An exploratory study on the influence of the Own-Race Bias on the Serial Position Effect in Facial Recognition

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By

Erik Petrus Gouws

SUPERVISOR: Prof. D.J.F. Maree (PhD)

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SUMMARY

The research aimed to explore the potential occurrence of the serial position effect and the own-race bias in facial recognition, and to explore whether these two socio-cognitive psychological phenomena had any influence on each other. Specifically, the researcher suggested that other-race facial recognition will show diminished U-type serial position curves in comparison to own-race facial recognition U-type serial position curves. This was done through a quasi-experimental design, testing 48 participants from an environmental consulting and ground engineering firm in Midrand, Johannesburg. Twelve (12) sets of slides showing either 5 black or 5 white faces were presented to participants, the sequence of faces was randomised and then displayed again to participants. Participants had to identify the original position in which the face was displayed (forcing a serial reconstruction task). Results yielded a U-type serial position curves for overall recognition, with a statistically significant effect for own-race bias effect. Specific interactions indicated that recognition for own-race facial stimuli exhibit clear serial position effect trends, whilst recognition of other-race facial stimuli recognition show increased recognition for the first, middle and last faces in a set. The researcher suggests that the results within this study could be attributed to the effect of an attentional primacy gradient within the Serial Information Processing model. However, further studies are required to eliminate numerous other confounding factors which may have played a role in the study. The results of this research have implications for the judicial system, in which false eyewitness identifications have profound consequences.

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1 Introduction

Human memory remains one of the most investigated and least understood phenomena in the field of psychology. A quick literature search yields thousands of publications in the last few years investigating aspects related to memory. A recent four volume textbook publication presented the current state of research in neurobiology and psychology of learning and memory (Hockley, 2008), which attests to the depth and breadth of the field of learning and memory. Memory itself is a complex phenomenon, and has (amongst others) been studied in the fields of neurochemistry, neurobiology, systems neurobiology, ethology and psychology.

Memory presents itself in a multitude of forms and is an integral part of the overall human psyche. It cannot easily be studied as an individual entity, as it is related to other processes, including cognitive and physiological processes (see, for example, Volume 4 of Learning and Memory: A Comprehensive Reference, 2008). Cognitive processes that cannot be separated from the investigations into memory include attention and the perception of objects and patterns, which both influence the cognitive process prior to the formation of memory (Galotti, 2004), whilst it may also be assumed that attention can influence the ability to retrieve memories.

Most of the literature indicates that, although philosophical investigations into memory can be traced back to Greco-Roman periods, the most recent paradigmatic shifts in the study of memory in cognitive psychology occurred in the 1960s (Draaisma, 2001; Healy & Bonk, 2008; Hockley, 2008). During each historical epoch, the specific material tools that helped people to remember were used by philosophers and psychologists as analogies to explain the working of memory. For the philosopher, Plato, memory was a wax tablet on which could be engraved, whilst for St. Augustine, memory was a storehouse in which memories could be stored. For Freud, memory was a mystic writing pad, whilst for modern psychologists memory was initially analogous to a photograph, then a phonograph, then the cinema, then a telephone exchange, and finally (with the most recent paradigmatic shifts) a computer (Draaisma, 2001).

These various analogies for memory dictated ideas of the specific processes by which memory functions, and theoretical approaches have developed in line with these analogies. Some models distinguish between the modality of memory, suggesting that memory for auditory/verbal stimuli is attended to, encoded, stored and retrieved differently than memory for visual-spatial stimuli (for example, refer to Baddeley and Hitch's working model of memory, Baddeley, 1986), whilst others only distinguish between the kinds of memory according to the length of time the information is stored in memory (refer to Atkinson and Shiffrin's modal model of memory, Atkinson & Shiffrin, 1968). The modal model of memory was the theoretical approach of memory which dominated cognitive psychology in the 1960s and 1970s, and is analogous to the workings of computers. This model assumed that information is received, processed and stored differently in each kind of memory (Atkinson & Shiffrin, 1968). This model distinguished between sensory memory, in which unattended information is stored, short term memory, in which attended information is stored for periods between 20 and 30 seconds, and long term memory, in which information that is needed for longer periods of time is stored.

Empirical findings, including the free recall experiments and ordered recall experiments, supported the modal model as well as the working model of memory. Seminal research that was conducted by Sternberg (1966, 1969) investigated the reaction-times of subjects in recognising lists of information, which sparked multitudes of follow-up research (Hockley, 2008). One of the areas in which most research of memory has been conducted involved the memorising of lists of information, commonly termed "serial memory". This follows the initial studies by Sternberg (1966, 1969), and certain salient aspects related to serial memory have been consistently found in research. These aspects include specific response times related to serial position and specific recognition and/or recall accuracy related to serial position. Recall accuracy related to serial position has consistently demonstrated that, when memorising sequences or lists of information, information that was presented first and last in the sequence is recalled much more successfully than information presented in the middle of the sequence. This specific phenomenon was termed the Serial Position Effect.

In line with the studies of memory, other research branched into the areas of visual recognition and memory. One of these areas includes facial recognition. Facial recognition is considered one of the expertise features of the human cognition, as we are generally much more efficient at recognising faces than at recognising most other objects (Hayward, Rhodes, & Schwaninger, 2008).

Facial recognition research consistently found evidence that the race of individuals influences their perception of faces of other-race individuals (see Meissner and Brigham, 2001, for a review). Prior to the 1970s, very few studies investigated the socio-cognitive mechanisms that account for recognition between races. Meissner and Brigham (2001) mention only three studies prior to the 1970s, of which only one was published (Berger, 1969; Horowitz & Horowitz, 1938; Malpass & Kravitz, 1969). However, with the infamous "Quincy Five" trial in Florida in the United States of America in 1971, eyewitness identification as admissible evidence in court cases came under the spotlight. The wrongful eyewitness identification of five black men for the murder of Khomas Revels during a robbery resulted in these five men being sentenced to jail, with no physical evidence linking them to the scene of the crime. It is during this trial that Dr William Haythorn of Florida State University, a social psychologist, set out to locate empirical evidence that the "they-all-look-alike" claim indeed carries weight (Meissner & Brigham, 2001). Although the susceptibility of eyewitness identification to errors was recognised as far back as the 1800s, little scientific study was undertaken. In 1907, Hugo Munsterberg published "On the Witness Stand", in which he questioned the reliability of eyewitness identification. Edwin Borchard, professor of law, studied 65 wrongful convictions for his pioneering book published in 1932 – "Convicting the Innocent", in which he found that eyewitness misidentification was the leading cause of wrongful convictions (www.innocenceproject.org, 2010).

The specific causes influencing these misidentifications came under the spotlight with the Quincy Five trial, and in subsequent years after this trial, a substantial base of research exists that have investigated the *own-race bias*, as the phenomenon became known. This perceptual own-race bias, also known as the *own-race advantage*, has been observed across differences in race and recognition/recall tasks (Hayward et al., 2008). Although the social and cognitive processes related to this own-race bias have been investigated extensively, the exact mechanisms by which this phenomenon develops still has no consensus, and therefore it remains a popular research subject (Meissner & Brigham, 2001).

This study investigated the simultaneous occurrence and influence of these two psychological cognitive phenomena on facial recognition. These phenomena are the Serial Position Effect (SPE) and the Own-Race Bias (ORB). A brief introductory discussion about these two psycho-cognitive phenomena are provided to familiarize the reader with these concepts, whilst a more detailed review of these concepts can be found in the Literature Review chapter.

1.1 The Serial Position Effect

The Serial Position Effect (SPE) is a cognitive phenomenon that occurs during recall of lists of visual or auditory information. For example, when engaged in a recognition or recall task of a list of words, individuals have shown a remarkable tendency to recognise or recall the words listed at the beginning and the end of the list. Recall or recognition of words in the middle of the list is much poorer. This phenomenon in which the first and last stimuli in a set are recalled and/or recognised with much greater success than stimuli in the middle of a list is termed the Serial Position Effect. When illustrated on a graph, the SPE typically forms a U-type curve when recall or recognition accuracy is measured by means of either repeated measures design or multiple subjects design (see Figure 1).

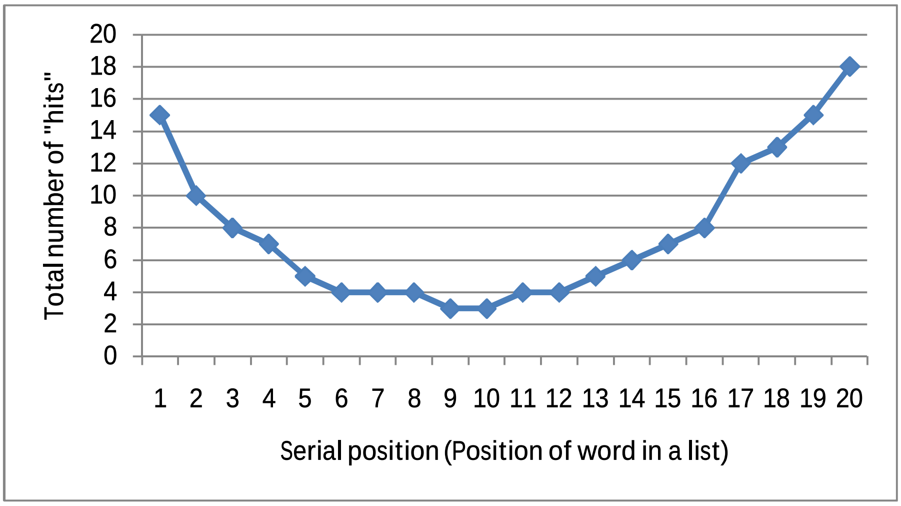

Figure 1: Hypothetical typical serial position effect U-curve, with the total number of correct recalls (“hits”) per serial position

In Figure 1, the x-axis represents a specific serial position in a list. For example, in a list of words, each word would be numbered in the sequence the list is printed. The list would then be given to a number of subjects to read, and a recall task would be administered after that. The number of times each word is successfully recalled is totalled, which can be represented on the y-axis on a graph.

As can be seen in the figure, the recall/recognition success rate is much higher for the items that were presented last on a list (termed the *recency effect*), whereas recall/recognition success is also much higher for items that were presented first on the list (termed the *primacy effect*) (Galotti, 2004). However, due to the nature of short-term memory, the recency effect is usually much more pronounced (resulting in recent items being recalled or recognised more successfully than those items at the beginning of the list).

1.2 The Own-Race Bias

The occurrence of Own-Race Bias (ORB) in Facial Recognition tasks has also been studied extensively due to its immense implications with regards to the judicial system (Smith, Stinson, & Prosser, 2004). The ORB effect states that a given person is more prone to make errors in recognizing faces of other-race individuals than the person would in recognizing faces of own-race individuals. This is colloquially described as the “they-all-look-the-same” stereotype, referring to recognition of other-race individuals.

Therefore, it is possible that Caucasian individuals may readily be able to distinguish and recognise faces of other Caucasian individuals, whereas these same individuals may battle to distinguish and recognise African individuals. The similar scenario can be expected with African individuals, who may distinguish between and recognise other African faces with ease but may battle to recognise Caucasian individuals.

1.3 The Research Question

The question that the researcher poses to investigate in this study is whether these two psycho-cognitive phenomena may occur at the same time in facial recognition tasks, and whether they may influence each other. The research question is further refined following the literature review.

2 Literature Review

A more thorough review of the Serial Position Effect and the Own-Race Bias is provided in this section. As both of these cognitive phenomena form part of human memory systems for faces as well as specific cognitive processes related to facial recognition, an introductory discussion on memory systems is provided, following which a discussion of the cognitive processes that underlie facial recognition and memory for faces is given. Thereafter, the Serial Position Effect is reviewed, followed by a review of the Own-Race Bias. Finally, an integrative discussion on the Serial Position Effect and the Own-Race Bias is provided.

2.1 Memory Systems

The investigation to SPE and ORB cannot be separated from the functioning of memory. Various models to explain memory systems have been proposed through the decades. During the first detailed investigations into the Serial Position Effect in the 1960s, the **modal model of memory** was the dominant model. This model viewed the reception, processing and storing of information as being processed by three different memory systems, depending on the length of time that information is stored in the memory. This memory model posits that unattended information is stored briefly in **sensory memory**, whilst attended information is briefly stored in **short-term memory** between 20 and 30 seconds. Information that is required for longer than this period is stored in **long-term memory** (Galotti, 2004).

Once items are stored in memory, retrieval occurs through a process of search and compare. Two types of searching mechanisms were postulated and tested empirically to account for how items are searched for in memory, termed **parallel search** and **serial search** (Galotti, 2004). When searching for a specific item in memorised lists of information, **parallel search** stipulates that the search item is compared to the entire stored list at the same time. This therefore stipulates that, irrespective of memorised set size (whether one or ten items are memorised), it will take the same amount of time to search for a required item. **Serial search,** however, stipulates that the search item is compared to each item in memory sequentially. Two types of serial searching have been distinguished here, including **self-terminating** or **exhaustive** searches. Self-terminating searches indicate that, once the search item matches an item in the memory set, the search process is terminated. However, exhaustive searches indicate that, even if the search item matches an item in the memory set, the search process continues until the entire memory set has been scanned (Galotti, 2004; Hockley, 2008). A flowchart example of the exhaustive and self-terminating serial searches and parallel searches is provided in Figure 2. In this figure, a hypothetical list of 7 words is provided. After reading through the list, a search task is undertaken for the word “frog”. In a serial self-terminating search task, the word “frog” is compared to each memorised word in sequence. If a match is not found, the search continues to the next item, until a match is found. Once a match is found, the search task terminates. In a serial exhaustive search task, the word “frog” is compared to each memorised word in sequence. If a match is not found, the search continues to the next item. However, once a match is found, the search continues until the end of the list if reached. In a parallel search task, the word “frog” is compared to the entire memorised list at once, and if a match is found, the word “frog” is retrieved from memory. Empirical support for exhaustive serial searching was demonstrated with Sternberg’s classical experiments in 1966 (Sternberg, 1966) in which Sternberg illustrated that exhaustive search was the preferential method by which information was retrieved from the Short Term Memory. In spite of the process not sounding parsimonious, Sternberg explained the findings as being the result of the search process being so rapid and carrying so much momentum that it is difficult to stop the process once it starts (Galotti, 2004). This research by Sternberg in 1966 resulted in a wealth of follow-up research and refinements in models (Hockley, 2008). Recent research suggests that both these processes may be implicated in visual searches (Wenger & Townsend, 2006).

Figure 2: Flowchart illustration of self-terminating serial searches, exhaustive serial searches, and parallel searches

Input List	**Search Item**	**Serial search (self-terminating)**			**Search Item**	**Serial search (exhaustive)**			**Search Item**	**Parallel search**		
		Memory item	**Match**	**Search Result**		**Memory item**	**Match**	**Search Result**		**Memory items**	**Match**	**Search Result**
Cat	Frog	Cat	No	Search continues	Frog	Cat	No	Search continues	Frog	Cat	Yes	Match found
Hat		Hat	No	Search continues		Hat	No	Search continues		Hat		
Dog		Dog	No	Search continues		Dog	No	Search continues		Dog		
Log		Log	No	Search continues		Log	No	Search continues		Log		
Frog		Frog	Yes	Search terminates		Frog	Yes	Search continues		Frog		
Pig		Pig				Pig	No	Search continues		Pig		
Horse		Horse				Horse	No	Search terminates		Horse		

Later research indicated that the nature of information in the short term memory can change the capacity and processing of stored information (Galotti, 2004). In other words, auditory information and visual information are processed differently, and different capacity to process and store these types of information exists. These findings challenged the modal model of memory, and led to the development of further refined models, such as Atkinson and Shiffrin's **working memory model**.

Atkinson and Shiffrin proposed a further refined model in 1968 to the modal model of memory (Galotti, 2004). These authors distinguished between the information being stored, terming this "memory" – including short term memory and long term memory, and the structure that does the storing, terming this the "store" – including short term store and long term store. Baddeley and Hitch further refined this model by arguing for the existence of **working memory**, which functions as a limited-capacity "workspace" that can be divided between storage and control processing. Baddeley reported that working memory consists of three components, being the **central executive**, the **phonological loop** and the **visuospatial sketch pad**. The central executive directs the flow of information and chooses which information to operate on when and how, the **phonological loop** carries out subvocal rehearsal to maintain verbal material, and the **visuospatial sketch pad** maintains visual material through visualisation (Galotti, 2004). Galotti (2004) mentions that much research has subsequently been conducted to investigate working memory, and in spite of certain limitations illustrated by empirical evidence, it remains one of the most widely used models of memory. The model of the phonological loop evolved into other models, such as the **primacy model** of Page and Norris (Healy & Bonk, 2008). According to Healy and Bonk (2008), in the primacy model, the phonological loop is a qualitative description of working memory that describes the rehearsal processes, but does not provide any specific mechanisms for serial recall. Therefore, the primacy model can be viewed as a computational version of the phonological loop. Baddeley (2000) attempted to rectify the limitation to explain serial order recall by proposing an episodic buffer, which acts as a backup store when the phonological loop is not available. The visuospatial sketchpad may also play a role in nonphonological short-term memory for sequences, which therefore attests that it may play a role in serial recall (Page, Cumming, Norris, Hitch, & McNeil, 2006).

With the development of memory models, the question becomes whether the distinction between short-term and long-term memory is relevant to item recognition performance. In other words, is a single memory store involved in the memorising of lists of information, or are there indications of more than one memory store in this process? Hockley (2008) indicates that there are indications that recognition proceeds in the same fashion above and below short-term memory span (except possibly the most recent item), which may suggest that a singular memory process is involved in memorising and recalling lists of information. However, other research that specifically investigated memory for faces suggests that a dual-store memory process is involved in memorising faces (Bengner & Malina, 2007). Most models that explain the effects of serial position effects in memory are based on the premise of **working memory** (Lewandowsky & Farrell, 2002) or on the **modal model of memory** (Bengner & Malina, 2007), which both are dual process memory systems. In this study, memory is assumed to be a dual store process.

In summary, the modal model of memory developed into the working model of memory, which both assume that short-term memory is distinct from long-term memory. The primacy model developed out of the working model for memory, specifically to account for the serial position effect. Two types of memory search processes were investigated, including parallel search and serial search. With parallel search, a single search item is compared to the entire stored list simultaneously, whilst with serial search, a single search item is compared to each stored item sequentially. Serial searches may be self-terminating, in which the search is terminated once a match is found, whilst with exhaustive searches, the search process continues until the entire memory set is scanned. Both these searches are used in visual search processes (Wenger & Townsend, 2006). Although there are indications that visual recognition may occur through a single memory store, the dual process memory models are used predominantly in research investigating the serial position effect.

In light of the aforementioned memory models, a number of models exist that account for the Serial Position Effect as a cognitive function of memory encoding, storage, retrieval and recall. Models that explain the Serial Position Effect also make assumptions as to how memory functions, and as such models such as the perturbation model, start-end model, OSCAR and other models which explain the Serial Position Effect cannot be separated from their specific assumptions on how memory functions. Some of these models are discussed in the Section 2.3.1, whilst the cognitive processes that underlie facial recognition are discussed next.

2.2 Cognitive Processes Underlying Facial Recognition

The underlying cognitive mechanisms to process faces have been a subject of much research. It has been established that facial recognition is a specialised process, as we tend to recognise faces much more efficiently than other objects (Hayward et al., 2008). The expertise related to faces has been attributed to two types of cognitive facial processing, called **configural processing**, or **component processing**. Configural processing assumes that the facial features and their relative positions are processed as a whole (similar to parallel processing) (Hayward et al., 2008). This implies that one facial features is influenced by its configural relationship with other features, which especially seems to be the case with familiar faces (Tanaka & Farah, 1993). Component processing, in contrast, assumes that facial features and their relative position are processed sequentially (similar to serial processing), and other authors suggest that this serial processing of faces may occur in a top-to-bottom (processing of hair, then eyes, then nose, then mouth, then chin when looking at faces) or a bottom-to-top approach (processing of chin, then mouth, then nose, then eyes, then hair) (Hines & Braun, 1990).

Configural processing commonly involves three mechanisms (Wiese, Stahl, & Schweinberger, 2009), called first-order configural processing, holistic processing, and second-order configural processing. First, first-order configural processing entails the detection of features arranged in a face-like configuration, such as two eyes above a nose, which in turn is above a mouth, which results in the given stimulus being identified as a face. In order to identify an individual face, it is necessary to extract so-called second order information, referring to the distances between the individual features of a face. Furthermore, the components of the face cannot be treated independently, but are merged into a holistic representation or gestalt (Wiese et al., 2009).

The aforementioned mechanisms were discussed in a publication by Wenger and Townsend (2006), although these mechanisms were termed differently. According to these authors, the overall processing of facial stimuli has been shown to be influenced by four characteristics: Architecture, the stopping rule, independence and capacity (Wenger & Townsend, 2006). Architecture refers to whether visual search is conducted in a serial fashion or in a parallel fashion. This particular characteristic of visual processing remains a focus of research in both visual and memory search (Wenger & Townsend, 2006), with evidence provided for both approaches. The stopping rule refers to whether searches are exhaustive, meaning that all items are scanned even if a match has been found, or first-stopping, in which the memory search is terminated the moment a match is found. In terms of facial recognition, by assuming that faces are processed as a gestalt, it would be impossible to stop processing when only a portion of the processing of the face (such as a subset of facial features) has been completed (Wenger & Townsend, 2006). With independence, the meaningful organisation of individual characteristics, such as facial features arranged in the biologically correct places, would result in positive dependencies (in other words, interlinking between facial features), in which the speed of processing the face will be dependent on the facial features. However, the scrambled display of such features would allow for independence in the rates of processing of each of the elements (Wenger & Townsend, 2006). Finally, capacity refers to the number of different levels of analysis, including the capacity to process the individual elements as well as the system as a whole. These aspects become relevant to racial face recognition in research that supports **object superiority effects**, where items are presented in a meaningful context as opposed to meaningless contexts. Examples of object superiority effects include presenting facial features in the correct anatomical positions, as opposed to a scrambled display. These items are processed faster, are less subject to degradation in memory and are more accurately recalled (Wenger & Townsend, 2006). According to Wenger and Townsend (2006, p. 757), "If one assumes that meaning is functionally related to the level of familiarity one possesses with a particular class of stimuli (as in Tong & Nakayama, 1999), then there are also some provocative examples of how observers' ethnicity can influence their ability to perform visual search tasks with faces of individuals from other races (e.g., Levin, 2000; Levin, 1996, Levin & Angelone, 2001)." There is further evidence that individuals process their own-race faces more holistically than other-race faces (Maurer, Le Grand, & Mondloch, 2002; Rhodes, Brake, Taylor, & Tan, 1989; Tanaka, Kiefer, & Bukach, 2004).

However, more recent research has indicated that it would appear that the same perceptual mechanisms are used for both own-race and other race facial processing, and that the processing speed of other-race faces is not decreased but simply delayed (Wiese et al., 2009). It can therefore be concluded that the specific cognitive processes surrounding own and other-race facial recognition are still unclear.

Facial feature effects is furthermore dependent on factors such as the depth of processing, the encoding time, and on the type of processing that is utilised (configural or component processing).

Longer, deeper (such as semantic) and configural facial encoding, as opposed to shorter, shallower (such as physical attributes) and featural/component encoding, is associated with better face recognition overall (Goodman et al., 2007). However, encoding time has yielded mixed results on facial recognition (Meissner & Brigham, 2001). In addition, other effects on configural facial processing have implications on line-up eyewitness identification processes. It has been shown that providing a verbal description prior to making a line-up identification can impair performance, an effect known as verbal overshadowing (Schooler & Engstler-Schooler, 1990). This effect is argued to be the result of a shift toward featural processing at the test (Perfect, Weston, Dennis, & Snell, 2008). Macrae and Lewis (2002) argued that, since a shift toward featural processing reduces eyewitness performance, a shift toward configural processing would improve face recognition. By replacing a verbalisation condition of a verbal overshadowing paradigm with global or local responding to Navon stimuli – large letter shapes constructed from smaller letter features, Macrae and Lewis found that a shift toward featural processing impaired recognition, and global processing led to a significant improvement in recognition performance. This pattern of global and featural processing shifts has been replicated (Perfect, 2003; Perfect, Dennis, & Snell, 2007).

Dual-process theories of recognition memory have been widely advocated for their ability to account for cognitive processes underlying facial recognition performance (Gardiner & Richardson-Klavehn, 2000; Kelley & Jacoby, 2000). Such theories, generally distinguish between the retrieval of conscious-level conceptual information that is elaboratively encoded – termed “recollection” – and the retrieval of fluent/effortless, perceptually based information which is assumed to be encoded in an automatic, non-conscious manner – termed “familiarity”. (Meissner, Tredoux, Parker, & Maclin, 2005). Yonelinas (2002) demonstrated in his review of the dual-process memory literature that recollection is generally influenced by such manipulations as generative or semantic encoding, division of attention, speed of responding and novel learning, and is sensitive to the effects of aging and amnesia. Familiarity, on the other hand, is sensitive to fluency manipulations, forgetting over short retention intervals and changes in the response criterion. These facial recognition processes appear similar to the configural and holistic processing processes. These different sensitivities to specific manipulations may provide insight into cross-racial facial recognition strategies as well. The presentation of a lot of faces simultaneously is believed to result in stronger familiarity based retrieval than recollection (Meissner et al., 2005). Meissner and his colleagues (2005) argue that reliance upon familiarity may be reduced when faces are presented independently from one another, since the contextual basis that facilitates such judgements is taken away.

In summary, facial recognition and recall are specialised memory processes. Overall, four characteristics can be attributed to facial recognition, namely architecture, the stopping rule, independence and capacity. Architecture refers to whether the search of facial features occurs as component processing (similar to serial processing) or configural processing (similar to parallel fashion), whilst the stopping rule accounts for whether the search for facial features is first-stopping (self-terminating) or exhaustive. Independence accounts for whether positive dependencies exist between individual features of a face, and will therefore influence the speed of processing. Capacity refers to whether the facial features are processed as a whole or as individual elements, or as both. Capacity can therefore explain the effects from object superiority effects, and this object superiority effect may account for differences in facial recognition between races. The recognition of faces may also occur through one of two mechanisms, termed "recollection" and "familiarity". These two mechanisms are sensitive to different manipulations, and therefore may provide insight into cross-racial facial recognition.

The discussion in this section provided a cursory view of cognitive processes that underlie recognition in individual faces. The recognition of a face from a multitude of faces is expected to follow similar cognitive mechanisms, except that such a search process will form part of larger memory sets. With larger memory sets, the serial position effect has been reported to be a stable cognitive phenomenon. Hence, the discussion therefore reviews literature surrounding the serial position effect in the next section.

