FALSE FACIAL RECOGNITION: THE RELATIONSHIP BETWEEN FALSE ALARMS AND FRONTAL LOBE FUNCTIONING IN OLDER ADULTS

by

Emily C. Recknor

A Master's Thesis Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF ARTS

In the Graduate College

THE UNIVERSITY OF ARIZONA

2007

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for a Master's degree at The University of Arizona and is deposited in the University Library to be made available to borrower under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: _Emily C. Recknor________

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

______________________________ ___October 10, 2007___

Alfred W. Kaszniak — Date

Professor of Psychology

TABLE OF CONTENTS

TABLE OF CONTENTS – *Continued*

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Previous research has shown that older adults are more susceptible to false facial recognition than younger adults, possibly related to changes in the frontal cortices. We hypothesized that false recognition would be related to poorer performance on measures of memory monitoring, decision-making, and "frontal" functioning. Forty-one older adults, classified as high or low frontal based on standard neuropsychological measures, completed a face recognition memory task, a Feeling of Knowing (FOK) task, and the Iowa Gambling Task (IGT). There was a correlation between false alarm rates and response bias on the recognition memory test with bias on the FOK task. High false-alarmers had a liberal response bias and were overconfident in their memory predictions relative to low false-alarmers. Performance did not relate to standard neuropsychological tests, potentially due to their sensitivity to dorsolateral prefrontal functioning, while the FOK task and the IGT are related to ventromedial prefrontal functioning.

INTRODUCTION

Whether it is a family member, a colleague, an acquaintance we have not seen for years, or a relative stranger that we met only briefly, humans have the remarkable capacity to recognize thousands of different faces. Despite the relative similarity of all human faces, the healthy brain is able to process each unique face and to evoke in us a sense of familiarity for those individuals whom we have previously met. We are able to accurately monitor whether this sense of familiarity is related to a specific memory for an individual's face and to make accurate decisions as to whether or not we have encountered that individual in the past.

This ability to accurately recognize familiar faces can be dramatically altered after acquired injury to specific areas of the brain. The vast majority of research on face perception after brain damage has been in the area of prosopagnosia, a neurological disorder in which patients are unable to consciously recognize or identify familiar faces. However, a deficit in the recognition of familiar faces is not the only change in face processing that can occur after brain injury. Specifically, patients who have sustained damage to the frontal lobes may demonstrate deficits that are in stark contract to those seen in prosopagnosia (Vuilleumier, Mohr, Valenza, Wetzel, & Landis, 2003). While prosopagnosics lack an explicit feeling of familiarity for faces that should be familiar, some patients with damage to the frontal lobes, particularly on the right, have an increased sense of familiarity when viewing faces that they have never encountered previously. This heightened sense of familiarity may lead to false facial recognition, a phenomenon in which patients mistakenly believe that novel faces are familiar. False facial recognition has been attributed to a breakdown of specific functions of the frontal lobe, such as monitoring and decision-making functions, which may be instrumental in attributing a sense of familiarity to a specific source (Rapcsak, Reminger, Glisky, Kaszniak, & Comer, 1999; Rapcsak, Nielsen, Glisky, & Kaszniak, 2002). Intact monitoring and decision-making processes become increasingly crucial for accurate recognition when situations have a high degree of uncertainty or ambiguity (Rapcsak et al., 2002).

False Facial Recognition in Patients with Frontal Lobe Damage

False facial recognition following acquired frontal lobe brain damage has been reported in several case studies (Ward, Parkin, Powell, Squires, Townshend, & Bradley, 1999; Rapcsak, Kaszniak, Reminger, Glisky, Glisky, & Comer, 1998; Parkin, Bindschadeler, Harsent, & Metzler, 1996; Rapcsak, Polster, Comer, & Rubens, 1994). Ward et al. (1999) described patient M.R., a 53-year-old man who sustained frontal lobe damage due to multiple sclerosis. Although M.R. was able to accurately recognize familiar faces (i.e., famous faces), he had a tendency to claim that non-famous people were familiar. On recognition tasks using facial stimuli, M.R. demonstrated a pathologically high rate of false alarms to novel faces. The patient described his subjective experience in everyday life as "seeing film stars everywhere."

A similar experience was described in 63-year-old patient J.S., who sustained right frontal lobe damage following a ruptured anterior communicating artery aneurysm (Rapcsak et al., 1998). J.S. frequently misidentified unfamiliar faces in his everyday life, believing them to be faces of famous individuals, family members, or personal acquaintances.

Despite pathologically elevated false alarm rates, the patients described in the literature demonstrate normal hit rates on recognition tasks. In other words, they show no impairment in recognizing truly familiar faces. This finding supports the existence of a double dissociation between false facial recognition and prosopagnosia (Vuilleumier et al., 2003).

Group studies involving patients with focal frontal lobe lesions, primarily on the right side, have yielded a similar pattern of results. When compared to healthy controls, frontal patients show an elevated false alarm rate in the presence of a normal hit rate on recognition tasks using facial stimuli (Rapcsak et al., 1999; Rapcsak et al., 2002). These studies also included control groups of patients with damage to the right medial temporal lobe, the area thought to be critical face memory. Results indicated that the medial temporal patients had significantly lower hit rates when compared to both healthy controls and frontal patients, and their false alarm rates were higher than healthy controls but significantly lower than frontal patients. These findings suggest that false facial recognition is not simply the result of poor memory for faces. If this were the case, the medial temporal patients, who had the most severe face memory impairments, would show the greatest number of false alarms. However, the highest false alarm rate was found in the frontal patients, who apparently had an intact face memory storage system but impaired executive control and monitoring operations. The authors concluded that it is not face memory loss per se that leads to false facial recognition, but rather an impairment in the decision strategy adopted under conditions of reduced memory discrimination (Rapcsak et al., 1999; Rapcsak et al., 2002). This study also found that participants false-alarmed more to non-famous faces than to famous faces, which may be due to their having more detailed representations for the highly familiar faces, while their representations for the non-famous faces were weaker and placed greater demands on strategic frontal memory retrieval, monitoring, and decision functions (Rapcsak et al., 2002).

These group studies, along with the case descriptions, offer strong support for the role of the frontal lobe in accurate face recognition and the theory that damage to frontal structures may lead to increased susceptibility to false facial recognition.

Frontal Lobe Functioning in Older Adults

The frontal lobe hypothesis of cognitive aging posits that the frontal lobes are disproportionately affected by the aging process (West, 1996). Therefore, functions thought to be dependent on the frontal lobes may be subject to more rapid decline than cognitive functions supported by other neural substrates. The prefrontal cortex has been identified as particularly vulnerable to age-related change, potentially explaining the finding that older adults demonstrate greater deficits in frontally mediated processes, such as memory monitoring (Souchay, Isingrini, & Espagnet, 2000) and decision-making (Denburg, Tranel, & Bechara, 2005), as well as a greater susceptibility to false memories when compared to younger adults (Jacoby & Rhodes, 2006).

Despite these overall age differences, there appears to be a large amount of variability within older adults in terms of frontal functioning. Glisky, Polster, and Routhieaux (1995) examined a large sample of older adults and identified distinct subgroups of individuals as either having “high” frontal functioning or “low” frontal functioning based on a factor analysis of their scores on frontally-sensitive neuropsychological tasks. Studies have shown that individuals with high frontal functioning tend to perform as well as younger adults on many tasks, while the pattern of deficits seen in older adults with low frontal functioning may resemble those found in patients who have sustained frank neurological damage to the frontal lobes (Glisky, Rubin, & Davidson, 2001; West, 1996).

