Electrophysiological and behavioural indices of simulated recognition memory impairment

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ELECTROPHYSIOLOGICAL AND BEHAVIOURAL INDICES OF SIMULATED RECOGNITION MEMORY IMPAIRMENT

A thesis submitted in fulfilment of the requirements for the award of the degree

DOCTOR OF PHILOSOPHY

from

UNIVERSITY OF WOLLONGONG

by

HILARIE P. TARDIF, B.Sc.,(Hons.)

DEPARTMENT OF PSYCHOLOGY
2003
DECLARATION

I, Hilarie P. Tardif, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Department of Psychology, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Hilarie P. Tardif
March 2003
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I would like to dedicate this thesis to my parents, John and Patricia Tardif. Together you created an environment which valued and nurtured effort and achievement, but at the same time promised unconditional love and support, regardless of how successful I was.

Thank you!
ABSTRACT

This thesis examined the use of event-related potentials as a means of detecting feigned recognition memory impairment. In seven studies, undergraduate students were instructed either to complete a recognition memory test to the best of their abilities, or to simulate accident-related memory loss. These studies extended previous research by investigating electrophysiological differences between the control and malingering tasks (1) for stimuli which differed in linguistic frequency, (2) in tests which varied the format of word presentation, (3) during the initial encoding of the stimuli, and (4) using ERP components not previously considered in studies investigating the detection of malingering. The main results were that simulating individuals appear to use more active or additional cognitive processing during task performance compared to those who respond honestly, with this enhanced effort reflected in an ERP effect indexing earlier recognition of previously-studied words. This earlier recognition, considered to be the result of more elaborative or efficient encoding of the stimuli, was most evident in the easier forms of the recognition test and in malingerers who presented a more believable profile of impairment. The malingerers also demonstrated different electrophysiological responses to items that were incorrectly classified, and a pattern of response latency suggesting that they concealed recognition of previously-studied items. Overall, the results indicate that the simulation of amnesia on a recognition memory task involves qualitatively different processing of the word stimuli, which may be detected in the waveforms and more covert patterns of behaviour of these individuals.
OVERVIEW

This thesis aimed to extend knowledge regarding the use of ERPs to detect feigned memory impairment. This was achieved through examination of the effect of malingering task instructions on components and ERP effects other than the P3, which has been the focus of most previous studies investigating ERPs and malingering. Studies 1 to 5 examined the behavioural and electrophysiological responses of control and simulating malingering participants on recognition memory tests that varied the linguistic frequency of the stimuli, and the format in which the words were presented during the retrieval phase. Studies 4 and 5 also included a comparison of ERP outcomes of processes occurring in the two groups during initial encoding of the stimuli. Study 6 delayed assignment of participants to the malingering and control groups until after the encoding phase to further explore the relationship between encoding and retrieval ERPs. A final study compared the behavioural and electrophysiological data of malingerers who presented a believable deficit with those whose performance appeared to be less plausible. Discriminant function analyses were used throughout to assess the reliability of ERP and behavioural effects in predicting group membership at the individual level.

The first three chapters of this thesis provide comprehensive literature reviews on malingering (Chapter 1), the more traditional approaches to its detection (Chapter 2), and the use of ERPs for detecting simulated impairment (Chapter 3).

Study 1 (Chapter 4) investigated the performance of a group of 24 participants on a computerised version of the Words subtest of the Warrington Recognition Memory test. Twelve subjects were instructed to feign an accident-related recognition memory deficit,
while the remainder served as controls. In this and all following studies, EEG data from nine scalp sites were analysed. The malingerers performed poorly on the test compared to the control group. However, the “old-new effect”, an ERP measure thought to reflect recognition memory processes, did not differ in size or topography between the two groups. In addition, a second, earlier-emerging difference between old and new words was evident, confined to the waveforms of the malingering participants. These results suggest firstly, that the malingerers did recognise the previously-studied words despite poor test performance, and secondly, that the task of malingering involves differential or additional processing of the stimuli.

Study 2 (Chapter 5) aimed to replicate and extend the findings of the first study, using a statistically more powerful within-subject design, a principal components analysis of the data to define the underlying components of the waveform, and an analysis of response latency data. The data from 19 participants completing the task in both a control and malingering condition were analysed. Behaviourally, individuals performed poorly on the recognition task when simulating impairment. They also demonstrated equivalent reaction times regardless of the accuracy of their response, whereas correct responses were made more rapidly in the control task. The control task waveforms were characterised by old/new word differences associated with a frontally-distributed N400 component, and a later right frontal old/new effect, consistent with shallower processing and less confident recognition of the words. In contrast, old/new differences were broadly distributed across the scalp and emerged earlier in the malingering task. These results replicated the main findings of the first study, suggesting that recognition occurred earlier in those simulating
impairment. In addition, the qualitatively different ERPs were consistent with additional or enhanced cognitive processing of the stimuli in the malingering task.