2.3 The Serial Position Effect

One of the most early consistent findings during the study of serial order was the serial position effect, and this is currently considered the most widely cited experimental result in the study of serial order (Healy & Bonk, 2008). Originally, the serial position effect was noted in language recall and recognition tasks (Galotti, 2004), and Phillips and Christie (1977a) report that the first in-depth experiments investigating the Serial Position Effect were performed by Glanzer and Cunitz in 1966. However, the studies conducted by Sternberg (1966, 1969) are widely cited as the spark to multitudes of follow-up research (Galotti, 2004; Hockley, 2008).

Accounts in the literature regarding when the Serial Position Effect was originally reported is diverse. Healy and Bonk (2008) report that Nipher first described the "serial position function" in 1878, and that Ebbinghaus established the original procedure to investigate serial learning in 1885. In cognitive psychology, learning typically refers to the process of acquiring information over time, whilst memory rather refers to the retention (or forgetting) of information. The study of serial memory evolved from the initial research into serial learning, which was the dominant paradigm during the initial investigations (Healy & Bonk, 2008). The Serial Position Effect still remains one of the most widely cited experimental result in the study of serial order, with Saul Sternberg's research in the 1960s into memory paving the way for a wealth of follow up research on the serial position effect.

Much of the research following Sternberg's research focused on item recognition for subspan lists. Memory span is commonly defined as the typical assumed capacity of seven items being stored in short-term memory, which may fluctuate by two items more or two items less (Galotti, 2004). The subspan memory recognition tasks typically took the form of item-recall or associative and cued recall tasks. Item recall tasks commonly included free-recall tasks, in which subjects were tasked recall as much of the memorised set as possible, item recognition tasks, in which participants were tasked to state whether a single item was presented previously in a display set or is a novel item (Hockley, 2008), or serial recall tasks, in which respondents have to recall the memorised set in the original order (Healy & Bonk, 2008). In associative recognition tasks, participants study random pairs of items and during the test try to discriminate between intact or studied pairs and new pairings of rearranged study items, whilst with cued recall tasks, participants studied random pairs of items, and during the test, one item is presented as a cue to recall the associated member of the pair (Hockley, 2008). The goals of these tasks were to further understand the working of memory in memorising items in a specific order, in order to gain understanding on whether memory is searched in serial (be it exhaustive or self-terminating) or parallel, and whether other memory systems exist that need to be further defined.

Throughout these tests, two aspects were of paramount importance, namely response accuracy and response time. Measures of response accuracy and response time are often researched together as they are viewed as complementary to each other (Hockley, 2008). During Sternberg's research in 1966, he found that response time increased in a linear fashion with the number of items in the memory set (Hockley, 2008). He proposed that these results reflect a high-speed exhaustive serial search process, since more items in memory require more time to scan through. However, one of the problems that his exhaustive serial search process could not account for was the occurrence of the serial position effect. Contrary to the predictions of exhaustive serial scanning, the average response time for correctly recognised items was influenced by the position of the target item in the memory set. To account for this, some researchers proposed that searches may occur in parallel (Hockley, 2008), whilst others developed different memory models to account for this discrepancy (Healy & Bonk, 2008).

The Serial Position Effect appears to exhibit a distinct modality effect, in which auditory and verbal stimuli are recalled differently than visual information. Auditory research included recall of verbal, non-verbal and musical stimuli, which resulted in the postulation of numerous hypotheses to explain the occurrence of the SPE in this research. Initial findings of SPE studies indicated that, in serial recall, auditory stimuli exhibits a substantial recency effect, whilst visual stimuli does not exhibit this substantial recency effect (Conrad & Hull, 1964). Interestingly, auditory presentation is not necessary to elicit enhanced recency effects in serial recall. In studies conducted by researchers such as Campbell and Dodd (1980) it was determined that recency effects are found in the serial recall of lists that are lip-read by subjects (Greene & Samuel, 1986). Other studies by Greene and Crowder (1984) also indicated that the silent mouthing of visually presented items (such as words) would result in a strong recency effect (Greene & Samuel, 1986). Other research also suggested this **modality effect**, in which auditory items show greater recency effects in comparison to visual items, especially when taking into account a spatial modality as well (Tremblay, Guérard, Parmentier, Nicholls, & Jones, 2006). Many researchers believed that the serial position curve supports the concept of distinct verbal memory systems (which may process both auditory and visual modalities), and visuo-spatial memory systems (Ward, Avons, & Melling, 2005), which is in line with the **working memory model** of Atkinson and Shiffrin.

Following initial research into the serial position effect, researchers soon realized that this effect occurs in most short-term memory processes, and subsequently the serial position effect has been studied extensively in relation to both visual and auditory recall. Specifically related to visual recognition memory, Kerr, Avons & Ward (1999, p.1475) state that Phillips and Christie (1977a) first noted that

> "*visual recognition memory exhibits a distinct* ***recency effect****, whereby memory is superior for one or more items at the end of the list compared with earlier items, but it exhibits no* ***primacy effect****, whereby memory is superior for one or more items at the beginning of the list in comparison with later items*."

The result of this recency and primacy effect is a typical bow shape when presented as a function of successful recognition across serial positions. In serial learning, the primacy advantage is typically much larger and includes more items than the recency advantage, which sometimes includes only one item (Healy & Bonk, 2008). Examples of U-type serial position effect curves from other studies are presented in Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure 8 and Figure 9.

Figure 3 and Figure 4 presents typical examples of U-type serial position effect curves from the results of a study into the serial position effects of nonword repetition (Gupta, Lipinski, Abbs, & Lin, 2005). Figure 3 indicates strong primacy with moderate recency effects for both seven-syllable (A) and five-syllable (C) nonwords. Figure 4 indicates strong primacy with moderate recency effects for six-syllable (B) nonwords, whilst some primacy with almost no recency is found for four-syllable (D) nonwords. This lack of recency (and resultant declining serial position curve) was attributed to a general ceiling effect to recognition accuracy.

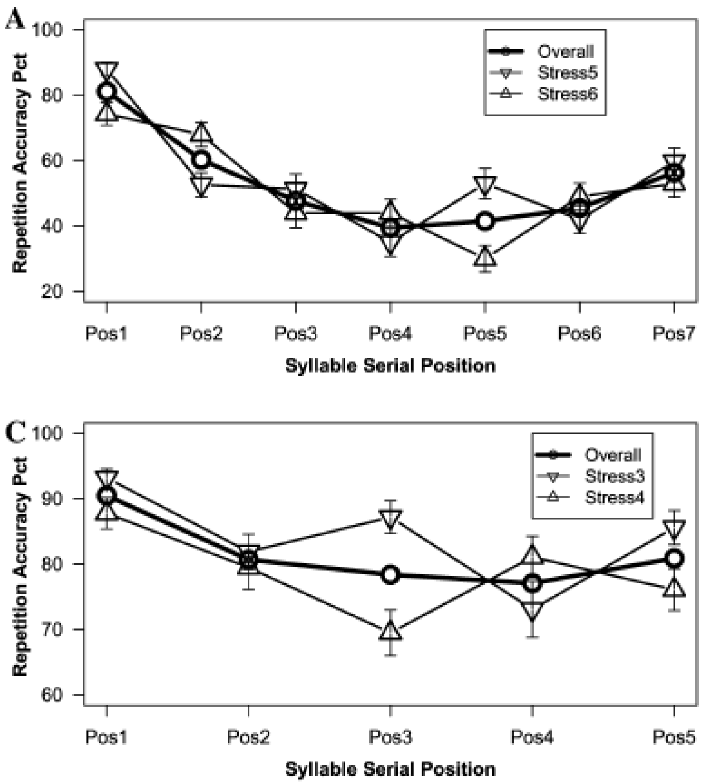

Figure 3: Serial position curves from a study by Gupta and his colleagues (Gupta et al., 2005), with repetition of (A) 7-syllable and (C) 5-syllable nonwords (with standard error bars) for three experimental conditions

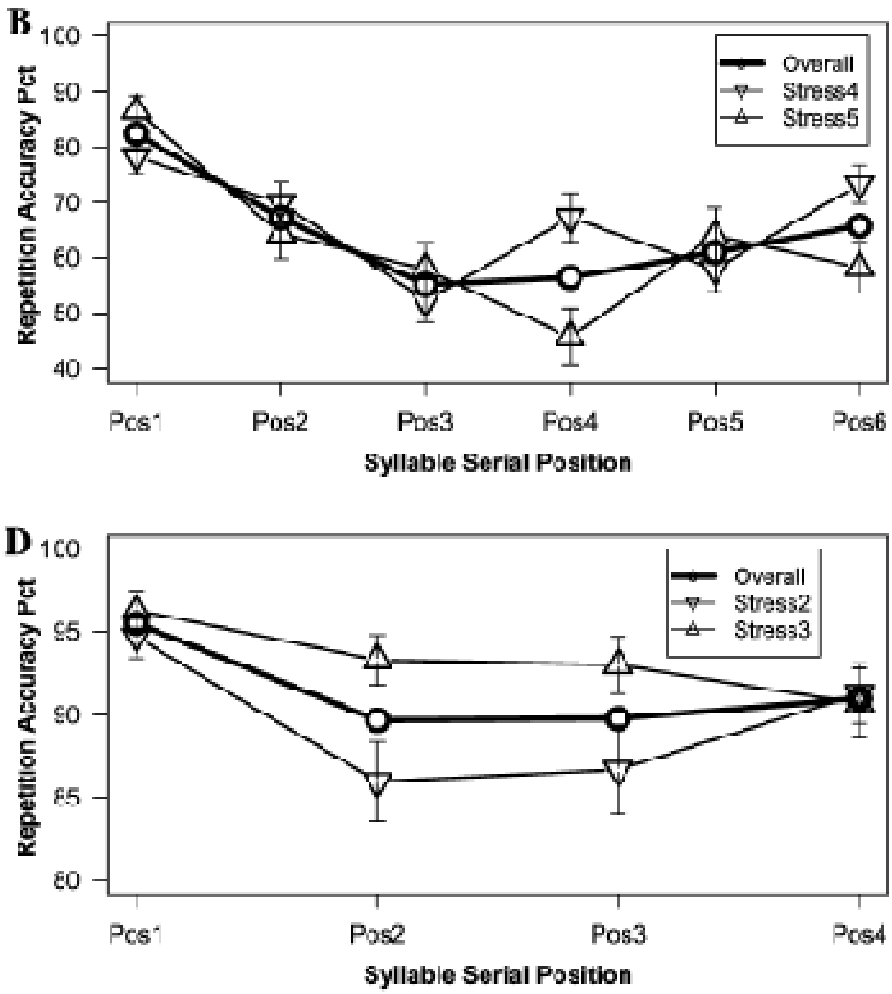

Figure 4: Serial position curves from a study by Gupta and his colleagues (Gupta et al., 2005), with repetition of (B) 6-syllable and (D) 4-syllable nonwords (with standard error bars) for three experimental conditions

Figure 5 is presented from a study by Oberauer (2003), in which the response accuracy of visual recognition tasks was evaluated in an experiment to deconfound input order, output order and the spatial order in short-term memory. The figure illustrates a strong primacy effect for recognition accuracy for global recognition, local recognition and serial recall tasks, whilst a moderate recency effect is illustrated for global recognition, local recognition and serial recall tasks.

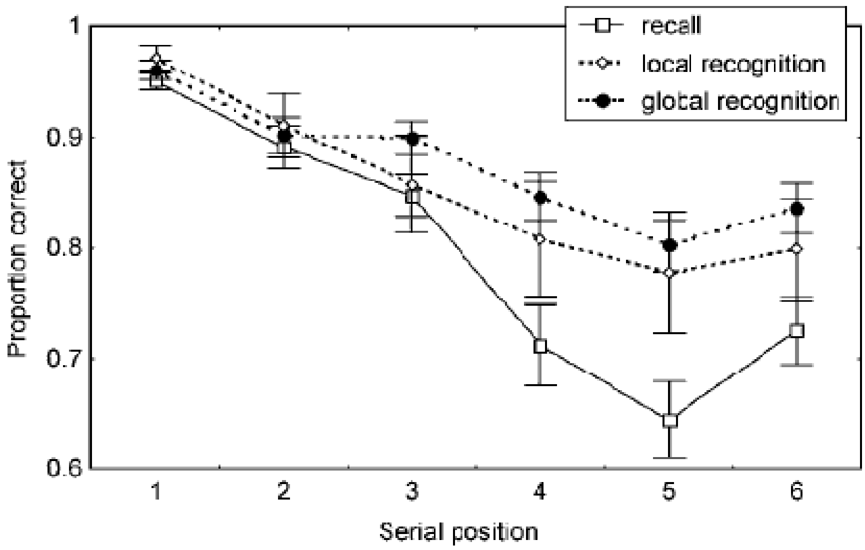

Figure 5: Example of serial position effect showing strong primacy and weaker recency effects in three experimental paradigms (recall, local recognition and global recognition) (Oberauer, 2003, p. 475)

Figure 6 and Figure 7 are presented from a study by Kerr and his colleagues (1999), in which these authors investigated the effects of different retention intervals on serial position curves. Figure 6 presents a graph showing the hypothethical normalised correct proportion values for recognition according to Ian Neath's (1993a, 1993b) dimensional distinctiveness model. As can be seen from these hypothesised results, with a 1 second display of stimuli, the U type serial position effect curve is expected to change according to the retention interval. At 0 seconds retention interval, virtually no primacy but very strong recency effects are expected to be seen. From a 2 seconds retention interval and longer, the U type serial position curve is expected to show an increasing primacy effect and a decreasing recency effect. Figure 7 presents the results of the study conducted by Kerr and his colleagues (Kerr et al., 1999) to determine what influence different retention intervals have on the U type serial position curve. As can be seen from the experimental results, strong recency effects was found in immediate recognition tasks, with virtually no primacy effects. The various longer retention intervals did show reduced recency effects, but did not illustrate any difference in primacy effects.

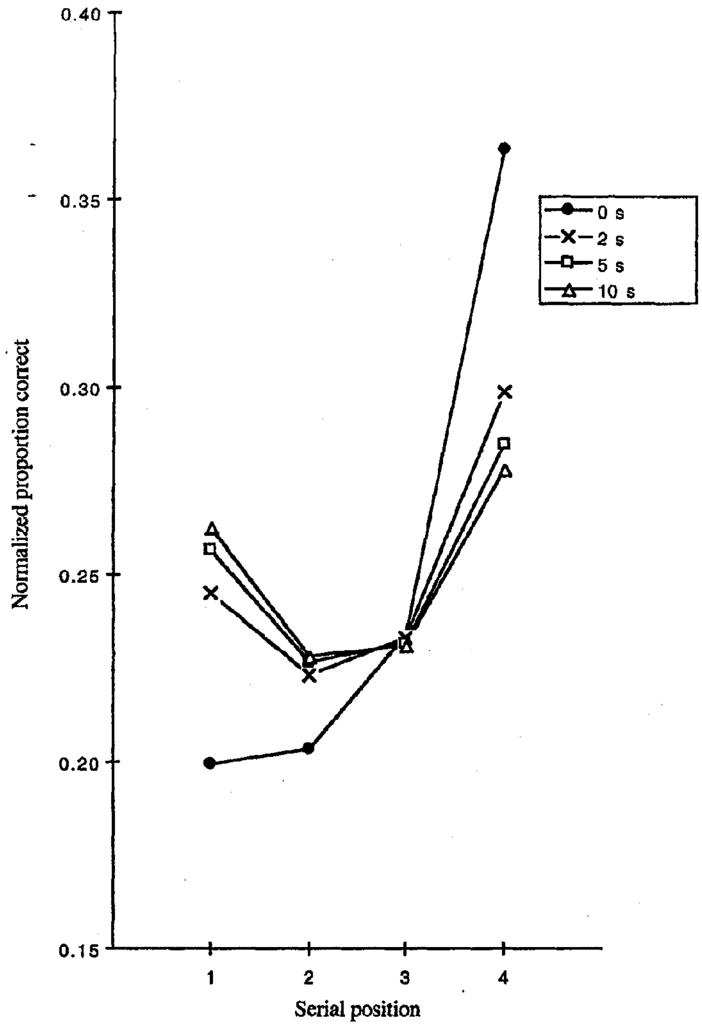

Figure 6: Graph illustrating the predictions of Neath's (1993) dimensional distinctiveness model: The proportion of correct responses for recognition memory tests using sequences of four items presented for 1 second, separated by a 1 second inter-stimulus interval of 0 seconds, 2 seconds, 5 seconds and 10 seconds (Kerr et al., 1999, p. 1479)

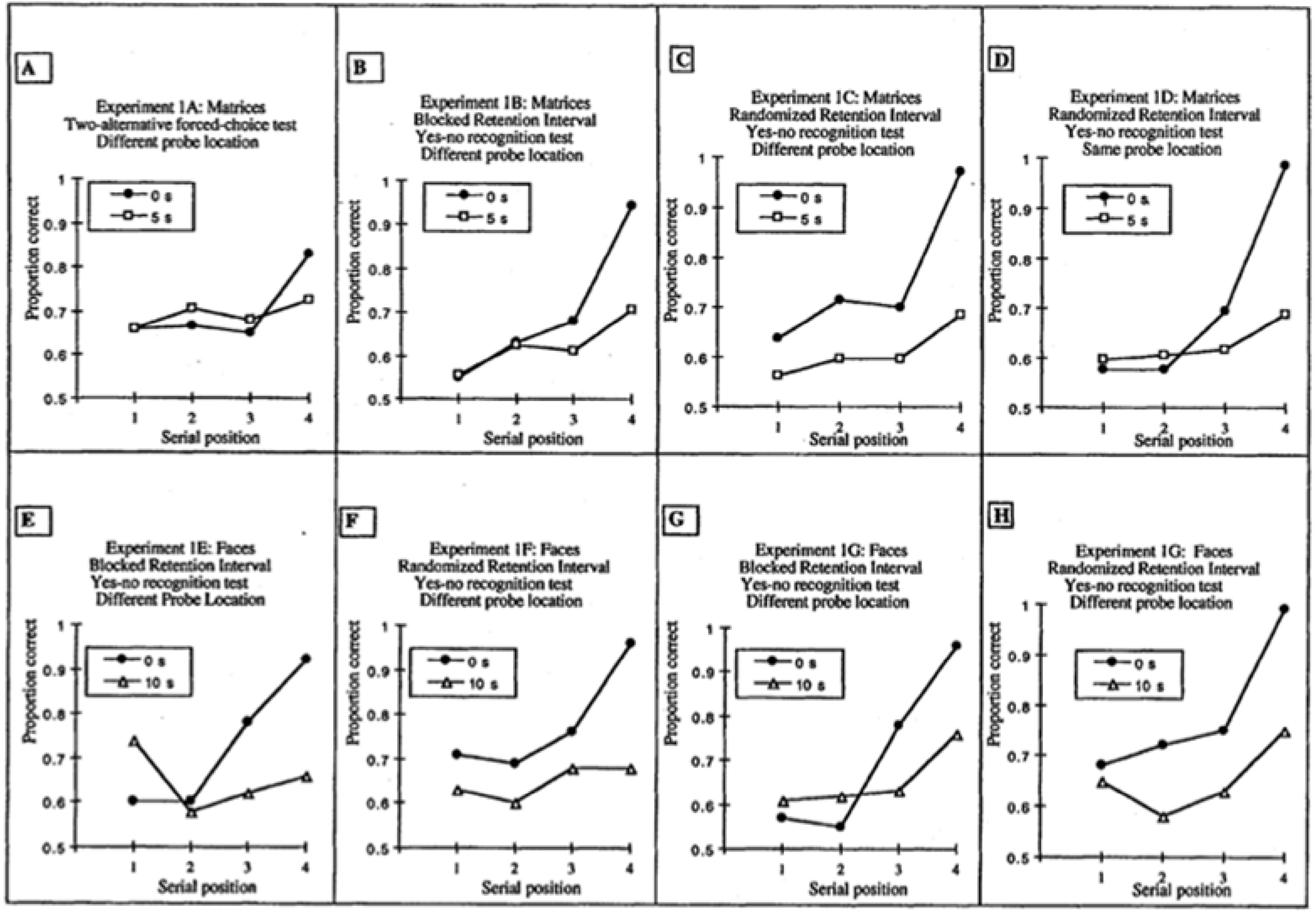

Figure 7: Data from experiments conducted by Kerr and his colleagues (Kerr et al., 1999, p. 1481), showing distinct recency effects (all panels) and some primacy effects (panel E and H)

Figure 8 presents a serial position curve that was obtained from a study by Wiswede, Rüsseler and Münte (2007), in which the event-related brain potentials (ERPs) associated with serial position effects were investigated. The graph indicates a strong recency effect, with recall success being about 80%, whilst a moderate primacy effect was found, with recall success being around 47%. The stimuli set size in this study was 12 stimuli. These authors simplified the typical serial position effect curve into five distinct areas, termed primacy, intermediate 1, plateau, intermediate 2 and recency (refer to Figure 8). In a set of 12 stimuli, the recognition curve in the primacy area is expected to show a sharp decline (approximately between stimulus 1 and 2), gradually levelling off in the intermediate 1 area (approximately between stimulus 2 and 4), after which a plateau is reached where recognition is lowest overall (approximately between stimulus 5 and 7). Following this, the recognition curve shows an increase in the intermediate 2 area (approximately between stimulus 8 and 10, with a sharp increase in the recency area (stimulus 11 and 12). A serial position curve from this categorisation is presented in Figure 9.

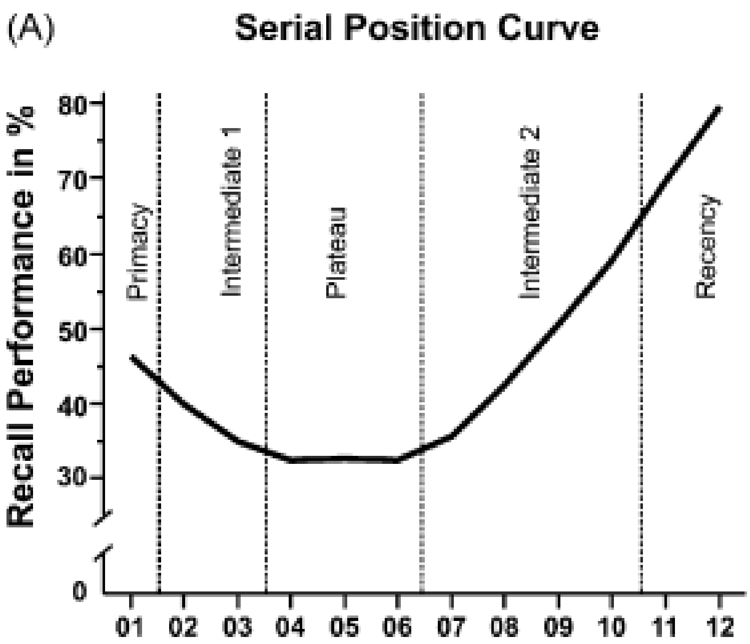

Figure 8: Serial position curve from a study by Wiswede, Rüsseler and Münte (2007), indicating the percentage of words recalled as a function of word presentation position

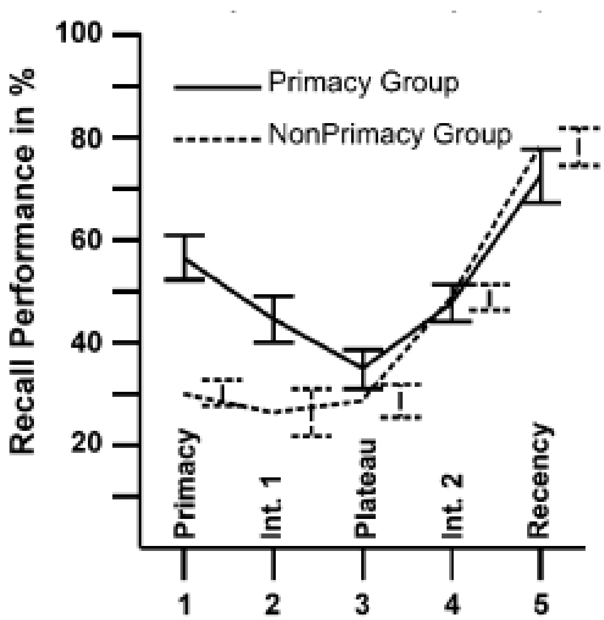

Figure 9: Serial position curve from a study by Wiswede, Rüsseler and Münte (2007), indicating the recall performance according to aggregated serial position curve areas for two experimental groups

Other widely studied results arising from serial learning and serial recall include the errors made by subjects, as these errors provide substantial clues into how memory functions. These errors include **transposition errors** and **nontransposition errors**. In transposition errors, subjects provide the correct item (during serial recall tasks) but do not place it into the correct position. This type of error frequently occurs as a pair, as two adjacent items usually are confused (for example, the item of serial position 4 and item of serial position 5 are transposed). Nontransposition errors is any other type of error in a serial recall task, such as when subjects substitute items in the original memorised list with other items that were not included in the original list. One such type of nontransposition error is the confusion error, when items in a memorised list may be confused with other similar items – such as confusing similar sounding letters in lists such as B and G (phonological confusion errors), or replacing words in a list with semantically similar words, such as cot and bed (semantic confusion errors).

Later studies (Bruyer & Vanberten, 1998; Kerr et al., 1999; Kerr, Ward, & Avons, 1998) have also supported initial research that visual recognition memory does indeed also show a strong primacy effect, and this finding has been reproduced specifically with regard to facial recognition (Bruyer & Vanberten, 1998; Kerr et al., 1999; Kerr et al., 1998). Unfortunately various authors researching the Serial Position Effect seem to generalize their models and theories to all visual stimuli, and therefore do not assume that certain types of visual stimuli (e.g. faces) may be processed differently from others (e.g. patterns of lines).

To summarise, the Serial Position Effect is considered the most widely cited experimental result in the study of serial order, and spans across auditory (including language, verbal and non-verbal) and visual (including patterns, objects and faces) stimuli. Initial research investigated the workings of memory, and established that although exhaustive serial searches may occur in memory, it could not account for the results of the Serial Position Effect. As a result, some authors suggested that searches occur in parallel, whilst others developed alternative memory models. Other robust findings in the study of serial order include the primacy and recency effects, as well as transposition and nontransposition errors. However, most research into visual Serial Position Effects assumed that faces are processed similarly to other visual stimuli, and this has only been addressed in the recent decade.

