting cognitive resources such as working memory (Betsch et al., 2001; Betsch et al., 2003; Betsch & Glöckner, 2010; Plessner et al., 2008). Even though decision making is heavily reliant on prior experience, the information integration process will use cues from both the environment and memory. Intuitive processes under this conceptualisation use all pieces of information activated in memory and what is salient to the individual within the environment (Betsch & Habertroh, 2005). This therefore goes through the process of valuation and integration as all pieces of information do. The more information that has been consolidated in memory, the more likely it will be activated by situational cues, thus forming a response weighted with this information (Betsch & Glöckner, 2010). Intuitive interaction research has described visual saliency from an attentional (Still, 2017) and visual search perspective (Still & Still, 2019a) but does not describe the core process through which salience is achieved.

Many researchers in JDM agree that intuition as a process draws on associations between stimuli in the environment, and for the purposes of the present study the mobile interface and information stored in long-term memory (Betsch et al., 2003; Dane & Pratt, 2007; Hogarth, 2001, 2010). The perceptual information is unconsciously matched to stored long-term memory and this matching process, described by the Parallel Constraint Model, results in an intuitive judgment that then becomes available to conscious processes (Betsch et al., 2003; Dane & Pratt, 2007; Hogarth, 2001, 2010). The implication is that associative processing is the default approach; it operates automatically and can influence behaviour (Kahneman, 2011).

Certain situations lend themselves to automatic associative processing (Kahneman, 2011). For example, in an HCI context, text that is **underlined** and **bold** is more salient in an interface because it is unique in contrast to its surroundings and implicitly is accorded greater importance because of the way it is presented (Still, 2017; Still & Still, 2019a). Still (2017) argues that salient features in the interface reduce search times and implicitly attract attention, but does not discuss what effect this potentially has in terms of processing fluency (Kahneman, 2011).

Processing fluency is a property of presentation format where the presentation, e.g. the bolding of text, can influence how it is understood (Kahneman, 2011; Still, 2017). In Kahneman's (2011) Hitler birth year example (section 2.4.5), the bolding of the text functions to give it prominence, but it also gives the viewer a cue that the bold text is the correct option because of prior experience they may have had with text being bolded. Still (2017) agrees that the text treatment (bold or underlined) gives it salience but beyond the suggestion that different types of treatment can direct attention in an interface, does not extend this concept further. Beyond salience, it has been suggested that the treatment and presentation of information can influence how individuals perceive and react to objects and situations without them necessarily being aware of it (Gigerenzer, 2007; Kahneman, 2002; Klein, 2008; Myers, 2004). If this hypothesis is correct, then it suggests that understanding automatic processing is key to how designers could design interfaces that are assistive in decision making processes.

In JDM research the automaticity of intuitive processes is a well-established part of the existing literature. Evidence from dual-task and open Mouselab experiments suggests that participants can integrate large amounts of information without impacting working memory (Betsch et al., 2001; Betsch et al., 2003; Betsch & Glöckner, 2010; Glöckner & Betsch, 2008; Plessner et al., 2008). Further to this, information that is presented in an accessible way in an interface can be captured in a perception-like process (Söllner et al., 2013).

The central tenet arising from this is that automatic processes occur involuntarily and are central to decision making (e.g. Betsch et al., 2006; Bodenhausen & Todd, 2010; Glöckner, 2009). Further to this the literature has provided a variety of empirical evidence that the automatic system can function without (or in opposition to) the deliberate mode of cognition (Type 2 processing) (Glöckner & Betsch, 2008). For example, the Stroop effect is a well-documented experiment that demonstrates how automatic processes can interfere with deliberate processes (Jacoby, 1991; Regan, 1978). In the Stroop task participants are shown words in colour, where the colour is either compatible with what the word is saying, i.e. **GREEN**, or it is incompatible (**GREEN**), or it is shown as neutral i.e. (GREEN) (Cohen, McClelland & Dunbar, 1990; MacLeod, 2015; MacLeod & MacDonald, 2000; Stroop, 1935). It has been repeatedly shown that when the colour word is in the incompatible condition (i.e. **GREEN)**, and the task is to name the colour of the ink itself and not the word, then naming it is much slower and more error prone than the control conditions, where, for example, **XXX** or **MMMMM,** are printed in green, and the expected response is that the participant will say ‘green’ (Cohen et al., 1990; Jacoby, 1991; MacLeod, 2015; MacLeod & MacDonald, 2000; Regan, 1978; Stroop, 1935).

What the Stroop task demonstrates is that subjects are slower overall at the naming of colours than they are at reading words, and this suggests that first, colour naming is not as practiced a task as reading. Secondly it shows that reading is an automatic process that does not require cognitive effort once it has been overlearned and the rules are embedded in long-term memory (Cohen et al., 1990). The Stroop effect is often used as an example of cognitive interference where an automatic process (reading) works in opposition to deliberate control (Glöckner & Betsch, 2008; MacLeod, 2015; MacLeod & MacDonald, 2000) and this demonstrates the effect that automatic processes can have on behaviour (Glöckner & Betsch, 2008). As a matter of interest, in Stroop's (1935) original experiment there was a difference between how well males and females performed on the task and it was suggested that the difference arose because of the gendered training of the two sexes with a supposed greater emphasis on colour training in females (Stroop, 1935). This suggests that the more tasks are practiced, the more they become automatic. Further to this, Stroop (1935) found that the interference in the conflicting condition could be reduced through training (eight days of practicing 200 reactions per day), but the effects could not be completely eliminated (Stroop, 1935), suggesting that the automatic processes are sensitive to experience, but reading is an extremely well consolidated automatic process that is difficult to override.

The present study takes the position that intuitive processes can operate on a completely automatic level and in order to demonstrate this, it replicates an experiment (see Betsch et al., 2001) from JDM research that investigates the automaticity of intuitive processes in a dual-task process as a counter to Blackler's (2008) claim that intuitive processes cannot operate automatically without extensive experience with technology.

2.6.6 Controlling cognitive mode

The second key consideration imported from JDM literature is that dual-process procedures have successfully been used to distinguish between explicit and automatic processes of cognition and provide an objective measure for intuition (Betsch et al., 2001). Further to this, dual-process procedures allow researchers to control the cognitive mode that participants use in the experiment (Haberstroh, 2008; Haberstroh & Betsch, 2002) which has not been evident in the intuitive interaction research as the instruments are inherently subjective (Fischer et al., 2015; Still & Still, 2019b). Research in JDM, however, severely constrains explicit processing capacities to ensure that participants do not form attitudes through deliberate processing but rather through the automatic processes that are under investigation (Betsch et al., 2001; Haberstroh, 2008; Haberstroh & Betsch, 2002).

2.7 Problem statement

Design and development practitioners suggest that animation in the mobile interface has cognitive benefits for users such as reducing cognitive load, aiding in decision making, and enabling intuitive use of these interfaces (Babich, 2017; Carine, 2019; McLeod, 2019; Head, 2016; Yalanska, 2015). Extant research into intuitive interaction in HCI does not address the role that animation plays in decision making processes. The research in HCI is cognitively under-described and so it is hard to predict which interface interactions will be intuitive (O'Brien, 2010; Still & Still, 2019b).

To date, research into intuitive interaction has focused on performance outcomes that are measurable in terms of usability metrics such as time on task, efficiency or errors made, but not necessarily the processes by which these intuitive outcomes are obtained (Antle et al., 2009; Blackler et al., 2007; Blackler & Popovic, 2015; McEwan, 2017; McEwan et al., 2014). There is also a large reliance on participants' subjective experience and researchers coding data from video analyses (Fischer et al., 2015; Still & Still, 2019b). Research into intuitive interaction needs to further consider theory and methods in cognitive science literature because there is an evident lack of understanding of key cognitive processes in the intuitive interaction field (Still & Still, 2019).

Research in the JDM literature suggests that information integration, and judgmental evaluation are central to intuition as a decision making process (Betsch et al., 2006;

Bodenhausen & Todd, 2010; Glöckner, 2009). It has been proposed that the automatic processes of intuition, in the right context, are capable of dealing with complex tasks and integrating a large amount of information without cognitive effort (Betsch et al., 2001; Betsch & Glöckner, 2010; Haberstroh, 2008). As Still and Still (2019) have suggested, the literature in HCI would benefit from a more cognitive description of the automatic processes underlying intuition and there is an opportunity to report the effects of design on intuitive interaction and discuss how research in JDM can be aligned with and used in intuitive interaction research.

The present study injects a paradigm from JDM research in an effort to better understand the underlying process of information integration. The goal is to enable designers to create interfaces that are informed by a clearer understanding of the automatic processes of cognition. The more that is understood about how people make decisions, the better we can design interfaces to support decision making and interaction (Still & Still, 2019b). The objective for the present study is twofold; first – to validate work conducted by Betsch et al. (2001) that posits automatic processes of intuition can integrate large amounts of information without impacting cognitive resources such as working memory; secondly – to extend this original research by introducing animation as an independent variable and investigating the impact it has on information integration. The purpose of this question is to first establish whether or not such a relationship exists. Secondly, if this relationship does exist, it aims to provide evidence that could be used within HCI when considering and designing animation for mobile interfaces.

2.8 Research question

RQ1: Determine if animated stimuli within an interface (independent variable) influences the way in which people evaluate investment share information (dependent variable).

H0: no difference is predicted in how participants evaluate share information, when the lowest value return is animated in the interface compared to when it isn’t animated.

H1: a difference is predicted in how participants evaluate share animation when the lowest value return is animated in the interface.

The hypothesis is that animation in the mobile interface can influence how automatic processing occurs and the prediction is that, in the experimental condition, individuals will rate the lowest value stock higher than it is rated in the control condition.

CHAPTER 3: METHODS

3.1 Introduction

This chapter will provide a description of the methodology used in this study. This includes the design of the research study, the ethical considerations and an explanation of the measurement instrumentation, sampling procedures, and data acquisition. A quantitative approach was used as it was believed it would provide the clearest measure of the proposed outcomes. This approach consisted of a demographic questionnaire, technology familiarity questionnaire, memorisation task, advert recall questionnaire and an evaluation task. Each of which will be discussed in greater detail below.

3.2 Research design

Controlled experiments are used extensively within the field of HCI to assess interfaces and interaction styles (Blandford, Cox & Cairns, 2008). A controlled experiment is where the researcher manipulates a variable (IV) in order to see the effects on the system under study (Blandford et al., 2008; Gergle & Tan, 2014). The current study was a controlled experiment and used a wholly between-subjects design, with each participant assigned to only one of two conditions. This design was chosen in order to test the relationship between a small set of variables and a clearly defined hypothesis (Blandford et al., 2008). In a between-subjects design participants are only exposed to one condition, and it is considered by many as the "gold standard of randomized experimental research" (Gergle & Tan, 2014, p. 204).

The key independent variable in the study was interface animation with the rating measure of the share as the dependent variable (DV). Since the present study attempts to replicate and extend previous work by Betsch et al. (2001), it is a comparative design where the control condition is a replication of their original experiment. This study differs with the inclusion of animation (IV) as a controlled variable within the interface in order to assess what impact this has on information integration and attitude formation about the shares (DV). The relationship between these two variables is explored in terms of key descriptive and inferential statistics identified in the results section.

The second novel aspect of the present study is that, unlike Betsch et al. (2001), it was conducted in the wild. *In the wild* is a common expression in HCI to indicate that the research was conducted *in situ* or in naturalistic settings (Rogers & Marshall, 2017). It refers to how the study was conducted and this type of investigation looks at technology use in a real-world setting (Rogers & Marshall, 2017). This method is used in order to ensure that the setting does not have undue influence on the results and further to this it provides insight into how people would use the technology under investigation more naturalistically (Crabtree et al., 2013; Rogers & Marshall, 2017).

Betsch et al., (2001) conducted their original study in laboratory-controlled conditions where participants used noise-cancelling headphones during the experiment. The research for the present study was conducted in the field in diverse places such as private homes, small businesses, outside gyms, coffee shops, and in a hospital waiting room, thus creating a more true-life experience than an overly sterile laboratory scenario. No noise-cancelling equipment was provided to participants. In cognitive psychology research there has been a trend towards research that is more ecologically sound because it allows studies to be more easily generalised (Kvavilashvili & Ellis, 2004). Since the present study was conducted in more natural settings, this suggests that the research may have higher ecological validity and may predict performance in real-world settings more accurately.

3.3 Participants

3.3.1 Sampling methods

In order to reduce potential systematic effects, a simple random sampling scheme was used in the selection of the study's participants (Woodward, 2014) so that everyone in the sampling frame had an equal chance of being selected. Participants were therefore recruited through a combination of methods including flyers, social media posts to community groups, e-mail and directly approaching participants unknown to the researcher. For examples of the templates used, please see Appendix 12. Each participant in the sampling frame thus had an equal and independent chance of selection in the sample so as not to be influenced by factors such as personal preference of the researcher (Kumar, 2011).

A randomisation plan was used to assign participants to either the control or experimental group. In order to make sure this assignment was random, an online randomiser (http://www.jerrydallal.com/random/assign.htm) was used. The online randomiser creates a plan based on the number of experimental conditions and participants required, and generates a randomised assignment scheme for the study. Appendix 7 illustrates the randomised plan that was followed for both the control and experimental condition, and participants were sequentially allocated a condition as shown in the plan.

The rationale for using a randomisation plan was so that hidden attributes of the participants did not conflate with the variables under investigation (Gergle & Tan, 2014). Randomised assignment of participants to either the control or experimental group ensures that there is no systematic bias (Gergle & Tan, 2014). For example, assigning a large group of computer science students to only one group in an HCI study may have an influence on the results collected because of their training.

3.3.2 Sample

The sampling frame for the current study was determined as people in the Johannesburg North area between the ages of 18 and 65, who had previous experience with a smartphone (iOS or Android). Thereafter, G*Power sample size calculations (Faul et al., 2007) were carried out, which determined that one hundred and twenty-eight (128) participants were required for the study. Sample size estimation was based on the key research question to be answered, in this case the comparison of each share measure (judgmental evaluation, estimated sum of returns, estimated average return) between the two study groups. This required a two-way repeated-measures Analysis of Variance (ANOVA) with the measure as the dependent variable, group and share as the independent variables, and respondent as the repeated measure. For the detection of small, medium, and large effect sizes (f=0.2, 0.5 and 0.8 respectively) between groups with 80% power at the 5% significance level, total sample sizes of 788, 128 and 52 respectively were required. The aim was to detect at least a medium effect size, should it exist. Thus, a minimum sample size of 128 (64 per group) was required.