False Recognition in Older Adults

Previous research has established that older adults are more susceptible to false recognition than younger adults (Norman & Schacter, 1997). When presented with a list of words, older adults are more likely to falsely endorse the novel distracter items during a later recognition test. False recognition is particularly high when the lures are semantically related to the items on the list, suggesting that older adults are basing their recognition decision on a general sense of familiarity rather than searching for a specific memory trace for each item (Roediger & McDermott, 1995).

Consistent with the frontal lobe hypothesis of aging, LaVoie, Willoughby, and Faulkner (2006) demonstrated that false memory susceptibility on a recognition memory task was related to performance on a measure of frontal lobe functioning. Participants were presented with lists of words and were later given a yes/no recognition task for the list items. Results indicated that only those participants who were classified as having low frontal functioning showed a tendency to falsely recognize non-presented words. Older adults with high frontal functioning, on the other hand, performed similarly to young control participants. The study also included a group of patients with Alzheimer's disease in order to determine whether susceptibility to false recognition is related to poor memory for the list items. However, such a relationship was not found, as Alzheimer's patients did not have an elevated level of false recognition. The authors concluded that accurate recognition is dependent upon specific frontal processes, such as the ability to accurately monitor memory output (LaVoie et al., 2006). A limitation of this study was the use of the Trail Making Test Part B (US War Department, 1944), a graphomotor task requiring rapid visual scanning and mental tracking, as the only measure of frontal functioning. A controversy exists as to whether this test is sensitive to specific frontal impairments since the test is thought to rely on several cognitive processes and is often used as a more general indicator of cognitive dysfunction (Butters, Kaszniak, Glisky, Eslinger, & Schacter, 1994). In addition, the use of only one measure to describe frontal functioning is of questionable validity.

Rubin, Van Petten, Glisky, and Newberg (1999) used the factor-analytic method developed by Glisky et al. (1995), which is based on a composite measure of several neuropsychological tests sensitive to frontal lobe functioning, to classify a group of older adults as "high frontal" or "low frontal." Participants completed a recognition memory test in which they had to distinguish previously studied words from highly similar lures.

Results showed that frontal functioning significantly predicted false alarm rates on the task, with the low frontal group demonstrating more false positive errors than the high frontals. This may be the result of faulty monitoring and decision-making processes during memory retrieval in the low frontal group, as the prefrontal cortex is critical for monitoring the output of the memory system and making decisions about the veracity of that output (Rubin et al., 1999). These processes may be particularly crucial when there is a high degree of similarity between the studied items and the lures, as was the case in this study.

Similar results were found in a study of recall, as opposed to recognition, in order adults (Butler, McDaniel, Dornburg, Price, & Roediger, 2004). Participants studied 36 different lists of 15 words each. Immediately following each list, they were asked to recall as many items as possible within a 2 minute period. Results showed that the participants with low frontal functioning falsely recalled significantly more words than both the high frontal functioning group and the younger adults, who performed equivalently. A recognition test was also given after each set of 12 lists. Performance on the recognition test showed the same pattern of results, although differences between groups did not reach significance.

To date, the majority of studies of false recognition in aging have used verbal materials, while fewer studies have examined false recognition in the facial domain. However, there have been several studies which demonstrated that older adults are less accurate than younger adults at recognizing faces, which is attributable to an elevated false alarm rate in older adults in the presence of similar hit rates (Bartlett & Fulton, 1991; Bartlett, Leslie, Tubbs, & Fulton, 1989; Lamont, Stewert-Williams, & Podd, 2005). Bartlett and colleagues have explained the higher rate of false alarms in older adults as greater reliance on familiarity, rather than recollection of specific contextual information, when making recognition decisions. This propensity to falsely recognize unfamiliar faces may have important implications for eyewitness testimony (Memon, Bartlett, Rose, & Gray, 2003), as well as the everyday lives of older adults.

Rationale for Current Study

False facial recognition has been discussed in the literature as resulting from a breakdown of specific frontally-based functions, including monitoring and decision-making, which are thought to be crucial in evaluating the veracity of retrieved memories (Rapcsak et al., 2002; Rapcsak, Nielsen, Littrell, Glisky, Kaszniak, & Laguna, 2001; Moscovitch & Melo, 1997; Schacter, Curran, Galluccio, Milberg, & Bates, 1996; Davidson, Troyer, & Moscovitch, 2006). However, no known study has specifically examined the monitoring and decision-making processes in older adults who demonstrate false facial recognition. Therefore, the current study was designed to further investigate these frontal functions, as this may be an important step in understanding the mechanisms underlying recognition of human faces and how a breakdown in these processes may contribute to the phenomenon of false facial recognition.

The ability to monitor memory output for accuracy is conceptualized as an aspect of metamemory, defined as knowledge about one's out memory capabilities (Shimamura, 1994). Monitoring involves the ability to reflect on the potential success of one's retrieval efforts (Schnyer, Verfaeillie, Alexander, LaFleche, Nicholls, & Kaszniak, 2004). The current study implemented a prospective feeling-of-knowing (FOK) paradigm, in which participants were asked to make predictions about their ability to remember previously encountered information. Previous research has found that patients with lesions to the frontal lobe show impairments in the accuracy of their FOK judgments (Janowsky, Shimamura, & Squire, 1989; Schnyer et al., 2004; Pinon, Allain, Kefi, Dubas, & Gall, 2005). Specific neuroanatomical areas that have been implicated in FOK judgments are the ventromedial frontal lobe area (Pannu, Kaszniak, & Rapcsak, 2005) and, more specifically, the right medial prefrontal cortex (Schnyer et al, 2004).

There is also strong empirical evidence supporting an association between metamemory impairment and frontal lobe dysfunction in older adults. Several studies have shown that older adults are less accurate in their FOK judgments compared to younger adults, and their accuracy is related to performance on measures sensitive to frontal lobe functioning (Souchay et al., 2000; Rhodes & Kelley, 2005; Perrotin, Isingrini, Souchay, Clarys, & Taconnat, 2006). In the absence of effective monitoring abilities, individuals may fail to adequately evaluate the familiarity signal generated by facial cues, causing them to falsely recognize faces (Rapcsak et al., 1999).

In addition to monitoring abilities, accurate responding on yes/no recognition tasks may depend on intact decision-making processes, as individuals must set appropriate decision criterion in order to correctly recognize faces (Rapcsak et al., 1999). The current study uses the Iowa Gambling Task (IGT), a task designed to simulate real-life decision-making (Bechara, Damasio, Damasio, & Anderson, 1994). There is a well documented association between decision-making in the IGT and the integrity of the ventromedial prefrontal structures. Patients with lesions in this area perform disadvantageously when compared to patients with damage to other areas of the frontal lobe, such as the dorsolateral prefrontal cortex (Bechara, Damasio, Tranel, Anderson, 1998), as well as when compared to brain damaged controls (with lesions outside of the frontal lobe) and healthy controls (Bechara, 2004). Neuroimaging data also supports the role of the ventromedial prefrontal cortices in IGT performance (Northoff et al., 2006).