Many different theories have emerged in an attempt to explain why the SPE occurs. These are discussed briefly below. Lewandowsky and Farrel (2002) indicated that most of the models that explain serial memory are premised on a **working memory model** or on the **modal model of memory**, which both are dual-store approaches in which short-term stores are distinguished from long-term stores. This explanation can be attributed to the early studies of Glanzer and Cunitz (1966), in which it was found that distraction tasks during the retention interval results in the erasure of the recency effect. It is assumed that items from the end of a list are stored in the short-term memory store, and are vulnerable to distraction tasks, whilst items from the beginning of the list are recalled from a more stable long-term memory store (Bengner & Malina, 2007).

2.3.1 Central SPE models.

Various serial position effect models have been postulated through the years, which have evolved from classic theories to more contemporary theories. Three classic theories are described briefly below, after which five more contemporary theories are described. The models can also be divided in terms of viewing working memory as active localist units, in which each item is represented by a distinct unit whose activation represents memorial strength, or as a distributed network, in which memory items are represented not by identifiable single units but as patterns of activation across a collection of units (Lewandowsky & Farrell, 2002).

Classic theories

The classic theories are largely theories of serial learning, as the most popular experimental paradigm that was used at the time they were developed was the method of anticipation. These theories include *associative chaining*, *positional coding*, and *positional distinctiveness*.

Associative chaining

The associative chaining model works on the assumption that one item in a sequence is linked to (or associated with) the next item in a chain (Healy & Bonk, 2008). This model therefore assumes that, in a serial learning task, each item in a list is given as a cue for the next item. Therefore, missing one item may result in the inability to recall all subsequent items in the list. This does not occur in reality, which can be explained by assuming that there are associative links of varying strengths between all items in the list, not just between neighbouring items. The associations between neighbouring items are stronger than the more remote associations that link items that are not adjacent in lists.

However, the associative chaining model encountered empirical problems which it could not account for. For example, subjects did not memorise paired associations any faster than they memorised unrelated associations (Young, 1962).

Positional coding

Another early model that explained serial learning was also based on the associations between stimuli and responses, and involved a simple positional coding model. However, associations were not formed between one item and the next, but rather between a specific item and its ordinal position (Healy & Bonk, 2008). The box model of Conrad (1965) stipulates that each successive item in a list is stored in a preordered array of boxes in memory. Item information in the boxes gets degraded with the passage of time, and during recall subjects retrieve items for each box in turn using whatever information is still available. Transposition is the result of an item being so degraded that it may be consistent with another item. However, this model also encountered empirical problems. Using anticipation, subjects learned a list of adjectives until they completed one perfect trial recall. When tasked to learn a set of paired associates, the subjects did not perform as well on the paired associate task as they would have considering that they learned those same associations previously (Healy & Bonk, 2008).

Positional distinctiveness

The distinctiveness models is a relatively simply but powerful model proposed by Murdock (1960), and has been adopted by other researchers (Nairne, Neath, Serra, & Buyn, 1997; Neath, 1993a, 1993b; Neath & Knoedler, 1994; Ward, 2002). Two versions of distinctiveness models exist. The aforementioned *item distinctiveness* is based on its position in an ordinal set, whereas other distinctiveness models are based on an item's *temporal distinctiveness* (Oberauer, 2003). Von Restorff (1933) reported that *item distinctiveness* affects memory performance. This model proposes that an item's distinctiveness can be determined by comparing its ordinal position value to the value of all the other list positions. As an example, in a list that contains five items, the distinctiveness of the first item can be calculated by adding the values of |1-2|, |1-3|, |1-4| and |1-5|, which is 1 + 2 + 3 + 4 = 10. However, the centre position (position 3) is |3-1|, |3-2|, |3-4| and |3-5|, which is 2 + 1 + 1 + 2 = 6. The first position is therefore more *distinct* than the centre position. Proponents of this model therefore believe that the primacy effect occurs because there are no items preceding the first few items, which implies that these items are more distinct in the memory, and similarly the last items are more distinct since no items follow the last few items. The actual calculation of the distinctiveness of items is more complex as log values are used instead of ordinal numbers, which allows the model to account for the finding that primacy effects are typically stronger than recency effects (Healy & Bonk, 2008).

Neath (1993a, 1993b) proposed that the temporal distinctiveness of an item may also be crucial for serial position effects. Neath's (1993a, 1993b) Dimensional Distinctiveness model states that the recognition memory for any item in a specific list of items is determined by that items *temporal* *position* in relation to the other items. More recent distinctiveness models such as SIMPLE (Brown, Neath, & Chater, 2002) stipulate that distinctiveness decreases over time because the cognitive time dimension is logarithmically suppressed, and effectively compressing the perceived distance between events as they recede in time. Therefore, while memorising a list, a distinctiveness advantage can be observed for the most recent items (resulting in a recency effect), whilst during recall, an advantage can be observed for the items recalled first during recall (resulting in a primacy effect) (Oberauer, 2003). This differs from Phillips and Christie's (1977a, 1977b) explanation of the SPE - that recognition performance associated with serial position is determined by differences of *item information* in their Serial Information-Processing Model.

Serial information processing model

One of the old, but influential accounts that explains the typical U-curve of the SPE is that posited by Atkinson and Shiffrin (1968) and Waugh and Norman (1965). These accounts explain the primacy effect as a result of the first items being selectively transferred into a more stable long-term memory, whereas the recency effect reflects a function of short-term memory (Wiswede et al., 2007). The primacy effect may also be explained by the fact that first items are rehearsed more often (Rundus, 1971). This forms the basis of the Serial Information Processing model as utilised by Phillips and Christie (1977a, 1977b) to explain the SPE.

According to the Serial Information Processing model in recognition tasks, Phillips and Christie posited that attention is allocated to each of a series of items in turn (Kerr et al., 1999). At the display of a stimulus, it can be visualised and maintained in the short-term visual memory (similar to the visuo-spatial sketchpad, as proposed by Baddeley and Hitch). With the presentation of the next stimulus, the attention will shift to encoding that stimulus, and the previous stimulus will no longer be maintained. Recognition performance is superior for the stimulus that is currently being being visualised, since additional details of the stimulus are present in the short-term visual memory (Kerr et al., 1999). This model explains the SPE as occurring due to the differences in item information (owing to the level of detail that can be recalled while visualising the stimulus in the short-term memory, whilst the detail of the previous stimulus is lost).

However, researchers noted that with the increase in retention interval (the time that passes between presenting the stimuli and the recognition task), the first stimulus was recognised at a much higher frequency than the last stimulus (Kerr et al., 1999; Kerr et al., 1998; Neath, 1993a, 1993b; Neath & Knoedler, 1994). This phenomenon was termed the "recency-to-primacy shift", and challenged the explanation of SPE of the Serial Information Processing model (Kerr et al., 1999). The Serial Information Processing model predicted that the passage of time would only result in the most recent items also being stored in the long-term memory, which could not explain these results.

The recency-to-primacy shift provides severe problems to SPE studies, since different retention intervals (the time between the presentation of stimuli and recall) may lead to different recency and primacy effect and serial position effect results. Kerr and his colleagues (1998) suggested that the recency-to-primacy shift could be caused by response bias in participants. Subjects are more biased to selecting an early stimulus than they would a later one with the passage of time, leading to attenuated primacy and diminished recency effects.

Kerr, Avons and Ward (1998) conducted a follow-up study to investigate the recency-to-primacy shift with both the Serial Information Processing and the Dimensional Distinctiveness models. These authors found very little evidence supporting Neath's Dimensional Distinctiveness model with regard to the recency and primacy effects, but the findings were consistent with the Serial Information-Processing Model of Phillips and Christie (Phillips & Christie, 1977a, 1977b). The recency-to-primacy shift can be explained by the Serial Information-Processing model by considering that there are strategic differences in encoding – as the retention interval is lengthened, there is a greater demand on cognitive resources to visualise the final item. This will result in the devotion of resources to rather encode and maintain earlier list items (Kerr et al., 1999).

Phillips and Christie (1977a) state in their Serial Information Processing model that a central executive determines performance of visualization. This indicates that there is a specific cognitive and/or anatomical function that determines the visualisation process, which has been corroborated by both neurological studies and cognitive studies (see, for example, Maurer et al., 2002; Wenger & Townsend, 2006; Wiese et al., 2009; Wiswede et al., 2007). However, this does not imply that there are no special purpose processors for other visual operations. For example, Bruyer & Vanberten (1998) suggest a possible specific short-term store for faces. This is in agreement with the intuitive thought that memory for faces is one of the most important features the human being must acquire. It is known that facial processing involves a huge amount of different processes, although which, and how, are still being investigated. The researcher assumed, for the purpose of this study, that specific neuro-anatomical and psychological processors and types of memory do exist for faces, which are distinct from other kinds of visual stimuli. This idea is best supported by neuropsychological cases such as *prosopagnosia*, in which damage to specific parts of the brain anatomy can lead to the inability to recognise faces although the recognition of other visual stimuli is still intact. What is clear is that the human mind is oriented towards extensive cognitive processing of faces as visual stimuli (refer to Section 2.2 for more literature related to this). However, we also know how this processing can go awry by looking at everyday examples of inability to recall faces, or misidentification of criminals in the judicial system.

Contemporary theories

The contemporary theories differ from the classical theories in terms of their primary focus on serial memory, rather than serial learning. As the immediate serial recall paradigm become the dominant experimental methodology (especially following Sternberg's research in 1966), the models to explain the findings also developed (Healy & Bonk, 2008). These include the *perturbation model*, the *start-end model*, the *primacy model*, *OSCAR*, and *TODAM*.

Perturbation model

Estes proposed the perturbation model in 1972 to account for serial recall performance in the distractor paradigm. The distractor paradigm was utilised with very short lists of information that needs to be memorised, after which an interpolating task is presented prior to recall. This distractor is used to prevent rehearsal of information. The perturbation model is also based on simple associations, but the associations are between the individual list item and a control element. The control element is considered the given context or environment in which the list was learned (Healy & Bonk, 2008).

The core of the model is a reverberating loop that links the control element to a specific list item. Each time the control element is accessed, the list item is reactivated. As all items in the list are associated to the same control element, the difference in activation times reflects their input order (Healy & Bonk, 2008). The failure to recall items in the correct order is ascribed to either loss of access to the control element (possibly the original context has shifted as a function of time or because of some interfering activity), or there may be perturbations, or disturbances, in the timing of the recurrent reactivations (presumably due to random neural activity). If timing perturbations are large enough, two items may be transposed. The Serial Position Effect can be explained as a result of a higher likelihood of interchanges at intermediate list items (which have neighbouring items on both sides) than end-of-list items (which have only neighbouring items on one side).

Start-end model

The start-end model was proposed by Henson in 1998 (Healy & Bonk, 2008; Henson, 1998b). The start-end model can be considered an evolution of the positional distinctiveness models that are not related to temporal distinctiveness (Oberauer, 2003). This model assumes that memory functions as active localist units (Lewandowsky & Farrell, 2002). The presumption is that the start and the end of a list are the most salient and therefore act as anchors or markers, and items in between are coded in relation to these two markers. Each item therefore gets a two-value code, based on the strength of both the start and end markers at that specific point in the list. It is furthermore assumed that subjects anticipate the end of the list when they know the length of the list, which increases the strength of the end marker toward the end. The model furthermore makes a distinction between types and tokens as a way of representing items. The same item may feature in many lists, but in different positions. Therefore the item may have the same type in all the lists, but may have a different token in each list. The item token codes both the identity and positional information. The positional information of each item is derived from the relative strength of the start and end markers for that item token (Healy & Bonk, 2008; Henson, 1998b).

Primacy model

The primacy model that was proposed by Page and Norris in 1998 is related to both the perturbation and start-end models, but was formulated to account for the results that formed that basis of Baddeley and Hitch’s model of the phonological loop (Healy & Bonk, 2008). Therefore, this model also assumes that working model of memory functions as active localist units (Lewandowsky & Farrell, 2002). The primacy model is effectively a computational version of the phonological loop model, and is based on the premise of an attentional primacy gradient, which stipulates that less-and-less attention is devoted to each additional list item, resulting in memory traces of decreasing strength (Oberauer, 2003). This model does not specifically code position information, but position information is determined at the time of recall from the relative strengths of list items. The activation strengths of list items is determined as a function of the time when the list items occurred, forming a primacy gradient, with the strength greatest for the first item and then declining for successive items in the list. Therefore the start-of-the-list context is similar to both the control element in the perturbation model and the start marker of the start-end model. However, there is no corresponding end marker in the primacy model. The attentional gradient fulfils a functional role in this model, as it is used to preserve the order of the items (Oberauer, 2003)

During recall, a repeating cycle occurs in which the item with the greatest activation is selected for recall, and after it is recalled, it is suppressed. Subsequently the item with the next highest activation is recalled and suppressed. However, the activations of the list items are subject to exponential decay over time. Errors in recall therefore occur as a result of noise in the process of selecting the item with the highest activation – similar to noise in the perception of the activation strengths. Primacy effects result naturally from the primacy gradient, and recency effects occur due to the end items only being able to be subject to paired transposition errors in one direction (end items have only one neighbouring item), whilst central items can be subject to transposition errors in two directions.

Paired transposition errors may occur when the perceived activation strengths of a selected item is either less than the perceived activation strength of the subsequent list item, or greater than the perceived activation strength of the preceding list item (Healy & Bonk, 2008). A property called fill in also accounts for these paired transposition errors, in which a missed item is likely to be recalled in the next position.

Diffusion model

Further research evaluated the different classes of exhaustive and self-terminating search models, using the results observed in Sternberg's research. This research indicated that exhaustive processing models were not tenable, and suggested that self-terminating models provide a better description of rapid visual and memory search processes (Van Zandt & Townsend, 1993). The assumption behind such self-terminating models is that the most recent items have the highest latency in memory, and therefore the highest "activation strength" in the memory trace. Consequently, a number of strength-based models have been postulated as alternatives, of which Ratcliff's diffusion model is one of the most developed and influential models (Hockley, 2008; Rattcliff, 1978).

Ratcliff's diffusion model suggests that the search item is compared to all the items in the search set in parallel. Evidence is accumulated for each comparison, based on the degree of how related the search item and the memory item is. This model accounted for the findings observed in the Sternberg paradigm, including response time set size effects, serial position effects, and the appropriate characteristics of the response time distributions and the speed-accuracy tradeoffs (SAT) (Hockley, 2008). However, this model postulated that, should no match be found during the parallel comparison due to insufficient evidence to match the search item and the memory item, the default option that is reached is a negative decision. In other words, a stimulus item that should not be rejected could be rejected if insufficient evidence is found to match the item with memory, which may also be the case with correct rejections. It was therefore unclear whether the rejection of items (for example, research participants mentioning that the search item was not included in the memorised list) is due to really remembering that the item was not included in the list, or whether the item just cannot be matched to an item in the list. Further research into this resolved this problem. For example, the research by Mewhort and Johns (1978) illustrated by investigating the "extralist feature effect", that contradiction (differentiating between uncertain rejections and certain rejections of search stimuli) is highly possible in recognition decisions, given that information to support the rejection is available and that the memory set is well-defined in memory (Hockley, 2008). Research participants therefore can clearly differentiate between items that they are certain can be rejected and items that they are uncertain can be rejected. However, it must be noted that Ratcliff's diffusion model only provides a theory that explains the retrieval and decision process, but does not provide an account of how items are represented in memory or how they are compared. Other models, such as Gillund and Shiffrin's search of associative memory (SAM) model and Hintzman's MINERVA 2 model can therefore be complementary approaches to Ratcliff's model, as these models do make explicit assumptions of how items are represented in memory or how they are compared (Hockley, 2008).

OSCAR

OSCAR is considered a novel approach in explaining serial recall (Healy & Bonk, 2008), as it is an oscillator-based computational model and is based on an assumption of working memory as a distributed network (Lewandowsky & Farrell, 2002). Oscillators are timing mechanisms that generate continuously changing rhythmic output at different frequencies. An analogy that Healy and Bonk (2008) use is the hands in a clock face, with the second hand completing its cycle more rapidly than the minute hand, which completes its cycle more rapidly than the hour hand. The learning of order, according to OSCAR, makes use of the naturally occurring oscillators timing mechanisms in the mind.

During list presentation, associations are formed between a vector (an ordered series of numbers) that represent a list item and a vector that represents successive states of the learning context. The learning context is the current state of the dynamically changing internal set of timing oscillators. Therefore, the associations between items and representations are considered dynamic as the learning context changes continuously during list presentation (Healy & Bonk, 2008; Lewandowsky & Farrell, 2002). During retrieval, a sequence is recalled by reinstating the states of the oscillators that comprise the learning context. Therefore, it is assumed that recall order errors occur in OSCAR only during the retrieval stage. Each successive learning context vector is used as a probe recovering the list item vector that it is associated with. When the learning context vectors are highly similar in time are more likely to result in order errors (Healy & Bonk, 2008).

TODAM

The theory of distributed associative memory (TODAM) model that was proposed by Lewandowsky and Murdock in 1989 is designed to account for both serial learning and serial recall, and is based on the associative chaining model and also utilises the concept of an attentional primacy gradient, in which less attention is paid to each additional association, resulting in memory traces of decreasing strength (Oberauer, 2003). TODAM is based on an assumption of working memory as a distributed network (Lewandowsky & Farrell, 2002), but also provides a more general account of memory, and is not necessarily restricted to memory for serial order (Healy & Bonk, 2008).

In TODAM, the representations of all list items are stored in a common memory vector, with the numbers that make up the memory vector representing the values of individual features. Successive items are associated with this memory vector using a mathematical operation called convolution, which blends the constituent item vectors. The resulting convolution is also added to the common memory vector. In order to retrieve individual items from this convoluted memory vector, a process called correlation is implemented to undo the convolution, which is effectively the inverse of convolution. Therefore, a memory search for a specific item can first be correlated with the common memory vector, the result which yields another vector that approximates the response item with which it had been associated. Once the approximation item has been generated via the correlation process, it must be deblurred, or interpreted, before it can be recalled. If the deblurring process yields an overt recall response, the new vector that is generated by that response can be used as stimulus to recover the next item in the list. However, the deblurring process may not actually result in a match. If this occurs, the vector approximation from the correlation process can be used as stimulus for a subsequent response, effectively allowing the recall process to continue, even if a specific item cannot be recalled (Healy & Bonk, 2008).

However, according to Lewandowsky and Farrell (2002), other research has cast doubt on the assumption of chaining to explain the recall of items. Chaining of items predicts catastrophic errors in lists of mixed confusable and non-confusable items, as the large overlap between similar items should cause massive interference among cues, and recall of the following items should be impaired. The data does not show this pattern. In this, OSCAR and TODAM fail to adequately explain serial recall, and inter-item associations do not play a crucial role in the representation of serial order information.

Summary of models

In summary, the classical theories were developed towards explaining serial learning, whilst the contemporary theories were developed explaining immediate serial recall. However, certain aspects of the classical theories are also applicable to serial recall.

The classical theories are mostly based on associations between list items, the earliest of which was the associative chaining model, in which list items were associated with the previous item. The positional coding model assumed associations being made between list items and a preset memory vector. The positional distinctiveness model (which is still currently under development in the dimensional distinctiveness model and others) assumed associations being made between list items and either the ordinal value of the items or the temporal order of the items. The serial information processing model is not based on associations, but assumes that items are maintained in a short-term specialised visual memory, and a rehearsal process is adopted to maintain earlier items. The most recent item will be remembered in the short term memory as well, which may account for both primacy and recency effects.

Most of the contemporary theories are based on associations between list items and some additional controlling element. The perturbation model assumes that associations are made between list items and a reverberating loop, which reactivates list items continuously with each successive recall. The serial position effect is explained as the result of more transposition errors in intermediate list items. The start-end model assumes that each list item is assigned a unique type and token that is based on the relative strength of a start-marker and an end-marker, assuming that subjects know the list length. Once again, the serial position effect is explained as the result of increased numbers of transposition errors in intermediate list items. The primacy model is similar to the working memory model proposed by Baddeley and Hitch, and essentially is an integration of the perturbation model and the start-end model. List items are encoded as a function of the time that items were encoded, the strength of which declines as more items are encoded, forming a primacy gradient. During recall, the item with the highest activation strength is recalled first, then suppressed, after which the item with the next highest activation strength is recalled and suppressed. The serial position effect occurs as a result of transposition errors in intermediate items as well as the strong activation strength of the first item. OSCAR assumes that list items are encoded using oscillators in the mind, which therefore constitutes a constantly changing learning context that can be used to recall items when the oscillators are reset to the unique positions when the list items were memorised. The serial position effect occurs as a result of transposition errors. TODAM represents a general account of memory as well as accounts for serial memory. This model assumes that list items are convoluted to an overall memory vector, and each successive item is also subject to this convolution and added as a unique vector to the overall memory vector. Recall is the result of correlation, which undoes the process of convolution. However, OSCAR and TODAM fail to fully explain recent research results.

This study adopted the Serial Information Processing model as an explanation of the occurrence of the SPE, as this model does not rely on a system of association.

2.3.2 Mechanisms and variables influencing facial recognition and the serial position effect.

Various mechanisms and variables influence facial recognition, and some of these mechanisms may bear relevance on the Serial Position Effect in facial recognition as well. These mechanisms and various variables are discussed in this section. Variables and mechanisms by which the serial position effect occurs is discussed first, followed by a discussion on variables that may generally influence the serial position effect in facial recognition.

Mechanisms and variables influencing Serial Position Effect

The serial position effect can be explained in the context of the various memory models discussed in the previous section, yet, like the memory models, the specific mechanisms by which the serial position effect occurs remain under investigation. The study by Klaus Oberauer (Oberauer, 2003) attempted to deconfound the specific mechanisms under which serial position effects occur. Most of the research investigating the Serial Position Effect used one of three types of recall tasks, being forward serial recall, backward serial recall and Sternberg recognition tasks (Oberauer, 2003). All three recall types involve the memorisation of a set of stimuli (for example, 6 items, presented in random order). Forward serial recall tasks are tasks where participants are requested to recall these items in the original order in which they were presented. Backward serial recall tasks are tasks where participants are requested to recall these items in the reverse order in which they were presented. The Sternberg recognition task involves the presentation of each of the stimuli, with the task being to identify whether the presented stimulus was seen before or not. This may or may not include distractor stimuli – stimuli that were never included in the original stimuli set. A modification of this task may also involve identification of specific serial position in which the presented stimulus was seen.

The Sternberg recognition task differs from the serial recall tasks on three aspects (Oberauer, 2003). First, the retrieval demands are different between the two. Serial recall involves a recall task demand, whilst the standard Sternberg recognition task involves a recognition demand. Second, the standard Sternberg task requires only item information (in other words, only which items were in the list), whilst the serial recall tasks also requires information on the serial order to be recalled (in other words, which serial position each item had on the list). Finally, whereas serial recall requires the retrieval of the all the list items, the Sternberg task involves only a single retrieval event.

In addition to the type of recall/recognition task involved in the study, three dimensions of serial position could influence performance in the memory task. First, the serial order of encoding a list, termed encoding position or input position. Second, the serial order of retrieving list elements, termed retrieval position or output position. Third, the serial order of items which needs to be remembered, called memory position (Oberauer, 2003). The standard experimental paradigms usually confound these three dimensions of serial position. In forward serial recall, the encoding position and the retrieval position are identical, therefore the serial order to memorised is identical to them as well. In the backward serial recall condition the encoding and retrieval position are negatively correlated, and the order information to be maintained in memory is either the encoding order or its reverse. In Sternberg tasks, there is no retrieval order, and no order information has to be remembered. Oberauer (2003) therefore stated that Sternberg tasks are the closest to an unconfounded picture of input position effects, and his study subsequently attempted to determine whether the same serial position curve could be found when input position is separated from memory and output position.

Classically, memory items are presented in frames arranged in a row from left to right in random order, and retrieval of each item is required in a different order. Therefore, the temporal order of presentation, the spatial order from left to right, and the temporal order of retrieval are uncorrelated.

In tasks that require order information, it is memory for spatial position that must be remembered because items have to be retrieved by their frames. Therefore, memory order is the same as the spatial order from left to right. Within this presentation paradigm, three different retrieval demands can be made: Cued recall by spatial position, global recognition and local recognition. Oberauer (2003) operationalises these recall demands as follows: Cued recall by spatial position is standard recall in which the spatial position of a probe must be provided. Global recognition is a task where a probe is compared to the whole list, as in the Sternberg recall task. Local recognition is a task where a probe is compared to an item at a particular position. Local recognition therefore shares with global recognition the type of retrieval demand and with serial and cued recall the requirement to memorise order (or position) information.

Several mechanisms by which primacy and recency effects in short-term memory tasks can occur are discussed in the literature, and these mechanisms attribute the effects to different dimensions of serial position (Oberauer, 2003). These mechanisms predict serial position effects over different dimensions in a paradigm that allows separating these dimensions, and include:

- Modality of stimuli
- Type of recall task
- Retroactive interference
- Primacy gradient, response suppression, chaining
- Distinctiveness and edge effects

Modality of stimuli

The type of stimuli that is used in serial recall tasks has been shown to influence the recency effect. Auditory-verbal items have consistently shown greater recency effects than visual-verbal items in typical forward serial recall tasks (Page et al., 2006; Tremblay et al., 2006). This effect can be explained by the temporal distinctiveness theory, which would suggest that the recency advantage for auditory-verbal information emerges because auditory events are more distinct than visual ones. The more successful retrieval or recent items (with the observed recency effect) occurs as the search set for the last items is narrowed (Tremblay et al., 2006). The Start-End model (Henson, 1998b) may also explain this effect by adjusting the strength of the start and end markers relative to those used in visual presentations. The feature or dimensional distinctiveness model also assumes that more modality-dependent features are encoded for auditory items than for visual items. Retrieval is therefore a function of the similarity between memory traces, and the memory traces for visual information is assumed to degrade more rapidly than auditory information (Tremblay et al., 2006).

Type of recall task

Five types of measures are commonly used to investigate human memory, including item recognition, associative recognition, cued recall, and free and serial recall (Hockley, 2008). Serial recall tasks are usually performed in SPE experimental paradigms, namely forward serial recall, backward serial recall, and immediate recognition (Oberauer, 2003). Forward serial recall tasks are ones in which stimuli that were presented first are recalled first, whereas backward serial recall tasks are ones in which stimuli that were presented last are recalled first. Immediate recognition entails the recognition of stimuli in any order (random or non-random) between distractor stimuli.

Forward serial recall generally results in a large primacy effect and a small recency effect, whereas backward serial recall usually results in a larger recency and relatively small primacy effect. The immediate recognition condition typically results in a large recency effect both for reaction times and accuracy, accompanied by a small primacy effect (Oberauer, 2003). In addition, a difference in performance between serial recall and serial reconstruction may also exist. This is based on the premise that serial recall tasks may be subject to both item (omissions and intrusions from other sequences) and order errors (transposition errors), whilst serial reconstruction tasks are only subject to order errors (transposition errors) (Tremblay et al., 2006).