The recognition tests used in these first two studies presented words with a high linguistic frequency in a forced-choice format, whereby the participant decides which one of a pair of words was shown in the study phase. Numerous studies have demonstrated that cognitive processing differs according to word frequency, and the format in which the words are presented. The following three studies therefore aimed to assess the reliability of the findings of Studies 1 and 2 through the systematic manipulation of test format and word frequency.

Responses to words with a low frequency of occurrence presented in a forced-choice test of recognition memory were investigated in Study 3 (Chapter 6). Ten controls and nine simulating malingerers completed the task. ERP effects indicating earlier recognition of studied items in those simulating impairment were again observed. In addition, the response latency effect observed in the previous study was again evident in the malingering participants. These results demonstrate the reliability of those reported in Studies 1 and 2, using low-frequency word stimuli.

These results were also replicated in Study 4 (Chapter 7), which assessed the responses of 17 control and 23 simulators to high-frequency words, presented in a yes-no test format. In addition, qualitative differences in the ERPs recorded during both the study and test phases suggested that encoding strategy influenced processes occurring during retrieval, and that these processes differed in the two groups. Furthermore, the ERPs of the malingering group were consistent with more elaborative and efficient encoding of the stimuli. An analysis of the ERPs associated with incorrect responses revealed that these
elicited an increased negativity at about 600 ms in the control group only. This was interpreted as reflecting the purposeful provision of incorrect responses in individuals simulating impairment.

Study 5 (Chapter 8) completed the series of studies manipulating word frequency and test format, assessing recognition memory in 20 controls and 22 simulating malingers on a test using low-frequency words in a yes-no format. Group differences in the time taken to classify correct and incorrect responses were again evident in this study. However, the ERP effects identified previously and taken to reflect additional or enhanced cognitive processing in the malingering group were not observed. These results suggest that the additional processing or effort hypothesised in the malingers in the previous studies might be a function of the combined effect of word frequency and test format.

The findings of Studies 2 to 5 were integrated and discussed in Chapter 9. While the behavioural group differences in test scores and in response latency as a function of accuracy were evident in all studies, ERP effects signaling additional effort were most evident in the easier forms of the recognition task – those involving highly familiar words and/or a forced-choice format. These results suggest that easier tasks may enable additional processing or planning in malingering participants and may therefore be preferable in ERP studies aiming to distinguish feigned from honest performance.

Study 6 (Chapter 10) further investigated the relationship between encoding and retrieval phase ERPs. Twenty participants completed a recognition memory task that presented low-frequency words in a forced-choice format, and were assigned to either the control or simulating group after the initial presentation and encoding of the words. The study phase ERPs of the two groups did not differ, and the early malingering recognition
effect was absent. These results indicate that the early recognition of the words in those simulating impairment, identified in previous studies in this thesis, may be the result of differential processing during the initial encoding of the stimuli.

Study 7 (Chapter 11) identified malingerers from the previous studies in this thesis who responded at chance levels, and compared them to malingerers who presented a more believable deficit. ERP effects interpreted previously as reflecting more effort in the processing of the stimuli, in particular, the early malingering recognition effect, were larger in the simulators who were more able to feign a believable impairment. The results of this study therefore suggest that ERPs may play an important role in the detection of these typically difficult-to-identify individuals.

An overall summary of the main results obtained in this thesis, and suggestions for future research, are provided in Chapter 12.
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CHAPTER 1. MALINGERING

1.1 DEFINITION OF MALINGERING

The word “maligner” is derived from the French malingre, meaning sickly, sore, scabby, ugly and loathsome, and was used to describe the action of soldiers and sailors who purposefully produced ulcers on their legs in order to escape duty (Bailey, 1998, p. 77). In military contexts, the term “malingering” is still used to describe the evasion of military duty through pretense of illness or incapacitation. In wider circles however, its definition has broadened to describe the deliberate and conscious feigning or exaggeration of symptoms in order to achieve an identifiable external reward, or avoid aversive situations or outcomes. The definition thus encompasses both “pure” malingering, where there is fabrication of a condition or symptoms, and “partial” malingering, which refers to the exaggeration of existing symptoms (Haines & Norris, 1995). Symptoms feigned or exaggerated may include cognitive disorders such as amnesia, psychopathology, including conversion or dissociative disorder, and physical disorders such as pain and paraplegia. Thus, the term “malingering” could describe the actions of an individual who feigns memory loss following an industrial accident in order to obtain financial compensation, the exaggeration of pain in order to obtain drugs, or the individual who feigns dissociative amnesia to avoid a prison sentence for a crime committed.
1.2 MODELS OF MALINGERING

Rogers (1990, 1997) outlines three explanatory models of malingering which differ according to how the underlying motivation is viewed.