Denburg et al. (2005) examined the effect of aging on decision-making performance using the IGT. Results showed a clear effect of age, as healthy older adults performed significantly worse than younger adults on the task. However, further investigation revealed two distinct groups of older adults; those who were “unimpaired” on the IGT, performing equally to younger adults, and those who were “impaired” on the task, demonstrating performance reminiscent of patients with lesions to the ventromedial prefrontal cortex (Denburg, 2005; Denburg, Recknor, & Bechara, 2006). These distinct decision-making profiles offer support for the notion that age-associated frontal dysfunction occurs in some, but not all, older adults (Glisky et al., 1995; Butler et al., 2004).

The current study aims to further investigate the relationship between frontal functioning, specifically monitoring and decision-making functions, and facial recognition in older adults. We hypothesized that:

1) Participants would have fewer false alarms on the Famous Faces Task than on the Non-famous Faces Task, and performance on the Famous Faces Task would not be

related to composite scores of frontal functioning. In a task with such highly distinctive stimuli, we predicted that participants would not need to rely on frontally-based processes when making yes/no recognition decisions.

2) Performance on the Non-famous Faces Task would be related to composite scores of frontal functioning, with the low frontal group demonstrating a higher rate of false alarms than the high frontal group. The high degree of similarity between the studied and distracter stimuli in this task creates ambiguity and uncertainty. In such situations, we predicted that frontally-based processes would play a critical role when making yes/no recognition decisions.

3) Participants in the high frontal group would be more accurate in their memory predictions on the FOK Task than those in the low frontal group.

4) Participants in the high frontal group would perform more advantageously on the IGT than those in the low frontal group.

5) Performance on the FOK Task and the IGT would be positively correlated, as both may involve similar monitoring and decision-making processes and both have been shown to rely on similar neural substrates, specifically, ventromedial prefrontal structures (Pannu et al., 2005; Bechara et al., 1994). The FOK Task and the IGT, therefore, are used here as convergent methods of investigating the role of inferred ventromedial prefrontal processes in false facial recognition.

6) Participants with higher false alarm rates on the Non-famous Faces Task would be less accurate in their memory predictions on the FOK Task than those with a lower false alarm rate, reflecting poorer monitoring/decision-making processes.

7) Participants with higher false alarm rates on the Non-famous Faces Task would be more likely to perform disadvantageously on the IGT than those with a lower false alarm rate, also reflecting poorer monitoring/decision-making processes.

METHODS

Participants

Participants for the study were 41 healthy older adults (mean age = 75.4, range = 65-87, SD = 5.9 years) who were drawn from a database of individuals currently participating in a longitudinal study being conducted in the Amnesia and Cognition Unit lab at the University of Arizona. All participants had received previous neuropsychological testing, including a battery of tasks sensitive to frontal lobe functioning which have been shown to load together in factor analyses (Glisky et al., 1995). Frontal lobe measures included the number of categories achieved on the modified Wisconsin Card Sorting Task (Hart, Kwentus, Wade, & Taylor, 1988), the Mental Arithmetic subtest from the Wechsler Adult Intelligence Scale—Revised (Wechsler, 1981), the Mental Control and Backward Digit Span subtests from the Wechsler Memory Scale—III (Wechsler, 1997), and the total number of words generated on the Controlled Oral Word Association Test (Benton & Hamsher, 1976). Individuals were classified as "high frontal" or "low frontal" based on their performance on these measures relative to the group mean of a large sample of healthy older adults (Glisky et al., 1995). Participants for the current study were selected based on their frontal factor z-score; 20 were high frontal and 21 low frontal. There were no differences between the groups in terms of age, education, or gender (see Table 1). Inclusion criteria required that participants had no neurological or psychological conditions, no history of head injury, or and no substance abuse problems. All participants had normal eyesight based on a brief vision screening (American Optical Corporation, 1942) and performance within the normal range on the Benton Facial Recognition Test (Benton, Sivan, Hamsher, Varney, & Spreen, 1983), indicating that basic face perception abilities were intact.

Table 1. Demographic Information for High and Low Frontal Participants. Comparisons

	High Frontal (n=20)		Low Frontal (n=21)		
	M	SD	*M*	SD	*p*
Age	75.2	5.2	75.5	6.6	*ns*
Education	16.3	2.2	15.2	2.0	*ns*
Gender	10 males/10 female		6 male/15 female		*ns*
Handedness	17 right/3 left		20 right/1 left		*ns*
Frontal Factor z-score	.72	.38	-.67	.46	$p < .001$
Benton Facial Recognition Test	48.9	3.4	47.6	4.3	*ns*

Note: Comparisons were computed using independent-samples t-tests or chi-square test, where appropriate; *ns* = nonsignificant.

Tasks

Famous Faces Task

In the Famous Faces Task (FFT), participants studied 32 famous faces, half male and half female. Faces were randomly presented at the rate of 5 seconds per face in the middle of a 21 inch widescreen computer monitor that was placed approximately 24 inches away from participants. Famous faces spanned the decades from the 1920s to the present and included actors, actresses, entertainers, politicians, sports stars, and musicians. Following the study phase, participants were given a yes/no recognition memory test in which they were shown the same 32 famous faces along with 32 distracter famous faces, and they were asked to indicate whether they had seen each face in the previous set. Responses were made by a keyboard button press. The studied faces and the distracter faces were counterbalanced across participants. In order to ensure that the famous faces were indeed well-known by the older adults, participants were asked to provide the name of each individual upon completion of the task. The primary dependent variable in the FFT was the number of false alarms to distracter faces on the recognition memory task.

Non-famous Faces Task

In the Non-famous Faces Task (NFT), participants studied 32 non-famous faces, half male and half female. Faces were randomly presented at the rate of 5 seconds per face in the middle of a 21 inch widescreen computer monitor that was placed approximately 24 inches away from participants. Non-famous faces were taken from a high school yearbook. Following the study phase, participants were given a yes/no recognition memory test in which they were shown the same 32 non-famous faces along with 32 distracter faces from the same yearbook, and they were asked to indicate whether they had seen each face in the previous set. Responses were made by a keyboard button press. The studied faces and the distracter faces were counterbalanced across participants. The primary dependent variable in the NFT was the number of false alarms to distracter faces on the recognition memory task.

Feeling of Knowing Task

During the Feeling-of-Knowing (FOK) Task, participants were presented with a series of 20 unfamiliar faces, half male and half female. Each face was paired with a unique first name. The stimuli were randomly presented at the rate of 6 seconds per face in the middle of a 21 inch widescreen computer monitor that was placed approximately 24 inches away from participants. Participants were instructed to remember both the faces and the name that was paired with them. Following the study phase, participants were presented with the same 20 faces and were asked to recall the name that had been paired with each face. If they were unable to recall a name for a face, or if they gave an incorrect response, they were then asked to make a FOK judgment. Specifically, they were asked to rate how likely they would be to select the correct name if given a list of eight choices. They were told that the list of choices would include some names that they had seen paired with other faces and some new names. Ratings were made using a six point scale (0%, 20%, 40%, 60%, 80%, 100%). In the final phase of the task, participants were given the recognition task, in which they saw the correct name and seven distracter names, and were asked to select the name that was originally paired with each face. The primary dependent variable in the FOK Task was the accuracy of participants' FOK ratings.