Retroactive interference or decay

Retroactive interference or decay may occur during both encoding (termed input interference) or during output or recall (termed output interference) (Oberauer, 2003). During encoding, retroactive interference naturally produces a recency effect as a result of the earlier items on the list suffering interference from later items in the list. Therefore, input interference naturally causes a recency effect (Oberauer, 2003). Retroactive interference during a series of outputs provides an advantage for items retrieved first, since early earlier output items interfere with items still to be recalled in the output sequence, irrespective of input or spatial position. In the event of this task being a strict forward serial recall task, this would generate a primacy effect over output position. Results from a study by Cowan and his colleagues (Cowan, Saults, Elliot, & Moreno, 2002) also suggest that output interference contributes to the primacy effect in serial recall.

In summary, retroactive interference, which is an increasingly rapid degradation in the ability to recall stimuli as time passes, influences both primacy and recency effects. During encoding, retroactive interference is more likely to produce a recency effect, whilst during retrieval, retroactive interference is more likely to produce a primacy effect.

Attention primacy gradient, response suppression, and chaining

An attention gradient (in which attention decreases as time passes) is stated as one source of primacy in serial recall – since attention is optimal at the start of an encoding task (Brown, Preece, & Hulme, 2000; Farrell & Lewandowsky, 2002; Lewandowsky & Murdock, 1989; Oberauer, 2003; Page & Norris, 1998). As more items are presented to a subject, the subject's attention becomes divided between storing the previous items and encoding the new item, resulting in memory traces of decreasing strength or activation (or to each additional association in TODAM, Lewandowsky & Murdock, 1989). It is therefore logical that this will increase the primacy effect, since the most attention will have been given to the encoding of the first stimulus during forward serial recall.

In the Primacy Model (Page & Norris, 1998) and in SOB (Farrell & Lewandowsky, 2002) the attentional gradient also serves a function in preserving the order of items (Oberauer, 2003). Forward serial recall tasks are executed by recalling the most-activated item, which is then followed by suppression of the recalled item (response suppression). This *response suppression* is essential in many of the attentional gradient models, since removal of the strongest items is necessary to make room for later list items to be recalled next. Continuous suppression of recalled earlier items leaves only a few items in the candidate set when the end the list is reached. If recall has been relatively accurate up to that point, the remaining items are most likely those that have actually been presented at the end of the list (Oberauer, 2003). An activation gradient is not expected to have any function in a task requiring no order information, and therefore no effects from attention primacy gradients should be expected in "global recall" tasks (Oberauer, 2003), but may produce a primacy effect by means of spatial position. Unintentional attention gradients arising from basic attentional mechanisms, such as attentional capture of the list onset, or the distraction from later list elements by elements already held in memory, may produce a primacy effect over input position and will affect spatial recall, local recall and global recall tasks. With response suppression, the reduction of recall candidates occurs over successive recall attempts, which will generate a recency effect over output position (Oberauer, 2003).

TODAM (Lewandowsky & Murdock, 1989), one of the early models of serial recall, was based on a mechanisms called *chaining*. *Chaining* is the mechanism by which each new item is associated to its predecessor. This generates a primacy effect in forward serial recall, since items later in the chain depend on the accurate recall of earlier items, which can subsequently be used as cues (Oberauer, 2003). If the chaining mechanism is under the control of the cognitive system, it should build a chain that preserves the memory order and not necessarily the encoding order. This would imply that one would expect a primacy effect over spatial serial position for the paradigms that require order information (i.e. spatial recall and local recognition tasks) (Oberauer, 2003). However, if chaining occurs automatically during encoding, regardless of the type of task, it generates little effect for spatial, local and global recognition since it is largely useless for a task where retrieval order does not match encoding order. In these cases, successful retrieval needs to rely on other cues (Oberauer, 2003).

Distinctiveness and edge effects

Serial position effects can also occur from differential *distinctiveness* or discriminability of list items in memory, which may be based on two versions of the distinctiveness explanations. One of these is *temporal distinctiveness*, whilst the other is a more general distinctiveness approach (Oberauer, 2003). *Temporal distinctiveness* theories (Brown et al., 2000; Burgess & Hitch, 1999; Glenberg, Bradley, Kraus, & Renzaglia, 1983), as discussed in section 2.3.1, purports that successive events are associated with a continually changing context representation. An attempt to recall an event (such as a list item) uses a reconstruction of the context representation as a cue. The distinctiveness of a list item decreases when the interval between encoding and retrieval increases, because the temporal context at encoding and the one at the time of recall have less and less in common. This makes it increasingly difficult to reconstruct the encoding context (Oberauer, 2003). The temporal distinctiveness model predicts a recency effect over input position, because items presented more recently will be more distinctive on average. Furthermore, distinctiveness decreases over the time of recall, generating an advantage for items recalled first, that is, a primacy effect over output position (Oberauer, 2003). In general, it would seem that an increase in retention interval (the time that passes between the stimuli being presented and the recall task) results in a strongly diminished recency effect and a slightly stronger primacy effect (Hannigan & Reinitz, 2000; Kerr et al., 1999; Phillips & Christie, 1977a; Warrington & Taylor, 1973). This implies that the first stimulus in a set of stimuli would demonstrate improved performance recognition compared to both later serial positions in a delayed retention interval and to the first serial position in an immediate test condition (Kerr et al., 1999). Kerr et al. (1998) and Kerr et al. (1999) argue that the recency-to-primacy shift that normally is seen with a longer retention interval is due to a bias in subjects to respond specifically to increase the apparent "primacy" effect. This implies that, when presented with a recall task in which the respondents have to provide the serial number in which a specific item was presented, subjects are more likely to select "primary" numbers, such as position "1".

However, if items are presented randomly, the temporal context is not a useful cue for recall, so participants would have to rely on other cues such as spatial cues. The temporal distinctiveness model therefore would not be expected to be a relevant hypothetical account for primacy and recency effects in a randomised presentation paradigm.

However, a temporal distinctiveness model could still be based on *between-list* discriminability, where items at the end of an input sequence are further removed from previous lists, and these items may therefore be less likely to be confused across lists, thus generating a recency advantage (Oberauer, 2003). The delay over successive outputs also reduces discriminability between lists, which generates a primacy gradient over output position. However, this discrimination between lists should affect only memory for items (in other words, which items were in the current list), not memory for order (in other words, at which position an item was in the list). The predictions from temporal discriminability therefore are confined to memory for items (Oberauer, 2003).

A second category of distinctiveness models is based on the discriminability of items on dimensions that may not necessarily be linked to time. Some of these models were discussed in section 2.3.1, such as the Start-End model proposed by (Henson, 1998b). Henson (1998b) assumes that each list item is associated to a context formed by a vector of two context units: A start unit with activation decreasing from the beginning to the end of the list, and an end unit, with activation decreasing from the end of the list to the beginning of the list. Items at the start and the end of the list have strong activation gradients, which rapidly declines toward the middle of the list, and then gradually level off. SIMPLE (Brown et al., 2002) also incorporates dimensions beside time to calculate overall discriminability (Oberauer, 2003).

For models such as the Start-End model, one should assume that the context representation would be arranged to capture the memory order, and not necessarily the input order (Oberauer, 2003). If a task requires memory for spatial position instead of input order, the start- and end-markers would be set on the left and the right end of the row, respectively. This should generate primacy and recency effects over the spatial dimension (Oberauer, 2003). Oberauer (2003) reports that U shaped serial position curves over spatial position have been reported for the accuracy of recalling the spatial position of a given item (Anderson, 1976; Healy, 1975a; Nairne & Dutta, 1992).

Primacy and recency effects can also arise from the differential probability of transposition errors (Oberauer, 2003). Transpositions (i.e. recall of the correct items at the wrong positions occur from the positional confusion errors among neighbouring items in a list, with migrations to positions further away being increasingly rare (Healy, 1974; Henson, Norris, Page, & Baddeley, 1996). This pattern may either arise from a lack of temporal disctinctiveness, as discussed above, or from random noise in the activation levels of items ordered by a primacy gradient (Page & Norris, 1998), or from perturbations in between neighbouring items in the retention phase (Estes, 1972). The first and last items in a set of stimuli to be memorized have only one neighbour, and therefore have less chance of being confused than other items toward the middle of lists. These *edge effects* also are a contributing factor to primacy as well as recency effects (Brown et al., 2002; Estes, 1972).

Serial position research into letters, digits and symbols has convincingly illustrated that the set size has an influence on the type of serial position curve that is obtained. Whilst typical U-type curves are found for sets of 4 letter strings (or any even number), W-shaped curves have been found for 5 letter strings (or any odd number) (Tydgat & Grainger, 2009). This is explained as being the result of a drop in visual acuity as a function of the distance of fixation (commonly the centre letter), and by the amount of lateral interference (crowding), which is determined by the number of flanking letters (Tydgat & Grainger, 2009).

In spatial memory order, edge effects should only appear as primacy and recency over the spatial dimension (Oberauer, 2003).

Summary of variables and mechanisms influencing Serial Position Effects

In summary, various variables and mechanisms occur to which primacy and recency effects can be attributed. The modality of stimuli appears to influence the amount of recency, with auditory stimuli having more pronounced recency effects than visual stimuli. The type of recall task required during any experiment influences the amount of primacy and recency observed during recall, with forward serial recall resulting in a large primacy effect and a small recency effect, whereas backward serial recall usually results in a larger recency and relatively small primacy effect. The immediate recognition condition typically results in a large recency effect both for reaction times and accuracy, accompanied by a small primacy effect. Retroactive interference naturally produces a recency effect during encoding, whereas a primacy effect over output position would be found in strict forward serial recall tasks. The attention primacy gradient suggests that an increase in the primacy effect will be seen during encoding tasks, whilst response suppression will show a recency effect over output position. Chaining also predicts a primacy effect over spatial serial position for the paradigms that require order information. Distinctiveness and edge effects are influenced by the retention interval as well as the encoding time, and a recency effect over input position is expected whilst a primacy effect is expected over output position for temporal distinctiveness theories. In distinctiveness theories that rely on differentiation other than temporal cues, such as the Start-End model, both stronger primacy and recency effects can be expected over spatial recall and output.

Table 1 (adapted from Oberauer, 2003) summarises the mechanisms potentially responsible for primacy and recency effects in short-term memory tasks. The table also presents the dimension of serial order for which these mechanisms predict effects in the random presentation condition, distinguishing between tasks that require order information (recall and local recognition) and the task that does not require order information (global recognition). The last column of the table summarises the support for these mechanisms gained from the previous discussion.

Table 1: Hypothetical mechanisms and their predictions for separate dimensions of serial order (adapted from Oberauer, 2003)

	Relevant dimension (recall, local recognition)	**Relevant dimension (global recognition)**	**Evidence?**
Mechanisms for primacy			
Forward serial recall tasks	Unknown	Unknown	+
Backward serial recall tasks	Unknown	Unknown	+
Immediate recognition/spatial order tasks	Unknown	Unknown	+
Output interference/decay	Output	Output	+
Attentional gradient (automatic)	Input	Input	++
Attentional gradient (functional)	Memory	(None)	+
Chaining (automatic)	(None)	(None)	-
Chaining (functional)	Memory	(None)	+
Distinctiveness (temporal context)	Output	Output	-
Edge effects	Memory	(None)	-
Mechanisms for recency			
Auditory stimuli	(None)	Unknown	+
Visual stimuli	(None)	Unknown	+

	Relevant dimension (recall, local recognition)	**Relevant dimension (global recognition)**	**Evidence?**
Forward serial recall tasks	Unknown	Unknown	+
Backward serial recall tasks	Unknown	Unknown	+
Immediate recognition/spatial order tasks	Unknown	Unknown	+
Input Interference/decay	Input	Input	+
Distinctiveness (temporal context)	Input	Input	-
Distinctiveness (arbitrary context)	Memory	(None)	-
Response suppression	Output	(None)	-
Edge effects	Memory	(None)	-

Variables influencing facial recognition

Various other variables have been shown to influence facial recognition overall. Some of these are listed and discussed below. This is not an exhaustive list, though the aim of the discussion is to present some of the prevailing variables that may influence facial recognition and, possibly, serial position effects in facial recognition. These variables include:

- Encoding time
- Familiarity of items and facial features
- Intact brain anatomy and physiology
- Imitation of the face
- Gender
- Age

Encoding time and retention interval

Encoding time has yielded mixed results on facial recognition (Meissner & Brigham, 2001). Generally, it would seem that reducing the length of time in which participants can study target faces influences the ability of participants to discriminate between faces, resulting in a lower discrimination accuracy. This is especially the case, where false alarms for other-race facial stimuli increases significantly with shorter encoding times (typically less than 3 seconds) (Meissner & Brigham, 2001). However, this is not limited only to other-race facial stimuli, but also own-race facial stimuli.

Familiarity of items and facial features

Familiarity with faces seems to influence the way that faces are processed. Familiar faces are processed in parallel, whilst unfamiliar faces are processed in a serial top-to-bottom order (Hines & Braun, 1990). This has implications on the way that faces are stored in the memory as well and the accuracy of facial recognition, since the most salient features to differentiate unfamiliar faces are hair and eyes, whilst very little salient features are used to differentiate familiar faces (Hines & Braun, 1990).

Intact brain anatomy and physiology

Facial recognition research has been of interest to both neuropsychology and cognitive psychology for decades (Hines & Braun, 1990). Much research has gone into integrating information from both these fields, such as Bruce and Young (1986), Ellis (1986). What is clear is that facial processing relies on intact brain anatomy and physiology, with specialised neuropsychological structures that process faces. A study by Chiaravalloti (2004) states that lesions in the right medial-temporal lobe, adjacent to the cortical structures believed to be specialized for facial recognition, specifically impairs the memory encoding for new faces, but not spatial locations, as was previously thought. Other disorders such as prosopagnosia re-emphasise the importance of intact brain neurology, something easily taken for granted. Other neural research indicates that cells in the temporal cortex are involved in the rapid categorisation of faces (though not scrambled faces) (Donneley, Humphreys, & Sawyer, 1994). More recent research indicates that visually presented words and faces are processed in different areas of the brain, specifically the visual word form area and the fusiform face area (Dien, 2008). There is evidence that hemispherical differentiation also occurs in terms of visual word versus facial processing, regarding ways in which information is represented, processed and selected. It is suggested that each hemisphere utilises efficient parallel processing when stimuli is congruent with the preferred processing style, whilst inefficient serial processing is utilised when it is incongruent, which results in the right-lateralisation for face analysis and left-lateralisation for orthographic analysis (such as words) (Dien, 2008).

Imitation of the face

Whereas earlier literature indicated that imitation of faces enhanced recall ability of those faces, Graziano, Smith, Tassinary, Sun & Pilkington (1996) interestingly found that persons who initially imitated faces later recognized fewer faces than did persons in various control conditions. These authors suggested that attempts to imitate faces results in a less-specific ability to distinguish between individual facial features, whereas concentrating on memorising facial features allows that distinction to occur. More interestingly, these authors also found that a mixture between concentrating on facial features and imitating faces resulted in highest levels of recognition. This suggested that imitation of- and concentration on facial features activates different memory processes.

Gender

Wright and Sladden (2003) reported that there is an effect of gender in recognising faces, in that other-gender facial recognition is diminished. The gender biases usually show up as main effects in statistical analyses, and are explained by different encoding mechanisms utilised by each gender. Women tend to encode faces verbally, whilst men encode faces visuospatially (Wright & Sladden, 2003). Although verbal encoding has already been mentioned as resulting in stronger recency effects than visuospatial encoding of visual stimuli (Hines & Braun, 1990), more recent research indicated that faces may not necessarily be encoded verbally (Lewin & Herlitz, 2002). Although the study by Wright and Sladden (2003) indicates that males outperform females on facial recognition, this finding has only been reported in two studies (Rehnman & Herlitz, 2007). Recent research does not corroborate this finding, indicating that women are better at recognising faces than men, and reflect the best recognition for other female faces (Rehnman & Herlitz, 2007). Other explanations for this gender bias would be that faces evoke more interest in women than in men, although this hypothesis does not explain why female faces result in greater interest (Rehnman & Herlitz, 2007). This own-gender bias is, interestingly, robust enough to surpass age and ethnic effects.

Age

Bruyer & Vanberten (1998) reported that there may be a diminished recency effect in the recall of faces in elderly subjects. This may show that older subjects are not as able to learn new faces in comparison with younger subjects. Korsnes & Magnussen (1996) reported that this inability to recall faces may be due to the fact that elderly subjects (implying subjects older than 60 years of age) have slower cognitive processing speeds. This slower cognitive speed will diminish effective encoding strategies and affect decision times. In addition, when dealing with young adults recognising older adults and vice-versa, an own-age bias has been found (Bartlett & Leslie, 1986; Fulton & Bartlett, 1991), although this finding may not necessarily be replicated by all studies (Rehnman & Herlitz, 2007).

Summary of variables influencing facial recognition

To summarize, longer encoding times and shorter retention intervals leads to more accurate facial recognition overall, whilst shorter encoding times and longer retention intervals leads to less accurate facial recognition. Familiar faces are likely to be processed in parallel, whilst unfamiliar faces are more likely to be processed in serial in a top-to-bottom fashion, resulting in differences in overall recognition. Damaged brain anatomy harms facial recognition in general. Women tend to encode faces using verbal strategies, whilst men use visuospatial strategies, which may result in different results if stimuli are auditory or visual, and generally, women appear to be better at recalling faces than men. Success in recall is inhibited when imitating a face as well. Age influences facial recognition negatively (overall recognition is lower and a less pronounced SPE is observed) when the subjects are very old (older than 60 years of age).

General comments on mechanisms and variables of facial recognition and the Serial Position Effect

Given the aforementioned discussion, what is clear from the research is that the serial position effect itself is not clearly understood and no satisfactory model has been developed to date that can provide for all the aspects of serial recall (Hockley, 2008). Most authors in the literature generalize their findings from using patterns to all visual stimuli (Hines & Smith, 1977; Kerr et al., 1999; Kerr et al., 1998; Phillips & Christie, 1977a, 1977b). The value of the aforementioned research is unquestionable in examining and understanding the serial position effect, and also in specific regard to serial position effect in facial recognition. However, as already mentioned, there is evidence showing specific memory and processors for faces. The cases that do study the serial position effect by using faces do not indicate the race of their subjects or the race of the faces used as stimuli. As will be discussed in the following section, the specific processing of faces should be influenced by some socio-cognitive factors as well, such as the race of participants and faces used in stimuli. The researcher therefore believes that some of the literature may not be as sensitive to all variables influencing facial processing and the SPE, and more studies are needed in this regard. One of these influencing socio-cognitive factors is the Own-Race Bias effect.

2.4 The Own-Race Bias

As was mentioned in the introduction chapter, the Own-Race Bias is a socio-cognitive phenomenon that has been observed in facial recognition tasks between races. The Own-Race Bias (or Own-Race Advantage, as cited in some literature) can effectively be regarded as a "expertise effect within an expertise effect" (Hayward et al., 2008, p. 1018), since we are most expert with own-race facial recognition whilst we are also more expert at recognising faces than at recognising other objects. According to Wright and Sladden (2003), most of eyewitness experts believe that the Own-Race Bias has generated results that are reliable and large enough to be accepted as expert scientific testimony, which is echoed by Wright, Boyd and Tredoux (2003) and by Kassin, Tubb, Hosch and Memon (2001). The most common explanation for this bias is that "people become experts in recognising faces of their own race because of having much interest in and contact with people of their own race" (Wright & Sladden, 2003, pp. 101-102).

Various reviews have occurred on the Own-Race Bias (ORB), of which one of the most recent provides an overview of the previous thirty years of investigation (Meissner & Brigham, 2001). This study indicated that the ORB has been shown to be reliable, replicable, consistent across racial/ethnic groups, generalisable across memory tasks and reliable across individuals. This would furthermore include age, as Pezdek and her colleagues demonstrated (Pezdek, Blandon-Gitlin, & Moore, 2003). The cross-race effect has been shown to possibly have a developmental aspect to it, as children develop a stronger own-race bias as they grow older (Furl, Phillips, & O'Toole, 2002), which could be attributed to quantitative rather than qualitative changes in the cognitive processes underlying facial recognition memory (Pezdek et al., 2003).

The own-race bias bears special relevance to the judicial system, where eyewitness identification is eligible evidence to implicate accused persons in crimes. In 1971, five black men, who became known as the "Quincy Five" were wrongfully indicted for the murder of Khomas Revels during a robbery in Tallahassee, Florida (in the USA). Although no forensic evidence obtained from the crime scene ever was linked to any of these men, five white eyewitnesses positively identified them as the perpetrators. Two of the defendants, Dave Roby Keaton and Johnny Frederick were found guilty on the basis of eyewitness testimony and coerced confessions obtained by investigators – in spite of the lack of any physical evidence against the accused men. During the third trial involving David Charles Smith, hired investigators of the defense team located the three actual perpetrators of the crime, who became known as the "Jacksonville Three". These men were brought to trial and convicted based on latent fingerprint evidence and identification of the car used in the murder (Meissner & Brigham, 2001). This example sparked a plethora of research into cross-racial facial recognition and the "they [other-race individuals] all look alike" claim. Now, four decades later, this field still remains one of the most actively researched fields in social and cognitive psychology.

In a survey of eyewitness testimony experts, Kassin et al (2001) reported that 90% of experts regarded the ORB results as sufficiently reliable to comprise admissible expert testimony. More than 70% of these experts stated that they would personally testify that the own-race bias exists. In addition, a meta-analysis by Field (2001) indicated that people were 1.38 times more likely to correctly identify the face of someone of their own race, and 1.50 times less likely to incorrectly identify someone of their own race than other races.

The mechanisms behind how faces are cognitively processed also provided insight into the Own-Race Bias, with two potential memory processing systems accounting for how faces are processed. These processing systems were the serial processing system and the parallel processing system, which also could be described as component anwd configural component processing, respectively (Hayward et al., 2008). Faces are processed serially when individual features of faces are processed in a sequence, whilst faces are processed in parallel when the facial features are all processed simultaneously.

Various theories have been outlined as the cause of ORB, which includes racial attitudes, physiognomic homogeneity, interracial contact and perceptual learning (Meissner & Brigham, 2001). These are discussed shortly below.

Proposed social-cognitive mechanisms underlying the ORB

Detailed expositions of the various theories have been provided in various publications (Meissner & Brigham, 2001), and therefore only the salient aspects of these theories are provided here.

Racial attitudes

One of the initial explanations for the ORB was that individuals with less prejudiced racial attitudes would be more motivated to differentiate other-race members, when compared to more prejudiced individuals (Meissner & Brigham, 2001). Although this finding was supported by initial studies in the 1950s through to the 1970s, recent studies have failed to find any relationship between racial attitudes and memory for other-race faces (Meissner & Brigham, 2001). Racial attitudes may feed into another one of the explanations for the ORB, namely the Contact Hypothesis (see later discussion).

Physiognomic homogeneity

The physiognomic homogeneity hypothesis stated that certain races have faces that have more physiognomic variability than other races, which makes those faces more or less difficult to remember. However, little support has been found in any studies for this hypothesis (Meissner & Brigham, 2001).

Race-feature hypothesis

The race-feature hypothesis states that individuals tend to pay more attention to classifying specific own-race facial features, whilst ignoring most of the facial features of other-race faces. This results in individuals displaying a tendency to be slower at classifying an own-race face, termed the other-race classification advantage (ORCA) (Meissner & Brigham, 2001). This is the case where cross racial effects can be explained by means of featural encoding by positing that people will attend to less informative features in cross race faces than in own race faces (Brigham, Bennett, Meissner, & Mitchell, 2007), which may also be attributed to development of specialised cognitive processing features as children develop (Goodman et al., 2007). As was noted by Corenblum and Meissner (2006), given the admissibility of children's eyewitness testimony in judicial cases, remarkably few studies have examined whether and how the own-race bias occurs in children. Brigham (2002, p. 131) stated the matter succinctly: "At present, we do not know whether the ORB (own-race bias) occurs in children as well [as adults]; nor do we know whether the ability to recognize faces of other-race children develops at the same rate as the ability to recognise same race others." The study by Corenblum and Meissner (2006) illustrated that children show an own-group bias in discrimination accuracy as well as other measures, such as response criterion, response time and response confidence. This was in line with the contact theory, which is further discussed below. This developmental approach shares links with the perceptual learning approach discussed in the following section.

Interracial contact and perceptual learning

The "contact hypothesis" has been termed one of the most successful ideas in the history of social psychology, according to Brewer and Brown (1998) and Dixon, Durrheim and Tredoux (2005), and relates to the particular socio-cognitive mechanisms that underlie intergroup and inter-racial interaction. This becomes especially relevant in societies where intergroup and inter-racial segregation occurred. The underlying assumption is that with little intergroup and/or inter-racial contact, a high level of intergroup prejudice will be present, whilst with interaction between group members, intergroup prejudice will reduce (Dixon et al., 2005). However, the major caveat to this hypothesis is that intergroup prejudice will be reduced only if certain conditions have been met. These include (Devine, 1995; Dixon et al., 2005):

- Contact should be regular and frequent;
- Contact should involve a balanced ratio of in-group to out-group members, or preferably high levels of intimacy such as one-on-one interactions among individual members of two groups;
- Contact should have genuine "acquaintance potential";
- Contact should occur across a variety of social settings and situations;
- Contact should be free from competition;
- The outcomes of the contact should be positive;
- Contact should be evaluated as "important" to the participants involved;
- Contact should occur between individuals who share equality of status;
- Contact should involve interaction with a counterstereotypic member of another group;
- Contact should be organized around cooperation toward the achievement of a superordinate goal;
- Contact should be normatively and institutionally sanctioned;
- Contact should be free from anxiety or other negative emotions;
- Contact should be personalized and involve genuine friendship formation;
- Individuals who interact should share similarity in beliefs and values;
- Some form of institutional support for the contact should be present, such as support from the authorities for the contact; and
- Contact should be with a person who is not deemed a typical or representative member of another group.