In total, 152 participants were interviewed for this study and after exclusions 142 participants remained for analysis. The exclusions were predicated on participants suspecting the purpose of the experiment or not understanding principal elements in the questionnaire. It was important that participants did not suspect that the share returns shown to them were the target objective of the study. As part of the post-interview questions, participants were asked if they had expected to be asked about the share information. Two out of the 152 respondents indicated that they had suspected the share information was pertinent to the study, and so their responses were discarded from analysis.

Further to this, in the share evaluation task, for each share participants were asked to provide a sum (all returns added up) and average value of share returns. From the data gathered there were eight participants who had recorded the average values as larger than the summative values, i.e. average estimate > sum estimate. It can be assumed that the participants had not understood the question and so their responses were discarded from analysis.

This brought the final sample size to 142 which met the sample size requirement for the detection of a medium size effect (f=0.5) between groups with 80% power at the 5% significance level. Data analysis was carried out using SAS (version 9.4 for Windows). The research was conducted in the period between 06 March 2019 and 01 May 2019.

3.3.3 Incentives

Participants were not paid for their participation in the study, but in order to secure a large enough sample size, participation in the study was incentivised through a raffle for a ZAR 1500.00 Takealot.com voucher. Participation in the raffle was voluntary and contact details were only kept in order to notify the winner once the draw had taken place. Participants were not made to feel obligated to take part. The raffle winner was randomly selected using a list randomiser at random.org and sent the ZAR 1500.00 voucher by email. There is no affiliation between Takealot.com and the researcher.

3.4 Apparatus

3.4.1 Materials

The researcher specifically developed an Angular application for purposes of the present study. This was not paid for and took approximately three weeks to develop. Angular is a development framework made by Google © (2010-2018) to build applications with web software that enables these applications to exist seamlessly on both mobile or desktop devices (Google, "What is Angular?", 2010). It was chosen as a framework because the present researcher is familiar with it and it is easy to create mobile applications that work on a variety of devices. A secondary consideration in using the Angular platform was that it is easy to maintain and edit for future academic work and its codebase is freely available on the researcher's Github.com account (https://github.com/schemafault/infint-experiment.git).

Twenty images had to be sourced for the experimental portion of the study. In order not to infringe on the rights of copyright holders, the images used in the current study either had a Creative Commons license or were in the public domain. Links or descriptions of the license type for each of the twenty images have been provided in Appendix 8.

An iPhone X or Android phone was made available to participants to use for the experiment depending on their familiarity with either smartphone operating system.

3.4.2 Demographic questionnaire

The demographic questionnaire (Appendix 3) was primarily used to show that a random sample of the population had been taken (Lazar, Feng & Hochheiser, 2017). The secondary purpose of the questionnaire was that it was used as a record for analysis to see if any significant results become apparent when controlling for different variables such as age or level of education. On the demographic questionnaire the following data were collected:

1. Age
2. Gender
3. Home language
4. Highest level of education (HLOE)
5. Employment status
6. If employed, area of employment

3.4.3 Memorisation task

3.4.3.1 Control condition

In this condition twenty static visual adverts were shown to participants and these adverts changed at 10-second intervals (Figure 3.1). Each participant was asked to memorise as much as they could about each advert in the allotted time of four minutes. The memorisation task was a single session only and each participant only had one chance at the task. This task was framed as the primary task in the experiment. At the bottom of the mobile screen, share information was displayed similar to the way in which share information is presented on TV news, the only exception being that it was not displayed as a tickertape, but rather the values appeared and disappeared on the screen at 3-second intervals (a sample video for the control condition can be found here: http://bit.ly/control-group).

In total there were 5 shares with 75 return values shown on screen (Appendix 13). Participants were told that this was a distraction element and were asked to read this information out loud when it appeared on screen. Betsch et al. (2001) presented 15 share returns for each share in their experiment, where the smallest number shown for any share was 10 and the highest number shown was 55. The actual share return values for each share presented to participants can be seen in Appendix 13. In order to simulate this random array of numbers between a lower and upper limit, the researcher modified an existing Python 2.7 script for random sum generation (Appendix 14). The script generates N positive integers within a range adding up to a total. For example, if a total sum of 300 with a lower limit of 10 and an upper limit of 55 is input, then the script will generate a random array of numbers between those two limits similar to Table 6.1. To increase the prospects of replication of this study (Field & Hole, 2013) the entire script can be found in Appendix 14.

Betsch et al. (2001) determined through a pilot test that the share labels they used did not evoke any familiarity or preference in participants. The names they used were RONAT, ELSKAR, FAMO, NARWIG, and PATEL. In order to validate that the original share names used by Betsch et al. (2001) elicited no affective responses in participants for the current study, a pre-study with 15 participants was conducted. The share names used were RONAT, ELSKAR, FAMO, NARWIG and PATEL. In the pre-study, participants did not accord any especial value to the share names except for PATEL. Participants felt that it was a common South African name and as such elicited an affective response. In order to not draw undue attention to the share name, it was changed to PITTLER and in a further 5 pre-study tests it did not elicit any further association.

An online version of this Angular web application can be viewed at https://infintapp.firebaseapp.com/stage-3. Please note that if viewed on a desktop machine the application will not appear as intended. It is intended to be viewed via the Chrome browser on either an Android or iPhone smartphone device, an example of which can be seen in Figure 3.1.

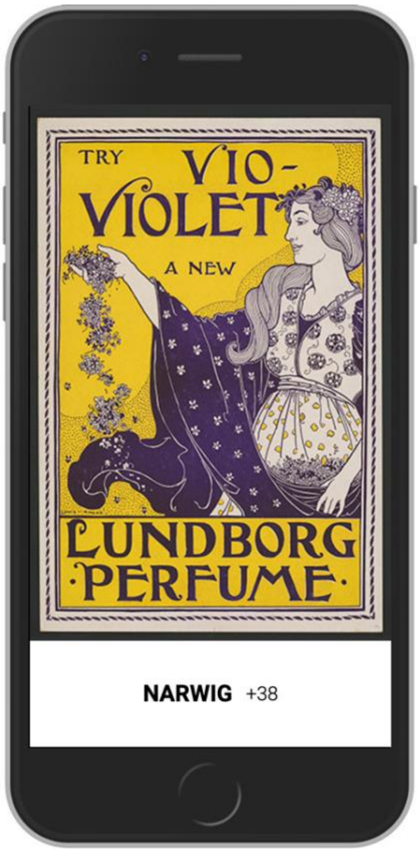

Figure 3.1 Control condition: share values presented on screen without animation

Participants were instructed to concentrate on the advertisements and memorise as much as possible about each one, but at the same time they were asked to read the share values shown out loud. Participants were told that the purpose of reading the share information out loud is to constrain their information-processing capacities and to ascertain how working memory functions under such strain (Plessner, Betsch, Schallies et al., 2008, p. 109).

3.4.3.2 Experimental condition

The experimental condition proceeded almost identically to the control condition. The only difference was that each return value of the lowest value share (RONAT) was animated on the screen in an exaggerated manner (an example of which can be seen in Figure 3.2 and a sample video can be found here: http://bit.ly/experimental-group). Participants were asked to read all share values out loud and participants were told that this was a distraction to the primary task of advert memorisation. An online version of this web application can be viewed at https://infintapp.firebaseapp.com/stage-2. Please note that if viewed on a desktop machine the application will not appear as intended. It is intended to be viewed via the Chrome browser on either an Android or iPhone smartphone device.

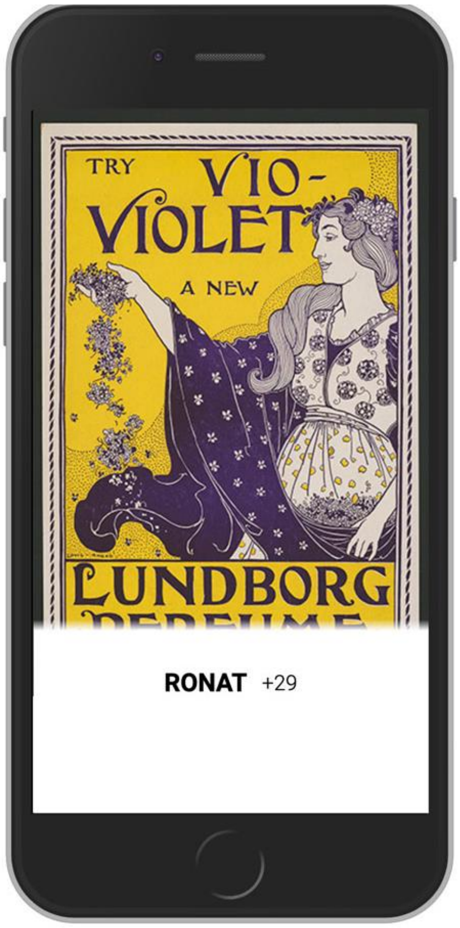

Figure 3.2 Experimental condition: lowest value share is animated on screen

3.4.4 Advert recall questionnaire

A set of twenty multiple choice questions (Appendix 5), focused on the advert content, was presented to the participant to assess how well the memorisation task had proceeded. This questionnaire gave the advert recall score for each participant (20 questions; score 1 point per correct answer; possible score range 0-20). Separating the memorisation task (section 3.4.3) from the share evaluation task (section 3.4.5) with a multiple choice questionnaire further ensured that no residual share return information could be recalled from memory (Betsch et al., 2001).

3.4.5 Share evaluation task

As per the original experiment by Betsch et al. (2001), participants were asked to evaluate the shares on a scale from good to bad. The key dependent measure is the judgmental evaluation that participants form about each share return. In order to assess this summary judgment, a horizontal scroll bar was shown on screen where extreme left was labelled ‘very bad’, while the extreme right was labelled ‘very good’. Figure 3.3 shows how participants were asked to rate shares on a mobile phone using a Likert-type scale anchored by 0 (very bad) and 10 (very good) (see Appendix 6 for the extended view).

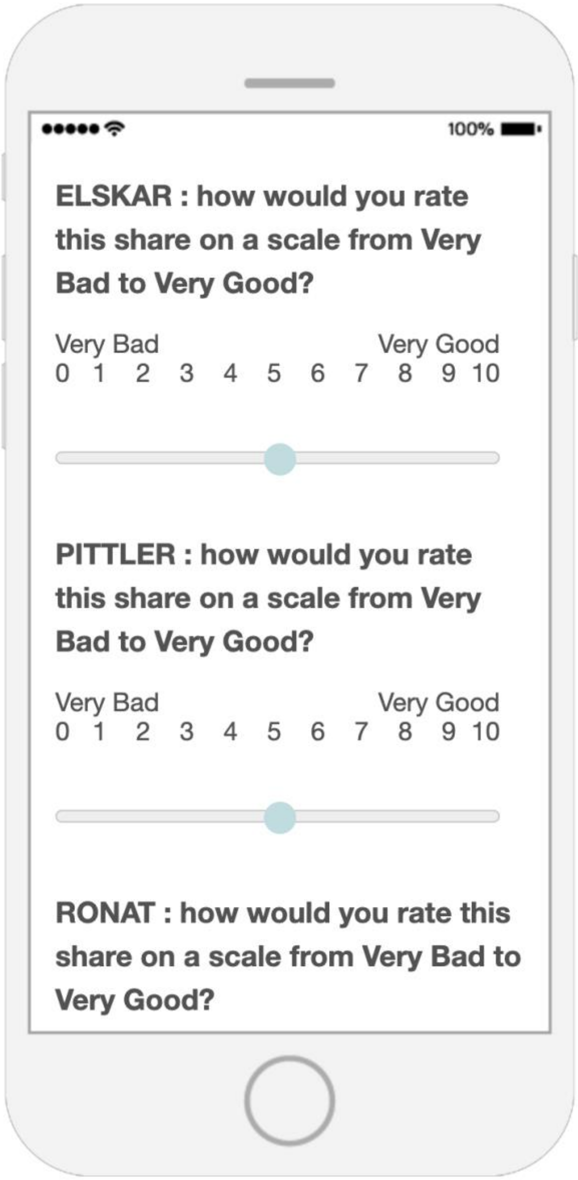

Figure 3.3 Scale measuring participant evaluative judgment towards each share

In this task the data collected were:

1. Judgmental rating of shares
2. Sum and average estimations of shares

3.5 Procedure

The experiment in the present study is a replication and extension of work conducted in JDM (see Betsch et al., 2006; Betsch et al., 2001). Participants were randomly assigned either to the experimental or control condition (see section 3.3.1).

In the original experiment, participants were seated in front of a personal computer screen with audio cancelling headphones and told that the objective of the study was to memorise the pictorial adverts while being distracted by share information running on a tickertape on the screen below (Figure 3.4). Participants had to read the share return information out loud and after the memorisation task they had to answer questions about the adverts and, unexpectedly to the participants, they then had to answer questions about how they evaluated the different shares (Betsch et al., 2001).

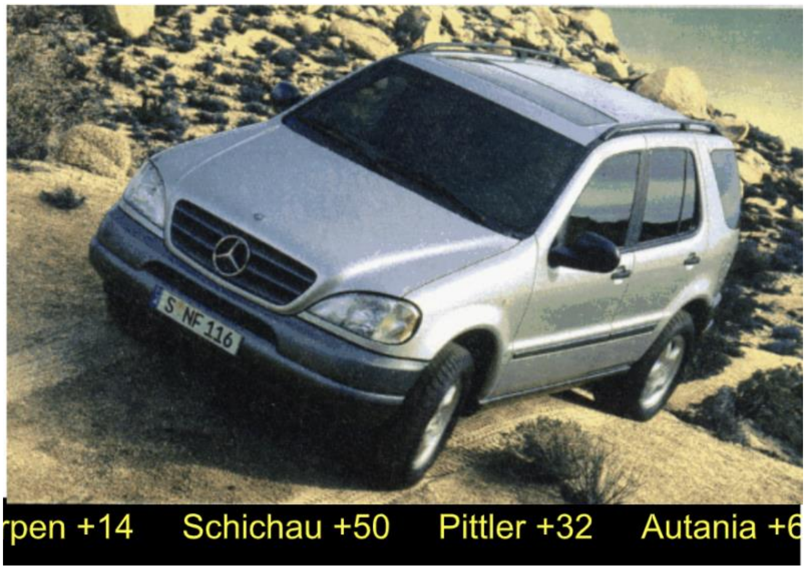

Figure 3.4 Information integration experiment showing share returns and advert (Betsch & Glöckner, 2010, p. 282). Reprinted with permission.

The present study replicated the dual-task format of this experiment and participants were shown pictorial adverts while reading, out loud, share information shown to them.