1.2.1 Psychopathological model

Early views of malingering were that this behaviour reflected an underlying psychological disorder, with the individual’s complaints of illness or pain indicating early stages of psychopathology. For example, Hay (1983) studied six patients thought to be feigning schizophrenia and found that on follow-up, five had become clearly schizophrenic. He thus argued that the simulation of schizophrenia reflects the prodromal phase of the condition. This view is consistent with other research that reports the presence of non-psychotic symptoms prior to the onset of mental disorders. For example, Lewis, Davis, Malmberg and Allebeck (2000) reported an increased prevalence of symptoms such as headaches, difficulty sleeping, depression and anxiety in the years leading up to the onset of schizophrenia.

The psychopathological model of malingering lost favour however, as researchers and clinicians observed that individuals malingering impairment generally did not go on to development mental illness. Furthermore, it was noted that a number of these patients showed remission of their symptoms once a particular outcome or goal was attained.
1.2.2 Criminological model

These observations led to a shift from a model of malingering based on disease to one involving a moralistic component – that malingerers were “bad” people. It has been suggested for example (Blinder, 1970, cited by Gerson, 2002), that malingerers are preoccupied with cash rather than cure, possess detailed knowledge of the laws and precedents relating to his or her case which often surpasses that of their lawyers, and whose symptom severity varies with the legal proceedings. Blinder (1970, cited by Gerson, 2002) goes on to suggest that malingerers tend to have a long history of drifting about, of spotty employment or of shirking work, are dependent upon others, have poor impulse control and a history of dishonesty. In a similar vein, others have employed terms such as “goldbricking”, “shamming illness” (Gorman, 1982) and “compensation neurosis” (Youngjohn, Burrows, & Erdal, 1995) to describe symptoms that were believed to be fabricated, and cured by financial compensation. According to Kennedy, (1946, cited by Resnick, 1997), compensation neurosis is a “state of mind, born out of fear, kept alive by avarice, stimulated by lawyers, and cured by a verdict” (p.139).

While extreme views such as these are less common today, Rogers (1990, 1997) believes that this criminological explanation for malingering is expounded in the most widely consulted manual in psychological practice - the Diagnostic and Statistical Manual of Mental Disorders (DSM). The most recent revision of the DSM (DSM-IV-TR) (American Psychiatric Association, 2000) defines malingering as the “intentional production of false or grossly exaggerated physical or psychological symptoms, motivated by external incentives such as avoiding military duty, avoiding work, obtaining financial compensation, evading criminal prosecution, or obtaining drugs” (p.739). Further, it states that
malingering should be strongly suspected if any combination of the following is noted: medicolegal context of presentation, marked discrepancy between the person’s claimed stress or disability and the objective findings, lack of cooperation during the diagnostic evaluation and in complying with treatment, and the presence of antisocial personality disorder. According to Rogers (1990), this describes a “bad person (sociopath) in a bad situation (forensic assessment), who is a bad participant (lack of cooperation)” (p.183).

The DSM interpretation of malingering has been praised by some for providing a behavioural rather than psychoanalytical focus, which permits objectivity and uniformity in the diagnosis of malingering (e.g. LoPiccolo, Goodkin, & Baldewicz, 1999). Others, however, have criticised this view as being too narrow and too focused on criminality, and therefore of limited value in the identification and diagnosis of malingering (e.g. Clark, 1997; Cunnien, 1997; Gerson, 2002; Rogers, 1990, 1997). For example, a review of the relevant literature failed to find an association between antisocial personality disorder and malingering (Clark, 1997), lack of cooperation is typical of several other conditions (Rogers, 1990), while the apparent link between malingering and medicolegal situations largely may be due to the predominance of research being conducted within forensic contexts (Cunnien, 1997).

1.2.3 Adaptational model

The limitations of the criminological model led Rogers (1990, 1997) to propose an adaptational explanation for malingering. The assumptions underlying this model are that the individual (1) sees the evaluation as being involuntary and adversarial, (2) has significant personal investment in the outcome of the evaluation, and (3) sees no other way
in which to achieve the desired goal. The adaptive aspect of malingering has been demonstrated in a study of inmate’s scores on the MMPI (Walters, 1988) in which high scores were obtained on scales measuring psychopathology when inmates were trying to demonstrate disturbance severe enough to warrant a single cell. However, the same individuals suppressed these symptoms when they were being evaluated for parole. Similarly, Lo Piccolo et al. (1999) describes instances of “patients” appearing in the emergency units of hospitals on cold, rainy winter evenings, feigning illness in order to obtain food and shelter.