The numerous results from the contact hypothesis studies have resulted in a firm empirical research base, to such an extent that Dovidio and his colleagues have termed the contact hypothesis as "one of psychology's most effective strategies for improving intergroup relations" (Dovidio, Gaertner, & Kawakami, 2003, p. 5). These conditions, although ideal for the experimental social psychology setting, are limited in that they often represent idealised conditions which are rarely found in reality. In her chapter discussing prejudice and out-group perception, Devine (1995) mentions that the literature on the contact hypothesis is large and complex, but faces two major limitations. First, the beneficial effect of contact in the literature rarely generalises beyond the contact situation – in other words, contact has rarely produced changes in general prejudice. The complexity of the literature makes it difficult to draw firm conclusions about which aspects of cooperative contact promotes favourable intergroup relations. Second, although a long list of necessary conditions has been identified, until recently little attention has been given to examining the theoretical mechanisms that underlie the beneficial effects of cooperative interdependent contact. One suggestion by Gaertner and colleagues (Gaertner, Mann, Dovidio, Murrel, & Pomare, 1990) was that the key process underlying the beneficial effects of cooperation involved the recategorisation of former out-group members as in-group members. Racial isolation remains a reality in the United States of America and in South Africa. For example, a survey by Sigelman and his colleagues (Sigelman, Bledsoe, Welch, & Combs, 1996) reported that over 70% of white Americans have no black friends at all, and those who do have black friends generally only have a few. In South Africa, Gibson's (2001) survey of 3 700 South Africans indicated a similar pattern in spite of the abolishment of apartheid. This racial "homophily" (McPherson, Smith-Lovin, & Cook, 2001) clearly occurs across many countries and, in provides a reality check to the idealised conditions in which the contact hypothesis purports to reduce inter-racial prejudice. In this light, Dixon and his colleagues (2005) argue for a reorientation of the contact hypothesis research field, in order to bridge the gap between how intergroup contact is defined in the social psychological literature, and contact as it is practiced, experienced and regulated in everyday life. The contact hypothesis therefore has generated a vast amount of research, and remains one of the most researched socio-cognitive phenomena in social psychology (Dixon et al., 2005). However, the question which remains can be asked: How does the amount of contact influence cognition of own-race and other-race faces, and how does this tie into the own-race bias?

According to Wenger and Townsend (2006, p. 757), "If one assumes that meaning is functionally related to the level of familiarity one possesses with a particular class of stimuli (as in Tong & Nakayama, 1999), then there are also some provocative examples of how observers' ethnicity can influence their ability to perform visual search tasks with faces of individuals from other races (e.g., D.N. Levin [sic], 2000; D.T. Levin [sic], 1996, D.T. Levin & Angelone, 2001 [sic])." There is further evidence that individuals process their own-race faces more holistically than other-race faces (Maurer et al., 2002; Tanaka et al., 2004). This refers to the Own-Race Bias effect, and ties this effect to cognitive processes that influence the ability to memorise and recall own and other race faces.

The quality and quantity of interracial contact that an individual has had may play a vital role in the degree of the ORB of that individual. Although initial research did not indicate any significant relationship, this hypothesis has been supported across a large number of more recent studies. (Meissner & Brigham, 2001). Researchers have proposed that increased contact with other-race individuals may increase memory performance by reducing the likelihood that individuals may look for more individuating information, or by influencing the individuals' motivation to accurately recognise other-race persons through associated social rewards and punishments, or by reducing the perceived complexity of unfamiliar other-race faces (Meissner & Brigham, 2001). Simplified, it implies that, through practice, we become "experts" at discriminating between own-race faces (Wright, Boyd, & Tredoux, 2001).

Researchers are still trying to explain the specific socio-cognitive mechanisms through which inter-race contact might reduce the ORB, and the most popular explanation is that of perceptual learning (Meissner & Brigham, 2001). Perceptual learning was defined by Gibson (1969, p. 3) as "an increase in the ability to extract information from the environment, as a result of practice and experience with stimulation coming from it".

This model has led to various attempts to explain the ORB, including discrimination training, in which individuals were provided with training on discriminating more effectively between own-race faces and other-race faces. This training assisted subjects in discriminating between facial features of own-race and other-race faces. Interestingly, the training appears to have no effect on own-race facial recognition, but does improve other-race facial recognition abilities (Meissner & Brigham, 2001). This suggests that subject's ability to discriminate between facial features of own-race individuals is already developed quite effectively, whereas this ability may be not developed as well in recognising other-race individuals. Training therefore improves other-race facial recognition.

Other hypotheses include the configural-featural hypothesis and the "face space" models. The configural-featural hypothesis posits that when individuals have had a lot of experience with a specific stimulus, they develop a reliance on the configural (or relational) properties of a stimulus. When individuals have not had a lot of experience with the stimulus, they rely more on the featural (or isolated) aspects of a face (Meissner & Brigham, 2001). Face space models have challenged the configural-featural hypothesis.

Various algorithms have been proposed as well to account for the developmental contact hypothesis. With these computational algorithms, the models vary in the way faces are represented and retrieved from memory. However, common to all algorithms, a face representation can be thought of as a point in a multidimensional similarity space, or as a vector from the origin (the average face) of the space to the face location. The axes of this multidimensional space can be interpreted as the "features" with which faces are encoded. The coordinates of the face in a space specify its feature values with respect to each of the axes, and as such, the distances between points (faces) in this space represent the similarities between the faces (Furl et al., 2002). When looking at a face, the face is encoded into the face space representation. The unique coordinate of the face that is determined by its features are used to compare this face to the closest match. If this distance between the face and the closest match exceeds a certain criterion, the face is considered a "novel" face.

Two contact hypotheses representations of facial algorithms are discussed briefly. These are the generic contact hypothesis and the developmental contact hypothesis algorithms. With both these models, principal component analysis (PCA) is the basis for calculating the properties of the faces. PCA effectively provides a statistical learning method to construct an "average" face in the multidimensional space. The developmental contact hypothesis, however, utilises both PCA and a Fisher discriminant analysis to allow the algorithm to be sensitive to the overall similarity structure or distribution of the entire set of faces but also the individual faces in a stimulus set (Furl et al., 2002). Results from the evaluation of these algorithms indicated that other-race faces may, in certain cases, be recognised much more effectively than own-race faces. The explanation behind this could be that other-race faces are much more distinct in a multidimensional space (located far away) from own-race, typical faces. Distinctive faces have been shown to be more accurately recognised than typical faces (Light, Hollander, & Kayra-Stuart, 1981).

One of the most prominent face space models includes Valentine's multi-dimensional space (MDS) framework (Chiroro & Valentine, 1995; Meissner & Brigham, 2001; Smith et al., 2004; Valentine, 1995). This framework is used as a theoretical base to understand the ORB in this study, and will be discussed in a following section.

Proposed Own-Race Bias model

The Multidimensional Space (MDS) Framework of Face Encoding will be used as theoretical base to understand the ORB in this study[1]. The MDS Framework was proposed by Valentine and his colleagues, a detailed explanation of the model can be found in Valentine (1995). The basic assumption is that facial features for Own-Race are encoded around a certain "point" in a theoretical space. The more "typical" faces are clustered together around this point, with "atypical" faces further away from it (see Figure 10). However, due to increased contact with an individual's own-race (see the contact hypothesis study by Chiroro & Valentine (1995) the individual learns to distinguish very efficiently amongst the necessary facial features, resulting in the cluster of faces being very accurate for specific features. For other races, however, the same set of features cannot be used in distinguishing between faces of other race individuals. Therefore, a new "point" needs to be created for each other race (see Figure 11). The individual does not, however, know which facial features to distinguish between yet. The other-race faces are, as a result, clustered much closer together in the Multidimensional Space, leading to decreased ability to distinguish between other race faces.

This decreased ability to distinguish between other-race faces impacts our memory for other-race faces by resulting in less accuracy. Therefore, we can view the ORB as having an impact on recall of faces.

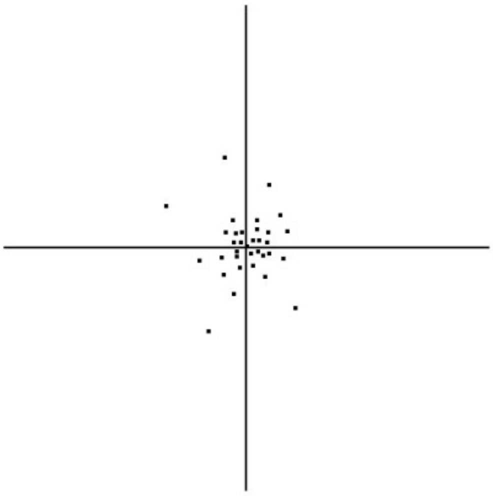

Figure 10: A representation of the distribution of distinctive and typical faces encoded in the face space. The central tendency of own-race faces is located at the origin. Typical faces will be located close to the origin; more distinctive faces are located in the outlying, less densely populated regions of the space. Only two dimensions are shown for the purposes of illustration. (Valentine, 1995)

[1] The researcher suggests this particular model to analyze the influence of ORB on SPE in facial recognition since the MDS Framework model allows an adequate explanation of how the ORB can influence SPE in facial recognition.

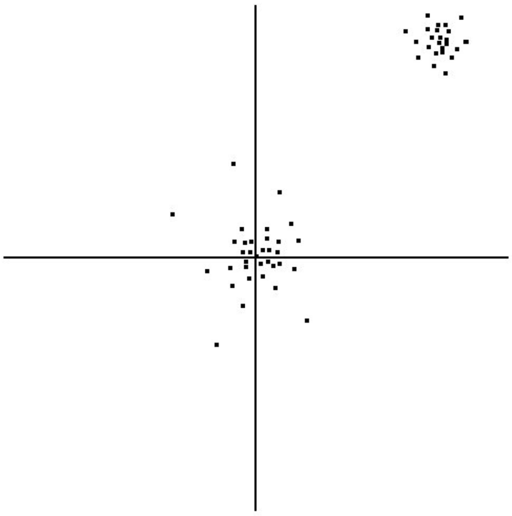

Figure 11: A representation of own-race and other-race faces encoded in the face space. It is assumed that the two races differ in their central tendency on the dimensions shown. The central tendency of own-race faces is located at the origin of the space. The other-race faces are more densely clustered than the own-race faces because it is assumed that the dimensions of the space are not optimal to recognize other race faces. Again, two dimensions are shown for the purposes of illustration only. (Valentine, 1995)

Three major factors can influence the occurrence of ORB, which are facial features (Maclin & Malpass, 2001; Smith et al., 2004), racial prejudice (Valentine, 1995) and the amount of contact with other races (Chiroro & Valentine, 1995; Smith et al., 2004; Valentine, 1995). In addition to an Own-Race Bias, an Own-Age Bias has also been identified (Wright & Stroud, 2002), as well as an Own-Gender Bias (Shaw & Skolnick, 1994, 1999).

According the to the Multidimensional Framework Hypothesis, the ORB could result from a number of perceptual or cognitive sources such as the use of inappropriate dimensions, attention to salient but nondiagnostic encoding cues, and use of stereotypes of other category-based expectancies at each phase of the information processing sequence (Valentine, 1991). Corenblum and Meissner (2006) recommend that studies also attend to the response criterion that participants use as well as the level of accuracy they achieve when discriminating between previously seen in-group and out-group members.

2.5 The Multidimensional Space (MDS) Framework Hypothesis in SPE and ORB

Due to the ORB being the result of inefficient distinguishing amongst distinctive features of other-race faces (according to the MDS Framework Hypothesis), it impacts on the recall ability of other-race faces. We could therefore suggest that the ORB will have no significant impairing influence on general recall of own-race faces, but indeed some impairing influence on the general recall of other-race faces. It has already been mentioned that unfamiliar faces are more likely to be processed in serial fashion, in a top-to-bottom approach (Wenger & Townsend, 2006). Considering a **working model of memory**, one of two scenarios emerges in the own-race bias. The task to maintain a face in the visuospatial sketchpad or in the phonological loop (should verbal encoding of faces occur) may become much more taxing when other-race faces are involved, as subjects may be uncertain as to which facial features to focus on maintaining during any kind of rehearsal strategies. Decay may therefore set in on the encoded facial features (which were scanned in a serial fashion), and subsequent recall may be weaker. Alternatively, less features of the other-race face may be encoded, as subjects will not know which features to focus on. This will result in an overall lower ability to distinguish amongst other-race faces during recall. Both these scenarios therefore predict an overall lower recognition of other-race faces.

As was discussed earlier, the recognition of a series of faces is also subject to the Serial Position Effect (SPE), in which faces presented earlier and those presented later in a series are recalled with much higher accuracy and efficiency than faces that were presented in the middle of a series. The Serial Information Processing model is adopted as the model to explain the SPE, as it is closely related to the **working model of memory** as well. The serial position effect is explained by this model as the result of a primacy gradient, in which the most detail is memorised for the first face presented in a set, and this face is rehearsed in the short-term visual memory. As subsequent faces are presented, fewer resources are available to continue rehearsal of the initial face whilst encoding detail of subsequent faces. Eventually the subject is expected to switch back to focussing only on rehearsing the first face, whilst the last item should be readily available in the visuospatial sketchpad of working memory. This will therefore result in better recall of the first face and the last face in a stimulus set.

However, the researcher proposes that an interaction between the Own-Race Bias and the Serial Position Effect will occur during recall of faces. Should the subject be presented with facial stimuli of the same racial category of the subject, the influence of the Own-Race Bias is expected to be limited during recall tasks, since features will be encoded much more efficiently, and little attentional resources will be devoted to maintaining unfamiliar facial features. However, with the presentation of other-race faces, the Own-Race Bias is expected to diminish the ability to recall faces effectively, since attentional resources will be much more strained to maintain unfamiliar facial features during presentation of a set of faces.

The researcher thereby suggests that it is possible that the ORB will lead to no significantly diminished SPE in the recall of own-race faces (in other words, a normal SPE curve with very strong recency recognition success, moderate primacy recognition success and low central recognition success). However, the ORB will lead to a significantly diminished SPE in the recall of other-race faces (in other words, weak recency recognition success, very weak primacy recognition success and extremely weak central recognition success).

Using the Multidimensional Space (MDS) framework to explain this expected phenomenon, the interaction between the Own-Race Bias and the Serial Position Effect can be viewed as follows: Due to own-race faces being clustered around a central point in the multi-dimensional space; and also being distinguished between much more efficiently (*i.e.* clustered less densely), we should see a normal SPE type curve during recall of own-race faces. In the case of other-race faces, the faces are clustered around a different point; and are distinguished between with much less accuracy (*i.e.* clustered more densely). We could therefore suggest that the recall of other-race faces would show a remarkably diminished SPE curve due to incorrect recall of faces. Please see Figure 12 as an illustration of the hypothesized results. Please note that the illustrations of the expected serial position effect graphs are exaggerated significantly. More realistic results can be seen in Figure 13.

Figure 4 is a more realistic representation of the hypothesized results for the serial position curves in facial recognition. An ideal SPE curve is shown (see legend). However, due to the nature of short-term memory, we would expect a stronger recency- than primacy-effect. Therefore, a more realistic representation of the expected results for the recognition of own-race facial stimuli is shown (see legend). The expected diminished SPE curve in the other-race facial recognition condition is also shown (legend). Please note that the results are entirely hypothetical (although based in theory).

	Black Faces	**White Faces**
Black Subjects	1 	2
White Subjects	3	4 

Figure 12: Diagrammatical representation of the hypothesized results of this study. Black subjects will show the normal SPE curve with the recall of black faces, but no SPE curve with the recall of white faces. White subjects will show the normal SPE curve with the recall of white faces, but no SPE curve with the recall of black faces

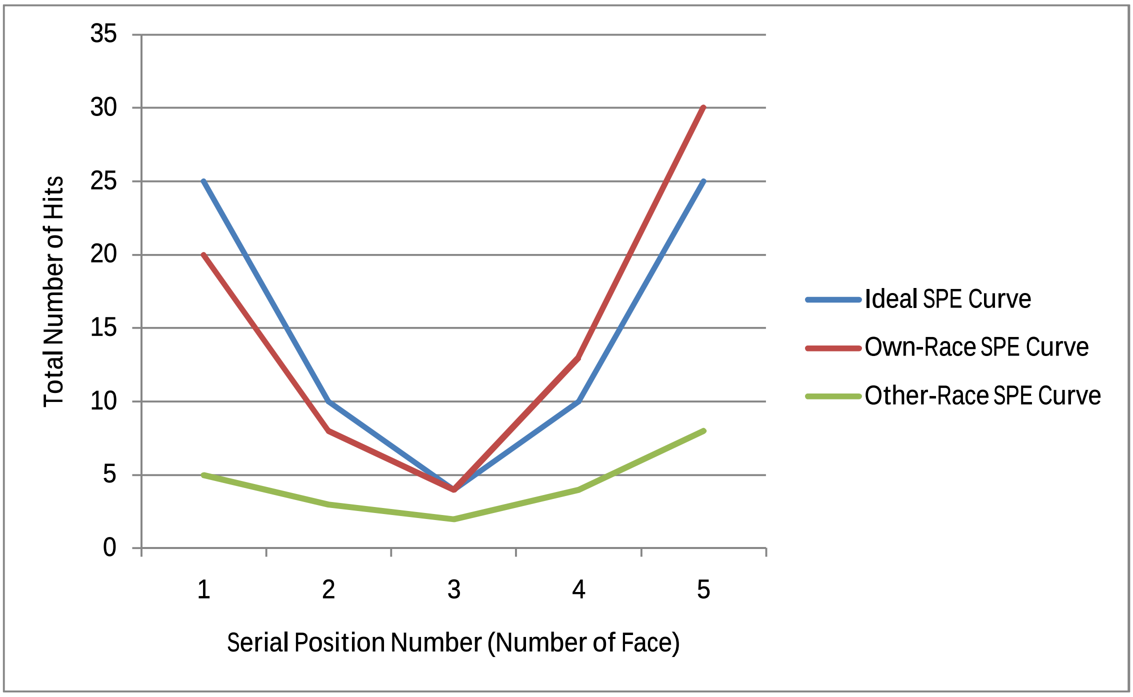

Figure 13: A graphic representation of more realistic hypothesized serial position effect curves. Each serial position number corresponds to the position of the displayed facial stimulus. The total amount of hits is scored on the Y-axis. The results (amount of hits) are theoretical. Please see text for explanation.

Figure 13 is a more realistic representation of the hypothesized results for the serial position curves in facial recognition. An ideal SPE curve is shown in blue. However, due to the nature of short-term memory, we would expect a stronger recency- than primacy-effect. Therefore, a more realistic representation of the expected results for the recognition of own-race facial stimuli is shown in red. The expected diminished SPE curve in the other-race facial recognition condition is shown in green. Please note that the results are entirely hypothetical.

3 Method

The following chapter describes the methodology that was applied during the study. Using appropriate methodology is an essential aspect of producing reliable and valid results, otherwise the results of a study will be unusable if the methodology is poorly chosen or applied (Babbie & Mouton, 2001).

3.1 Hypothesis

The hypothesis of the research study will include the variables of racial group, serial position and face recognition accuracy, and the aim is to investigate their possible relationship. Three research hypotheses can be presented. First, it is expected that the first and last faces that are presented in a set will be recognised at a higher frequency and accuracy than faces presented in the middle of a set. Second, it is expected that there will be a diminished face recognition accuracy for other-race faces. Third, it is expected that the first and last faces of own-race face recognition in a set will be recognised much more accurately than the first and last faces of other-race faces in a set, whilst the middle face of own-race faces in a set may be recognised only slightly more accurately than the middle face of other-race faces in a set.

To operationalise these variables quantitatively, they are denoted as follows:

Dependent Variable (DV): Face recognition accuracy are operationalised as the number of successful faces that are recognised at each serial position.

Independent Variables (IV): The independent variables include serial position and the race of participants.

3.2 Subjects and sampling

The study was limited to examining the facial recognition between white and black racial groups, therefore the subjects were of both Caucasian and African racial groups. Although gender effects have been shown to occur as a main effect in other Serial Position Effect studies (Wright & Sladden, 2003), both Caucasian and African females were included in the study to account for any ethnic group differences. A power/effect size analysis for 2 groups with 5 repeated measures yields a sample size of 48, with an effect size of 0.25 (Tabachnick & Fidel, 2001). Therefore, the ideal number of subjects for each group is 25 (black subjects and white subjects). A total number of 48 subjects participated in the experiment, which included 12 African females, 12 African males, 12 Caucasian females and 12 Caucasian males.

The subjects were all employees at an Environmental Consulting and Engineering firm located in Midrand, South Africa. All employees voluntarily participated in the study, and were briefed prior to the research study as to the purpose of the study. Subjects were informed that they may withdraw from the study at any given time without any negative repercussions or penalisations.

A control form was completed in which subjects reported whether they have received any head trauma in the past to account for any physiological and anatomical confounding factors, and no subjects reported having any head trauma.

Subjects all received the following instructions:

"The aim of the research project, in which you are participating, is to investigate what influence the racial group people are from has on their ability to recognise faces of people of their own or other races. The information gained from your participation will form part of a dissertation for a Master's degree, and will be published in a journal. You will be required to complete the computer experiment. This should take approximately ten (10) minutes. Your participation in this study is voluntary, and you may withdraw at any time without offering any explanation or suffering any consequences. You do not need to share any information that you feel uncomfortable disclosing.

It is not anticipated that participating in the study will harm you in any way. However, should you feel the need to talk about anything that arose during the interview; you can contact student support at the University of Pretoria.

Your participation in the computerised experiment is not linked to your work or to the company you are working for in any way. Therefore, the results of this study will not influence your work, salary, duties and so on in any positive or negative way.

Permission has been obtained from the management of the company to utilise the employees for the purposes of the research, but your participation remains completely voluntary.

You are not required to give us any identifying information like you ID number or personnel number. No one outside of the research team will have access to the survey questionnaire. The researchers will maintain confidentiality within the research team, and the findings from the study will be presented in a report where only the general patterns found in the surveys will be discussed."

3.3 Stimuli

A set of 65 photographed male Caucasian and 65 African faces was obtained from the University of Pretoria's Cognitive Laboratory. These faces have been used as standardised faces in a previous study (Chiroro, Tredoux, Radaelli, & Meissner, 2008), but the faces were unfamiliar to the research participants. Figure 14 and Figure 15 illustrate two examples of white facial stimuli sets, whilst Figure 16 and Figure 17 illustrate two examples of black facial stimuli sets. These faces are photographs of South African Caucasian and African individuals. These faces were digitally removed from their backgrounds during the study by Chiroro, Tredoux, Radaelli and Meissner, using RealDraw Pro 3.1, and were equated for light contrast using GIMP 2.0 (Chiroro et al., 2008).

Figure 14: Example of white facial stimuli set

Figure 15: Example of white facial stimuli set

Figure 16: Example of black facial stimuli set

Figure 17: Example of black facial stimuli set

3.4 Apparatus

The facial photographs were programmed into an experimental display programme using SuperLab Pro (version 2.0.4, Cedrus). The experiment was run on a Fujitsu Siemens Amilo Pro Laptop, with a resolution of 1280 x 762 pixels and a colour depth of 24 bits, using the keyboard as the primary input medium. Subjects were seated in front of the laptop in a quiet office whilst the experiment was running.

3.5 Procedure

A procedure similar to that which was used in Bruyer and Vanberten (1998) and Chiroro and Valentine (1995) was used. Participants were introduced to the study, and were instructed that they will randomly be shown a set of white or black faces. They were informed that these faces will be displayed to them again in a random order, and they would need to identify these faces in the original order in which the faces were displayed.

The facial stimuli were grouped into sets of 5 faces of the same race. In total, 12 sets of white faces and 12 sets of black faces were compiled. Participants were first instructed to study the set of 5 faces carefully and to try and remember the order in which they appeared. One random (white or black) set of 5 faces was displayed to the participants. Each photograph was displayed for 1.5 seconds, with a 0.5 seconds blank screen between each face (therefore, an inter-display interval of 0.5 seconds was used). After the final photograph, a blank screen was displayed for 3 seconds (therefore, a forced retention interval of 3 seconds was used). After the display, participants were instructed that they will be presented with the faces they just studied, and are required to enter the serial number in which they recall the face being displayed in. Therefore, if a participant recalled a face being displayed second, they would enter "2", similarly they would enter "5" if they remember the face being displayed last. The faces were presented again to participants in a random order with no time limit. Figure 18 and Figure 19 provides a flowchart illustration of a typical display, interstimulus interval and test task that was performed by subjects.

The display and test tasks were completed 12 times for black faces and 12 times for white faces. After completing the study, participants were thanked for their time and assistance.

The method of displaying the set of 5 stimuli individually, followed by an inter-stimulus interval, and then requiring a recall of serial position, is a mixture between the local recognition task and the serial recall task as differentiated by Oberauer (2003). The randomised procedure of presentation also eliminates theories that associate the distinctiveness of stimuli on the basis of time, and therefore only distinctiveness theories such as Neath's (Neath, 1993a, 1993b)dimensional distinctiveness model that differentiate distinctiveness on the basis of factors other than time may be applicable to this study. This is furthermore relevant in that all items are presented again in a stimuli set, therefore temporal cues may not necessarily be useful to distinguish between items. However, the serial information processing model is adopted in this study as a potential explanation of the serial position effect, as it takes cognisance of the variable nature of attention and short-term memory. Functional chaining effects may be of value in the study in that successive recognition tasks may result in enhanced recency effects.