Iowa Gambling Task

The Iowa Gambling Task (IGT) is a computerized task of decision-making (Bechara et al., 1994; Bechara, Tranel, & Damasio, 2000). The task involves presenting participants with four decks of cards, decks A', B', C' and D'. Each time a participant selects a card, a specified amount of play money is awarded. However, interspersed amongst these rewards are monetary punishments of varying amount. Two of the decks of cards, decks A' and B', produce high immediate gains but larger punishments, resulting in an overall net loss. Therefore, A' and B' are considered to be the "disadvantageous" decks. The other two decks, decks C' and D', are considered "advantageous" because they produce small immediate gains but also yield smaller punishments, resulting in an overall net gain. Participants were instructed that the goal of the game was to make as much money as possible and to avoid losing as much money as possible. They were told that they may choose cards from any deck that they wished and could switch decks at any time. Participants were also informed that some of the decks were better than others, and to win they should try to stay away from bad decks. The task consists of 100 card choices. The primary dependent variable for the IGT was the participants' overall net scores, which were calculated by subtracting the number of disadvantageous choices (decks A' and B') from the number of advantageous choices (decks C' and D').

Procedure

Participants were tested individually in the Department of Psychology at the University of Arizona. The testing session lasted 1 to 1½ hours and took place in a small, quiet testing room. Experimental tasks were given in the following order: 1) the FOK Task, 2) the IGT, and 3) the FFT and the NFT, counterbalanced across subjects. Sessions were held at approximately the same time for all subjects (i.e., morning) in order to minimize the effect of time of day on performance. Informed consent was obtained from all participants prior to testing and they were reimbursed at an hourly rate for their time.

RESULTS

Famous Faces Task & Non-famous Faces Task

Hit and false alarm rates for the FFT and the NFT are shown in Figure 1. Non-parametric methods were used to analyze hit and false alarm rates, as the data were not normally distributed. Mann-Whitney tests revealed no significant differences between the high frontal and low frontal groups in either hit rates or false alarm rates on the FFT [hits: $U = 170.50$, $p > .05$; false alarms: $U = 180.50$, $p > .05$] and the NFT [hits: $U = 207.00$, $p > .05$; false alarms: $U = 194.50$, $p > .05$]. As expected, false alarm rates were low and performance was near ceiling on the FFT, which could be attributed to the distinctiveness of the stimuli used in the FFT, as participants were able to name or give detailed biographical information about the majority of the 32 famous individuals they were asked to remember (mean = 26.77, SD = 4.00). A comparison of the two tasks using a Wilcoxon signed ranks test revealed a significantly lower hit rate [$T = 20.00$, $p < .001$] and higher false alarm rate [$T = 7.50$, $p < .001$] on the NFT than on the FFT. Therefore, all further analyses investigating false alarm rates were conducted using data from the NFT only.

In order to obtain more precise measures of performance on the NFT, we computed the discrimination and bias indexes derived from the two-high-threshold model of recognition memory (Snodgrass & Corwin, 1988). The discrimination index (Pr) is a measure of recognition accuracy and is computed from the formula H-FA (H=hit rate; FA=false alarm rate). The bias index (Br) is computed from the formula FA/1-Pr and indicates the probability of the participant to say “yes” when in a state of uncertainty. Br and Pr indexes are presented in Figure 2. No significant differences were found between the high and low frontal groups on either the Pr [$t(39) = -1.38$, $p > .05$] or the Br indexes [$t(33) = .01$, $p > .05$].

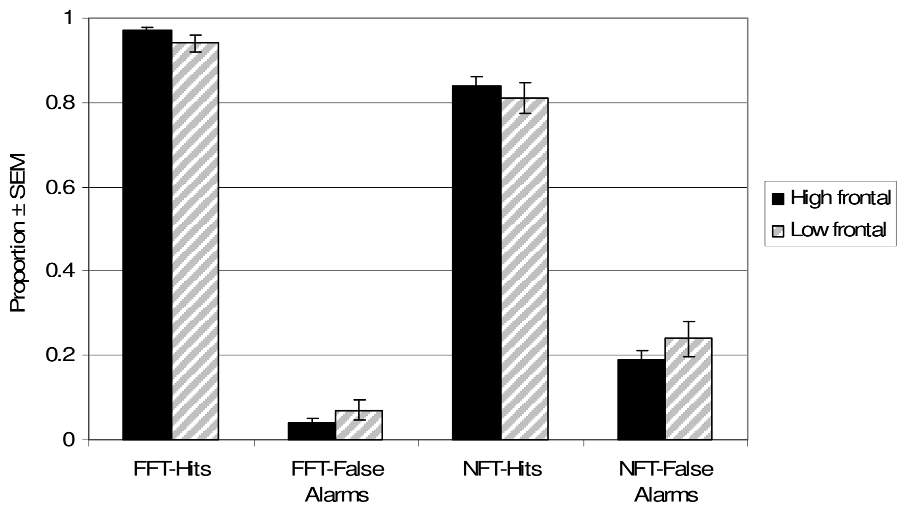

Figure 1. Famous Faces Task & Non-famous Faces Task: Hit and False Alarm Rates

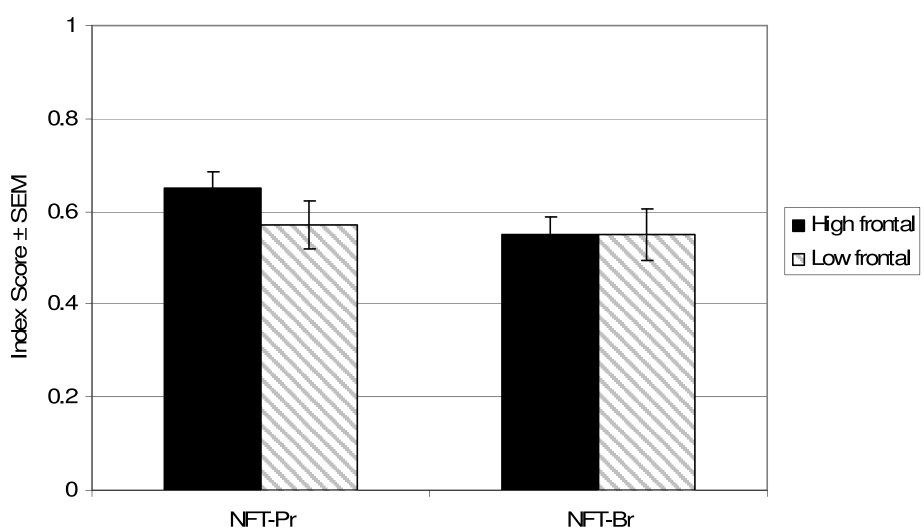

Figure 2. Non-famous Faces Task: Discrimination (Pr) & Bias (Br)

Feeling of Knowing Task

The proportion of faces correctly named in the recall phase and the recognition phase of the FOK Task is shown in Figure 3. There were no differences between the high and low frontal groups on memory performance [recall: $t(39) = -1.32$, $p > .05$; recognition: $t(39) = -1.46$, $p > .05$]. A Wilcoxon signed ranks test revealed that participants performed significantly better in the name recognition phase of the task as compared to the name recall phase [$T = 25$, $p < .001$]. Seventy-five percent of the errors in recognition occurred when participants selected a name that had been presented with another face, while twenty-five percent of the errors were due to participants selecting a name that had not been presented in the study phase.