1.2.4 Diagnostic importance of models of malingering

These three explanatory models were evaluated in a prototype analysis (Rogers, Salekin, Sewell, Goldstein, & Leonard, 1998) in which two hundred and twenty one clinical and forensic psychologists were asked to select two prototypical examples of malingering from their own practices – one forensic and the other nonforensic. They were then asked to rate the extent to which characteristics representative of the three models of malingering were present in each case. Using a principal axis factor analysis, the adaptational model was decomposed into two factors: a cost-benefit analysis, describing the weighing up of an individual’s alternatives and likelihood of success, and a factor reflecting the adversarial context, in which malingering was viewed as a way of coping with difficult circumstances. Overall, the results demonstrated that compared to the criminological and adaptational model, the pathogenic model assumed lesser importance in the understanding of malingering. The study also revealed complex interactions of the ratings of the models with the condition being feigned, gender, and forensic compared to
nonforensic settings. For example, the criminological model was more salient to men than to women in both forensic and nonforensic cases. In nonforensic cases, the pathogenic model was of more importance to women than to men, whereas malingering in men was influenced more by the weighing up of outcomes and likely success. According to Rogers et al. (1998), how the motivation underlying malingering is viewed influences the ability to detect it. For example, if a clinician believes that malingering is inspired by criminal motivations, he or she may be more sensitised to its occurrence in forensic cases. The study by Rogers et al. (1998) therefore provides important information regarding the motivation for malingering in a variety of situations, while the complex interactions of the factors highlight the complexity of the issues involved in its detection.

1.3 DIFFERENTIAL DIAGNOSIS

In addition to malingering, there are a number of other conditions in which symptoms are viewed with suspicion. Malingering is primarily differentiated from these by the conscious awareness of, and motives underlying, symptom production. For example, the somatoform disorders involve reporting of physical symptoms that are unable to be explained by a known medical condition. Similarly, dissociative disorders involve difficult-to-explain psychological dysfunction. Conditions such as these are differentiated from malingering by the unconscious production of symptoms, and the absence of a tangible secondary gain (American Psychiatric Association, 2000). Factitious disorder, on the other hand, is characterised by the intentional fabrication of physical or psychological symptoms. It differs from malingering however, in the nature of the secondary gain: while malingerers are motivated by an external goal, the motivation in factitious disorder is the
psychological need to assume the sick or disabled role (American Psychiatric Association, 2000; Drogin, 2001).

Other researchers believe these distinctions are not so clear-cut however, and that other factors, both conscious and unconscious, can influence performance. For example, Bierley et al. (2001) examined four head-injury patients whose consistently poor performance on forced-choice recognition memory tests was suggestive of malingering. However patterns of responding on other measures were inconsistent with this diagnosis, and did not differ significantly from performance in a group of head-injured patients not suspected of malingering. These researchers also noted that instances of particularly poor recognition memory performance were associated with high scores on the Hamilton Rating Scale for Depression. They therefore attributed the individuals’ poor memory performance to depression, and stressed the importance of not depending on a single test for the diagnosis of malingering. Similar concerns that suboptimal motivation and performance might arise from depressive disorder rather than conscious intentions to deceive have been expressed by others (Iverson & Binder, 2000; Rees, Tombaugh, & Boulay, 2001). Conscious exaggeration or fabrication of symptoms may also occur in individuals suffering genuine impairment. For example, exaggeration of symptom severity may reflect a “cry for help”, where the patient dramatises their condition in order to ensure they receive assistance or attention (Berry et al., 1996). Observations such as these led Haines and Norris (1995) to state that “malingering behaviour should not be thought of as a dichotomy, but rather as a continuum that ranges from purposeful conscious deception to involuntary unconscious psychogenic deficits” (p. 127).
1.4 PREVALENCE

This lack of clarity surrounding the identification of malingering behaviour clearly complicates any estimates of its prevalence. Nevertheless, a number of studies have attempted to provide base rates of malingering for a variety of conditions. For example, in a study of patients hospitalised for being at risk of suicide, 10% admitted that they were motivated by an external incentive to exaggerate or lie about their suicide attempts or intentions (Rismiller et al., 1998). The proportion of people thought to be feigning chronic pain has been estimated to range from 1-75% (Fishbain, Cutler, Rosomoff, & Rosomoff, 1999). In terms of cognitive deficits, Binder and Willis (1991) and Binder (1993) observed that around 30% of their mild head-injured patients scored worse than non-litigating severe head-trauma patients, and thus proposed that this might reflect a base rate of malingering. Greiffenstein, Baker and Gola (1994) on the other hand, argued that this figure might represent the lower limit, estimating that around 60% of head-injured patients were simulating impairment.

Other studies have reported differences in the prevalence of malingering according to the context in which the individual is evaluated. For example, Rogers, Sewell and Goldstein (1994) suggest that 15.7% of participants in a forensic setting, and 7.4% in non-forensic settings, are malingering. Similarly, Schmand et al. (1998) examined post-whiplash patients and claimed that 61% of patients in forensic, and 29% in non-forensic contexts were exaggerating or fabricating their symptoms.