The key differences in the present study were that it was performed on a mobile smartphone and a tickertape was not used as the mechanism to display share information (see Figure 3.1). Since the principal research question asks whether or not animation can influence automatic information integration, the tickertape was not used as this is an animated device and the study needed a way to display static and animated shares that were not far removed in their display method.

All questionnaires and instruments were formatted for use on a mobile device in that the content adapted automatically to the size of the mobile screen it was presented on. This was done to optimise the legibility of the text and ease of interaction on the mobile screen. The Qualtrics platform was used for all questionnaires since it natively supports mobile presentation of content and it is widely used for academic research to distribute surveys (Qualtrics, n.d.).

Participants were asked to read the participant information sheet (Appendix 1) where the conditions of the study were explained. Participants had to voluntarily agree to the conditions of the study by signing the consent form (Appendix 2) before continuing to the demographic questionnaire (Appendix 3). Each participant was then asked to carefully read the instructions (Appendix 4) where the memorisation task was explained. Participants were encouraged to ask the researcher any questions. In the memorisation task participants had to follow the method described (section 3.4.3.1) and study a set of 20 pictorial adverts while reading out loud the 75 share returns shown at the bottom of the screen. The memorisation task took approximately four minutes to complete and after this task participants were presented with the advert recall questionnaire (Appendix 5) where twenty multiple choice questions were asked about the pictorial adverts.

The final task for the study constituted the share evaluation task (Appendix 6) where participants were asked to evaluate each share on a scale from 0 (very bad) to 10 (very good).

If asked, the researcher would explain that the rating reflected how they felt about each share in terms of which they considered more valuable, and which less valuable. After the rating section, and as part of the evaluation task, participants were asked to give an average and summative estimation of all return values they had seen for each share.

A short post-experiment interview (Appendix 10) was conducted because it was important that participants did not suspect that the share returns shown to them were the target objective of the study. The purpose of the post-experimental question "Did you expect to be asked about the share information after the memorisation task?" (Appendix 10) was to filter participant data (Betsch et al., 2001). If the participant had suspected that they would be asked about the shares, it meant that they might have spent time consciously memorising the share return values and this would have been contra the purposes of the experiment. If any participant indicated that they were suspicious of the purpose relayed to them, then that participant's data was discarded from analysis.

3.6 Data analysis

Data analysis was carried out using SAS (version 9.4 for Windows) on an Intel Core i7 processor with 16GB RAM and 1TB solid state hard drive. The 5% significance level was used as it is the most typical significance level used within the field of HCI (Dragicevic, 2016, p. 12; Gergle & Tan, 2014, p. 197; Hornbæk, 2011). The 5% level represents the degree of risk a researcher is willing to take that a difference exists between groups when there is no actual difference (Type 1 error) (Kim, 2015). The 5% level was used as a practical benchmark as it is commonly used in HCI studies (Dragicevic, 2016, p. 12; Gergle & Tan, 2014, p. 197; Hornbæk, 2011) and the researcher deemed it an acceptable risk for purposes of this study.

3.7 Ethical considerations

In conducting research, numerous ethical considerations were taken into account and steps were taken to ensure participants' rights. These considerations are detailed below. The key ethical considerations for this study involved how to deal with vulnerable participants, how to obtain informed consent and how to maintain confidentiality and privacy (Blandford et al., 2008). As Blandford et al. (2008) note, vulnerable participants also include those that the researcher may have a power relationship with, for example junior work colleagues or students. This power relationship was excluded from being a concern through the researcher using a random sampling method that did not include any people known to him, thus reducing the effects of an imbalanced power relationship.

3.7.1 Informed consent, participation and withdrawal

The researcher clearly explained the task and questionnaire format of the study when recruiting each participant, the time commitment needed to take part, and the focus of the study. As a reiteration of this, all participants were required to read the participant information sheet (Appendix 1) and were encouraged to ask questions and have anything unclear explained by the researcher. On the consent form (Appendix 2) participants were required to tap each block to indicate that they had read and understood the separate conditions of the study and in addition to this they had to sign to indicated informed consent before they could continue with the study. Participants were informed that they could ask questions or withdraw from the study at any point without any consequences or penalty to them. All submissions were recorded in a coded format (Appendix 9) so that individual participants could not be identified except by the researcher. Completed questionnaires were submitted through a secure platform and the raw data was only seen by the researcher.

3.7.2 Protection of data

When collecting data during the course of the study, personal data that identified individuals was kept to a minimum and only a name, surname and a contact number were required for voluntary entry into the Takealot.com raffle. Each participant was assigned a unique code that refers back to a password protected Microsoft Excel document where such personal data was stored. The document generated a unique participant ID (Appendix 9) that was used in all analysis. After completion of the study, the anonymised raw data was not destroyed but stored on a private, password-protected hard drive. All data will be destroyed after a five-year period from the date of submission of this thesis.

3.7.3 Human research ethics clearance

An application for ethics clearance was considered and approved by the University of the Witwatersrand's Human Research Ethics Committee (HREC) on 15 February 2019 (Appendix 11).

CHAPTER 4: RESULTS

4.1 Introduction

This chapter will present the statistical results and the analyses used to obtain them. This will include a discussion of the descriptive statistics and then a discussion of the inferential statistics as they are related to the research question.

4.2 Participants under analysis

The control group comprised of sixty-eight participants (37 female and 31 male; ages ranged from 18 – 64; mean age = 27.9), while the experimental group consisted of seventy-four participants (39 female and 34 male and 1 preferred not to say; ages ranged from 18 – 59; mean age = 30.7). See Table 4.1 and Figure 4.1.

Table 4.1

Participant Gender by Group

Gender	Control		Experimental	
	n	%	n	%
Female	37	54	39	53
Male	31	46	34	47
Prefer not to say			1	

This gender distribution closely matches the South African population where, of the 58.78 million people, approximately 52% of the population are female and 48.8% are male, based on 2019 mid-year estimates by Statistics South Africa (Maluleke, 2019).

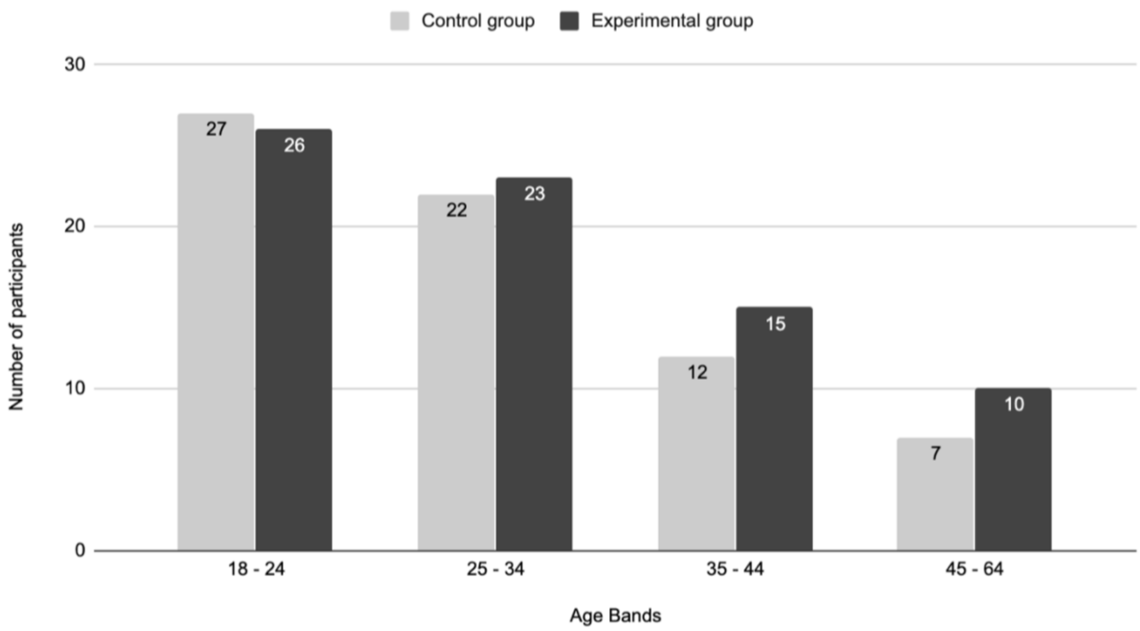

Figure 4.1 Age of participants grouped by bands

The age bands of the sample are fairly representative of the South African population if you consider the fact that approximately 65.25% of South Africans fall between the ages of 18 and 64 (Maluleke, 2019, p. 10).

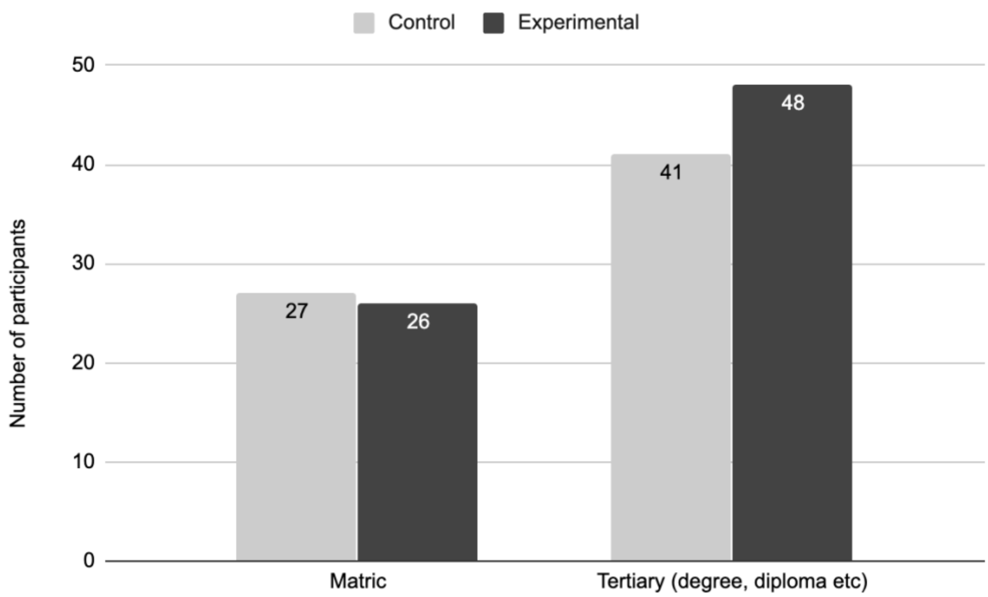

Figure 4.2 Participants by highest level of education completed

Based on national education demographics the sample was not specifically representative of the country as most of the participants in the sample had achieved Matric or a higher level of education (Figure 4.2), whereas in the general population only 27.5% have completed secondary school and 2.5% have attained a bachelor's degree ("*CENSUS 2011*", 2011).

Table 4.2

Participant Employment Status

Employment status	Control		Experimental	
	n	%	N	%
Employed full-time	42	62	52	70
Full-time student	22	32	19	26
Unemployed	3	4	3	4
Working part-time	1	1	0	0

Of the participants randomly selected for the study, 66.19% were employed and 33.81% were either unemployed or studying full-time (Table 4.2). This does not accurately reflect the total South African population where the unemployment rate is 29% and the employed ratio is 42.4% (*Quarterly Labour Force Survey: Quarter 2*, 2019). However, the sample for the present study differs in selection frame in that Statistics South Africa considers the population as between the ages of 15 – 64 (*Quarterly Labour Force Survey: Quarter 2,* 2019, p. 1), while the age range for the present study is 18 – 64 and this might slightly account for the difference in employment rates.

4.3 Baseline variables

In order to ascertain if the randomisation plan (Appendix 7) was conducted thoroughly and the allocation of participants was done in a truly random fashion, a common test used is the comparison of baseline variables between groups (Roberts & Torgerson, 1999). Therefore, baseline variables (age, gender, home language, highest level of education (HLOE), employment status, and employment type), were compared using the standardised mean effect size (SMES) (Woodward, 2014, p. 633). As noted by Woodward (2014), SMES is a statistic that is useful because it operates independently of the sample size. By definition, the participants in the two groups in a randomised trial are 'the same' in the population at large, and hypothesis testing will only be of the efficacy of the randomisation process used; the larger the sample size, and the greater comparisons made, thus the more likely we are to obtain at least one significant result (Woodward, 2014). Yatani (2016) points out that Null Hypothesis Significance Testing (NHST) is a common method of analysis in HCI, but this is frequently problematic as by simply increasing the sample size one can gain a significant result. The present study hopes to determine if there is a difference in the samples which were obtained, and not merely finding a significant result due to the sample size. The concern for the present study is whether there are any differences in the sample obtained and so the SMES is used to compare the groups to ascertain if there were any differences.

The SMES of the baseline variables are tabulated (Table 4.3) and normally a threshold of 10% for important imbalance is used (Woodward, 2014). Most of the baseline variables; age, gender, and highest level of education are below the 10% threshold so it can be concluded that there is no significant difference between the control and experimental groups based on these variables. There is, however, a difference between the two groups based on home language (16.7%) and employment status (18%). Woodward (2014) notes that the SMES should only be considered important if it is predictive for outcomes.

Table 4.3

SMES of the Baseline Variables

Variable	Category	SMES (%)
Age (grouped) (years)	18 - 24	9.5
	25 - 34	2.7
	35 - 44	6.7
	45 - 64	10.0
Gender		2.0
Home language (grouped)		16.7
HLOE		9.5
Employment status (grouped)		18.0

4.4 Advert recall

Table 4.4 shows how participants performed on the advert recall questionnaire in each group. The cumulative probability ($P(X \geq x)$) that participants got 13 or more correct out of 20 (with three choice options per question) is 0.0037. Therefore, the observed mean advert recall scores in both groups suggest that working memory of participants were fully engaged in order to achieve 13.2 and 13.8 out of 20 respectively.

Table 4.4

Working Memory Test (advert recall questionnaire)

Advert recall score	Mean score	Std Dev	Cumulative Probability
Control	13.2	3.2	0.0037
Experimental	13.8	3.1	

4.5 Share rating measures

4.5.1 Share evaluation (within-groups analysis)

Table 4.5 shows the descriptive statistics and true sum values of the shares shown to participants. The only share manipulated in the experimental condition was RONAT, where the share returns were animated on screen. After the memorisation task and advert recall questionnaire, participants were asked to evaluate each of the 5 shares on a scale from 0 (very bad) to 10 (very good).

Table 4.5

Descriptive Statistics Showing the True Sum Values for the Shares

	RONAT	ELSKAR	FAMO	NARWIG	PITTLER
True median	21	28	32	44	48
True sum of share	300	400	500	600	700
No of returns shown	15	15	15	15	15

Comparison of a share rating measure across the 5 shares, within a group, was done by one-way repeated measures ANOVA with the rating measure as the dependent variable, share as the independent variable, and participant as the repeated measure. Post-hoc tests were carried out using the Tukey adjustment for multiple comparisons. The correlation between each pair of ratings, within a group, was determine by Spearman's correlation coefficient, since not all the variables were normally distributed and hence the assumptions for Pearson's correlation were not met.