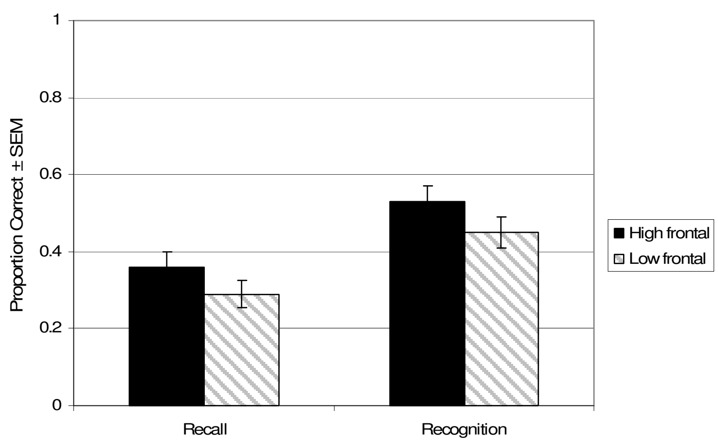

Figure 3. Feeling of Knowing Task: Memory Performance

Memory monitoring has been reported in the literature using a number of different statistical methods, with the gamma correlation and the Hamann index being two of the most commonly used calculations (Pannu & Kaszniak, 2005). However, several studies comparing these measures have concluded that the Hamann index is either superior (Schraw, 1995) or equal (Schnyer et al., 2004; Souchay et al., 2000) to the gamma correlation as a measure of memory monitoring accuracy. Schraw (1995) reports a more sophisticated method of measuring accuracy that should be used in place of the Hamann coefficient whenever memory prediction ratings are made along a continuous scale, such as the six point scale used in the current study. This method measures *bias* and *accuracy* by taking into account the distance between the predicated and the observed memory performance (Schraw, 1995). Bias is computed by subtracting the observed performance from the predicted performance and ranges from -1 to 1; accuracy is computed by squaring the bias value and ranges from 0 to 1. The accuracy measure reflects the magnitude of judgment error, with larger scores indicating greater error in predicting memory performance.

Participants in the sample had a mean accuracy score of .004 (SD = .20), indicating high accuracy. While accuracy measures the magnitude of judgment errors, bias is a more sensitive measure of memory monitoring because it reveals the direction of the errors, with scores greater than zero reflecting overconfident predictions and scores less than zero reflecting underconfident predictions (Schraw, 1995). The mean bias score for the sample was .16 (SD = .12), signifying a tendency towards overconfidence in memory predictions.

Results indicated that overconfidence on the FOK Task was related to more false alarms on the NFT, as there was a significant correlation between FOK bias scores and false alarm rates on the NFT, $r_s = .39$, $p = .01$. There was also significant correlation between FOK bias scores and the bias scores on the NFT (Br), $r = .45$, $p < .01$, showing that overconfidence on the FOK Task was related to an increase tendency to say "yes" when uncertain on the NFT. These results are presented in Figures 4 & 5. These relationships did not differ between the high and low frontal groups. Performance on the FOK Task was not related to hit rates on the NFT, $r_s = .12$, $p > .05$.

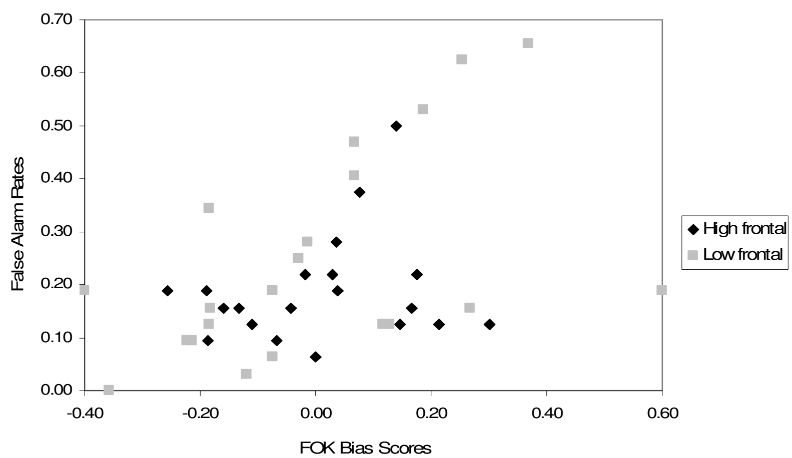

Figure 4. Relationship Between Feeling of Knowing Bias Scores & False Alarm Rates

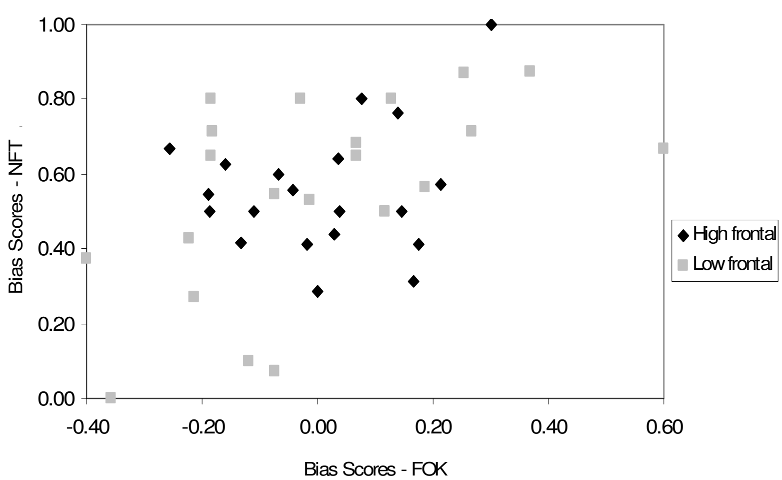

Figure 5. Relationship Between Bias on the Feeling of Knowing Task & Bias on the Non-famous Faces Task

Iowa Gambling Task

Net scores for the IGT were calculated by subtracting the number of disadvantageous choices (decks A' and B') from the number of advantageous choices (decks C' and D'). Therefore, scores below zero indicated disadvantageous performance and scores above zero indicated advantageous performance. Overall net scores are presented in Figure 6; net scores across the five blocks of the task (20 card selections in each block) are presented in Figure 7. Displayed is the average for all 40 participants (the data for one participant was not saved due to a computer error), as well the averages for the high and low frontal groups, whose performance was not significantly different [$t(38) = -.76$, $p > .05$]. The distribution of IGT net scores was not normally distributed, as displayed in Figure 8, but fit more of a bimodal distribution with a subgroup of "good" gamblers, participants who chose more from the advantageous decks (n=23), and a subgroup of "bad" gamblers, those who chose more from the disadvantageous decks (n=17).