While these estimates vary considerably for various contexts and conditions, they serve to indicate that a significant proportion of patients seen by clinicians may be feigning or exaggerating impairment.
1.5 IMPORTANCE OF DETECTING MALINGERERS

The apparently large number of individuals fraudulently claiming compensation for non-existent or exaggerated injuries negatively impacts on society in many ways. In the United States, the estimated cost of health insurance fraud is $54 billion per year (New York Alliance Against Insurance Fraud, 2002). A report by the Australian Institute of Criminology estimates that up to 10 percent of all insurance premiums are paid to individuals who have exaggerated or fabricated a claim, with a true annual cost to the country of up to AUS$9 billion (Baldock, 1997). The report goes on to state that the rising number of insurance claims results in increased premiums for all citizens, with the average Australian family contributing in excess of AUS$400 per year towards fraudulent claims.

Socially, spurious claims erode services established to assist those in need, such as schemes to assist injured workers (Lees-Haley, 1992; Mendelson & Mendelson, 1993). In numerous countries, budgetary restraints increasingly stretch health care resources, and those who feign impairment impose an additional and unnecessary burden on these, and may delay or prevent treatment being provided to those in genuine need.

The ability to accurately identify malingered or fraudulent claims also has important implications for the individual, both client and clinician. The labeling of an individual as a malingering is a highly pejorative accusation. For a genuinely impaired person, wrongful accusation can be devastating both psychologically and through the withdrawal of necessary treatment. Wrongful accusation can also have severe implications for the clinician. Mendelson and Mendelson (1993) for example, recount the case of a patient who killed the orthopaedic surgeons who claimed his lower back pain was fabricated.
Such actions, along with fears of litigation, have led to concerns that malingering is probably greatly underreported by clinicians (Iverson & Binder, 2000; Williams, 1998).

1.6 SUMMARY

The explanations for why individuals feign illness or impairment are varied and complex. For some, simulating impairment is viewed as the best and sometimes only option given the adverse circumstances in which they find themselves. In other individuals, criminal, antisocial or pathogenic factors underlie malingering behaviour. The situation is complicated by findings that indicate that these motivating factors vary with the condition being feigned, the gender of the individual and whether they are involved in a forensic or nonforensic situation. Furthermore, while malingering has generally been viewed as a deliberate act, recent evidence suggests that unconscious processes, such as depression, may produce behaviour that might be misinterpreted as provision of sub-optimal effort.

While these factors complicate the identification of those simulating impairment, a growing body of research indicates that a substantial number of people feign or exaggerate deficits. The resulting cost to society, both social and economic, highlights the importance of accurate measures to detect this behaviour.
CHAPTER 2. DETECTION OF MALINGERING

Numerous studies have demonstrated that lies and deception are difficult to identify (e.g. Akehurst, Koehnken, Vrij, & Bull, 1996; DePaulo, 1994; Ekman & O'Sullivan, 1991; Vrij & Mann, 2001). Ekman and O’Sullivan (1991) for example, showed ten videotapes to members of the United States Secret Service, polygraphers, judges, police, psychiatrists and college students. Five videos depicted a female answering questions honestly, while in the remainder, the answers were lies. With the exception of the Secret Service, none of the groups were able to distinguish honest from deceptive responses at better than chance levels. Along with lies and deception, studies have also demonstrated the difficulty of identifying genuine from feigned mental illness. In the now classic study of Rosenhan (1973), eight individuals feigning symptoms of psychopathology were able to gain admittance to a number of psychiatric institutions. Simulation of symptoms ceased following admittance, yet during their average 19 days of hospitalisation, none of the “pseudopatients” were identified as such, suggesting an inability to distinguish between mental health and illness and feigned symptoms of psychopathology.

The ability of clinicians to accurately detect simulated cognitive deficits has also been challenged. Faust, Hart, Guilmette and Arkes (1988) asked three healthy teenagers with no neurological impairment to perform below their ability on two neuropsychological tests. One hundred and thirteen practicing neuropsychologists assessed their test results, together with a fabricated patient history of mild to moderate head injury. Approximately 75% of the neuropsychologists diagnosed cortical dysfunction – none attributed the low scores to malingering. Furthermore, despite warning a group of 26 neuropsychologists that the base
rate of malingering in a series of test protocols was 50%, detection of those malingering impairment did not exceed chance levels. Similar difficulties in detecting malingering in children has also been reported (Faust, Hart, & Guilmette, 1988).

Recognition of the limited ability of clinicians to identify feigned impairment and sub-optimal effort using clinical judgement alone led to the view that more-objective measures were required to accurately detect malingering. According to Sweet (1999), “we can no longer take comfort in the belief, now shown to be false, that we will simply know when malingering is evident, without addressing the issue deliberately and prospectively” (p.278). The past decade has thus seen the development of numerous tests and strategies aiming to identify malingering on a wide range of disorders, including depression (Walters & Clopton, 2000), post traumatic stress disorder (Lees-Haley, 1992; Orr & Pitman, 1993), chronic pain (Meyers & Diep, 2000) and psychosis (Pesna, Dorfman, Gold, & Schneider, 1996; Resnick, 1999). However, the majority of research has focused on identification of feigned memory disorders. This is likely to be due, firstly, to memory deficits being among the most common complaints seen in neuropsychological practice (Cercy, Schretlen, & Brandt, 1997), and secondly, because closed head injury is considered the most likely syndrome to be feigned (Haines & Norris, 1995). Memory loss is a typical symptom of this type of injury, and importantly, one with which the general public is familiar (Williams, 1998).