4.5.2 Share evaluation in the control group (within-group)

The overall between-share test was significant ($p<0.0001$). The Least-Squares (LS)-mean evaluation scores are shown in Figure 4.3 (error bars denote the 95% confidence interval (CI) for the mean). Post-hoc tests showed the following between-share differences:

RONAT < ELSKAR, NARWIG, PITTLER; FAMO < NARWIG, PITTLER. This result reveals how the participants' evaluative judgments consistently reflect the rank order (ordinal ranking) for each share (Table 4.5) with the exception of the FAMO share.

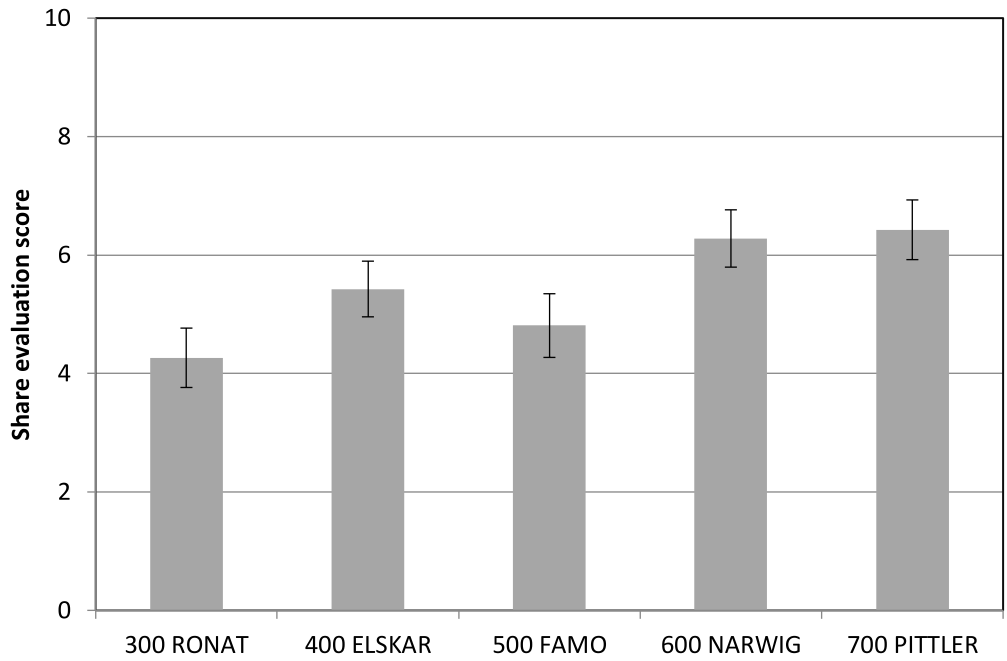

Figure 4.3 Share evaluation (within-group) control group

4.5.3 Share evaluation in the experimental group (within-group)

In the experimental group the setup was exactly the same as for the control group except the lowest value share (RONAT) was manipulated to animate on screen (see video link for example: http://bit.ly/experimental-group). The overall between-share test was significant ($p<0.0001$). Post-hoc tests indicate interactions between-share differences: ELSKAR, FAMO < RONAT, NARWIG (Figure 4.4). The evaluative judgments in the experimental group do not reflect the ordinal ranking of the actual shares accurately as they do in the control group. The study therefore rejects the null hypothesis in favour of the alternative hypothesis that animation can alter the way in which information is integrated and the resulting judgmental evaluation that is formed.

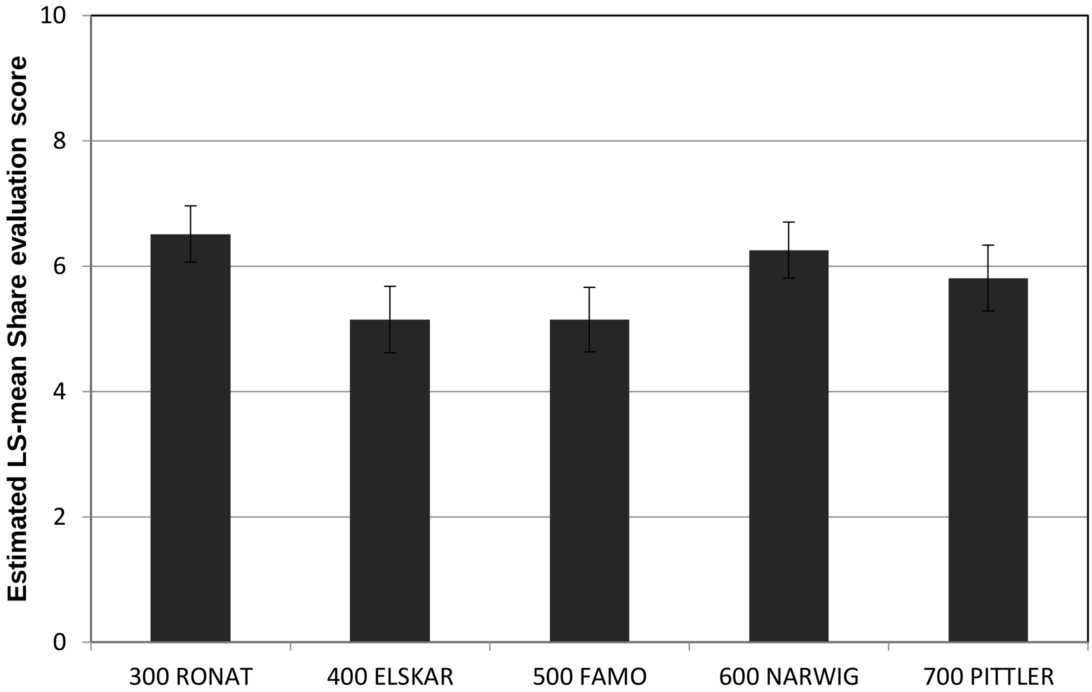

Figure 4.4 Share evaluation (within-group) experimental group

4.6 Share evaluation between groups (base model without covariates)

The between-groups analysis was done using a two-way repeated-measures ANOVA with the rating measure as the dependent variable, group and share, and their interaction, as the independent variables, and participant as the repeated measure (Appendix 15). Post-hoc tests were carried out using the Tukey adjustment for multiple comparisons. The effect of group ($p=0.028$), share ($p<0.0001$), and the share-group interaction ($p<0.0001$) were all found to be significant.

The share-group interaction displays the difference between the groups for a given share. Post-hoc tests indicated the following significant differences in the control group (Figure 4.3), RONAT, FAMO < NARWIG, PITTLER. This result reproduces Betsch et al.'s (2001) original research where evaluative judgments accurately reflected the actual sum values of the shares. By contrast, in the experimental group this pattern of evaluative judgments was not maintained and the participants evaluated the shares as follows ELSKAR, FAMO < RONAT; ELSKAR < NARWIG (Figure 4.5).

The independent variable in the present study was animation, where in the control group no animation was used in the interface, but in the experimental group the lowest value share, RONAT, was animated on screen. The between-groups analysis for RONAT indicates that the evaluative judgment for the share is significantly different ($p<0.0001$) and it suggests that animation has had an effect on the judgmental evaluation that participants have made for each share (Figure 4.5).

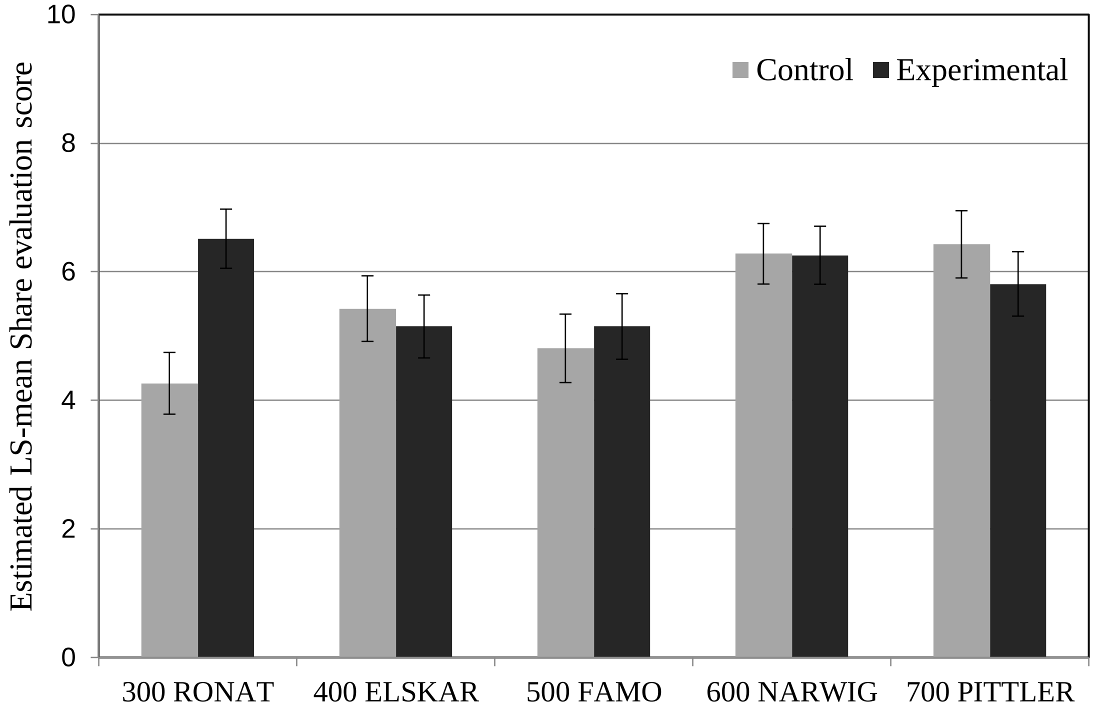

Figure 4.5 Differences between control and experimental groups

4.6.1 Examination of covariates

The variable pairs (age, employment), (age, HLOE) and (HLOE, employment) were strongly associated (Cramer's V or Phi coefficient > 0.70), and hence could not be used together in the model with covariates. Of these variables, HLOE was assumed to be the most likely to influence the dependent variable metrics, and HLOE was retained as a covariate and age and employment status were removed from consideration.

In the model with covariates the effect of share, and the share-group interaction were significant (both $p<0.0001$). However, none of the covariates were determined to be significant and all conclusions were as for the base model (Figure 4.6).

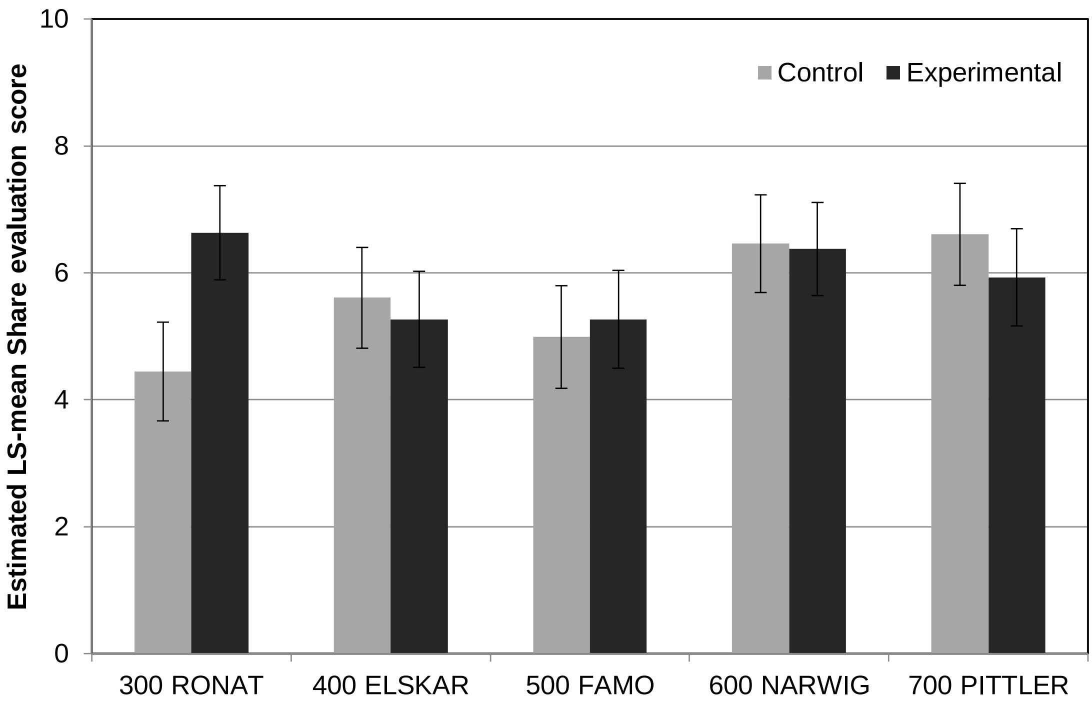

Figure 4.6 Model with highest level of education as covariate

4.7 Estimated sums and averages for shares

The ordinal ranking of the shares (i.e. the actual return values for each share added up and then ranked in order of their summative value) should be RONAT 300, ELSKAR 400, FAMO 500, NARWIG 600, and PITTLER 700 (Table 4.5). Participants were asked to estimate the sum and average values after they had given a judgmental rating for each share. The median estimated sum and average returns for each share were compared to their corresponding true values using the Wilcoxon Signed-Rank test.

4.7.1 Sum estimations (control group)

In the control group, for the sum of returns, the overall between-share test was significant ($p=0.0013$). Post-hoc tests showed the following between-share differences: FAMO < NARWIG, PITTLER. Figure 4.7 shows that the estimated mean sum of the returns did not correspond at all to the actual sum of the returns. This suggests that participants had not memorised the values and were not able to give a close estimate for this value.