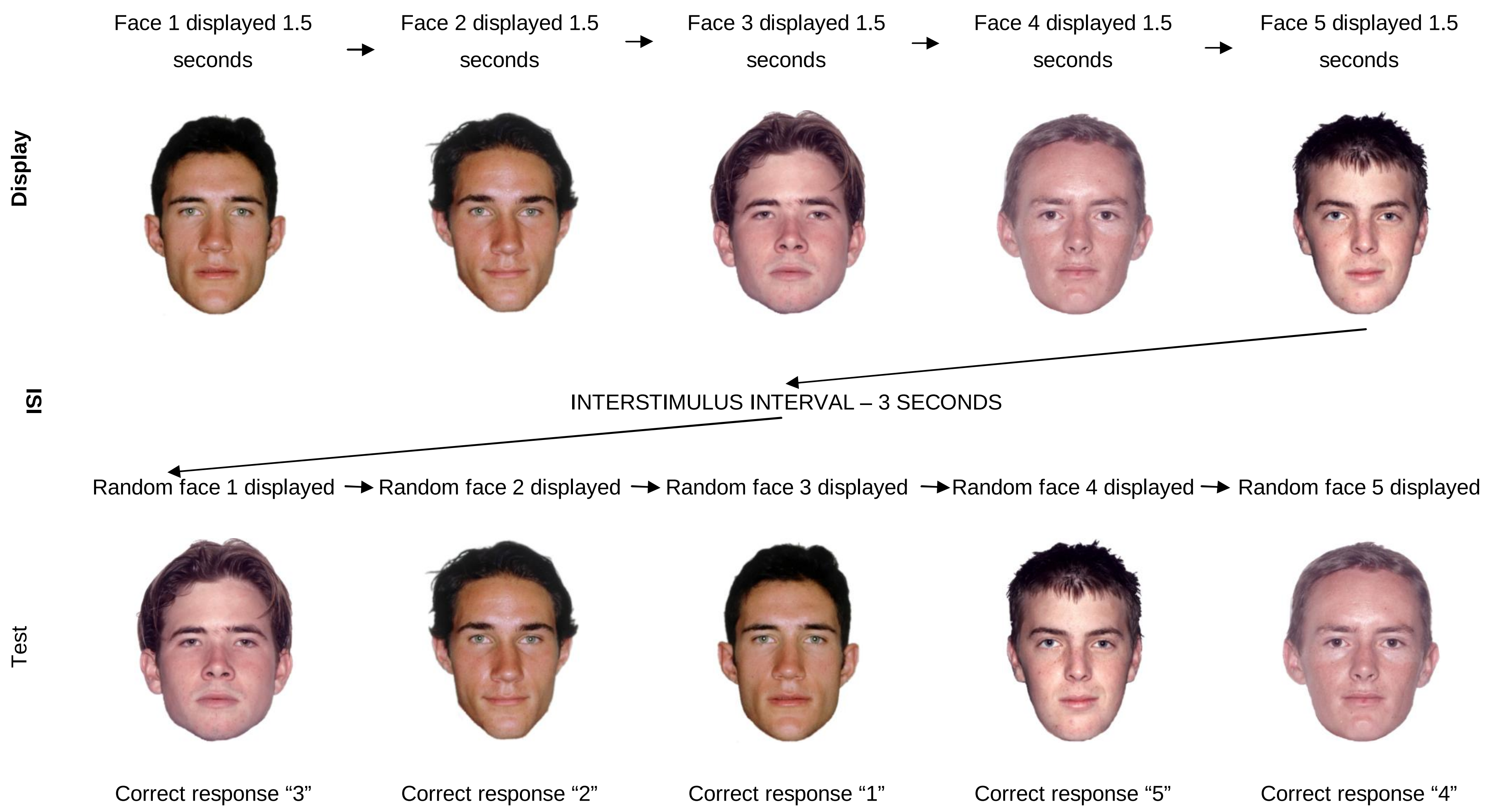

Figure 18: Flowchart example of display and test tasks for white facial stimuli

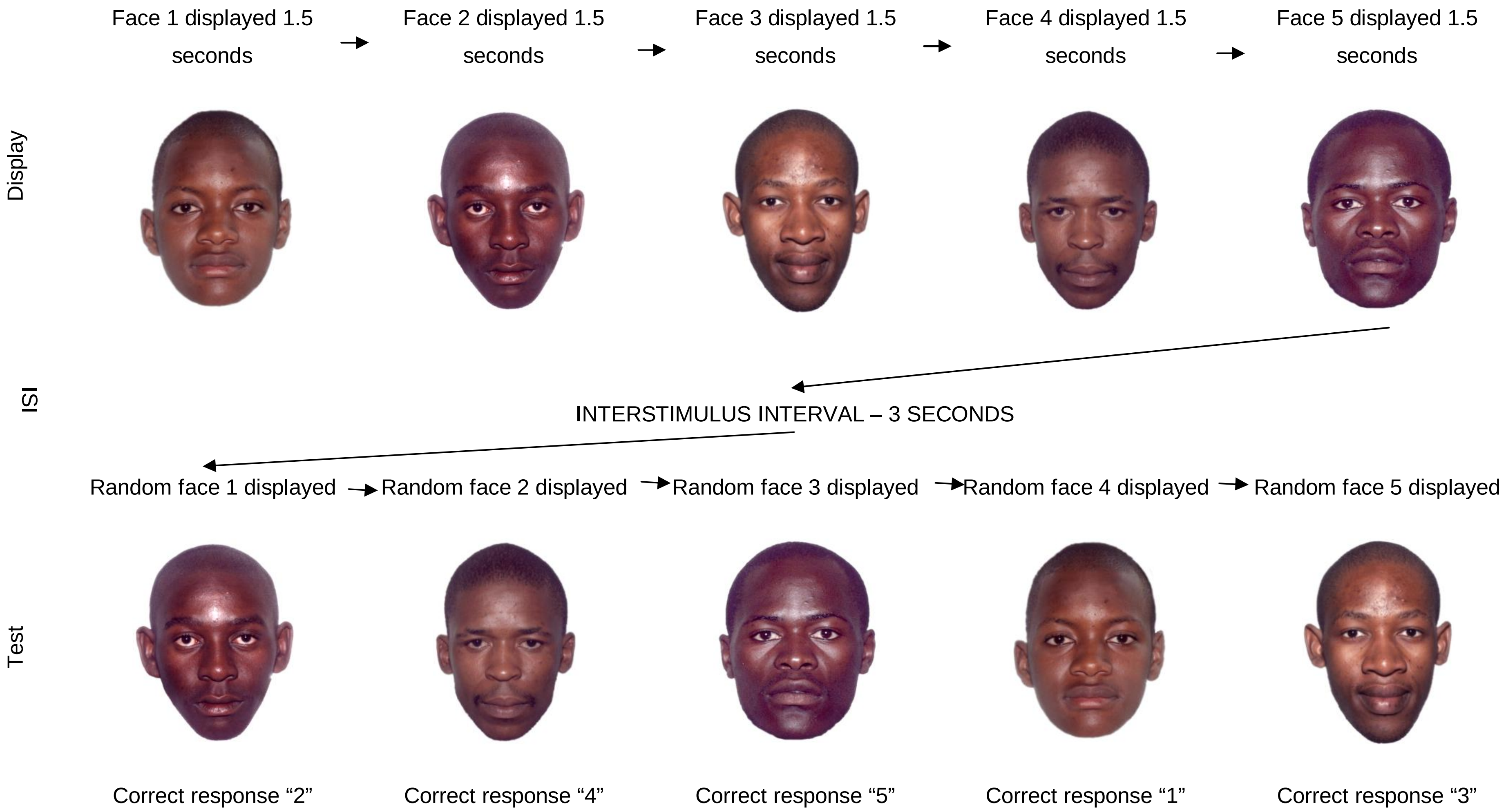

Figure 19: Flowchart example of display and test tasks for black facial stimuli

4 Results

The results and information of the individual respondents were captured in an electronic database. The total correct responses for each respondent were summarised for each serial position and each category of stimuli (i.e. black facial stimuli and white facial stimuli). Therefore, 12 scores were totalled for each respondent. The ethnic group (i.e. black or white), gender and age of the respondent was also captured.

A total number of 48 individuals participated in the study, distributed as 12 black females, 12 black males, 12 white males and 12 white females. The individual characteristics of participants are presented in Table 2, indicating participants' ethnic group, gender and age.

Table 2: Individual characteristics of participants in the study

Participant	Ethnic Group	Gender	Age
Participant 1	Black	Female	32
Participant 2	Black	Female	54
Participant 3	Black	Female	30
Participant 4	Black	Female	49
Participant 5	Black	Female	38
Participant 6	Black	Female	22
Participant 7	Black	Female	40
Participant 8	Black	Female	31
Participant 9	Black	Female	30
Participant 10	Black	Female	40
Participant 11	Black	Female	48
Participant 12	Black	Female	39
Participant 13	Black	Male	47
Participant 14	Black	Male	36
Participant 15	Black	Male	27

Participant	Ethnic Group	Gender	Age
Participant 16	Black	Male	47
Participant 17	Black	Male	26
Participant 18	Black	Male	36
Participant 19	Black	Male	40
Participant 20	Black	Male	42
Participant 21	Black	Male	42
Participant 22	Black	Male	42
Participant 23	Black	Male	38
Participant 24	Black	Male	39
Participant 25	White	Female	32
Participant 26	White	Female	45
Participant 27	White	Female	22
Participant 28	White	Female	43
Participant 29	White	Female	27
Participant 30	White	Female	38
Participant 31	White	Female	28
Participant 32	White	Female	27
Participant 33	White	Female	27
Participant 34	White	Female	56
Participant 35	White	Female	21
Participant 36	White	Female	35
Participant 37	White	Male	27

Participant	Ethnic Group	Gender	Age
Participant 38	White	Male	31
Participant 39	White	Male	27
Participant 40	White	Male	42
Participant 41	White	Male	58
Participant 42	White	Male	32
Participant 43	White	Male	27
Participant 44	White	Male	54
Participant 45	White	Male	53
Participant 46	White	Male	52
Participant 47	White	Male	29
Participant 48	White	Male	50

The average age of all participants was 37.5 years, with a mode of 27 and a median of 38, indicating a slight positive skew. Figure 20 illustrates the distribution of participants according to age categories. As can be seen from this figure, 13 participants lie in the 18-29 age category, accounting for 27.1% of the entire sample, whilst 15 participants lie in the 30-39 age category, accounting for 31.3% of the entire sample. A further 13 participants are aged between 40 and 49 years of age, accounting for 27.1% of the sample. Seven (7) participants are between the ages of 50 and 59, constituting 14.6% of the entire sample. This was in line with the quasi-experimental design of the study, which requisite selected participants between 18 and 60 years of age.

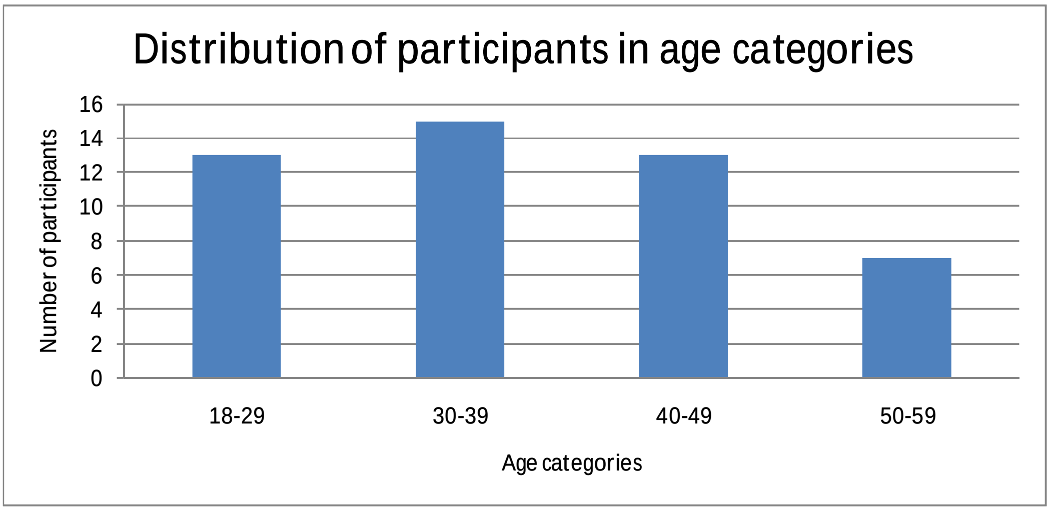

Figure 20: Distribution of participants in age categories

Table 3 presents a summary of the descriptive statistics for the study. Participants were selected on the basis of the ethnicity, their gender, and intact brain anatomy. The mean for recognition was 5.269 (out of a maximum total of 12), with a median of 5 and a mode of 5, illustrating that data is distributed quite evenly with no apparent skew. The standard deviation of the study is 2.266, with a large range of 11. This can be accounted for by a minimum score of 0 and a maximum score of 11, indicating that in some cases, there were participants who failed to identify a single face in a given position correctly, whilst no participants managed to identify all faces correctly in any given serial position.

Table 3: Descriptive statistics for the study

Statistics

Face_T_TOT

N	Valid	48
	Missing	0
Mean		5.27
Median		5
Mode		5
Std. Deviation		2.266
Variance		5.136
Range		11
Minimum		0
Maximum		11

Table 4 through to Table 11 show the statistical averages of the face test totals for the 48 participants who participated in the study, illustrating the estimated marginal means according to the overall results (Table 4), ethnic group results (Table 5), facial stimuli type results (Table 6), serial position results (Table 7), ethnic group and facial stimuli type interaction results (Table 8), ethnic group and serial position interaction results (Table 9), facial stimuli type and serial position interaction results (

Table 10), and the facial stimuli type, serial position and participant ethnic group interaction (Table 11).

Table 4: Estimated marginal grand mean for the study

		95% Confidence Interval	
Mean	Std. Error	Lower Bound	Upper Bound
5.269	.198	4.871	5.666

Table 5: Marginal mean for ethnic group

			95% Confidence Interval	
Participant Ethnic Group	Mean	Std. Error	Lower Bound	Upper Bound
White	6.150	.279	5.588	6.712
Black	4.388	.279	3.825	4.950

Table 6: Estimated marginal mean for type of facial stimuli

			95% Confidence Interval	
Facial stimuli type	Mean	Std. Error	Lower Bound	Upper Bound
Black	5.371	.211	4.945	5.797
White	5.167	.228	4.707	5.626

Table 7: Estimated marginal mean for serial position

			95% Confidence Interval	
Serial position	Mean	Std. Error	Lower Bound	Upper Bound
1	5.510	.183	5.141	5.879
2	4.938	.211	4.512	5.363
3	5.198	.253	4.689	5.706
4	5.167	.286	4.591	5.743
5	5.531	.306	4.916	6.147

Table 8: Estimated marginal mean for the ethnic group and facial stimuli type interaction

				95% Confidence Interval	
Participant Ethnic Group	Face stimuli type	Mean	Std. Error	Lower Bound	Upper Bound
White	Black	6.067	.299	5.465	6.669
	White	6.233	.323	5.583	6.883
Black	Black	4.675	.299	4.073	5.277
	White	4.100	.323	3.450	4.750

Table 9: Estimated marginal mean for the participant ethnic group and serial position interaction

Participant Ethnic Group	Serial position	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
White	1	6.542	.259	6.020	7.064
	2	6.000	.299	5.398	6.602
	3	6.292	.357	5.572	7.011
	4	6.000	.405	5.185	6.815
	5	5.917	.433	5.046	6.787
Black	1	4.479	.259	3.957	5.001
	2	3.875	.299	3.273	4.477
	3	4.104	.357	3.385	4.823
	4	4.333	.405	3.519	5.148
	5	5.146	.433	4.275	6.017

Table 10: Estimated marginal mean for the facial stimuli type and serial position interaction

Face stimuli type	Serial position	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	5.521	.270	4.977	6.065
	2	4.979	.280	4.415	5.543
	3	5.229	.280	4.666	5.792
	4	5.354	.314	4.722	5.986
	5	5.771	.303	5.161	6.381
2	1	5.500	.261	4.974	6.026
	2	4.896	.253	4.387	5.404
	3	5.167	.315	4.533	5.800
	4	4.979	.340	4.294	5.664
	5	5.292	.365	4.557	6.026

Table 11: Estimated marginal mean of the ethnic group, facial stimuli type and ethnic group interaction

					95% Confidence Interval	
Participant Ethnic Group	Face stimuli type	Serial position	Mean	Std. Error	Lower Bound	Upper Bound
White	Black	1	6.417	.382	5.647	7.186
		2	5.708	.396	4.910	6.506
		3	6.417	.396	5.620	7.213
		4	5.750	.444	4.857	6.643
		5	6.042	.429	5.179	6.905
	White	1	6.667	.369	5.923	7.410
		2	6.292	.357	5.572	7.011
		3	6.167	.445	5.271	7.063
		4	6.250	.481	5.282	7.218
		5	5.792	.516	4.753	6.830
Black	Black	1	4.625	.382	3.855	5.395
		2	4.250	.396	3.452	5.048
		3	4.042	.396	3.245	4.838
		4	4.958	.444	4.065	5.852
		5	5.500	.429	4.637	6.363
	White	1	4.333	.369	3.590	5.077
		2	3.500	.357	2.781	4.219
		3	4.167	.445	3.271	5.063
		4	3.708	.481	2.740	4.677
		5	4.792	.516	3.753	5.830

Table 12 provides the descriptive statistics for each serial position, disaggregated according to stimuli type and ethnic group of study participants. As can be seen from this table, the average recognition by white participants is higher for almost all the stimuli, irrespective of serial position.

Table 12: Descriptive statistics of each serial position by stimuli type and ethnic group of participants

Descriptive Statistics

	Ethnic Group	Mean	Std. Deviation	N
Black Face 1	White	6.42	1.792	24
	Black	4.63	1.952	24
	Total	5.52	2.063	48
Black Face 2	White	5.71	1.876	24
	Black	4.25	2.005	24
	Total	4.98	2.058	48
Black Face 3	White	6.42	2.244	24
	Black	4.04	1.574	24
	Total	5.23	2.262	48
Black Face 4	White	5.75	2.472	24
	Black	4.96	1.829	24
	Total	5.35	2.188	48
Black Face 5	White	6.04	2.156	24
	Black	5.50	2.043	24
	Total	5.77	2.096	48
White Face 1	White	6.67	1.551	24
	Black	4.33	2.036	24
	Total	5.50	2.144	48
White Face 2	White	6.29	1.967	24
	Black	3.50	1.504	24
	Total	4.90	2.234	48
White Face 3	White	6.17	2.316	24
	Black	4.17	2.036	24
	Total	5.17	2.382	48
White Face 4	White	6.25	2.817	24
	Black	3.71	1.781	24
	Total	4.98	2.662	48
White Face 5	White	5.79	2.519	24
	Black	4.79	2.536	24
	Total	5.29	2.551	48

A 2x2x5 multivariate factor analysis was undertaken using SPSS software (version 17) on the data, and interpretation of the data was based on the discussion of multivariate analysis in Field (2005). Ethnic group of the respondents served as the between-subjects variable, with within-subjects variables being type of facial stimuli (black or white faces, i.e. two levels) and serial position (1, 2, 3, 4 or 5, i.e. 5 levels). Results the multivariate factor analysis indicates that, overall, sphericity of the data can be assumed for type of Face Type Stimuli, Mauchly's W (0) = .000, but not for Serial Position or the Face Type Stimuli with Serial Position interaction, Mauchly's W (9) = 21.655 and 26.616, respectively. Greenhouse-Geisser values were also below 0.85, and therefore Huynh-Feldt values were used. Therefore, interpretations of Serial Position and the interaction Face Type Stimuli and Serial Position were based on the Huyhn–Feldt transformation.

All effects are reported as significant at $p < .05$. Main effects for Face Type Stimuli were found not to be significant, $F(1, 46) = 1.108$ ($p = 0.298$), indicating that, irrespective of serial position or ethnicity of participants, facial recognition was relatively similar for white and black facial stimuli. Estimated marginal means indicate that recognition of black facial stimuli was only slightly higher than that of white facial stimuli (see Figure 21).

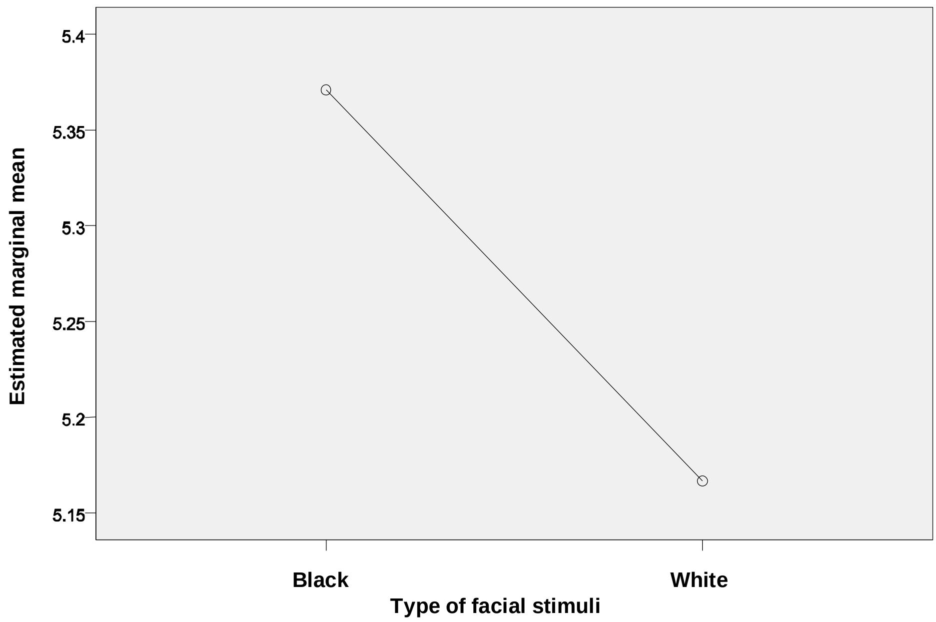

Figure 21: Estimated marginal means of recognition between black facial stimuli (1) and white facial stimuli (2). This difference was not statistically significant.

Main effects for Serial Position were also not found to be significant, $F(4, 3.178) = 2.064$ ($p = 0.097$), indicating that some serial positions scored high whilst others scored low, resulting in a non-significant difference (see Figure 22) . Contrasts on Serial Position found that a significant difference was found between serial position 1 and serial position 2, $F(1.394, 46) = 8.582$ ($p = 0.005$), indicating that the stimulus face (serial position 2) that was presented second was recognised at a much lower frequency than the stimulus face that was presented first (serial position 1). The difference between serial position 2 and position 3 was found not to be statistically significant

F(1, 2.336) = 1.394 (*p* = 0.244). Similarly, the difference between serial position 3 and position 4 was not statistically significant *F*(1, 46) = 0.015 (*p* = 0.903). The difference between serial position 4 and serial position 5 were also found not to be statistically significant, *F*(1, 46) = 1.455 (*p* = 0.234). Referring to Figure 22, it can be clearly seen that a trend towards the typical U curve as evidenced from the Serial Position Effect exists. This explains why SP1 differs from SP2, and why SP4 and SP5 do not differ statistically.

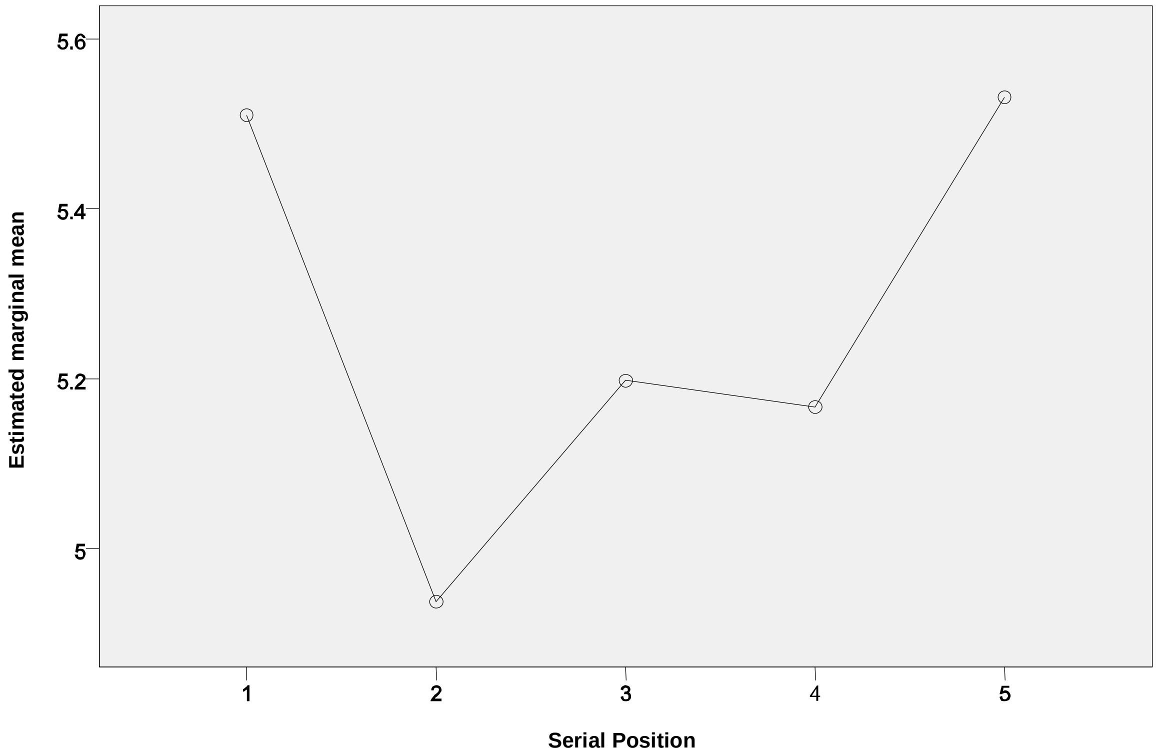

Figure 22: Estimated marginal means for Serial Position (SP). The figure clearly indicates a trend to a U curve.

A significant effect for ethnic group of participants was found *F*(1, 46) = 19.891 (*p* < 0.000), indicating that overall, white and black subjects scored differently on the facial recognition task, irrespective of serial position or race of facial stimuli. Comparison of marginal means indicated that white participants scored significantly higher in the recognition task than black participants.

Although a definite trend towards an interaction effect between facial stimuli type and ethnic group was observed, this interaction effect was only found to be nearly significant, *F*(1, 46) = 3.657 (*p* = 0.062). This indicates that a trend exists toward successful facial recognition of white and black facial stimuli being different for white and black subjects, as is evidenced by the estimated marginal means indicating that white subjects scored consistently higher on facial recognition, irrespective of race of facial stimuli. Similarly, black participants scored consistently lower on facial recognition, irrespective of race of facial stimuli (refer to Figure 23).

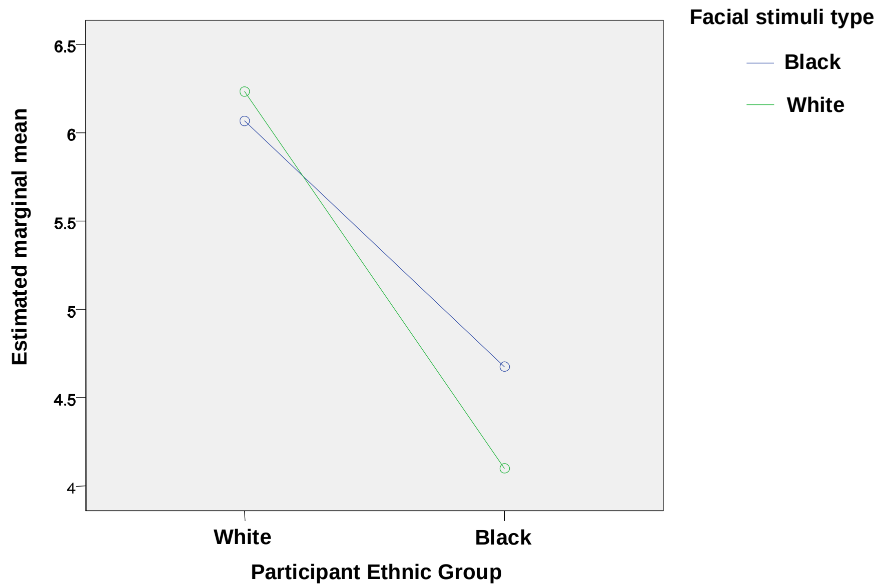

Figure 23: Estimated marginal means for recognition of white (green line) and black facial stimuli (blue line) by black and white ethnic group participants. A significant interaction can be seen with the lines crossing over each other.