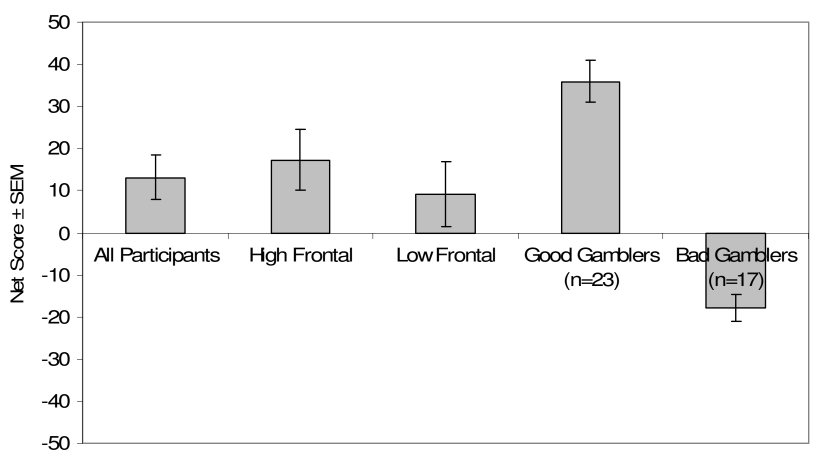

Figure 6. Iowa Gambling Task Performance: Overall Net Scores

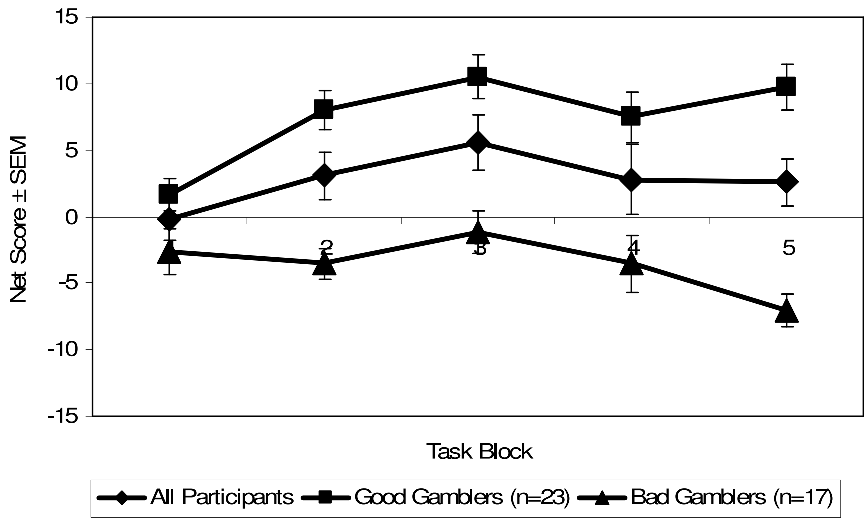

Figure 7. Iowa Gambling Task Performance: Net Scores by Task Block

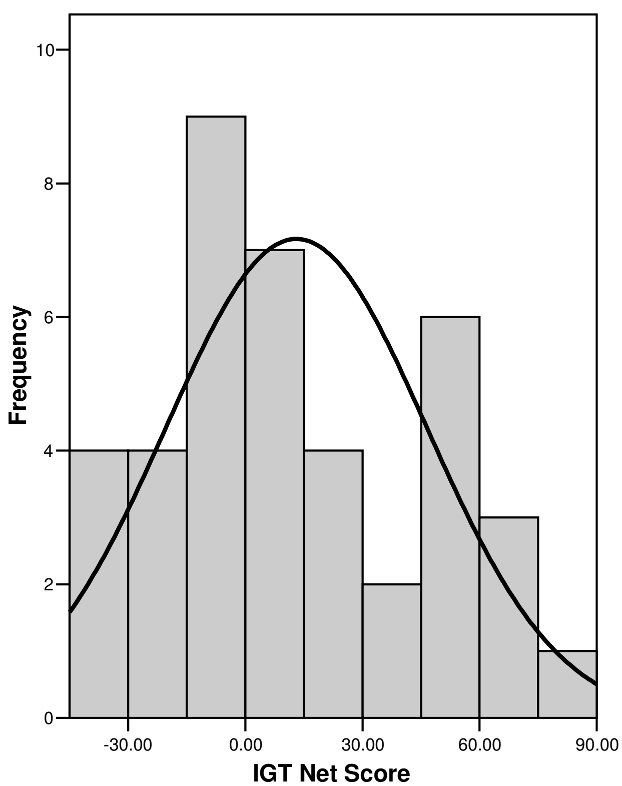

Figure 8. Distribution of Iowa Gambling Task Net Scores

Mann-Whitney and *t*-tests revealed no significant relationships between IGT performance and false alarm rates [$U = 313.50$, $p > .05$] or bias (Br) scores [$t(38) = -1.42$, $p > .05$] on the NFT. However, there was a trend toward a relationship between performance on the IGT and accuracy on the FOK Task, shown in Figure 9. Although this finding did not reach significance, there was a tendency for good gamblers to be more accurate in their memory predictions than bad gamblers [$t(38) = -1.86$, $p = .07$]. No relationship was found between IGT performance and bias scores on the FOK Task [$t(38) = -1.48$, $p > .05$], indicating that although disadvantageous IGT performance was related to poorer FOK accuracy, it was not associated with overconfidence or underconfidence per se.

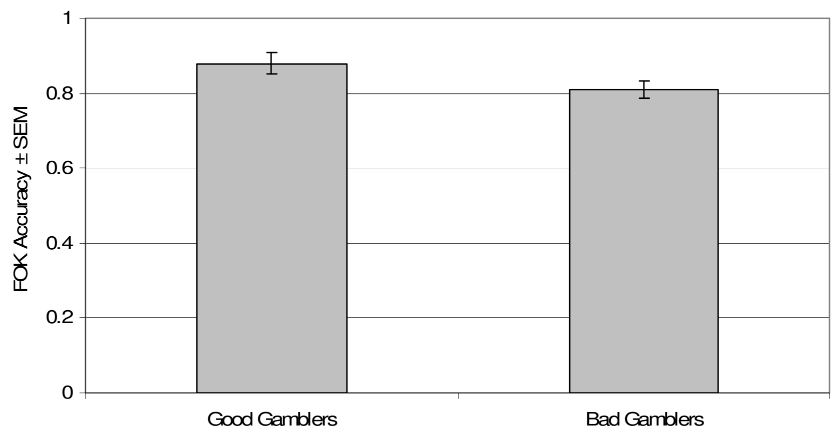

Figure 9. Feeling of Knowing Accuracy for Good and Bad Gamblers

DISCUSSION

The results of this study show that older adults demonstrate a higher false alarm rate during the NFT, a task involving unfamiliar faces, than during the FFT, which used familiar, highly distinctive faces whom the participants were able to identify. Performance on both the FFT and the NFT tasks were found to be unrelated to composite scores of frontal functioning. There was also no relationship found between frontal functioning and the FOK Task or the IGT. Participants with higher false alarm rates on the NFT had significantly higher bias scores on the FOK Task, indicating overconfidence in their memory predictions, compared to those with lower false alarm rates. No direct relationship was found between false alarms on the NFT and performance on the IGT, as good and bad gamblers had an equal rate of false alarms. However, there was a tendency for participants who performed more advantageously on the IGT to be more accurate in their memory predictions on the FOK Task.

These findings lend initial support to the hypotheses that accurate recognition of faces is related to intact memory monitoring and decision-making processes. The significant relationship between false alarms and bias scores on the NFT and bias scores on the FOK Task reveals that high false-alarmers had a more liberal response bias and tended to be overconfident in their memory predictions relative to low false-alarmers. These findings could be explained as individuals relying on a general sense of familiarly rather than a specific memory trace when making recognition decisions or when predicting one's own memory. In the NFT, relying on a general sense of familiarity would lead one astray, as the distracter faces were highly similar to the target faces and, therefore, would likely appear familiar on a general level. In such cases, frontal processes may play a critical role in accurately discriminating target from distracter faces. Specifically, if one's is able to accurately monitor their memory, he/she will evaluate this general sense of familiarity in order to determine whether it is because the specific face was indeed seen before or is familiar only because it matches the general features of a previously presented faces (e.g., young, smiling female). In addition to this monitoring process, intact decision-making is crucial for accurate face recognition for similar reasons. If one's decision-making criteria are too lenient, as was the case with the false-alarmers in the current study, there would be a tendency to say "yes" during recognition tests when a face appears familiar, although this may simply be because it resembles one of the target faces but is not an exact match. These participants would have made fewer false-alarm errors if they had adopted more conservative criteria for the decision to say "yes" to a face, such as the ability to recall specific details from when the face was originally presented.