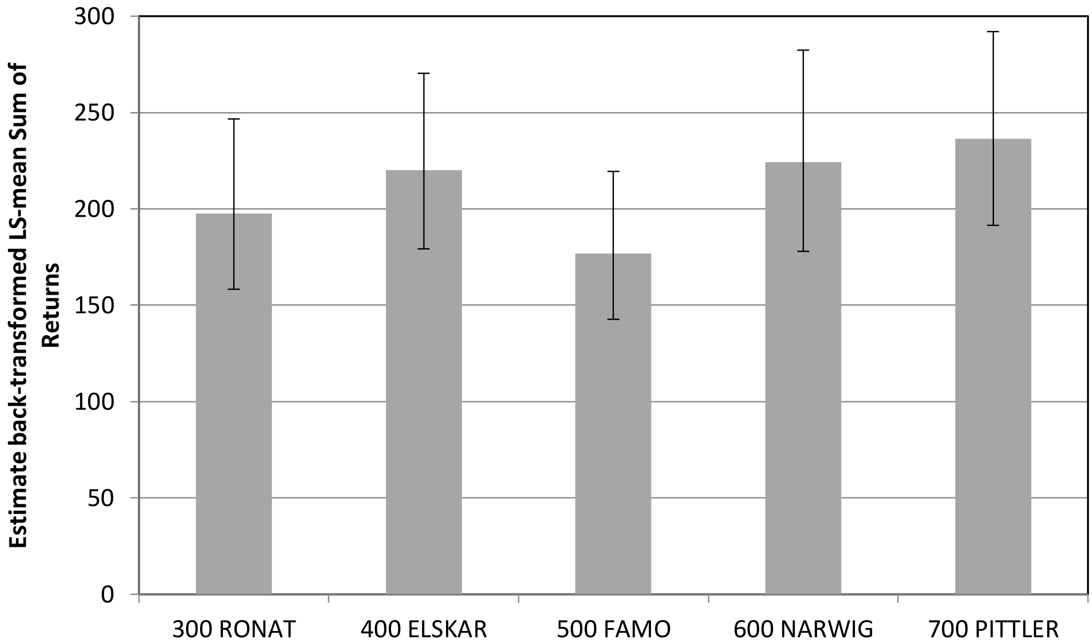

Figure 4.7 Estimated mean sum of returns vs true sum of returns (control)

In order to explicitly test that the estimated values were lower than the true values, the Wilcoxon Signed-Rank test was used. This test was used because the data were not normally distributed and it is a nonparametric test that compares two related samples (Laake & Fagerland, 2015). For each share the observed median sum of returns was significantly lower than the true value (Table 4.6).

Table 4.6

Comparison of Estimated (observed) Median to True Median (control group)

Share	Observed Median	True Median	p-value
RONAT	33	21	<0.0001
ELSKAR	36	28	0.025
FAMO	22	32	0.012
NARWIG	35	44	0.0030
PITTLER	40	48	<0.0001

4.7.2 Sum estimations (experimental group)

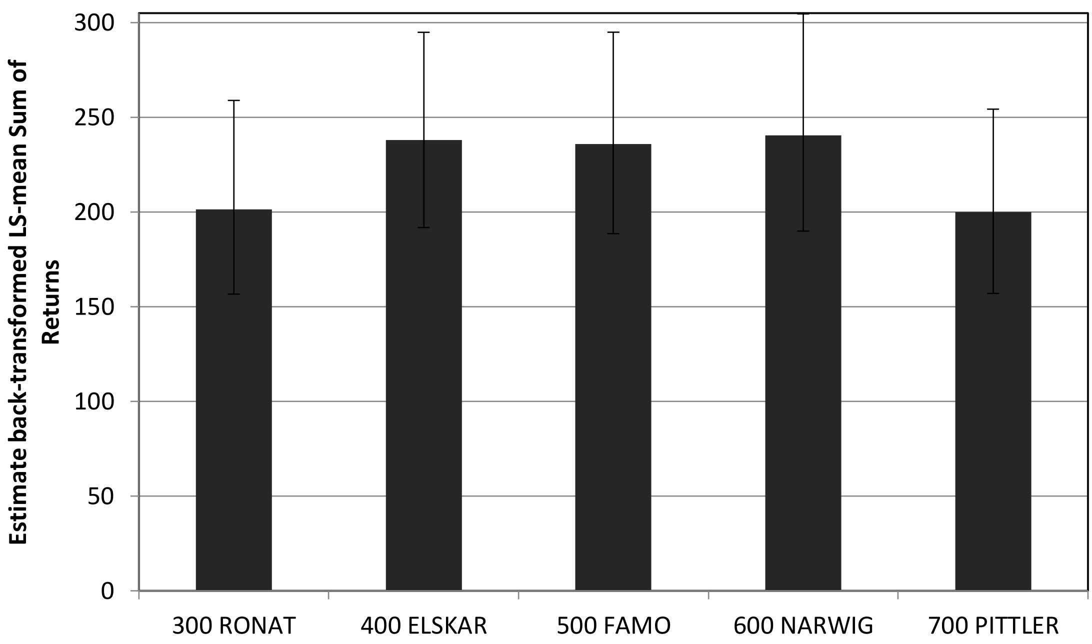

Figure 4.8 Estimated mean sum returns vs true sum of returns (experimental)

With the exception of RONAT, for each share the observed mean (Figure 4.8) and median sum of returns was significantly lower than the true value (Table 4.7). As in the results for the control group, this suggests that participants had not memorised the values and were not able to give a close estimate for this value.

Table 4.7

Comparison of Estimated Median to True Median (experimental group)

Share	Observed Median	True Median	p-value
RONAT	33	21	<0.0001
ELSKAR	36	28	0.025
FAMO	22	32	0.012
NARWIG	35	44	0.0030
PITTLER	40	48	<0.0001

From the data presented in both the control and experimental groups it can be concluded that the observed medians showed no trend with regard to the true values.

4.7.3 Average estimations (control group)

For RONAT ($p < 0.0001$) and ELSKAR ($p = 0.025$), the observed median average return was significantly higher than the true median value; while for the other three shares, the observed median average return was significantly lower than the true median value (FAMO, $p = 0.012$; NARWIG, $p = 0.0030$; PITTLER, $p < 0.0001$). Figure 4.9 illustrates the difference between the observed median and the true median with error bars denoting 95% confidence interval for the mean.

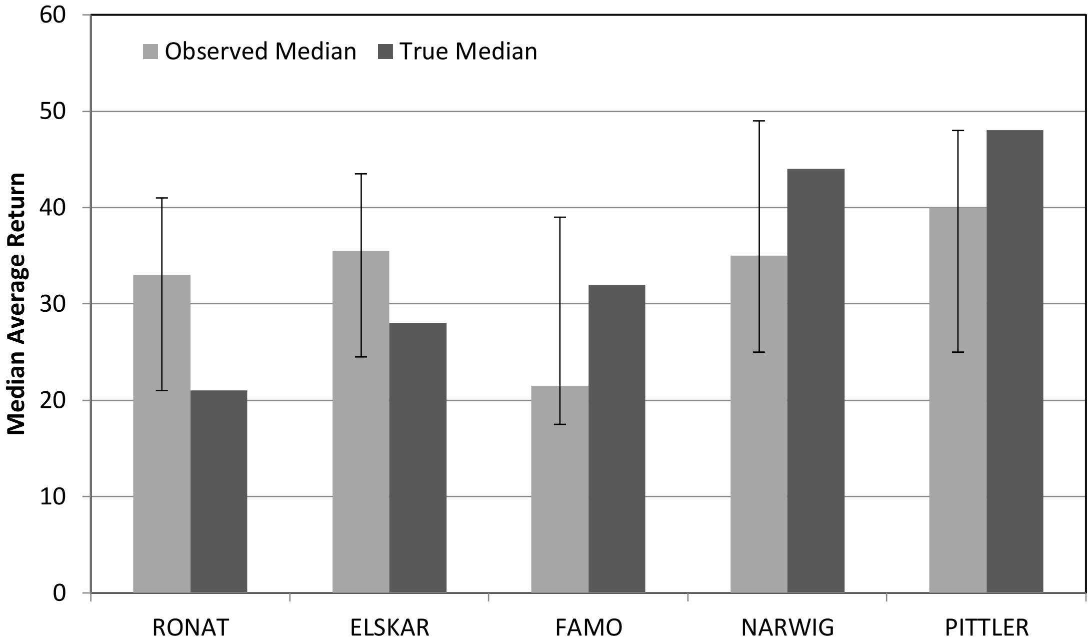

Figure 4.9 Observed median average vs true median average (control group)

4.7.4 Average estimations (experimental group)

For RONAT (p = 0.0001), the observed median average return was significantly higher than the true median value; while for NARWIG (p = 0.003) and PITTLER (<0.0001), the observed median average return was significantly lower than the true median value. There was no significant difference for the other two shares (ELSKAR, p = 0.050; FAMO, p = 0.60). Although there are two non-significant comparisons, no overall trend was observed in the average estimations made by participants (Figure 4.10).

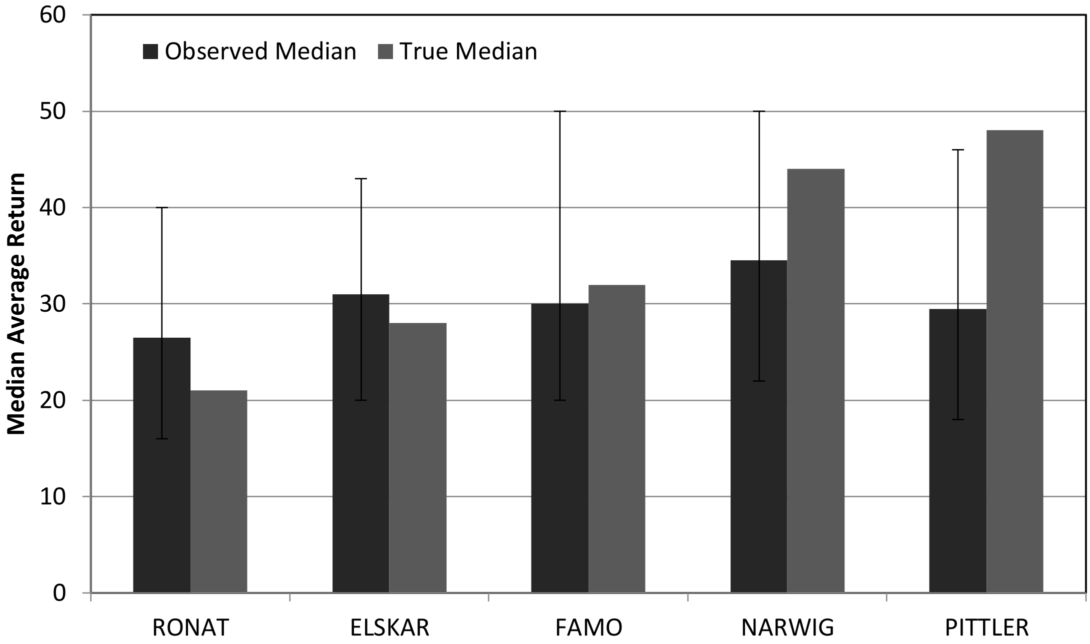

Figure 4.10 Observed median average vs true median average (experimental group)

4.8 Summary of key results

On the advert recall questionnaire, participants achieved 13.2 out of 20 in the control group and 13.8 out of 20 in the experimental group. The cumulative probability of getting 13, or more, correct at random in a multiple choice questionnaire with 3 option selections for each question is 0.0037.

In the share evaluation task, the overall between-share test was significant in the control group ($p<0.0001$) as well as in the experimental group ($p<0.0001$). In the control group the judgmental evaluation of the shares reflected the true ordinal ranking of shares. In the experimental group the judgmental evaluations did not reflect the true ordinal ranking of the shares.

In the between-groups analysis for judgmental evaluation of shares, the effect of group ($p=0.028$), share ($p<0.0001$), and the share-group interaction ($p<0.0001$) were all found to be significant. The between-groups analysis for the share RONAT (the only variable manipulated in the experimental condition) indicates a significant difference in evaluative judgment for the share ($p<0.0001$).

When participants were asked to give estimates for the sum of all returns for a share and the average value of each share, it was found that there was no trend in the data. The estimated sum and average values showed no correspondence with the actual sums and averages of the returns.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter discusses the principal results obtained, through relating them to the study hypothesis and previous research. The relationship of decision making to intuitive interaction has been discussed in terms of information integration and judgmental evaluation which are considered core processes of intuition from the JDM perspective (Betsch & Roth, 2018; Betsch & Glöckner, 2010; Glöckner & Betsch, 2012).

The key hypothesis was that animation could have an effect on how individuals perceive and evaluate information in a mobile interface. The control condition replicated an experiment by Betsch et al. (2001) which suggested that individuals could integrate a large amount of information without intending to do so, and without an impact on working memory. The experimental condition in the present study extended this research by introducing interface animation as an independent variable to determine what effect this would have on information integration. The results are discussed below with reference to the prevailing theories in JDM and HCI and specifically related to what contribution it might imply to the study of intuitive interaction.

5.2 Information integration and judgmental evaluation

The primary prediction for the control group was that participants would rate the shares in an ordinal ranking, i.e. they would be able to rank the shares from least to most valuable. The secondary prediction was also that participants would not be able to give accurate estimated values for the sums and averages of each of the five shares. The dual-task nature of the experiment ensured that it would be highly unlikely that participants could form explicit attitudes about the shares. This was accomplished in two ways. First, participants were told that the share information was the distractor from the main task of memorising the pictorial adverts, and secondly 75 share returns were presented during the experiment which is a much greater number than working memory can retain (Baddeley, 2003). As per Betsch et al. (2001), participants in the present study were told that the aim of the experiment was to assess the functioning of working memory under distraction conditions. They were therefore requested to memorise pictorial adverts (framed as the main task) while reading out share return values that appeared on the screen (framed as the distractor task). Thus, participants were encouraged to focus on memorising the pictorial adverts.

In the control group, a significant relationship ($p<0.0001$) was found between the judgmental evaluations made and the overall between-share test. The outcomes are thus consistent with those from the original experiment conducted by Betsch et al. (2001). The attitude judgments (Figure 4.3) reflected a remarkable sensitivity to the actual sum values of the share returns (Table 4.5). Participants were able to ordinally rank the shares without explicitly being able to say why they ranked each share as they did. All the between-share rankings were significant except for FAMO which will be discussed in the limitations (section 5.4). These results therefore suggest that participants in the control group were able to automatically and accurately integrate all 75 share return values shown to them during the memorisation task.

In order to test that working memory was engaged during the memorisation task, participants were asked to complete a multiple choice questionnaire to assess their recall of the adverts (Betsch et al., 2001; Betsch & Glöckner, 2010). This study found that advert recall scores in the multiple choice test were higher than chance since the cumulative probability of getting an average of 13 out of 20 by chance was very low (0.0037).

Participants' judgmental evaluations of the shares had a significant relationship to the actual sum values of those shares. This infers that automatic processing is capable of integrating multiple pieces of information in parallel, without participants intending to do so. Further to this finding, it also corroborates the hypothesis that automatic information integration does not significantly impact cognitive resources such as working memory (Betsch et al., 2001; Betsch & Glöckner, 2010).