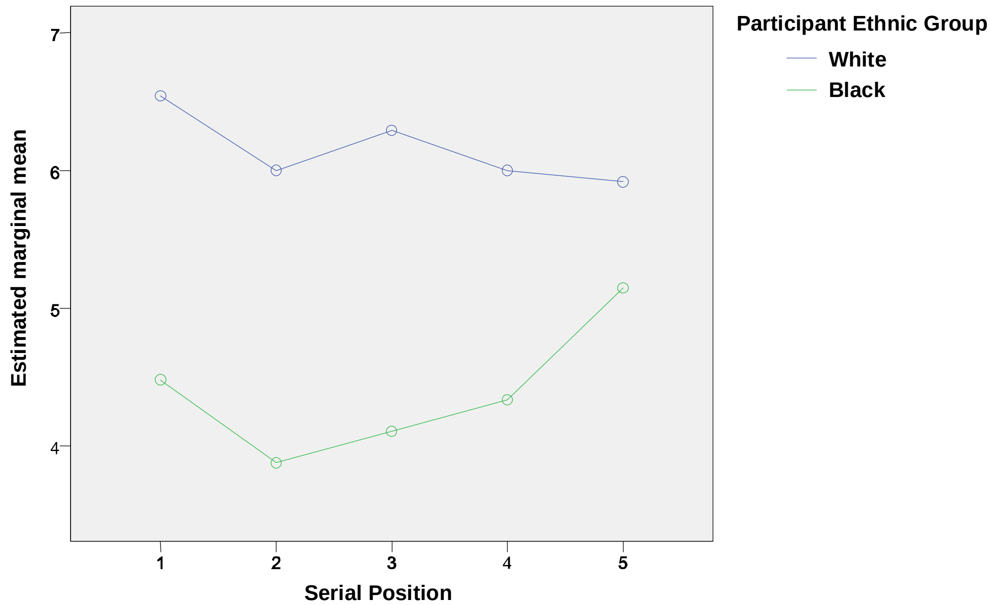

Figure 24: Performance of white and black ethnic group participants for each serial position. A general trend towards a U-type serial position curve can be seen for black ethnic group participants, whilst a general decline in recognition can be seen for white ethnic group participants.

There was a significant interaction effect between serial position and ethnic group, $F(3.515, 161.704) = 2.850$ ($p = 0.025$). This indicates that successful facial recognition differs across all serial positions for white and black subjects. Referring to Figure 24, it can be seen that a distinct trend towards a typical serial position curve is exhibited for black ethnic group subjects in facial recognition, whilst white ethnic group subjects provided a relatively flat curve in facial recognition. Contrasts indicated that the difference between serial position 1 and serial position 2 does not differ statistically between ethnic groups *F*(1, 46) = 0.026 (*p* = 0.874), neither is difference between serial position 2 and serial position 3 statistically significant between ethnic groups, *F*(1, 46) = 0.020 (*p* = 0.888). The difference between serial position 3 and serial position 4 is not statistically significant, *F*(1, 46) = 1.051 (*p* = 0.311), neither is the difference between serial position 4 and serial position 5, *F*(1, 46) = 2.196 (*p* = 0.145). Overall, this indicates that the general profiles of the recognition between ethnic groups are similar between each other for serial position, although the statistical difference for the interaction can be explained on account of white subjects scoring higher on average across all serial positions than black subjects.

No significant interaction effect could be found between type of facial stimuli and serial position, *F*(3.476, 159.883) = 1.195 (*p* = 0.706). This indicates that, irrespective of ethnic group of the participants, recognition over the serial positions was relatively similar for black and white facial stimuli (refer to Figure 25). Contrasts indicated no significant differences in profiles of type of facial stimuli between any of the serial positions: Serial position 1 and serial position 2 were not significant, *F*(1, 46) = 0.019 (*p* = 0.891), neither were serial position 2 and serial position 3, *F*(1, 46) = 0.003 (*p* = 0.955). Serial position 3 and serial position 4 were not significant, *F*(1, 46) = 1.146 (*p* = 0.290), as were serial position 4 and serial position 5, *F*(1, 46) = 0.068 (*p* = 0.795). This indicates that the profiles for both white and black facial stimuli are highly similar, and by referring to Figure 25, it can be seen that the recognition profiles exhibit a general trend toward a serial position U curve.

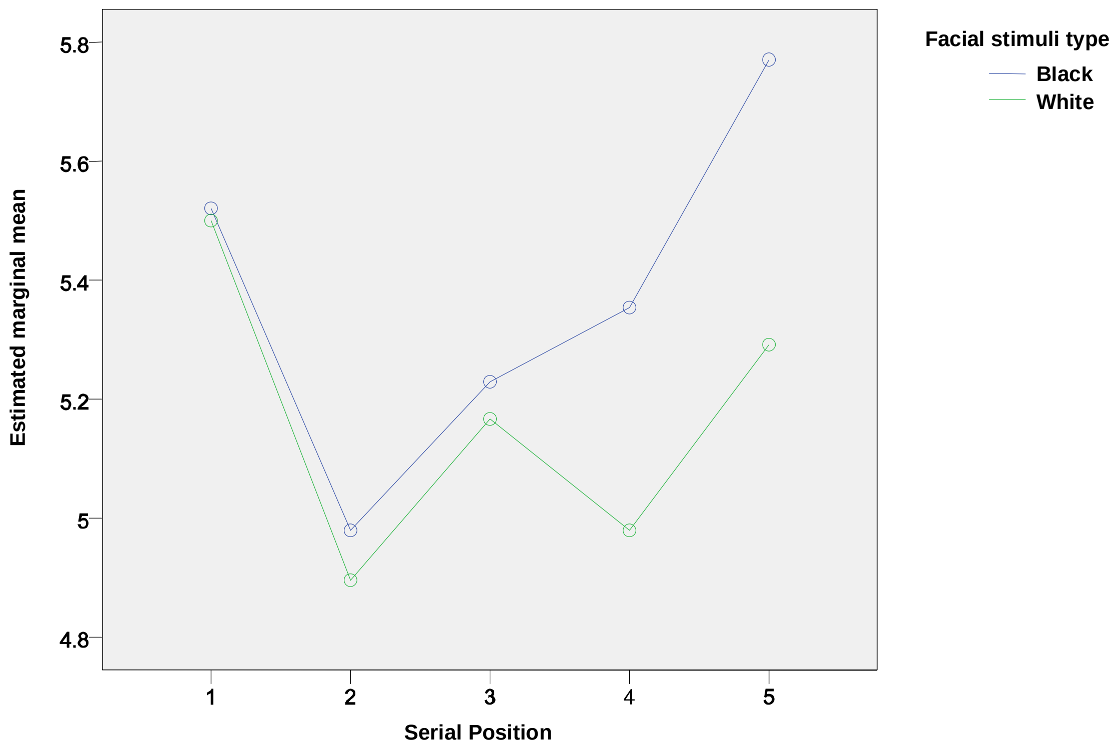

Figure 25: Estimated marginal means of recognition of white (green line) and black facial stimuli (blue line). The recognition profile for different facial stimuli is highly similar, leaning towards a typical U curve.

No significant interaction effect could be found between the type of facial stimuli, the serial position, and the ethnic group of the participants, $F(3.476, 159.883) = 1.997$ ($p = 0.097$). This indicates that for white and black subjects, recognition performance across all serial positions were similar for both white and black facial stimuli. To further interpret this interaction, contrasts were analysed for each serial position. Referring to Figure 26, the difference between the profiles of serial position 1 and serial 2 for white participants and black participants is highly similar, in that recognition of serial position 2 is lower, irrespective of ethnic group or type of facial stimuli. This is verified by a non-statistically significant interaction, $F(1, 46) = 0.763$ ($p = 0.387$). However, looking at the profiles between serial position 2 and serial position 3 (refer to Figure 26), a clear difference is visible. With white ethnic group subjects, recognition for white faces decreases between serial position 2 and serial position 3, whilst recognition for black faces increases between serial position 2 and serial position 3. With black ethnic group subjects, recognition for black faces decreases between serial position 2 and serial position 3, with an increase in recognition for white faces between serial position 2 and serial position 3. This accounts for a statistically significant contrast between serial position 2 and serial position 3 for the face stimuli type, serial position and ethnic group interaction, $F(1, 46) = 5.3$ ($p = 0.026$). For white ethnic group subjects, recognition for white faces increases slightly, whilst recognition for black faces drops to similar levels as that of serial position 2. For black ethnic group subjects, recognition of black faces increases markedly between serial position 3 and serial position 4, and recognition for white faces decreases to levels slightly higher than that of serial position 2. This specific profile accounts for the statistically significant contrast between serial position 3 and serial position 4, $F(1, 46) = 13.250$ ($p = 0.001$). For white ethnic group subjects, recognition between serial position 4 and serial position 5 decreases for white facial stimuli, whilst it increases for black facial stimuli. However, with black ethnic group subjects, recognition of both white and black facial stimuli increases markedly. The concomitant similarity in profiles between serial position 4 and serial position 5 accounts for the non-statistically significant contrast, $F(1, 46) = 2.628$ ($p = 0.112$). Overall, this indicates that initial recognition of serial positions 1 and 2 are similar between both ethnic groups, with the first face being recognised more successfully, and the second face being recognised less successfully. Interestingly, both ethnic groups recognise other-race subjects better than own-race subjects in the middle of a series (a potential explanation for this occurrence is provided in the Discussion chapter). Furthermore, the contrasts suggest that recognition of that the face in a series (e.g. serial position 5) is more successful than recognition of faces immediately prior to the last face (e.g. serial position 4).

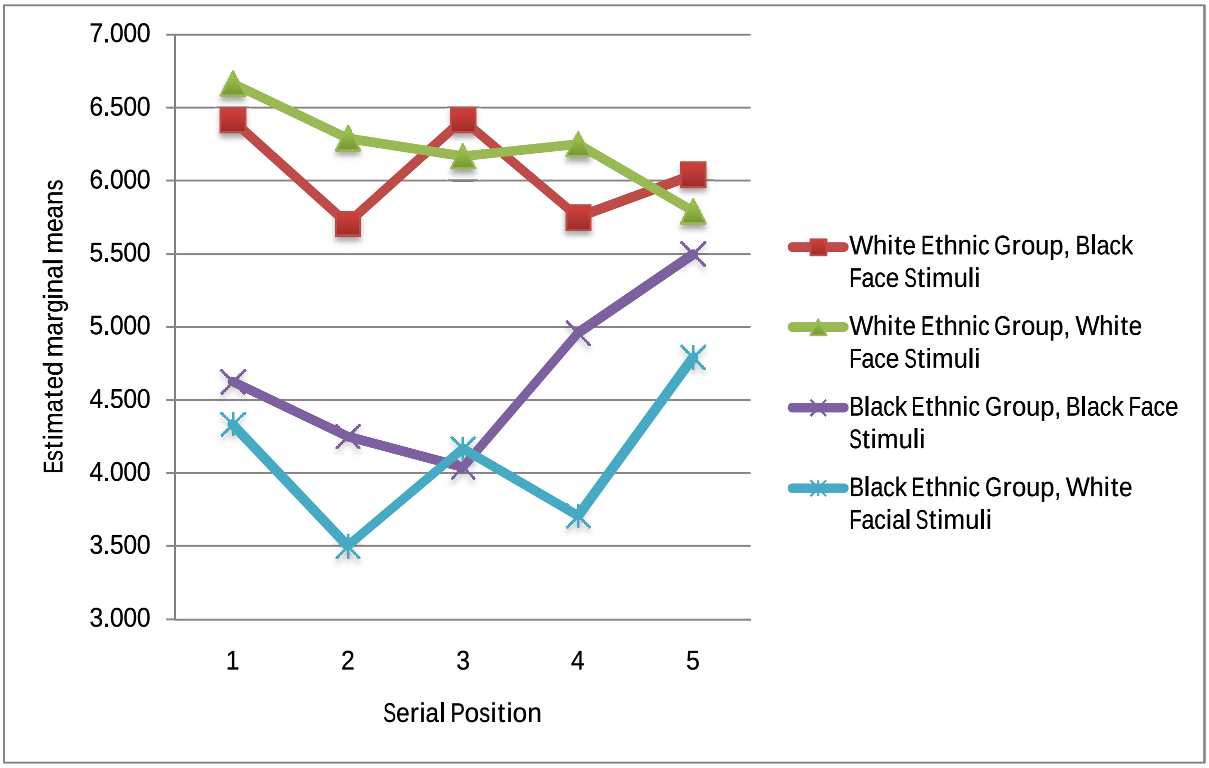

Figure 26: The interaction between face stimuli type and serial position for each ethnic group.

In summary, results of the study indicate that white ethnic group subjects were more successful in recognising faces than black ethnic group subjects. No statistically significant difference of recognition could be determined between white facial stimuli and black facial stimuli. A trend towards a U-type serial position effect curve could be seen in the serial position results. Both white facial stimuli and black facial stimuli exhibited a similar trend toward a U-type serial position effect curve (face stimuli type and serial position interaction). Although black ethnic group participants exhibited a trend toward a U-type serial position effect curve in facial recognition, white participants exhibited a much flatter curve in facial recognition (ethnic group and serial position interaction). The interaction between face type stimuli, serial position and ethnic group of participants indicated that white ethnic group participants exhibited a steady decrease in recognition of white faces, but showed high recognition for the first, middle and last black faces – high enough to match recognition of white faces that occur first in a series. Black ethnic group participants exhibited clearer U-type serial position effect curves for both black facial recognition and white facial recognition, with black faces being recognised much more successfully than white faces.

5 Discussion

Overall, the results provide indications that the serial position effect can be observed in facial recognition data, which is in line with what the literature suggests (Bruyer & Vanberten, 1998; Kerr et al., 1999; Kerr et al., 1998). Furthermore, a trend exists in which it appears that own-race faces are recognised more successfully than other-race faces, which is in support of the own-race bias hypothesis (e.g. Chiroro et al., 2008; Chiroro & Valentine, 1995; Maclin & Malpass, 2001; Meissner & Brigham, 2001; Smith et al., 2004). However, this study aimed at exploring the simultaneous occurrence and potential interaction of these socio-cognitive processes. The serial position effect, own-race bias and the interaction of these are discussed in the following sections, followed by a general discussion of the results found in this study.

5.1 Serial Position Effect

In view of the above results, there are indications that a U-type serial position effect curve is prevalent in the facial recognition task. The main effect of serial position clearly indicates a trend toward a U-type curve to be present (refer to Figure 22). The non-significance of the main effect can be explained by the high scores for serial position 1 and serial position 5, with low scores on serial position 2 and average scores for serial position 3 and 4. This results in a trend that overall can be considered non-significant. Contrasts between serial position curves indicate that the curve can indeed be considered a U-type curve.

The interaction of serial position and ethnic group of participants was significant, $F(3.515, 161.704) = 2.850$ ($p = 0.025$). This indicated that there was a different recognition pattern for faces between white and black ethnic group participants. Looking at Figure 24, these differences can be explained. Primarily, white ethnic group participants scored higher on recognition of faces than black ethnic group participants. White participants did not exhibit a clear U-type serial position curve, but rather a slight decline in facial recognition during the series of 5 faces. This accounts for a stronger primacy effect in the recognition task with a weak recency effect. Black participants showed a clear U-type serial position curve, with a moderately strong primacy effect and a very strong recency effect. The differences in the primacy and recency effects that was found in this study provide some preliminary insight into potential cognitive mechanisms that underlie facial recognition between races.

Table 13 provides a summary of potential mechanisms which may account for the primacy and recency effects that were observed in the study, as adapted from the study by Oberauer (2003).

Table 13: Hypothetical mechanisms which may account for primacy and recency effects observed in the study (adapted from Oberauer, 2003)

	Relevant to this study	**Relevant dimension**	**Motivation**
Mechanisms for primacy			
Forward serial recall tasks	No	Unknown	Serial reconstruction task
Backward serial recall tasks	No	Unknown	Serial reconstruction task
Immediate recognition/spatial order tasks	Yes	Unknown	Serial reconstruction task
Output interference/decay	Yes	Output	Serial reconstruction requires output, which may be subject to decay
Attentional gradient (automatic)	Yes	Input	Attention may decrease as more stimuli is presented during input
Attentional gradient (functional)	Yes	Memory	Ability to maintain items in memory may degrade as attention cannot be sustained to maintain items in memory
Chaining (automatic)	No	(None)	No effect if automatic
Chaining (functional)	Yes	Memory	Primary items have stronger chain links to subsequent items
Distinctiveness (temporal context)	Yes	Output	Especially relevant with longer retention intervals, as it becomes more difficult to reconstruct the original temporal context during output
Edge effects	Yes	Memory	Start items less likely to be transposed

	Relevant to this study	**Relevant dimension**	**Motivation**
Mechanisms for recency			
Auditory stimuli	No	Unknown	This study uses visual stimuli
Visual stimuli	Yes	Unknown	This study uses visual stimuli
Forward serial recall tasks	No	Unknown	Serial reconstruction task
Backward serial recall tasks	No	Unknown	Serial reconstruction task
Immediate recognition/spatial order tasks	Yes	Unknown	Serial reconstruction task
Input Interference/decay	Yes	Input	Later items interfere with maintaining earlier items in memory during input
Distinctiveness (temporal context)	Yes	Input	Later items are temporally more distinct that earlier items
Distinctiveness (arbitrary context)	Yes	Memory	Later items remain more distinct in memory than earlier items, and have stronger activation strengths in memory
Response suppression	Yes	Output	Reducing potential recall candidates with successful recall
Edge effects	Yes	Memory	Later items are less likely to be transposed than middle items

As can be seen from this table, during input, the overall primacy effect could be the result of an attentional gradient. Whilst maintaining items in memory, the primacy effect could be the result of a functional attentional gradient, functional chaining, or edge effects. During output, the primacy effect could result from output interference or item temporal distinctiveness. It is unknown whether input, maintaining or output is affected by serial order reconstruction tasks, though these are known to produce stronger primacy effects. The overall recency effect could, during input, be the result of input interference or item temporal distinctiveness. Whilst maintaining items in memory, the recency effect could result from item distinctiveness unrelated to temporal factors and edge effects. During output, the recency effect could result from response suppression. It is unknown whether input, maintaining or output is affected by visual stimuli and the serial order reconstruction tasks, though these have been noted to produce recency effects.

Although the researcher cannot with certainty rule out any of these potential mechanisms according to which the serial position effect occurred, it is suggested that the strong primacy effect can be attributed to the effects of the attentional gradient, in which attention is given most successfully to the first stimulus that was presented. Full cognitive capabilities (attention) are devoted to encoding and storing the first face in short-term memory. As subsequent stimuli were presented, the ability to divide attention between encoding and storing the new faces and maintaining the first face in short-term memory becomes limited. Therefore, the ability to successfully store later faces diminishes. This is the primacy attention gradient accounts for the primacy effects in the Serial Information Processing model, and the results of this study appear to support this finding in the Serial Information Processing model. Strong recency effects can be attributed to the working of short-term memory, in which the most recent face(s) are most readily available for retrieval and successful recognition. However, with an increase of retention interval, the recency effect typically diminishes and the primacy effect typically becomes more pronounced due to retroactive interference, which is also supported by research into the Serial Information Processing model (Kerr et al., 1999). The retention interval of 3 seconds attempted to strike a balance between the effects of the attention primacy gradient, the effects of short-term memory and retroactive interference or decay. Given that the primacy effect is strong for both white and black ethnic group subjects, and that a recency effect could only be determined for black ethnic group subjects, it is unclear whether this retention interval was too long or too short as it produced different results between the two ethnic groups. The influence of other variables cannot be ruled out either, such as practice effects, different retention strategies, familiarity with the task and familiarity with using computers.

Interestingly, the retention interval may have played a pivotal role in influencing the serial position effect. Some of the black ethnic group subjects were unfamiliar with working with computers, and therefore exhibited slower reaction times in identifying the correct buttons to press on the computer. White ethnic group subjects were all quite familiar with the use of computers. This slower reaction time may have artificially increased the retention interval to more than 3 seconds. Given a sufficiently large retention interval, the recency effect diminishes and the primacy effect becomes more pronounced (Hannigan & Reinitz, 2000; Kerr et al., 1999; Phillips & Christie, 1977a; Warrington & Taylor, 1973). This may not explain why black ethnic group subjects do exhibit a strong recency effect whilst the white ethnic group subjects show no recency effect, but there may be some interplay between the slower responses and the recency effect.

The recognition of the white facial stimuli and the black facial stimuli showed no significant difference, yet show a clear U-type serial position effect curve for both types of stimuli (refer to Figure 25). Recognition of black facial stimuli was slightly higher than recognition of white facial stimuli. This indicates that the two sets of stimuli were similar with overall recognition. Black facial stimuli, however, showed a more pronounced U-type serial position effect curve (with a strong primacy and recency effect) in comparison to white facial stimuli (which exhibits a strong primacy effect and a weak recency effect).

The interaction of the type of facial stimuli, ethnic group and serial position furthermore indicates the U-type serial position effect curve that exists for black ethnic subjects (refer to Figure 26). However, interestingly, with white ethnic group participants, the first, middle and last black facial stimuli were recognised most successfully. The same pattern emerges with black ethnic group participants, in which the first, middle and last white facial stimuli were recognised most successfully. This indicates that encoding strategies were more successful in identifying not only the first face in a set (which could be explained by the attention gradient as posited in the serial information processing model) and the last face in a set (which could be attributed to the nature of short-term memory as explained by the working model of memory or the modal model of memory, as well as the serial information processing model), but also in identifying the middle face in a set – which contradicts the Serial Position Effect hypothesis. The fact that this occurs with other-race faces and not with own-race faces offers some insight into the possibility that different encoding strategies are used to memorise sequences of own-race and other-race faces. The possibility that other cognitive strategies to memorise sequences of other-race faces have been explored in other research as well. Wiese, Stahl and Schweinberger (2009) report on numerous studies that provide indications that first-order configural processing, holistic processing and second-order configural processing differ between own-race faces and other-race faces (see, for example, Bruce & Young, 1986; Diamond & Carey, 1986; Meissner & Brigham, 2001; Michel, Caldara, & Rossion, 2006a; Michel, Rossion, Han, Chung, & Caldara, 2006b; Murray, Rhodes, & Schuchinsky, 2003; Tanaka & Farah, 1993; Valentine & Endo, 1992). Recent research indicates that the processing of own-race faces shows processing advantages when compared to other-race faces in perceptual or matching tasks, which were interpreted to be the result of enhanced configural or holistic processing (Wiese et al., 2009). It is therefore possible that the results obtained in this study may be the result of different processing strategies between own-race and other-race faces.

However, other factors may also have played a role in providing these results. Although all attempts were taken to randomise the faces that were presented as far as possible, it may be possible that, by chance, facial stimuli that were remarkably easily memorisable were randomly assigned to serial position 3 (even though this explanation seems highly unlikely). It may also be possible that, due to the fact that individuals know they struggle more with other-race faces, they paid more attention to the full set of other-race stimuli than they would with own-race stimuli. As a result of the interaction between the attentional gradient, which results in stronger recognition of first items, and the nature of short-term memory, which results in stronger recognition of later items, a specific interaction may have occurred to optimise the recognition of middle items much more successfully than normal. The artificially sustained attention span would then yield a higher recognition of stimuli in the middle of a set than would normally be the case (such as with own-race faces). This could further be motivated by the fact that it may also be likely that a set of 5 faces was too little to elicit the expected serial position curve, and that the task therefore was too easy with subjects devoting enough attention to the memorising and recognition task.

The fact that the own-race facial recognition profiles are dissimilar between white and black ethnic group participants may indicate that white and black ethnic groups utilise different encoding strategies in memorising sequences of own-race faces as well. However, this may again be explained by a bias toward ability of memorising own-race faces – more attention was given to memorising other-race faces because of perceived difficulty in memorising other-race faces. This may also explain why white ethnic group participants have a slowly decreasing performance in recognition of own-race faces – attention was not sustained for the duration of encoding. The attentional gradient therefore suggests that attention may have been optimal at the start of the presentation of stimuli, and as more stimuli were presented in a set, the already low amount of cognitive resources being devoted to the task were increasingly strained to maintain the first stimulus in memory whilst encoding the following stimuli. With each subsequent stimulus, less cognitive resources are available to encode and store the new face being presented, until eventually the subject gives up trying to encode new stimuli and switches solely to maintaining the first stimuli in the set in memory. With the attentional gradient it can therefore be expected that a clear downward trend will be exhibited in recognition of a set of stimuli, which may explain the downward trend in recognition of white subjects on own-race faces.

It can be concluded that, in general, a serial position effect was found in facial recognition tasks, except in the case of white ethnic group participants, the lack of which may be explained by a perceived bias in ability to memorise faces, and the resulting weaker attention span given to own-race faces. The possibility exists that other encoding strategies are utilised to memorise other-race faces than own-race faces, as other-race faces indicate a strong primacy and recency effect, as well as high recognition in the middle stimuli.

5.2 Own-Race Bias

In this particular study, the own race bias would be evidenced through successful recognition of own-race stimuli faces, with less successful recognition of other-race stimuli faces. Overall, a statistically significant main effect for ethnic groups was found, ($F(1, 46) = 19.891$, $p < 0.000$), indicating that white and black ethnic groups differed in their ability to recognise all facial stimuli. White ethnic group participants scored significantly higher on identifying both white and black facial stimuli than black ethnic group participants did. This difference could be attributed to a multitude of factors. Some of the black ethnic group participants were unfamiliar with operating computers, and therefore may have been intimidated by operating a computer. This could influence their ability to pay full attention to memorising information negatively. It may be possible that the familiarity with computers provided white ethnic group respondents with an unfair advantage in terms paying attention to the experiment and in terms of speed at which the test could be taken. It is possible that fatigue played a role in memorising the faces, as the stimuli were presented quite rapidly and a large number of stimuli were presented to subjects, requiring intense concentration for approximately 10-15 minutes. If subjects responded slowly, the test may have taken up to 25 minutes, resulting in more fatigue. However, the study of Brigham and Barkowitz (1978) also illustrated a clear own-race bias for white faces, but no own-race bias for black faces, which is also an interaction (Wright et al., 2001). The presentation rate and display time could potentially have yielded this particular result. A comparison with Ng and Lindsay's (1994) study indicated that facial stimuli was presented for approximately 10 seconds, whilst Brigham and Barkowitz's (1978) study presented facial stimuli for only 1.8 seconds. Ng and Lindsay's (1994) study illustrated a clear own-race bias across both races, whilst Brigham and Barkowitz's study illustrated the own-race bias only for white faces. The study presented here also displayed faces for only 1.5 seconds, and subsequently found that overall recognition by black participants was lower for both white and black facial stimuli. This possible interaction between ethnic group of participants, the rate and duration of stimuli presentation, and recognition can be a subject for future research. In addition, recognition accuracy in the study of Ng and Lindsay was much higher than that of Brigham and Barkowitz's study (Wright et al., 2001). This could also be attributed to the longer display intervals of facial stimuli. In the study presented here, overall recognition levels were low for both white and black participants (averaging less than half of faces correctly identified). Although the methodology presented in this study is slightly different from that of other studies, a longer presentation rate could yield more pronounced serial position effects.