This thesis will focus on the detection of feigned memory impairment, with the present chapter describing the methods employed and obstacles encountered in the search for an effective measure to identify those malingering on tests of memory.
2.1 SUBJECT POPULATION.

One of the major challenges facing investigators of deception and malingering has been obtaining a representative population of subjects. This is primarily due to the unavailability of a pool of self-confessed malingerers. Researchers have generally adopted one of three approaches to address this methodological difficulty in identifying groups of interest.

2.1.1 “Known groups” design

“Known group” studies (e.g. Viglione, Fals-Stewart, & Moxham, 1995) use individuals identified by clinicians as malingerers and compare them to those who it is assumed will respond to the best of their ability. The difficulty with this design is knowing for certain to which group a person belongs. This is because those suspected of malingering rarely identify themselves as such, or admit to non-optimal effort. Thus, even after obtaining test information which lends support to the suspicion of malingering, the refusal of the participant to confess means that the researcher is left uncertain of the accuracy of the diagnosis or the measure used to obtain it. According to Faust and colleagues (Faust & Ackley, 1998; Faust & Guilmette, 1990), this lack of feedback regarding the accuracy of decisions makes it impossible to determine the false negative and false positive rates, and thus complicates attempts to refine the tools and strategies to detect malingering.
2.1.2 Differential prevalence design

This approach is based on the assumption that malingering is more common in certain populations than in others. In the literature to date, one of the most common comparisons has been between compensation-seeking and non-compensation-seeking individuals, under the assumption that malingering is more common in the litigating population. In a typical study, Millis (1994) used the Warrington Recognition Memory Test (Warrington, 1984) to distinguish between a litigating mild head-injured group, mild head-injured subjects who had returned to work and were not pursuing compensation, and a group with moderate to severe head injury. This study demonstrated poor performance in litigating versus non-litigating participants, and mild head-injured litigating participants compared to the moderately to severely head injured, a result taken to indicate that those seeking compensation were more likely to be exaggerating or fabricating their impairment.

Studies such as this, which use litigation status as a means of group identification, have been criticised for ignoring other factors influencing performance in those seeking compensation. One obvious alternative explanation is that individuals seeking compensation do so because they are more severely affected than those who do not. Secondly, studies which compare mild, moderate and severely head-injured individuals rely on the questionable assumption that their impairments differ in magnitude, but not necessarily quality (Lezak, 1995). That is, if a mildly brain-injured person demonstrates poor recognition memory, a similar, only more pronounced deficit would be expected in a severely head-injured person.

Other studies using differential prevalence designs (e.g. Greiffenstein et al., 1994; Suhr, Tranel, Wefel, & Barrash, 1997) have addressed these concerns by using more-
comprehensive criteria for identification of groups within which malingering is thought to be common. For example, Greiffenstein et al. (1994) proposed guidelines which state that malingering could be suspected in participants who had sustained a mild head injury, were involved in litigation and demonstrated at least two of the following: total disability in a major social role, inconsistency of symptom history with medical records, improbable symptoms, and scores of 75% or less on a symptom validity test.

While studies using differential prevalence designs have the advantage of external validity, like the known groups studies, they too suffer from problems of unknown base rates – as malingerers in the real world rarely identify themselves, it is difficult to evaluate the accuracy of the assessment tool.

2.1.3 Simulation studies

One method of addressing the problem of unknown base rates has been to use “simulators” – normal individuals who are asked to feign specific deficits. In fact, the majority of studies investigating malingering have used simulators as the subject group (Rogers & Cruise, 1998). The primary advantage of this approach is that the proportion of malingerers is known, thus allowing assessment of the effectiveness of the detection method. The limitation however, is the lack of external validity – whether the results obtained in a laboratory under well-defined conditions can be applied to real-word situations. This has become known as the “simulation-malingering” paradox, whereby “persons are asked to comply with instructions to fake in order to study persons who fake when asked to comply” (Rogers & Cruise, 1998, p.274). Clearly, actual malingerers experience levels of motivation and incentive that cannot be replicated in the laboratory –
lucrative financial rewards if they appear convincingly impaired, or the possibility of a prison sentence, termination of benefits and/or public humiliation if they do not. A further criticism of simulation studies is that they generally use university undergraduates as participants, a group unlikely to accurately reflect the population in which brain injury typically occurs, which according to Haines and Norris (2001) includes older, less educated individuals in forensic settings.