From a theoretical perspective this provides support for the results shown by Betsch et al. (2001) and their assertion that intuition is capable of "quickly processing multiple pieces of information without noticeable cognitive effort" (Betsch & Glöckner, 2010, p. 279). Results from their original (see Betsch et al., 2001) and subsequent experiments (see Betsch et al., 2003; Plessner et al., 2008) indicate that participants were able to judgmentally evaluate information, without intending to do so, and these evaluations systematically covaried with the actual values presented in the interface.

If participants' evaluations were based on heuristic processing strategies, then it would be expected that there would be no relationship between the evaluations and the actual share values. This is because heuristic processing only considers a subset of information (Betsch, 2008; Evans & Stanovich, 2013b; Tversky & Kahneman, 1974). If automatic processes only considered a subset of the share information, then the judgmental evaluations of the shares would not have been as systematically accurate as has been observed in the control group. The results from both the present study and Betsch et al. (2001) indicate that participants gave judgmental evaluations that systematically covaried with the actual share values (Betsch et al., 2001; Betsch & Glöckner, 2010). This further infers that Betsch et al. (2001) are correct in their claim that intuitive processes are able to consider all the available information presented and integrate them in an additive fashion (Betsch et al., 2001; Glöckner & Betsch, 2008).

Participants were able to memorise advert information at the same time as automatically developing judgmental evaluations about the shares (without intending to do so). What this suggests is that explicit and automatic processes of cognition act in parallel (Betsch & Glöckner, 2010; Glöckner et al., 2014). The implication for research into intuitive interaction in HCI is that designers need to be aware that there are at least two ways the information provided in a mobile interface can be used by the different cognitive systems (Type 1 and Type 2). As suggested by work in JDM these distinct processes of cognition share decision making behaviour (Betsch et al., 2001; Betsch & Glöckner, 2010) and it would benefit HCI if this relationship was better understood when designing mobile interfaces.

5.3 Information integration and the effect of animation

The experimental condition in the study was a replication of that of Betsch et al. (2001). This research was extended by considering what effect interface animation (IV) would have on information integration. It was hypothesised that there would be a relationship between animation and how individuals integrate information based on previous work which has suggested that animacy in an interface captures visual attention (Abrams & Christ, 2002; Franconeri & Simons, 2005; Von Mühlenen & Lleras, 2013; Pratt et al., 2010) and automatically induces cognitive processing (Pratt et al., 2010). Further to this, previous research in JDM has also suggested that the way in which information is presented (the input stimulus) can influence how it is integrated (Glöckner & Betsch, 2008) and has an effect on how this information is processed (Söllner et al., 2013).

In the experimental condition the lowest value share (RONAT) was animated in the interface and was the only variable manipulated in this condition (compared to the control condition). The prediction for the experimental condition, based on the literature, was that participants would rate the animated share (RONAT) differently to how it was rated in the control condition. In the control condition, participants were able to evaluate the share information and systematically order each share from lowest to highest in summed value (i.e. all returns shown for each share added up). Further to this, in both groups, participants could not give accurate estimates for the summed or average values of each share. This infers that the dual-task had succeeded in focusing attention on the pictorial adverts and not the share returns. Participants in the control group, however, were still able to systematically rank the shares from lowest to highest value even though working memory was constrained by the memorisation task. This therefore suggests that the intuitive process of information integration was responsible for providing accurate judgmental evaluations of all five shares in the control condition.

In accordance with the prediction made, it was therefore found that RONAT was rated significantly higher in the experimental group than it was rated in the control group ($p <.0001$). Post-hoc tests using the Tukey procedure indicated that there was a significant difference in how participants rated RONAT (within-group) compared to ELSKAR and FAMO (significantly lower $p<0.0001$) and NARWIG (significantly higher $p<0.0001$).

The tasks in the experimental group were identical to the control group and the only variable that was changed was that RONAT was animated in the interface. The SMES comparison indicated that there were no major predictive differences between the two groups in terms of baseline variables. Two variables (Home Language 16.7% and Employment status 18%) had an SMES higher than 10% which is the threshold used to indicate imbalance (Woodward, 2014). As Woodward (2014) notes, however, an imbalance should only be considered important if it is regarded as predictive of the outcomes obtained. For the present study, the Highest Level of Education (HLOE) was regarded as a predictive variable and it had an SMES score of 9.5% which suggests that the two groups in the study were balanced in this regard. Further to this, HLOE as a covariate gave the same share-group interaction as the base model without covariates.

What this suggests is that there was a causal relationship between the animation applied to the interface and how the specific share information for RONAT was integrated by participants. The subsequent judgments made about this share when ranking it against the other four shares was significantly out of proportion in the between-share analysis and the between-group analysis.

In previous research it has been suggested that animation is prioritised by the visual system (Abrams & Christ, 2002) and that humans process animate objects over inanimate ones in an interface (Pratt et al., 2010). This infers that animation has a distinct interaction with the cognitive system. Further to this, the way that information is presented in an interface has an effect on how accessible it is to automatic processing (Söllner et al., 2013). It has also been suggested that this processing fluency effect is able to influence judgments (Bolte & Goschke, 2005; Kahneman, 2011; Topolinski & Strack, 2009). Results from the present study therefore corroborate the hypothesis that animation may have an influence on information integration and judgments. A significant difference ($p<0.0001$) was found between groups in how participants judgmentally evaluated the lowest value share (RONAT) and this validates the hypothesis proposed in H1 that animation has an effect on the automatic process of information integration. The study therefore rejects the null hypothesis. It is pertinent to note that while this result suggests that animation has an effect on information integration, it cannot be generalised to all interface animation types.

The observed influence on how information was integrated could be attributed to how animation is prioritised and processed by the cognitive system (Abrams & Christ, 2002; Pratt et al., 2010) and it could be argued that it makes the animated information more accessible to automatic processing (Söllner et al., 2013). What this suggests for the study of intuitive interaction in HCI is that the presentation format of information in a mobile interface could have an effect on how individuals interact with it. The concept of information integration and judgment formation could be used by designers to create assistive interfaces that are better geared towards helping individuals make decisions. The designer could also create interfaces that do not require their users to unnecessarily expend cognitive resources such as working memory (Cohen et al., 2016; Glöckner, 2010; Grgic, Still & Still, 2016). Further to these findings, the results of the study suggest that animation may be used to foster intuitive interaction through a better understanding of information integration and judgment formation. The current study therefore strongly infers that animation can have a significant effect on how information is integrated. The designer could use this knowledge to create interfaces that are automatically understood and used by individuals.

In terms of the conclusions reached by professionals in the design and development space (Babich, 2017; Carine, 2019; Head, 2016; Yalanska, 2015), the present study supports the notion that animation could contribute to how users cognitively engage with mobile interfaces. There are major limitations to the scope, however, and at present there is only crude evidence that animation can support decision making processes from the specific context of the experiment conducted. Further study is needed in order to fully understand how animation can support decision making, in which contexts it can assist in design and what presentation formats foster or detract from automatic information integration.

5.4 Limitations

This study has potential limitations. The first is that recruitment was problematic in that it had a disproportionate number of tertiary-educated participants and thus it is not representative of the general South African population, nor does it allow the study to make easily generalisable claims about the findings to those without a certain level of education. In the analysis of covariates, highest level of education was used, and all conclusions were the same as the base model, but a more representative sample could potentially produce differing results. The potential impact on the results could be that there might be a greater variance found in a population that is not tertiary educated and this is a limitation on the generalisability of how large amounts of information can be integrated and the effect that animation has on this process.

The second limitation concerns the variance with how the share FAMO was rated by participants. It was not evaluated and ordinally ranked as the other shares were. In the control group the share was rated as expected where FAMO < NARWIG, PITTLER, but it was also rated as FAMO < ELSKAR which was not expected. Similarly, in the experimental group it was expected that it would be rated less than NARWIG, PITTLER and RONAT (in line with the study hypothesis), but unexpectedly FAMO was also rated as FAMO = ELSKAR. This variance in rating did not present itself in the pre-study. In the main study it was ascertained from post-experimental interviews and from notes made while participants talked out loud during the experiment that FAMO sounded very like a culturally popular acronym FOMO or Fear Of Missing Out. This is the fear that “everyone else is having more fun, more excitement and more rewarding, anecdote-worthy experiences than you” (Cohen, 2013). This negative sounding name could have potentially culminated in a negative association for participants and thus the ability to skew the relevant shares.

5.5 Directions for future research

The study provides initial evidence that animation can influence how information is processed and future studies may extend this by investigating the exact properties of animation that have this effect. The present study provides crude evidence for this relationship and further study is needed in order to determine how generalisable these results are and which contexts they are applicable in.

The primary recommendation from this study is that the research programme into intuitive interaction needs to further consider the cognitive basis for intuition and incorporate research in cognitive science in order to progress. The secondary recommendation is that animation as a functional tool should be more closely studied as there is crude evidence that it might assist users in decision making processes. Further to this, it has been shown that functional animation does not create additional cognitive overhead. This finding is potentially useful to design researchers and may assist in a better understanding of how users and interfaces interact.

From the results obtained in the experiment, it is reasonable to suggest that there is a need to investigate interface animation as a functional cue to aid users in achieving their goals. It is also reasonable to make the claim that animation may be a valuable tool in the designer's toolkit because it, in effect, allows the designer to *hack* the user's perception and understanding of elements presented in the interface.

CHAPTER 6: CONCLUSION

In the IT space, design and development professionals have credited interface animation with cognitive benefits and making interfaces intuitively easy to use (Babich, 2017; Carine, 2019; McLeod, 2019; Head, 2016; Yalanska, 2015). There is, however, not much research in the intuitive interaction field that supports these claims.

Although intuitive interaction research has made substantial progress in creating models and instruments to explain and measure this type of interaction, it suffers from not referencing cognitive research (O'Brien, 2010; Still & Still, 2019b). The current study has attempted to address this gap by taking a first step toward combining cognitive and design research. It has imported an experiment from the JDM field (Betsch et al., 2001) that is purely cognitive in nature and applied it to design. It has also discussed the automatic nature of intuition in terms of information integration and judgmental evaluation as key concepts.

While the emphasis in HCI on prior experience as the leading contributor to intuitive interaction has several justifications (Blackler, 2019; Blackler et al., 2003, 2010; Blackler & Popovic, 2016), the existing research in HCI has failed to adequately describe the underlying processes of information integration and the automaticity of decision making.

The results from the present study have validated work in JDM in that intuitive processes, in certain contexts, can integrate large amounts of information without taxing cognitive resources (Betsch et al., 2001; Betsch & Glöckner, 2010; Haberstroh & Betsch, 2002). Further to this, the results suggest that the automatic processes of intuition are sensitive to animation as a design element in the mobile interface.

The key contributions made by the present study are that the automatic, or intuitive, process of information integration can be influenced by interface animation. This extends the research of intuitive interaction in HCI into the judgment and decision making field and may assist designers in re-conceptualising their approach to how information is made accessible and treated in mobile interfaces.

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Appendix 1 : Participant information sheet

THE WITS SCHOOL OF ARTS

PARTICIPATION INFORMATION SHEET

Good day, my name is Nathan Anderson and I am currently studying towards a master's degree in digital arts through the University of the Witwatersrand. I invite you to take part in this study where the purpose is to understand a person's capacity for memorising information about adverts while being distracted by other sources of information.

Activities: Firstly, you will be asked to fill out a short questionnaire, then you will be asked to view a set of twenty adverts and memorise them while reading out loud stock information that will appear at the bottom of the screen. The study activities also include completing questions about the adverts and two post-activity questions. Your participation in this study will require approximately 30 minutes of your time. Participation in this study will involve no cost to you. You will not be paid for being part of this research study, but if you choose to do so your name will be entered into a raffle where the randomly drawn winner will receive a R1500 gift voucher for the online shopping retailer Takealot.com. The raffle winner will be notified once data collection has been completed in approximately three to four months' time.

Risks: The only potential risk is that you might become frustrated with the speed of the experiment. There are no other risks associated with participation in the study. Should completion of any task become distressing to you, it will be terminated immediately.

Confidentiality: No sensitive information is needed for the purposes of this study. Your participation in this study will remain confidential. You will not be identified in the final dissertation and your individual data will be assigned a code for processing.

Voluntary: Participation in this study is voluntary. You MUST be over 18 years of age. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may refuse to answer questions that make you feel uncomfortable and you can withdraw from the study at any time.

I would also like to ask your permission to use the data collected for inclusion in academic journal articles and presented at academic conferences. These are places where industry professionals and academics can learn about design and mobile application development to improve their practice. The final dissertation will be made available on WITS online (Wired Space). Should you require a summary of the research this will be made available on request.

Study contacts: Should you have questions regarding the study please contact me: Nathan Anderson at 1608928@students.wits.ac.za / 079 490 6463. Alternatively, please contact my academic supervisor: Dr Tegan Bristow in the Digital Arts department at Wits University (Tegan.Bristow@wits.ac.za) / 011 717 4604, or Dr Ted White at the Westfalische Hochschule / Westphalian University of Applied Sciences (epgwhite@gmail.com).

Appendix 2 : Consent form

THE WITS SCHOOL OF ARTS

CONSENT FORM

I understand that as a participant in this study I will be asked to fill out questionnaires and complete a memorisation task and do a closing interview. I acknowledge that I will be required to view twenty pictorial adverts and answer questions about the content. I also declare that:

I have read and understood the information in this consent form.	I understand that I am not waiving my legal rights as a result of signing this consent form.
I have been encouraged to ask questions and am satisfied with the responses to my questions.	I understand that it is unlikely that this study will provide any benefits to me.
I understand all the data collected will be kept confidential and that the results are to be used for academic purposes.	I acknowledge that anonymised data from this study may be used for conference abstracts, presentations and for peer-reviewed publication.
I understand that my participation in this study is voluntary and I am free to withdraw at any time.	I confirm that I am at least 18 years of age

Please give your name and surname.

Your name will be used in case you need to be contacted for any reason. It will be substituted in the data files with a unique number so that you cannot be identified by anyone other than the principal researcher, Nathan Anderson.

Please sign to indicate that you have read and agree with the terms laid out in the participant information sheet and the consent form shown above.

× SIGN HERE

clear

I hereby declare that I have read and understood the participant information sheet. This research study has been explained to me and I understand what it means to be a participant in this study.

January 23, 2019

I agree to participate in this study.

I do not want to participate in this study.

Appendix 3 : Demographic Questionnaire

What is your age?

What is your gender?

- Female
- Male
- Transgender
- Other
- Prefer not to say

What is your home language?