In the FOK Task, monitoring and decision-making processes may have failed these participants in a similar way, leading to overconfidence in their memory predictions. When participants made their prediction ratings, their decisions may have been driven by a feeling that although they could not recall the name at the moment, it would look familiar if they saw the name in a list. Of course, when it was time to select the correct name from a list of choices, several of the names looked familiar because there were presented along with others faces. Participants would have been more accurate in their ratings if they were able to monitor not only their ability to recognize a name from the list of eight names, but also their ability to match the name to the correct face, and had make their prediction decisions accordingly.

While results of this study supported the hypothesis that higher false alarm rates would be correlated with decreased accuracy on the FOK Task, the hypothesis that false alarms would also be related to IGT performance was not supported by the data. It is not clear whether this finding represents a lack of statistical power or the absence of a true relationship. However, a trend-level relationship was found between the FOK Task and the IGT, suggesting that these tasks may be tapping similar monitoring/decision-making functions. Although this finding did not reach the preset alpha level, this likely reflects insufficient statistical power rather than a lack of relationship between the variables. Therefore, given the relationship of the NFT to the FOK Task and the FOK Task to the IGT, there may indeed by an association between the NFT and the IGT, although it was not detected in the current study. Future research is needed to clarify this issue.

The current study also failed to support the hypotheses that the high frontal participants would be more accurate in their memory predictions on the FOK Task and perform more advantageously on the IGT than those in the low frontal group. The finding that standard neuropsychological tests of frontal function did not predict performance on these tasks may be due to their presumed dependence upon dorsolateral prefrontal functioning, while there is evidence that the FOK Task and the IGT are likely mediated by ventromedial prefrontal cortices (Pannu et al., 2005; Bechara et al., 1994). The Wisconsin Card Sorting Task, in particular, is thought to reflect the functioning of the dorsolateral prefrontal cortex, as patients with damage to this area demonstrate impaired performance (Demakis, 2003) and it is the region found to be activated in healthy controls when they engage in the task (Berman et al., 1995). The other tasks that make up the composite scores are also likely to be dependent on dorsolateral prefrontal functions, which include working memory, set shifting, and suppressing habitual behavior (Miller & Cummings, 2007). Therefore, the findings of the current study are consistent with a dissociation between the processes associated with ventromedial function and those related to dorsolateral functioning, given previous research examining regions the prefrontal cortex (Bechara et al., 1998; Cavallaro et al., 2003; Miller & Cummings, 2007).

The use of neuropsychological tests to characterize frontal functioning is an inherent limitation of this study, as such tests may not adequately differentiate domains of frontal function. In addition, the traditional domains of frontal functioning assessed by standard instruments may not directly map on to neural activity within different regions of the prefrontal cortex (Stuss, 2007). Given the complexity of the frontal lobes, it is also likely that some measures, such as the FOK Task and the IGT, rely on several frontally-based processes, making it difficult to isolate particular constructs of interest (Kramer & Quitania, 2007). Continuing research is needed to increase the specificity and validity of our neuropsychological assessment instruments in order to more closely examine the role of specific subregions of the prefrontal cortex.

Another limitation of this study is that the participants were healthy older adults who are presumably not experiencing problems related to false facial recognition in their everyday lives. However, we intend to run future studies using patients who have sustained damage to the frontal lobe, who are more likely to be experiencing this type of memory distortion. The findings of the current study suggest that a liberal response bias and an overestimation of one's memory abilities may make older adults susceptible to false facial recognition, and it will be elucidating to investigate whether similar processes contribute to false recognition in patient populations.

REFERENCES

American Optical Corporation (1942). *Vision screening, No. 11968.* USA: American Optical Corporation.

Bartlett, J. C., & Fulton, A. (1991). Familiarity and recognition of faces in old age. *Memory & Cognition, 19,* 229-238.

Bartlett, J. C., Leslie, J. E., Tubbs, A., Fulton, A. (1989). Aging and memory for pictures of faces. *Psychology and Aging, 4,* 276-283.

Bechara, A., (2004). The role of emotion in decision-making: Evidence for neurological patients with orbitofrontal damage. *Brain and Cognition, 55,* 30-40.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50,* 7-15.

Bechara, A., Damasio, H., Tranel, D., & Anderson, S. W. (1998). Dissociation of working memory from decision making within the human prefrontal cortex. *Journal of Neuroscience, 18,* 428-437.

Bechara, A., Tranel, D., & Damasio, H. (2000). Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain, 123,* 2189-2202.

Benton, A., & Hamsher, K. (1976). *Multilingual Aphasia Examination Manual*. Iowa City: University of Iowa.

Benton, A. L., Sivan A. B., Hamsher K., Varney N. R., Spreen O. (1983). *Contribution to neuropsychological assessment.* New York: Oxford University Press.

Berman, K. F., Ostrem, J. C., Randolph, C., Gold, J., Goldberg, T. E., Coppola, R. et al. (1995). Physiological activation of a cortical network during performance of the Wisconsin Card Sorting Test: A positron emission tomography study. *Neuropsychologia, 33,* 1027-1046.

Butler, K. M., McDaniel, M. A., Dornburg, C. C., Price, A. L., & Roediger, H. L. (2004). Age differences in veridical and false recall are not inevitable: The role of frontal lobe function. *Psychonomic Bulletin & Review, 11,* 921-925.

Butters, M. A., Kaszniak, A. W., Glisky, E. L., Eslinger, P. J., & Schacter, D. L. (1994). Recency discrimination deficits in frontal lobe patients. *Neuropsychology, 8,* 343-353.

Cavallaro, R., Cavedini, P., Mistretta, P., Bassi, T., Angelone, S. M., Ubbiali, A. et al. (2003). Basal-corticofrontal circuits in schizophrenia and obsessive-compulsive disorder: A controlled, double dissociation study. *Biological Psychiatry, 54,* 437-443.

Cummings, J. L., & Miller, B. L. (2007). Conceptual and clinical aspects of the frontal lobes. In B. L. Miller and J. L. Cummings (Eds.), *The Human Frontal Lobes: Functions and Disorders, Second Ed.* (pp. 12-21). New York: Guilford Press.

Davidson, P. S. R., Troyer, A. K., & Moscovitch, M. (2006). Frontal lobe contributions to recognition and recall: Linking research with clinical evaluation and remediation. *Journal of the International Neuropsychological Society, 12,* 210-223.

Demakis, G. J. (2003). A meta-analytic review of the sensitivity of the Wisconsin Card Sorting Test to frontal and lateralized frontal brain damage. *Neuropsychology, 17,* 255-264.

Denburg, N. L., Recknor, E. C., Bechara, A. (2006). Psychophysiological anticipation of positive outcomes promotes advantageous decision-making in normal older persons. *International Journal of Psychophysiology, 61,* 19-25.

Denburg, N. L., Tranel, D., & Bechara, A. (2005). The ability to decide advantageously declines prematurely in some normal older persons. *Neuropsychologia, 43,* 1099-1106.

Glisky, E., Polster, M., & Routhieaux, B. (1995). Double dissociation between item and source memory. *Neuropsychology, 9,* 229-235.