A number of studies have attempted to investigate the effect of factors such as these on the performance of simulating malingerers. For example, Bernard and Fowler (1990) and Martin, Bolter, Todd, Gouvier and Niccolls (1993) compared performance of simulators with and without a financial incentive to produce believable memory problems. Both studies reported that financial motivation did not affect performance. Haines and Norris (2001) investigated the issue of the representativeness of undergraduate students, comparing the ability of college students and clinical participants to simulate impairment. Their results indicated that while all of the patients could be distinguished from actual brain-injured individuals, 26% of the student simulators were misclassified as head injured. This suggests that student malingerers may be more sophisticated in their approach to feigning impairment, and that compared to other community groups, appear to form a stringent comparison group.

As mentioned previously, simulation studies cannot hope to accurately replicate the motivation or financial incentives of real world malingerers. However, the results of the aforementioned studies provide some encouragement for investigators employing this approach, and it seems likely that researchers will continue to rely on simulation studies in the future. In particular, Bianchini, Mathias, and Greve (2001) note that simulation
designs are crucial in the early stages of the development of a test or strategy, due to the inaccessibility of real or suspected malingerers, and the difficulty of assessing the success of a technique using such a population.

2.2 METHODS OF DETECTING FEIGNED IMPAIRMENT

2.2.1 Test Development

The realisation that clinical judgment alone was an inaccurate method of identifying malingering and deception led to the move towards use of more-objective tests and measures in the clinical evaluation. These generally take the form of self-report measures, a number of which have been specifically devised for the purpose of distinguishing feigned from honest performance. These include tests such as the Amsterdam Short-Term Memory Test (Schagen, Schmand, de Sterke, & Lindeboom, 1997) and the Test of Memory Malingering (Tombaugh, 1996).

Rather than devising new tests, other researchers have used differential performance on existing neuropsychological tests as a means of detecting malingerers. For example, the Minnesota Multiphasic Personality Inventory (MMPI) has been extensively investigated as a tool to detect poor effort and motivation (e.g. Lamb, Berry, Wetter, & Baer, 1994; Lees-Haley, 1992; Pesna et al., 1996; Walters, 1988; Walters & Clopton, 2000). The Warrington Recognition Memory Test (RMT) is another standardised neuropsychological test that has been used by a number of researchers to detect non-optimal performance (Iverson & Franzen, 1994, 1998; Millis, 1994; Millis & Putnam, 1994). The RMT assesses verbal and non-verbal memory function, and consists of two subtests: recognition of words and
recognition of faces. In each subtest, subjects are shown a set of items after which follows a test phase, in which each of the initial stimuli are shown again, only this time paired with a new item. Participants must indicate which of the two had been presented in the study phase, thus testing their recognition memory in a forced-choice format. Millis (1992) used the RMT to distinguish a group of personal injury litigants from a group of head-injured patients not in litigation. Using discriminant function analysis and both subtests, he was able to correctly classify 76% of the participants.

Many researchers (e.g. Bernard, Houston, & Natoli, 1993; Iverson & Franzen, 1994; Suhr & Gunstad, 2000) consider that using existing tests such as the RMT is preferable to those purposefully devised for detecting malingering. Firstly, many specifically-designed tests have been criticised for being too transparent – their purpose is clear to all but the most blatant malingler, and performance is therefore adjusted accordingly. Secondly, tests designed solely to detect non-optimal performance add no additional clinical information to the evaluation. In contrast, existing neuropsychological tests have the advantage of being able to serve two functions – detection of non-optimal performance if it is present, and provision of information regarding cognitive function if it is not. In addition, their standard inclusion in the neuropsychological evaluation means they are less transparent to potential malingerers. Thus, tests such as the RMT provide information regarding the validity of a patient’s performance, without necessarily extending the length of the evaluation. According to Trueblood (1994), studies using standard neuropsychological tests should remain the focus of research in malingering, allowing assessment of symptom validity throughout the evaluation.
2.2.2 Strategies to detect memory impairment

The underlying assumption of most detection strategies is that malingerers and simulators will identify themselves by test performances that differ relative to normals and those with genuine cognitive impairment. These differences may be either qualitative or quantitative.

2.2.2.1 Quantitative Differences

Strategies based on quantitative differences arose from observations that suspected malingerers and simulators frequently performed worse on memory tests than controls or participants with documented head injury or memory loss. The most commonly used method of identifying such differences has been the forced-choice, or symptom validity test (SVT) (Bianchini et al., 2001). These tests generally follow the format described previously for the RMT, where participants are shown a series of items in a study phase, after which follows a test phase where items are presented in a two-alternative forced-choice format. Participants must decide which of the two items was presented in the study phase. The utility of this test format in the detection of feigned impairment is that by chance alone, subjects should obtain scores of around 50%. That is, even participants who respond randomly, or who have such severe memory loss that they are unable to distinguish previously seen from new items, should perform at chance levels. In contrast, below chance performance indicates that the subject must know the correct answer in order to consistently choose the incorrect one. Below chance performance therefore provides unequivocal evidence of feigned impairment. According to Trueblood and Binder (1997), “when results are below chance, other explanations such as depression, low interest in the testing, or that
this is an anomalously extremely impaired individual after a mild head injury, are ruled out and one explanation – intentionally poor performance – is indicated” (pg. 25).