- isiZulu
- isiXhosa
- Tshivenda
- Setswana
- Xitsonga
- Siswati
- Sesotho
- Afrikaans
- Sepedi
- isiNdebele
- English
- Other

What is your highest level of education?

No formal schooling

Grade 9 (old standard 7)

Completed Grade 12 (Matric)

Bachelor's degree

Honours degree

Master's degree

Doctor's degree (PhD)

Higher Certificates OR Advanced National (vocational) Certificate

National Diploma and Advanced certificates

What is your current employment status?

Working (paid employee)

Working (self-employed)

Not working (temporary layoff from a job)

Not working (looking for work)

Not working (retired)

Not working (disabled)

Not working (other)

Prefer not to answer

What area do you work in? (Choose the closest matching option):

- Management, professional, and related
- Service
- Sales and office
- Farming, fishing, and forestry
- Construction, extraction, and maintenance
- I.T. and technology
- Production, transportation, and material moving
- Advertising and media
- Government
- Retired
- Unemployed
- Full-time student

Appendix 4 : Written Instructions

In the following section, you will be shown a set of twenty adverts that you need to memorise. A short questionnaire will assess your memory of these adverts after you have had a chance to memorise them. The challenge is to try memorising the adverts while reading out loud the share information at the bottom of the screen. Please read all share values out loud at all times. The advert section will open up in a new browser tab and it will take approximately five minutes to complete. Once the section is complete you will navigate back to this tab to continue with the questionnaire. When you are ready - click this link to begin. *(Note: the link took the participant to the assigned experimental condition).*

Appendix 5 : Advert recall questionnaire (randomised order)

THE WITS SCHOOL OF ARTS

What type of product is the "New Desert Star"?

- A holiday adventure
- A diamond ring
- A bangle

What colour dress did the lady in the Virginia Slims advert wear?

- Pink / Red
- Yellow
- Green

What vitamin is Vitamin Donuts fortified with?

- Vitamin D
- Vitamin B1
- Vitamin A

What brand showed a clown with a plate of pasta?

- Pates Baroni
- Barony Pasta
- Fatti's & Moni's

What colour is the Hornitos label on the bottle?

- Red
- Green
- Blue

What was the background colour of the Nescafe coffee advert?

- Red
- Brown
- Yellow

What type of product is Vio-Violet?

- Perfume
- Fabric softener
- Food type

What completes this combination ... M&M's and:

- Candy
- Dark chocolate
- Cookies

In the "Do women have a higher sex drive" poster, what colour are the woman's sunglasses?

- Red
- Blue
- Silver

What kind of product is the Electrasol?

- Dishwashing powder
- Dishwasher
- Pasta

In the Head & Shoulders advert what colour was the model's hair?

- Brunette
- Blonde
- Black
- Ginger

What animal is in the Bourneville Cocoa advert?

- A squirrel
- A duck
- A horse
- A rabbit

How many calories does the Tab soft drink contain?

- 4
- 250
- 499
- 1

Which product used the slogan: "Flavor enough for the whole world"?

- Hornitos advert
- Vitamin Donuts advert
- Cookies & M&M's advert
- Carling Black Label advert

What was the bottle of Absolut Vodka resting on?

- A table
- A hand
- The floor

What origin does the Lime Juice advert claim?

- West Indian
- Beaufort-West
- The West Bank

What is the slogan of Guy's Tonic?

- Treat indigestion and nervousness
- The common cold treatment
- Guy's common-sense treatment

What key word is used to describe Listerine?

- Intense
- Relentless
- Fierce
- Unstoppable

What kind of soft drink is for those "who think young?"

- Fanta grape
- Tab
- Coke lite
- Pepsi
- None of the above

Which advert had a sailor and little girl in it?

- West Indian Lime Juice advert
- Lifebuoy soap advert
- Pates Baroni advert

Appendix 6 : Share evaluation task (randomised order)

THE WITS SCHOOL OF ARTS

NARWIG : how would you rate this share on a scale from Very Bad to Very Good?

Very Bad ... Very Good
0 1 2 3 4 5 6 7 8 9 10

RONAT : how would you rate this share on a scale from Very Bad to Very Good?

Very Bad ... Very Good
0 1 2 3 4 5 6 7 8 9 10

PATEL : how would you rate this share on a scale from Very Bad to Very Good?

Very Bad ... Very Good
0 1 2 3 4 5 6 7 8 9 10

FAMO : how would you rate this share on a scale from Very Bad to Very Good?

Very Bad ... Very Good
0 1 2 3 4 5 6 7 8 9 10

ELSKAR : how would you rate this share on a scale from Very Bad to Very Good?

Very Bad ... Very Good
0 1 2 3 4 5 6 7 8 9 10

THE WITS SCHOOL OF ARTS

In this section please give an estimate for the SUM and AVERAGE values for each share. The SUM is what you estimate all the share returns would add up to in total for each share. The AVERAGE is what you estimate the average value of the returns were for each share that was shown to you.

Please estimate the SUM and then the AVERAGE VALUES for : FAMO

FAMO SUM:

FAMO AVERAGE:

Please estimate the SUM and then the AVERAGE VALUES for : PATEL

PATEL SUM:

PATEL AVERAGE:

Please estimate the SUM and then the AVERAGE VALUES for : NARWIG

NARWIG SUM:

NARWIG AVERAGE:

Please estimate the SUM and then the AVERAGE VALUES for : RONAT

RONAT SUM:

RONAT AVERAGE:

Please estimate the SUM and then the AVERAGE VALUES for : ELSKAR

ELSKAR SUM:

ELSKAR AVERAGE:

Thank you for your time.

If you have any questions regarding this study you may contact me, Nathan Anderson, on e-mail: 1608928@students.wits.ac.za or on 079 *** **63. *(Note: number redacted here only)*

Appendix 7 : Randomisation plan

The randomisation plan has been generated with random assignment software created by Dallal (2013). The online software can be seen at http://www.randomization.com/. 68 subjects randomized into 2 blocks. To reproduce this plan, use the seed 18328 along with the number of subjects per block/number of blocks and (case-sensitive) treatment labels as entered originally. Randomization plan created on 20/01/2019, 05:32:48

1. Experiment
2. Control
3. Control
4. Experiment
5. Control
6. Experiment
7. Experiment
8. Control
9. Experiment
10. Experiment
11. Experiment
12. Experiment
13. Experiment
14. Control
15. Control
16. Control
17. Control
18. Control
19. Control
20. Control
21. Control
22. Experiment
23. Experiment
24. Experiment
25. Experiment
26. Control
27. Control
28. Control
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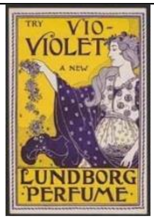
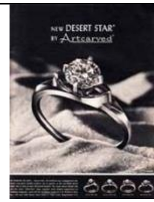
102. Experiment
103. Control
104. Control
105. Control
106. Control
107. Experiment
108. Control
109. Control
110. Experiment
111. Experiment
112. Experiment
113. Experiment
114. Experiment
115. Experiment
116. Experiment
117. Experiment
118. Control
119. Control
120. Control
121. Control
122. Experiment
123. Experiment
124. Experiment
125. Experiment
126. Experiment
127. Control
128. Control

Appendix 8 : Image sources and usage licenses

Image Label	Image Source (click link to view image online)	Usage license (click on links to view license)	Thumbnail
Do Women Have A Higher Sex Drive movie poster	Wikimedia Commons	Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)	
Lundborg Perfume advert (1890 – 1900)	Wikimedia Commons	This work is in the public domain in its country of origin and other countries and areas where the copyright term is the author's life plus 100 years or less.	
Guy's Tonic (1900 - 1909)	Wellcome Collection	Attribution 4.0 International (CC BY 4.0)	

Absolut Pure Vodka image	Wikimedia Commons	Attribution 4.0 International (CC BY 4.0)	
Pepsi-Cola advert (1962)	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	
Pates Baroni (circa 1921)	Wikimedia Commons	The author died in 1942, so this work is in the public domain in its country of origin and other countries and areas where the copyright term is the author's life plus 75 years or less.	
Nescafé advert (1950)	Flickr	Attribution-NonCommercial-NoDerivs 2.0 Generic (CC BY-NC-ND 2.0)	

Hornitos advert	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	
TAB advert (1966)	Flickr	Attribution-NonCommercial-NoDerivs 2.0 Generic (CC BY-NC-ND 2.0)	
Desert Star advert (1963)	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	
Electrasol Dishwasher advert (1973)	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	
Cookies & M&M's advert (2004)	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	

Carling Black Label advert (1972)	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	
Lifebuoy Soap advert (1900 – 1909)	Wellcome Collection	Attribution 4.0 International (CC BY 4.0)	
Virginia Slims advert (1972)	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	
West Indian Lime Juice advert	Wellcome Collection	Attribution 4.0 International (CC BY 4.0)	

Head & Shoulders advert (1966)	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	
Listerine advert (1968)	Flickr	Attribution-NonCommercial 2.0 Generic (CC BY-NC 2.0)	
Vitamin Donut advert	Wikimedia Commons	This image is a work of an employee of the Executive Office of the President of the United States, taken or made as part of that person's official duties. As a work of the U.S. federal government, the image is in the public domain.	
Bournville cocoa advert	Wellcome Collection	Attribution 4.0 International (CC BY 4.0)	

Appendix 9 : Participant unique code creation (sample)

Unique-Code	Date	Day	Gender	Participant increment	Random Seed
221124FWe79	24Feb	Wednesday	Male	79	2211
118724FTh85	24Feb	Thursday	Female	85	1187

Appendix 10 : Post-experiment interview

1. What do you think was the main purpose of the experiment?
2. Did you expect to be asked about share information after the memorisation task?
3. How much specific share return information do you feel you could recall?
4. Any other comments or questions about the experiment?

Appendix 11 : HREC ethics clearance (Non-medical)

Protocol number H19/02/01

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Anderson

CLEARANCE CERTIFICATE **PROTOCOL NUMBER: H19/02/01**

PROJECT TITLE	Intuitive interaction in mobile application interfaces and the role animation has on information integration: An empirical user study
INVESTIGATOR(S)	Mr N Anderson
SCHOOL/DEPARTMENT	Arts/
DATE CONSIDERED	15 February 2019
DECISION OF THE COMMITTEE	Approved
EXPIRY DATE	04 March 2022

DATE 05 March 2019 **CHAIRPERSON** (Professor J Knight)

cc: Supervisor : Dr T Bristow and Dr T White

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Signature

06 / 03 / 2019
Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix 12: Participant Recruitment Templates

All the below methods are examples of direct recruitment of participants unknown to the researcher.

Verbal recruitment guide (the recruiter will verbally mention all the following):

- Purpose of the study (without introducing undue bias)
- Required skills/experience to participate
- Expected duration and location
- No Rewards or compensation except for entry into a raffle for a R1500.00 Takealot.com voucher.
- How to enroll to the study or follow up to indicate interest.

Social media post (Facebook):

Facebook text post:

Do details of adverts on mobile phones stick in memory? Participate in a research study to take part of an empirical experiment to find out! A R1500.00 takealot.com voucher is up for grabs! (participation in the study gives one entry into a raffle for the Takealot.com voucher).

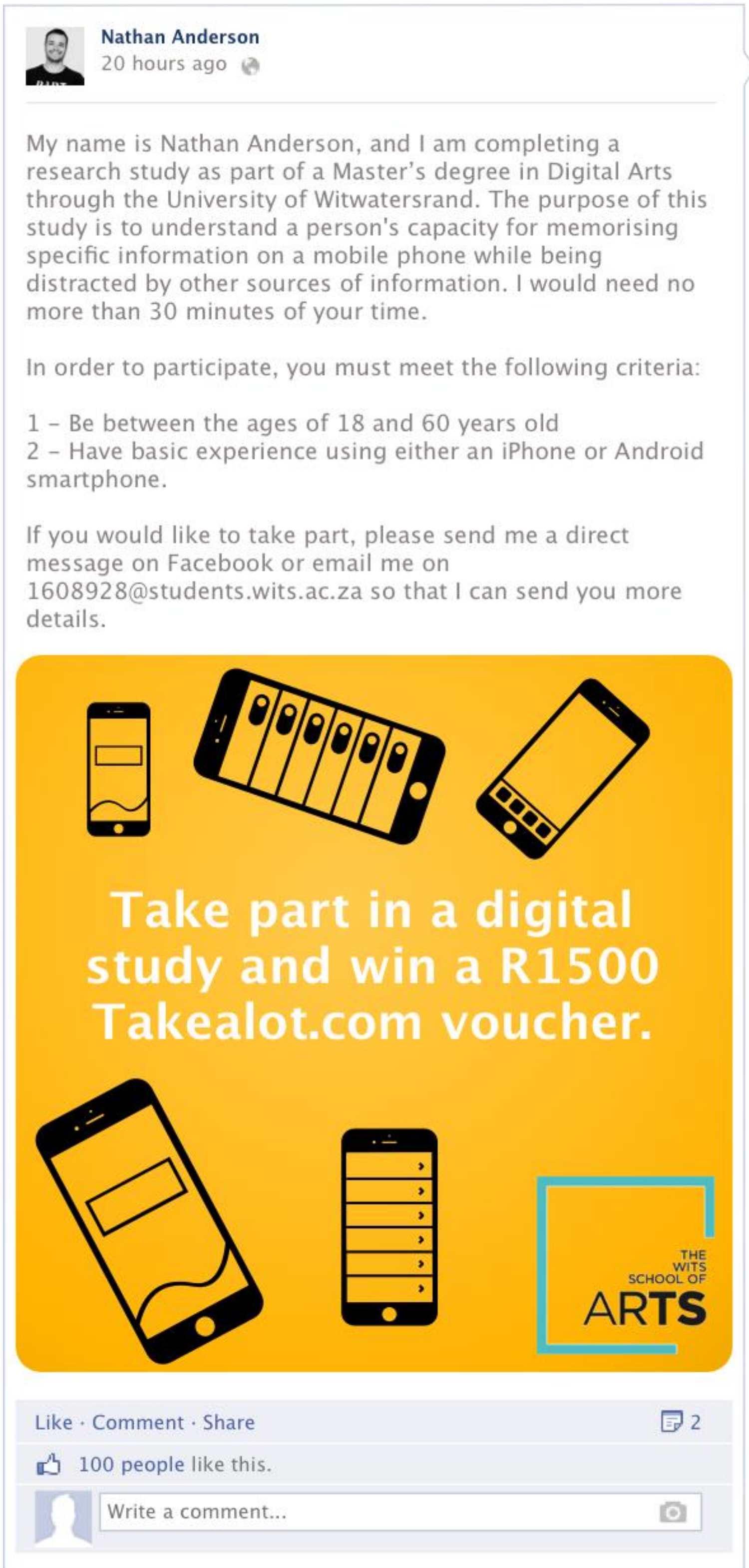
In order to participate, you must meet the following criteria:

1 - Be between the ages of 18 and 60 years old

2 - Have basic experience using either an iPhone or Android smartphone.