Glisky, E. L., Rubin, S. R., & Davidson, P. S. R. (2001). Source memory in older adults: An encoding or retrieval problem? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27,* 1131-1146.

Hart, R., Kwentus, J., Wade, J., & Taylor, J. (1988). Modified Wisconsin Card Sorting Test in elderly normal, depressed, and demented patients. *Clinical Neuropsychologist, 2,* 49-56.

Jacoby, L. L., & Rhodes, M. G. (2006). False remembering in the aged. *Current directions in psychological science, 15,* 49-53.

Janowsky, J. S., Shimamura, A. P., & Squire, L. R. (1989). Memory and metamemory: Comparisons between patients with frontal lobe lesions and amnestic patients. *Psychobiology, 17,* 3-11.

Kramer, J. H., & Quitania, L. (2007). Bedside frontal lobe testing. In B. L. Miller and J.

L. Cummings (Eds.), *The Human Frontal Lobes: Functions and Disorders, Second Ed.* (pp. 279-291). New York: Guilford Press.

Lamont, A. C., Stewert-Williams, S., & Podd, J. (2005). Face recognition and aging: Effects of target age and memory load. *Memory & Cognition, 33,* 1017-1024.

LaVoie, D. J., Willoughby, L., & Faulkner, K. (2006). Frontal lobe dysfunction and false memory susceptibility in older adults. *Experimental Aging Research, 32,* 1-21.

Memon, A., Bartlett, J., Rose, R., & Gray, C. (2003). The aging eyewitness: Effects of age on face, delay, and source-memory ability. *Journal of Gerontology: Psychological Sciences, 58B,* P338-P345.

Moscovitch, M, & Melo, B. (1997). Strategic retrieval and the frontal lobes: Evidence from confabulation and amnesia. *Neuropsychologia, 35,* 1017-1034.

Norman, K. A., & Schacter, D. L. (1997). False recognition in younger and older adults: Exploring the characteristics of illusory memories. *Memory & Cognition, 25,* 838-848.

Northoff, G., Grimm, S., Boeker, H., Schmidt, C., Bermpohl, F., Heinzel, A., et al. (2006). Affective judgment and beneficial decision making: Ventromedial prefrontal activity correlates with performance in the Iowa Gambling Task. *Human Brain Mapping, 27,* 572-587.

Pannu, J. K., & Kaszniak, A. W. (2005). Metamemory experiments in neurological populations: A review. *Neuropsychological Review, 15,* 105-130.

Pannu, J. K., Kaszniak, A. W., & Rapcsak, S. Z. (2005). Metamemory for faces following frontal lobe damage. *Journal of the International Neuropsychological Society, 11,* 668-676.

Parkin, A. J., Bindschadeler, C., Harsent, L., & Metzler, C. (1996). Pathological false alarm rates following damage to the left frontal cortex. *Brain and Cognition, 32,* 14-27.

Pinon, K., Allain, P., Kefi, M. Z., Dubas, F., & Gall, D. L. (2005). Monitoring processes and etamemory experiences in patients with executive syndrome. *Brain and Cognition, 57,* 185-188.

Perrotin, A., Isingrini, M., Souchay, C., Clarys, D., & Taconnat, L. (2006). Episodic feeling-of knowing accuracy and cued recall in the elderly: Evidence for double dissociation involving executive functioning and processing speed. *Acta Psychologica, 122,* 58-73.

Rapcsak, S. Z, Kaszniak, A. W., Reminger, S. L., Glisky, M. L., Glisky, E. L., & Comer, J. F. (1998). Dissociation between verbal and autonomic measures of memory following frontal lobe damage. *Neurology, 50,* 1259-1265.

Rapcsak, S.Z., Nielsen, L., Glisky, E.L., & Kaszniak, A. (2002). The neuropsychology of false facial recognition. In L.R. Squire & D.L. Schacter (Eds.), *Neuropsychology of Memory* (pp. 130-142). New York: Guilford.

Rapcsak, S.Z., Nielsen, L., Littrell, L.D., Glisky, E.L., Kaszniak, A.W., & Laguna, J.F. (2001). Face memory impairments in patients with frontal lobe damage. *Neurology, 57,* 1168-1175.

Rapcsak, S. Z., Polster, M. R., Comer, J. F., & Rubens, A. B. (1994). False recognition and misidentification of faces following right hemisphere damage. *Cortex, 30,* 565-583.

Rapcsak, S. Z., Reminger S. L., Glisky, E. L., Kasnziak, A. W., & Comer, J. F. (1999). Neuropsychological mechanisms of false facial recognition following frontal lobe damage. *Cognitive Neuropsychology, 16,* 267-292.

Rhodes, M. G., & Kelley, C. M. (2005). Executive processes, memory accuracy, and memory monitoring: An aging and individual difference analysis. *Journal of Memory and Language, 52,* 578-594.

Roediger, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 803-814.

Rubin, S. R., Van Petten, C., Glisky, E. L., & Newberg, W. M. (1999). Memory conjunction errors in younger and older adults: Event-related potential and neuropsychological data. *Cognitive Neuropsychology, 16,* 459-488.

Schacter, D. L., Curran, T., Galluccio, L., Milberg, W. P., & Bates, J. F. (1996). False recognition and the right frontal lobe: A case study. *Neuropsychologia, 34,* 793-808.

Schnyer, D. M., Verfaellie, M., Alexander, M. P., LaFleche, G., Nicholls, L., & Kaszniak, A. W. (2004). A role for right medial prefrontal cortex in accurate feeling-of-knowing judgments: Evidence from patients with lesions to frontal cortex. *Neuropsychologia, 42,* 957-966.

Schraw, G. (1995). Measures of feeling-of-knowing accuracy: A new look at an old problem. *Applied Cognitive Psychology, 9,* 321-332.

Shimamura, A. P. (1994). The neuropsychology of Metacognition. In J. Metcalfe & A. P. Simamura (Eds.), *Metacognition: Knowing about knowing* (pp. 253-276). Cambridge, MA: The MIT Press.

Snodgrass, J. G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General, 117,* 34-50.

Souchay, C., Isingrini, M., & Espagnet, L. (2000). Aging, episodic memory feeling-of knowing, and frontal functioning. *Neuropsychology, 14,* 299-309.

Stuss, D. T. (2007). New approaches to prefrontal lobe testing. In B. L. Miller and J. L. Cummings (Eds.), *The Human Frontal Lobes: Functions and Disorders, Second Ed.* (pp. 292-305). New York: Guilford Press.

US War Department (1944). *Army Individual Test Battery.* Washington, DC: War Department, Adjutant General's Office.

Vuilleumier, P., Mohr, C., Valenza, N., Wetzel, C., & Landis, T. (2003). Hyperfamiliarity for unknown faces after left lateral temporo-occipital venous infarction: A double dissociation with prosopagnosia. *Brain, 126,* 889-907.

Ward, J., Parkin, A. J., Powell, G., Squires, E. J., Townshend, J., & Bradley, V. (1999). False recognition of unfamiliar people: "Seeing film stars everywhere." *Cognitive Neuropsychology, 16,* 293-315.

Wechsler, D. (1981). *Wechsler Adult Intelligence Scale – Revised manual.* New York: Psychological Corp.

Wechsler, D., (1997). *Wechsler Memory Scale – III.* San Antonio, TX: Psychological Corporation, Harcourt Brace.

West, R. L. (1996). An application of prefrontal cortex function theory to cognitive aging. *Psychological Bulletin, 120,* 272-292.