As discussed previously, the racial group of facial stimuli type did not make a statistically significant difference ($F(1, 46) = 1.108$, $p = 0.298$) in ability to identify faces. However, the interaction between facial stimuli type and ethnic group was nearly significant ($F(1, 46) = 3.657$, $p = 0.062$), which suggests a trend toward the ethnic group of participants influencing the ability to identify faces correctly (refer to Figure 23). It would certainly appear that a trend toward own-race bias in facial recognition is present in the study, in spite of the interaction not being statistically significant. This implies that white subjects did score higher in identifying white facial stimuli than black facial stimuli, and that black subjects did score higher in identifying black facial stimuli than white facial stimuli.

The facial stimuli type, serial position and ethnic group interaction provided further insight into the occurrence of the own-race bias in this study (refer to Figure 26). For white ethnic group participants, recognition of white facial stimuli mostly is higher than that of black facial stimuli. However, recognition at serial position 3 is higher for black faces than for white faces. As discussed in the previous section, this could potentially be the result of the stimuli being biased toward highly recognisable faces at serial position 3. Yet it was attempted to avoid this by randomising the facial stimuli. Furthermore, this seems unlikely as the same pattern emerges with black ethnic group respondents, with serial position 3 of white facial stimuli being recognised slightly better than serial position 3 of black facial stimuli.

Another explanation could be that subjects are biased toward selecting "3" as an answer when they were unsure of faces. However, this also seems unlikely as a raw data check identified no respondents who repeatedly selected "3" as answer to all facial stimuli during the experiment. Therefore, the most likely explanation would appear to be that both black and white ethnic groups utilise different strategies in memorising sets of faces of other-race individuals than the strategies used in memorising sets of faces of own-race individuals. Part of this different strategy would involve consciously devoting more attention to recognising other-race individuals, and potentially, in the case of white ethnic group participants, devoting less attention to recognising own-race individuals.

However, it may also be likely that a set of 5 faces was insufficient to elicit the expected serial position curve, and that the task therefore was too easy.

It can be concluded that an own-race bias seems to be prevalent in the study results, and it would appear that attention plays a significant role in memorising sets of other-race faces.

5.3 Serial Position Effect and Own-Race Bias

From the previous sections we can conclude that it would appear that a serial position effect can indeed be observed from the facial recognition task. Furthermore, an own-race bias appears to be present in the facial recognition task as well. The purpose of this study was to investigate the interaction between the serial position effect and the own-race bias. From the results, salient features are that, for white subjects, recognition for white faces shows a decrease with no typical U-type serial position effect curve, whilst the recognition of black faces shows a tri-modal peak for the first stimuli, middle stimuli and last stimuli. However, recognition of white faces generally seems higher than recognition of black faces for white ethnic group participants (when comparing the marginal means of the white ethnic groups' results). Vice versa, recognition of black facial stimuli is generally much higher than recognition for white facial stimuli for black ethnic group participants. The black facial stimuli exhibited a clear U-type serial position curve, whilst the white facial stimuli also showed a tri-modal peak at the first, middle and last serial positions. It has already been posited that this tri-modal peak could have been the result of different encoding and memorisation strategies used for other-race faces by participants, in comparison to own-race faces. It may also be that a specific interaction between the attentional gradient and the nature of short-term memory produced unusual recognition ability for the middle stimuli in this set (given that the set was only 5 faces, the task may have been too easy when subjects utilised most of their attention resources). This is furthermore evident from the apparent ceiling effect that resulted in a small recency effect for white ethnic group participants. A similar pattern of results was found in a study by Gupta and his colleagues (2005), in which the recency effect nearly disappeared as a result of a ceiling effect – in other words, participants scored high on recognition accuracy across the board.

The retention interval of 3 seconds could have played an instrumental role between the different ethnic groups of participants. Kerr and his colleagues (Kerr et al., 1998) mentioned that, at short retention intervals, strong recency and no primacy effects occur, but as the retention interval increases, recency is attenuated and primacy increases. This study presented in here follows a similar identification strategy as that adopted in the study by Kerr and his colleagues. These authors presented 24 participants sets of 4 unfamiliar faces, and their subjects were asked to state the serial position of a probe after 0 or 10 seconds. Their study yielded a strong recency-to-primacy shift with an increasing retention interval, yet the study only used own-race faces. Evaluating the recognition curve for the white ethnic group participants in this study, a strong primacy effect can be seen, whilst no recency effect could be found. Evaluating this in view of the study by Kerr and his colleagues (Kerr et al., 1998), this could suggest that the retention interval was too long overall to produce a standard U-type Serial Position Effect curve. When comparing the recognition of white facial stimuli with the recognition of black facial stimuli for the white ethnic group participants, white facial stimuli (in other words, the own-race condition) exhibited a strong primacy effect with no recency effect, whilst black facial stimuli (the other-race condition) exhibited a strong primacy effect with a moderate recency effect. Evaluating this in terms of the retention interval, it is possible that the retention interval for white facial stimuli (own-race condition) may have been too long, and elicited a strong recency-to-primacy shift, whilst the retention interval for black facial stimuli (other-race condition) may have been slightly too long, eliciting a moderately strong recency-to-primacy shift. This results in an inflated primacy effect overall for white ethnic group participants. The researcher suggests that this recency-to-primacy shift could also be influenced by the attentional gradient and the cognitive resources that are available to encode the facial stimuli – both of which may influence the rate of decay of encoded stimuli. When evaluating the recognition curve for black ethnic group participants, a very strong recency effect was found overall, with a moderate primacy effect. This could suggest that the retention interval of 3 seconds was ideal to elicit a serial position curve for black ethnic group participants. When considering the black facial stimuli results for black ethnic group participants (i.e. the own-race condition), a very strong recency effect with a moderately strong primacy effect was found. This is the expected trend for a serial position curve, and suggests limited effects from the recency-to-primacy shift. The white facial stimuli results for the black ethnic group (i.e. the other-race condition) also exhibited a strong recency effect with a moderately strong primacy effect, which is the expected trend for a serial position effect curve.

However, what is noticeable within the other-race condition for both ethnic groups was the inflated level of recognition accuracy for the third (or middle) serial position. The fact that this was found in both ethnic groups only for the other-race condition renders it noteworthy and open to interpretation. This could potentially be an effect that is related to the recency-to-primacy shift and the attentional gradient, where the level of attention given artificially attempts to inflate recognition levels overall (resulting in a strong recency effect), and the recency-to-primacy shift, where a stronger primacy effect could be found. The interaction of these two cognitive phenomena could have resulted in a combined effect of inflating the middle serial position. However, it should be interesting to see whether future studies can replicate this tri-modal peak for other-race stimuli. The closest result to this tri-modal peak that the researcher could find in the literature was the so-called "W-curve" in the W/M shaped curve interactions that occur with letter and digit recall. These M and W shaped curves occur when letter arrays are presented to subjects, and they have to recall the letters that were presented. The caveat to this phenomenon is that the W/M-shaped function is typically found in strings of five letters or greater, where there is fixation on the central letter (Tydgat & Grainger, 2009). Experiments testing four-letter strings and/or using parafoveal stimulus presentation have typically shown U shaped serial position curves for recognition accuracy, whereas arrays of five or more letters (especially those with an odd number of arrays, allowing for visual fixation on the central letter) show a W-curve for recognition accuracy and an M-curve for recognition time (Bouma, 1973; A. J. Campbell & Mewhort, 1980; Estes, Allmeyer, & Reder, 1976; Jordan & Bevan, 1996; Jordan, Patching, & Millner, 2000; Jordan, Patching, & Thomas, 2003; Mewhort & Campbell, 1978; Tramer, Butler, & Mewhort, 1985). The explanations for these W/M curves relate to two factors – the drop in visual acuity as a function of distance from fixation, and the amount of lateral interference (crowding) determined by the number of flanking letters (Tydgat & Grainger, 2009). The researcher of the study presented here does not believe that these explanations could easily relate to the W-shaped curves found in the other-race recognition condition within this study. Therefore, it will be interesting to note whether future studies into the other-race condition for serial position effects can replicate the W-shaped curves. Figure 27 and Figure 28 provide examples of the W and M type curves that Tydgat and Grainger (2009) found in their study.

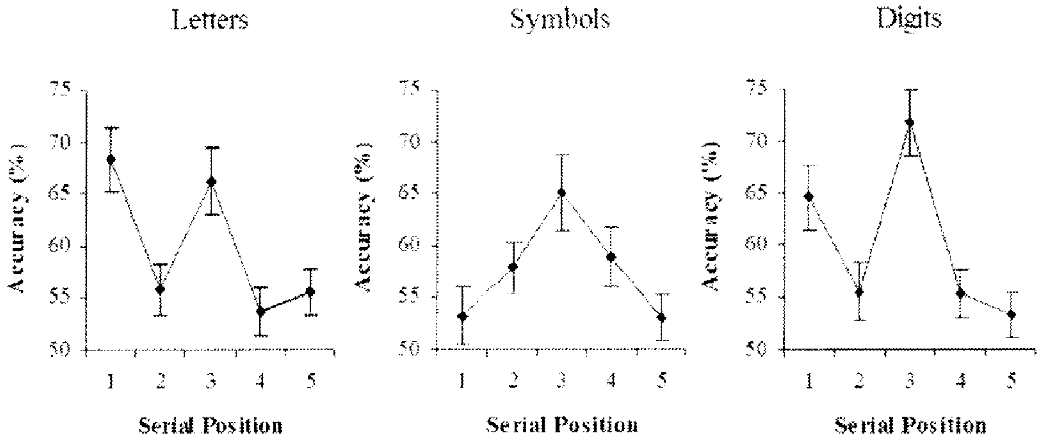

Figure 27: Typical W/M type curves found for recognition of letters, symbols and digits in a study by Tydgat and Grainger (2009)

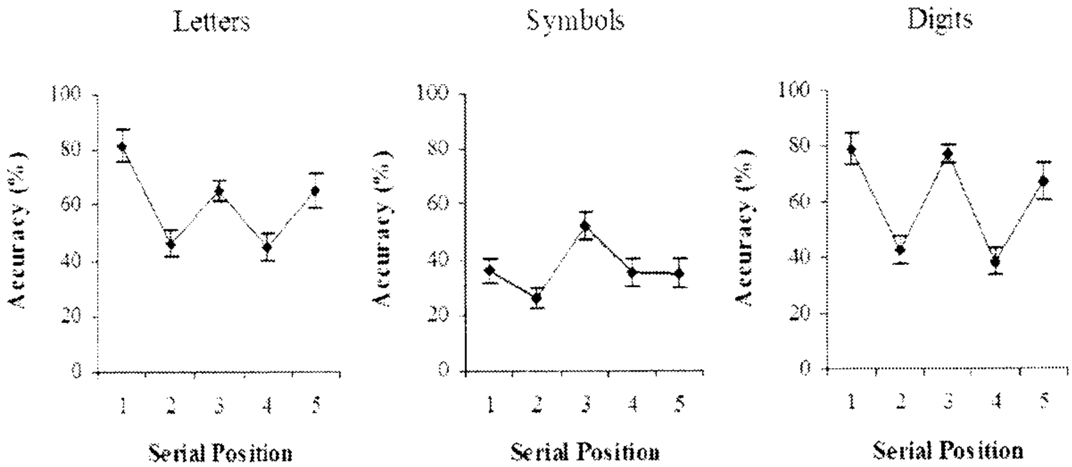

Figure 28: More typical W/M type curves found for recognition of letters, symbols and digits in a study by Tydgat and Grainger (2009)

However, what is clear is that although both the influence of the serial position effect and the own-race bias can be seen in the results, the interaction of these two socio-cognitive variables are much more subtle. As was postulated in section 2.5, it was expected that a moderately diminished primacy effect, a slightly diminished recency effect, and a highly diminished middle recognition would be observed as a result of the own-race bias for other-race facial stimuli. Generally, it would appear that this is not the case with the results. The tri-modal peaks in recognition for other-race faces result in very little difference between the first, middle and last stimuli between facial stimuli types being present. Furthermore, the fact that the white ethnic group subjects exhibited a strong primacy effect but weak recency effect whilst the black ethnic group subjects exhibited a moderately strong primacy effect but a very strong recency effect indicates that performance between ethnic groups in terms of the facial recognition task was different. Therefore, it is apparent that although there is some difference in recognition of sets of facial stimuli, the influence thereof on the serial position curve is primarily affected by the attentional resources given to the task at hand.

5.4 General Discussion and Implications

The study presented here posited three research hypotheses. First, it is expected that the first and last faces that are presented in a set will be recognised at a higher frequency and accuracy than faces presented in the middle of a set. Generally, this hypothesis was supported with an overall clear illustration of a serial position effect (irrespective of ethnic group of participants and the ethnic group of facial stimuli). This hypothesis was strongly supported by black ethnic group participants, the results of which presented a strong serial position effect for recognition of both white and black facial stimuli. Only the first face was recognised at a higher frequency than other faces for white ethnic group participants, irrespective of type of facial stimuli. The second research hypothesis stated that it is expected that there will be a diminished face recognition accuracy for other-race faces. This hypothesis was supported by the current study as well. Although white ethnic group participants showed a slight own-race bias in facial recognition, black ethnic group participants showed a strong own-race bias in facial recognition. The third research hypothesis stated that it is expected that the first and last faces of own-race face recognition in a set will be recognised much more accurately than the first and last faces of other-race faces in a set, whilst the middle face of own-race faces in a set may be recognised only slightly more accurately the middle face of other-race faces in a set. This hypothesis was not supported strongly in the current study. The middle other-race face in a stimuli set was recognised at a high frequency, at levels close to recognition of the first face in own-race face stimuli sets. This suggests that some moderating factor or alternative encoding strategies may be used in memorising a short set of facial stimuli, and different sets of encoding strategies may be employed when memorising and recognising own- and other-race faces.

In general, it can therefore be stated that the primary moderating factor that plays a role in determining the influence of own-race bias on recognition of sets of facial stimuli (both own-race and other-race) is attention. Since the attentional gradient can account for the primacy effect that is observed throughout the data, this is considered the primary moderating variable in the recognition task. In spite of subjects being instructed to attempt to memorise all faces, it would appear that more attention was given to memorising other-race faces than own-race faces, resulting in an unexpected interaction between high sustained attention levels and a strong short-term memory effect for other-race faces. This may have been ameliorated by increasing the sets of stimuli to display more than 5 faces, since attention most likely would decline much more rapidly with the presentation of more stimuli. Further studies could therefore investigate this issue.

Taking into account the influence of the attentional gradient, it cannot be ruled out that the presentation of more stimuli may indeed result in an overall flatter U-type serial position curve for other-race facial recognition. Neither can it be stated with certainty that other-race facial recognition is subject to other encoding and memorisation strategies in comparison to own-race facial recognition, although it seems possible that attention would influence these encoding and memorisation strategies as this is in line with other research that was conducted (Wiese et al., 2009). Further studies may be able to investigate whether this is indeed the case.

What can be concluded with a reasonable certainty from the results is that the attentional gradient not only plays a clear role in eliciting a serial position effect, but also plays a role in recognition of sets of other-race faces. With a lot of attention and a relatively small set of faces being presented, it seems likely that recognition of the first, middle and last other-race faces will compare with recognition levels of own-race faces.

According to the optimality hypothesis, confidence and accuracy in facial recognition are most associated when encoding conditions are optimal. In the field study of Wright et al (2001), unknowing random white or black subjects were approached by either a white or a black “confederate” in shopping malls. The confederate asked the subject for the time, or directions to a pertinent location, and attempted to maintain eye contact for approximately 15 seconds. Following the departure of the confederate, the researcher approached the unknowing subject after about 3 minutes, and identified themselves as researchers investigating eyewitness memory. With the consent of the subjects to participate in the study, the researcher asked the participant to identify the confederate in a set of 7 photographs. A clear own-race bias emerged from the study, with a strong correlation between the certainty of participants in their identification and the accuracy of their identification for own-race identifications, but not for other-race identifications. From a theoretical perspective, this suggests that own-race and other-race identifications are made in different ways (Wright et al., 2001) – a finding which is supported by the results presented in this study as well. The authors suggest that people potential pay more attention to the confederates when they are of the same race as the participant, as opposed to when the confederate was of another race (Wright et al., 2001). According to the optimality hypothesis (Bothwell, Brigham, & Deffenbacher, 1987), confidence and accuracy are most associated when encoding conditions are optimal. Therefore, when attention is given to an individual, the confidence and accuracy of identification is positively correlated, and overall accuracy seems to be higher as well (Wright et al., 2001).

The implications of these results could be applied to the line-up identification parade system used in presenting potential criminals for identification. Several methods of eyewitness identification parades have been utilised through the ages. Dock identification occurred when the witness was asked during the court case whether the person in the dock was the culprit. This usually resulted in a confrontation, as the witness is shown a single suspect, and the method is considered unacceptable due to the leading nature of the question involved where the suspect is the only real answer available to the witness. These limitations were recognised in England as early as 1860, and the identification parade was invented in that time with the explicit purpose of providing a better method of identification

(Rust & Tredoux, 1997). This process has the advantage of having the witness *recognise* the culprit rather than having to *recall* their features. However, Rust and Tredoux (1997) mention that internationally there is a recognition that even lineup identification parades need to be treated with caution and that they need to be conducted according to specific principles for them to be fair. South African courts have also recognised the potential fallacy of lineup identification parades. In spite of a witness being honest and the identification parade procedures being correct, mistakes do occur and lineup identification parades remain fallible procedures (Rust & Tredoux, 1997). Huff, Ratner and Sagarin (1996), Sheck, Neufeld and Dwyer (2000), and a review by Wright and Davies (1999) indicated that eyewitness misidentification is the leading cause of innocent people being falsely imprisoned. Wells and his colleagues (Wells et al., 2000; Wells et al., 1998) indicated that in most cases described in the National Institute of Justice's report (of the USA) (Connors, Lundregan, Miller, & McEwen, 1996), on convictions overturned based on DNA evidence, errant eyewitness identification was a factor. Wraight and McDaid found in a survey of identification parades conducted in London (i.e. line-ups) that in approximately 20% of line-ups an innocent person, a filler, was chosen. In these cases, the innocent filler would be chosen and arrested. Clearly the own-race bias is one of the explanations as to why cross-race misidentification occurs (Wright et al., 2003).

The implications of eyewitness misidentification are certainly far-reaching and severe, and explanations as to why this phenomenon occurs are diverse. The cognitive mechanisms underlying the Own-Race Bias are still not clearly understood, though this may have its roots in visual processing strategies. Darling and his colleagues (Darling, Martin, Hellmann, & Memon, 2009) indicated that a link exists between visual processing strategies and eyewitness identification. This follows on research conducted by Macrae and Lewis (2002), in which these authors indicated that people who focus on local stimulus elements had worse performance on identification tasks, whilst those focussing on global elements had increased performance in identification tasks. Although other research indicated strong evidence toward the possibility that global processing strategies make people better at recognising faces (for example, Martin & Macrae, in press), the study by Darling et al (2009) is the first to provide a statistically robust study to support this notion.

Should insufficient attention be given to the recognition task at hand, or if insufficient attention was given to memorising faces during witnessing of a crime, the successful identification of criminals would be influenced by the order in which the potential criminals are presented to the eyewitness. A potential solution to this problem would be to present smaller groups of potential criminals to eyewitnesses, although this may be impractical. Current practice in many jurisdictions in North America requires that lineup items are presented sequentially, with witnesses being required to make a specific and absolute judgement about each person in the lineup (Darling et al., 2009). It is argued by Wells, Mallpass, Lindsay, Fisher, Turtle and Fulero (Wells et al., 2000) that this reduces likelihood of relative judgements being made. In other words, it reduces the likelihood that subjects will compare people with each other during the lineup. The correct identification rate is about the same between this sequential identification parade and the simultaneous identification parade, but has reduced the false identification rate in comparison with the simultaneous identification parades and has proven to be a highly robust and substantially superior method to the traditional simultaneous identification parade (Rust & Tredoux, 1997). In the UK, most lineups currently are presented in a video format that is sequential in nature, though without the requirement to make an absolute judgement about each face (Valentine, Darling, & Memon, 2007).

When faced with recognition of other-race individuals, eyewitnesses may be specifically instructed to devote as much as attention as possible to recognising the faces to encourage absolute judgements and avoid comparative judgements. In the witnessing of highly traumatic criminal events, it may be expected that attention to memorising faces would be limited, which suggests that recognition may not be as accurate as in normal circumstances. More dated work by Christianson (1992) indicated that, although general eyewitness testimony literature claims that emotional stress leads to an impairment in memory due to a diminished processing capacity, this may not always be the case. Other factors need to be taken into account, such as the type of event, the type of detail information, the time of the identification test, and the type of retrieval information. Not only does recognition become relevant in such a traumatic experience, but the ability to recover from such an event also can be implied in this research. Several trauma theorists suggest that cognitive factors play an important role in trauma response (Ehlers & Steil, 1995; Foa, Steketee, & Rothbaum, 1989). Henning-Fast and his colleagues (Henning-Fast et al., 2009) found that in traumatised policemen, reaction time was slowed in facial recognition and identification.

The presence of a high number of other-race individuals also appears to enhance the potential for the "racial retreat" of individuals. An early study by Davis, Seibert, and Breed (1966) indicated that racial segregation on public transit vehicles actually increased as the number of passengers rose from low to medium levels of density. These authors suggested that crowding on buses cued passengers' sense of racial retreat, which in turn increased their tendency to separate from other-race individuals. A study by Clack, Dixon and Tredoux (2005) also suggested that this pattern of racial retreat may occur in a cafeteria setting, which was the focus of their study. The implication of this finding is that, although macro-socially, the opportunity for racial integration and contact exists in social settings, on a micro-social level this integration and contact may not necessarily occur. Although the specific socio-cognitive mechanisms underlying this result remains speculative, the implication of this finding may bear relevance to the results presented in this study. It is possible that a large number of other-race individuals may reduce an individual's willingness to engage in contact with them. Given the known difference between holistic and feature processing, a possible cognitive psychological explanation may be that the cognitive load to process a large number of other-race individuals may be too high for individuals to willingly engage in. Vice versa, a smaller number of other-race individuals may present less of a cognitive load to individuals. This may also be mediated by perceived ability to differentiate between other-race faces, as well as perceived contact with the other race. Future research could take into account these suggestions, and assess whether the holistic and featural processing strategies for facial recognition may be influenced by the number of own-race and other-race individuals presented to subjects.

The results also suggest that individuals are aware of the fact that they may battle with other-race facial recognition, and therefore try and pay more attention to memorising other-race faces when they know that they have to recall the faces at a later stage. Future studies may investigate whether an unexpected recall task will yield different results.

6 Limitations

The study that was conducted was subject to a number of limitations, and future studies may build on this current research by taking into account these limitations. Gender does elicit some influence on facial recognition, and the effect of gender needs to be controlled for in this study. Future studies may best control for this by utilising only one gender of participants through the study. Although the facial stimuli that were used in the current study were considered a standardised set, some of the stimuli did provide cues to participants based on the hair of the photographed stimulus faces. Future studies may best control for this by using facial stimuli that have hair edited to either be the same or, preferably, no hair at all.

The influence of the retention interval may have been more pronounced in the black ethnic group subjects, as some subjects were unfamiliar with using computers. This may have led to a more pronounced own-race bias (Meissner & Brigham, 2001) or as well as a more severe recency-to-primacy shift in the current study. It may also have resulted in the overall lower recognition accuracy of the black ethnic group participants. Future studies would need to attempt to standardise the retention interval and also utilise participants who are all familiarised with computers.

The results that were seen in the current study may also have been subject to some practice effects and a ceiling effect with the presentation of only 5 faces in a stimulus set. Given sufficient attention, the 5 faces may have been too easy for participants to memorise and recall, resulting in an artificial inflation of recognition results. As mentioned previously, this may have led to the high recognition of the middle stimuli in a set. Future studies may investigate using more than 5 faces in a stimulus set to evaluate whether a similar W-type curve can be observed.

The discrimination accuracy of participants was not included in this study. This measure allows the study to ascertain the certainty with which participants identify faces, and allows the researcher to distinguish between the “remember” and “know” judgements which often confound false positives and accurate hits. This would allow the researcher to calculate the relative discrimination accuracy of participants through signal detection theory, which would yield further insight into the particular cognitive processes adopted in facial recognition.

7 Conclusion and Final Recommendations

In general, it can be concluded that attention plays a pivotal role in both the serial position effect and own-race bias individually, as well as in the interaction between the two socio-cognitive phenomena. Facial recognition exhibits a clear serial position effect, and a bias to recognising own-race face is evident. If sufficient attention is given to memorising faces, the recognition of a series of other-race faces may be nearly equivalent to recognition of own-race faces. However, should insufficient attention be given to memorising faces, the successful identification of faces seems to be limited to the faces presented first in a series. Under normal circumstances, however, a clear U-type serial position effect curve can be observed in the recognition of faces.

Future research may need to therefore consider the race of facial stimuli that is used in serial position effect research as well, as this study provides indications that the race of the stimuli and the ethnicity of the subjects do indeed influence memorising strategies and/or capabilities. Future research that builds on this study may need to take into account the effects of gender and hair on facial stimuli, a standardised retention interval may be required, and the effects of more than 5 stimuli in a set may be more pronounced. Longer display intervals could yield more pronounced own-race bias effects (Wright et al., 2001), as well as a methodology in which distractors are built into the display set (Wright et al., 2001).

Future research could also investigate whether similar results are found between other ethnic groups, as this study was limited to only investigating facial recognition between white and black ethnic groups. In addition, cultural groups within ethnic groups could also have potentially different facial recognition features and/or strategies. For example, some differences may exist between South African Zulus and South African Xhosas, which this study did not account for.

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