If you would like to take part, please send me a direct message on Facebook or email me on 1608928@students.wits.ac.za so that I can send you more details.

Facebook graphic post:



E-mail Template (generic format)

Hello [individual's name],

[Summary of our last encounter or how I know the individual.] I hope you are doing well! I am completing a research study as part of a Master's degree in Digital Arts through the University of Witwatersrand. The purpose of this study is to understand a person's capacity for memorising specific information on a mobile phone while being distracted by other sources of information. I would need no more than 30 minutes of your time.

In order to participate, you must meet the following criteria:

1 - Be between the ages of 18 and 60 years old

2 - Have basic experience using either an iPhone or Android smartphone.

If you would like to take part, please reply to this email so that I can send you more details. Please feel free to forward this to your colleagues. I appreciate your help!

Example e-mail:

Hello Victoria,

We met through the Pixel up conference in early March this year and I helped you with a question you had regarding company resources. I hope you are doing well! I am completing a research study as part of a Master's degree in Digital Arts through the University of Witwatersrand. The purpose of this study is to understand a person's capacity for memorising specific information on a mobile phone while being distracted by other sources of information. I would need no more than 30 minutes of your time.

In order to participate, you must meet the following criteria:

1 - Be between the ages of 18 and 60 years old

2 - Have basic experience using either an iPhone or Android smartphone.

If you would like to take part, please reply to this email so that I can send you more details. Please feel free to forward this to your colleagues. I appreciate your help!

Thank you,

Nathan Anderson, Principal researcher

1608928@students.wits.ac.za

079 490 6463

Appendix 13: Share return values shown to participants

Table 6.1

Actual Share Returns Shown to Participants for Each Share

	RONAT	ELSKAR	FAMO	NARWIG	PITTLER
	29	28	18	38	55
	22	43	45	20	48
	22	39	32	31	31
	21	17	47	55	55
	24	41	38	28	38
	12	33	29	52	53
	10	20	31	45	41
	25	42	28	35	52
	15	33	15	44	40
	14	19	33	32	55
	18	11	30	44	52
	18	10	38	54	46
	27	30	50	50	36
	25	16	46	24	47
	18	18	20	48	51
MEDIAN	**21**	**28**	**32**	**44**	**48**
SUM	**300**	**400**	**500**	**600**	**700**

Appendix 14: Random sum generator script (Python 2.7)

This code was made freely available on stackoverflow.com and was adapted for use in the present study. Code was based on https://stackoverflow.com/questions/40231094/generate-n-positive-integers-within-a-range-adding-up-to-a-total-in-python. The script below uses the Python language (version 2.7).

```
import numpy as np
def rndSummer(samples, sum_to , range_list):
    assert range_list[0]<range_list[1], "Range should be a list, the first element of which is smaller than the second"
    arr = np.random.rand(samples)
    sum_arr = sum(arr)
    new_arr = np.array([int((item/sum_arr)*sum_to) if (int((item/sum_arr)*sum_to)>range_list[0]and int((item/sum_arr)*sum_to)<range_list[1]) \
                else np.random.choice(range(range_list[0],range_list[1]+1)) for item in arr])
    difference = sum(new_arr) - sum_to
    while difference != 0:
        if difference < 0 :
            for idx in np.random.choice(range(len(new_arr)),abs(difference)):
                if new_arr[idx] != range_list[1] :
                    new_arr[idx] += 1
        if difference > 0:
            for idx in np.random.choice(range(len(new_arr)), abs(difference)):
                if new_arr[idx] != 0 and new_arr[idx] != range_list[0] :
```

```
                new_arr[idx] -= 1
        difference = sum(new_arr) - sum_to
    return new_arr
new_arr = rndSummer (15,700,[10,55])
print ("Generated random array is :")
print (new_arr)
print ("Length of array:", len(new_arr))
print ("Max of array: ", max(new_arr))
print ("min of array: ", min(new_arr))
print ("and it sums up to %d" %sum(new_arr))

print("Print vertically for easy copying :)" )
for i in new_arr:
    print(i)
```

Appendix 15: Statistical analysis of share evaluation between groups

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Group	1	140	4.91	0.028
Share	4	137	8.62	<.0001
Share*Group	4	137	10.17	<.0001

Least Squares Means										
Effect	Share	Group	Estimate	Standard Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Share*Group	300 RONAT	Control	4.26	0.24	140	17.56	<.0001	0.05	3.78	4.74
Share*Group	400 ELSKAR	Control	5.43	0.26	140	21.03	<.0001	0.05	4.92	5.94
Share*Group	500 FAMO	Control	4.81	0.27	140	17.86	<.0001	0.05	4.28	5.34
Share*Group	600 NARWIG	Control	6.28	0.24	140	26.37	<.0001	0.05	5.81	6.75
Share*Group	700 PITTLER	Control	6.43	0.26	140	24.30	<.0001	0.05	5.90	6.95
Share*Group	300 RONAT	Experimental	6.51	0.23	140	27.97	<.0001	0.05	6.05	6.97
Share*Group	400 ELSKAR	Experimental	5.15	0.25	140	20.81	<.0001	0.05	4.66	5.64
Share*Group	500 FAMO	Experimental	5.15	0.26	140	19.95	<.0001	0.05	4.64	5.66
Share*Group	600 NARWIG	Experimental	6.26	0.23	140	27.41	<.0001	0.05	5.81	6.71
Share*Group	700 PITTLER	Experimental	5.81	0.25	140	22.92	<.0001	0.05	5.31	6.31

Please note for the differences of least squares means calculations below, the Tukey-Kramer adjustment was used for multiple comparisons. The Alpha value used was 0.05.

Differences of Least Squares Means

Effect	Share	Group	_Share	_Group	Estimate	Standard Error	DF	t Value	Pr > |t|	Adj P	Lower	Upper	Adj Lower	Adj Upper
Share*Group	300 RONAT	Control	300 RONAT	Experimental	-2.25	0.34	140	-6.68	<.0001	<.0001	-2.91	-1.58	-3.33	-1.17
Share*Group	300 RONAT	Control	400 ELSKAR	Control	-1.16	0.37	140	-3.17	0	0.057	-1.89	-0.44	-2.34	0.02
Share*Group	300 RONAT	Control	400 ELSKAR	Experimental	-0.88	0.35	279	-2.55	0.01	0.25	-1.57	-0.2	-2	0.23
Share*Group	300 RONAT	Control	500 FAMO	Control	-0.54	0.33	140	-1.64	0.1	0.83	-1.2	0.11	-1.61	0.53
Share*Group	300 RONAT	Control	500 FAMO	Experimental	-0.88	0.35	272	-2.49	0.01	0.28	-1.58	-0.19	-2.02	0.26
Share*Group	300 RONAT	Control	600 NARWIG	Control	-2.01	0.35	140	-5.84	<.0001	<.0001	-2.7	-1.33	-3.12	-0.91
Share*Group	300 RONAT	Control	600 NARWIG	Experimental	-1.99	0.33	279	-5.98	<.0001	<.0001	-2.65	-1.34	-3.06	-0.92
Share*Group	300 RONAT	Control	700 PITTLER	Control	-2.16	0.37	140	-5.79	<.0001	<.0001	-2.9	-1.42	-3.36	-0.96
Share*Group	300 RONAT	Control	700 PITTLER	Experimental	-1.55	0.35	278	-4.4	<.0001	0.001	-2.24	-0.85	-2.68	-0.42
Share*Group	300 RONAT	Experimental	400 ELSKAR	Control	1.09	0.35	276	3.13	0	0.064	0.4	1.77	-0.03	2.21
Share*Group	300 RONAT	Experimental	400 ELSKAR	Experimental	1.36	0.35	140	3.89	0	0.006	0.67	2.06	0.24	2.49
Share*Group	300 RONAT	Experimental	500 FAMO	Control	1.7	0.36	268	4.79	<.0001	0	1	2.41	0.56	2.85
Share*Group	300 RONAT	Experimental	500 FAMO	Experimental	1.36	0.32	140	4.28	<.0001	0.001	0.73	1.99	0.34	2.39
Share*Group	300 RONAT	Experimental	600 NARWIG	Control	0.23	0.33	280	0.7	0.48	>0.99	-0.42	0.89	-0.84	1.31
Share*Group	300 RONAT	Experimental	600 NARWIG	Experimental	0.26	0.33	140	0.78	0.44	>0.99	-0.4	0.91	-0.81	1.32
Share*Group	300 RONAT	Experimental	700 PITTLER	Control	0.09	0.35	274	0.25	0.81	>0.99	-0.61	0.78	-1.05	1.22
Share*Group	300 RONAT	Experimental	700 PITTLER	Experimental	0.7	0.36	140	1.96	0.05	0.63	0	1.41	-0.45	1.85
Share*Group	400 ELSKAR	Control	400 ELSKAR	Experimental	0.28	0.36	140	0.78	0.44	>0.99	-0.43	0.98	-0.87	1.43
Share*Group	400 ELSKAR	Control	500 FAMO	Control	0.62	0.36	140	1.7	0.09	0.79	-0.1	1.34	-0.55	1.79
Share*Group	400 ELSKAR	Control	500 FAMO	Experimental	0.28	0.36	279	0.76	0.45	>0.99	-0.44	1	-0.9	1.45
Share*Group	400 ELSKAR	Control	600 NARWIG	Control	-0.85	0.34	140	-2.54	0.01	0.26	-1.52	-0.19	-1.93	0.23
Share*Group	400 ELSKAR	Control	600 NARWIG	Experimental	-0.83	0.34	274	-2.41	0.02	0.33	-1.51	-0.15	-1.94	0.28

Share*Group	400 ELSKAR	Control	700 PITTLER	Control	-1	0.39	140	-2.59	0.01	0.23	-1.76	-0.24	-2.24	0.24
Share*Group	400 ELSKAR	Control	700 PITTLER	Experimental	-0.38	0.36	277	-1.06	0.29	0.99	-1.1	0.33	-1.55	0.78
Share*Group	400 ELSKAR	Experimental	500 FAMO	Control	0.34	0.37	277	0.93	0.35	>0.99	-0.38	1.06	-0.84	1.52
Share*Group	400 ELSKAR	Experimental	500 FAMO	Experimental	0	0.35	140	0	1	>0.99	-0.69	0.69	-1.12	1.12
Share*Group	400 ELSKAR	Experimental	600 NARWIG	Control	-1.13	0.34	278	-3.29	0	0.04	-1.81	-0.45	-2.24	-0.03
Share*Group	400 ELSKAR	Experimental	600 NARWIG	Experimental	-1.11	0.32	140	-3.44	0	0.026	-1.75	-0.47	-2.14	-0.07
Share*Group	400 ELSKAR	Experimental	700 PITTLER	Control	-1.28	0.36	276	-3.53	0	0.02	-1.99	-0.56	-2.44	-0.11
Share*Group	400 ELSKAR	Experimental	700 PITTLER	Experimental	-0.66	0.37	140	-1.79	0.08	0.74	-1.4	0.07	-1.85	0.53
Share*Group	500 FAMO	Control	500 FAMO	Experimental	-0.34	0.37	140	-0.91	0.36	>0.99	-1.08	0.4	-1.54	0.86
Share*Group	500 FAMO	Control	600 NARWIG	Control	-1.47	0.37	140	-4.03	<.0001	0.0036	-2.19	-0.75	-2.65	-0.3
Share*Group	500 FAMO	Control	600 NARWIG	Experimental	-1.45	0.35	272	-4.1	<.0001	0.0027	-2.14	-0.75	-2.58	-0.31
Share*Group	500 FAMO	Control	700 PITTLER	Control	-1.62	0.41	140	-3.96	0	0.0046	-2.43	-0.81	-2.93	-0.3
Share*Group	500 FAMO	Control	700 PITTLER	Experimental	-1	0.37	271	-2.71	0.01	0.18	-1.73	-0.27	-2.19	0.19
Share*Group	500 FAMO	Experimental	600 NARWIG	Control	-1.13	0.35	278	-3.22	0	0.05	-1.82	-0.44	-2.26	0
Share*Group	500 FAMO	Experimental	600 NARWIG	Experimental	-1.11	0.35	140	-3.16	0	0.058	-1.8	-0.42	-2.23	0.02
Share*Group	500 FAMO	Experimental	700 PITTLER	Control	-1.28	0.37	272	-3.46	0	0.024	-2.01	-0.55	-2.47	-0.09
Share*Group	500 FAMO	Experimental	700 PITTLER	Experimental	-0.66	0.39	140	-1.69	0.09	0.8	-1.44	0.11	-1.92	0.6
Share*Group	600 NARWIG	Control	600 NARWIG	Experimental	0.02	0.33	140	0.07	0.95	>0.99	-0.63	0.67	-1.04	1.08
Share*Group	600 NARWIG	Control	700 PITTLER	Control	-0.15	0.36	140	-0.41	0.68	>0.99	-0.86	0.56	-1.3	1.01
Share*Group	600 NARWIG	Control	700 PITTLER	Experimental	0.47	0.35	279	1.35	0.18	0.94	-0.22	1.15	-0.65	1.59
Share*Group	600 NARWIG	Experimental	700 PITTLER	Control	-0.17	0.35	274	-0.49	0.63	>0.99	-0.86	0.52	-1.29	0.95
Share*Group	600 NARWIG	Experimental	700 PITTLER	Experimental	0.45	0.34	140	1.3	0.2	0.95	-0.23	1.13	-0.66	1.55
Share*Group	700 PITTLER	Control	700 PITTLER	Experimental	0.62	0.37	140	1.68	0.1	0.8	-0.11	1.34	-0.56	1.79

Tests of Effect Slices						
Effect	**Share**	Group	Num DF	Den DF	F Value	Pr > F
Share*Group		Control	4	137	11.6	<.0001
Share*Group		Experimental	4	137	7	<.0001
Share*Group	**300 RONAT**		1	140	44.7	<.0001
Share*Group	**400 ELSKAR**		1	140	0.6	0.44
Share*Group	**500 FAMO**		1	140	0.8	0.36
Share*Group	**600 NARWIG**		1	140	0	0.95
Share*Group	**700 PITTLER**		1	140	2.8	0.1

Appendix 16: Turnitin report

1608928:Thesis-v17-24-February2020-review2.pdf

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