The promise of such definitive evidence led to increased use of SVTs as a means of detecting malingering. Early case studies employing these tests provided encouraging results, with individuals suspected of feigning memory impairment scoring below chance levels, thus providing compelling evidence that they had been malingering (Binder, 1987, 1992; Hiscock & Hiscock, 1989). Group studies however have shown less definitive results. The majority of these report that while simulators or individuals suspected of malingering score poorly on these tests, only a small proportion perform below chance levels (e.g. Binder, 1993; Binder & Willis, 1991; Frederick & Foster, 1991; Iverson & Franzen, 1994; Martin et al., 1993). This results in uncertainty as to whether these poor scores indicate actual memory impairment or non-optimal performance. In response to these findings, a number of researchers have devised “cutting scores” for particular tests, which specify levels below which scores would not normally fall (e.g. Bernard & Fowler, 1990; Iverson & Franzen, 1994). For example, in the Iverson and Franzen study, a score on the RMT of 33 rather than the chance level of 25 was used, resulting in correct classification of 90% of their simulating malingerers, and 100% of controls and head-injured patients. Cut-off scores have been criticised however, for increasing the probability of falsely classifying an honestly-responding individual as a malingerer to unacceptably high levels (Haines & Norris, 1995; Rosenfeld, Sweet, Chuang, Ellwanger, & Song, 1996; Suhr & Gunstad, 2000).
2.2.2.2 *Qualitative Differences*

Other investigations of feigned impairment have focussed on identifying qualitative differences between simulators, controls and head-injured participants. These strategies are often based on well-established principles of learning or memory, and assume that those simulating impairment will be unaware of these principles and therefore unable to perform according to the expected behaviour patterns. For example, it is well established that scores on tests of recognition are superior to those on tests of recall (Bower, 2000; Lockhart, 2000). A number of studies have therefore attempted to identify malingerers based on their naiveté to this typical pattern of performance, demonstrating exaggerated impairment on recognition vs. recall tasks in those simulating impairment (Bernard & Fowler, 1990; Holmquist & Wanlass, 2002; Wiggins & Brandt, 1988). Other studies have searched for patterns of inconsistency in measures such as serial position effects (Bernard, 1991; Suhr et al., 1997), performance curve indices, where it is expected that participants will score highly on easy relative to harder items (Strauss et al., 2002), ability on attention vs. memory tasks, memory performance following delays, and learning span (Suhr & Gunstad, 2000). According to Suhr and Gunstad (2000), the utility of measures of atypical performance lie in the difficulty of faking a believable *pattern* of test performance, compared to adjusting *level* of performance, as assessed in quantitative measures of detection.

However, studies investigating atypical patterns of performance have not always produced consistent results. For example, while Bernard (1991) demonstrated a reduced primacy effect in the serial position curve of malingerers but not controls, this has not been replicated in other studies (Bernard et al., 1993; Sullivan, Deffenti, & Keane, 2002). The Sullivan et al. study instead observed that the shape of the curve remained the same, but
with an overall decrease in recollection in the malingerers, regardless of the serial position of the item. Similarly, while many studies have revealed exaggerated impairment of recognition compared to recall in malingerers, Sullivan and colleagues (2002) reported that performance on both recognition and recall was reduced in those feigning deficits. Nies and Sweet (1994) note that the qualitative difference approach to detection requires more extensive research using numerous clinical populations in order to rule out the possibility that genuinely impaired individuals could produce such atypical patterns of performance. According to Bianchini et al. (2001) while measures demonstrating unlikely patterns of neuropsychological performance may alert clinicians to the possibility of non-optimal effort, they are as yet unable to provide an adequately compelling diagnosis of malingering.

In summary then, strategies of detection based on atypical patterns of performance are at present unable to provide a definitive diagnosis of malingering. Below-chance performance on SVTs on the other hand, provides unequivocal evidence of non-optimal performance. However, the relatively small number of participants that perform this poorly limits their usefulness, with only the most blatant of malingerers able to be accurately identified.

2.3 COACHING OF MALINGERERS

A further challenge for the detection of malingering lies in the realisation that individuals may not always be naïve to the procedures and implications of the clinical evaluation. Such information, which may enable an individual to modify his or her performance during an examination, is readily available to the potential malingerer. Lees-Hayley (1992) for example, describes newspaper advertisements that outline the symptoms that should be reported when filing a post-traumatic stress claim. Information accessible on
the internet is also a growing concern, with Ruiz, Drake, Glass, Marcotte and van Gorp (2002) identifying sites that contain details of the tests designed to detect malingering, correspondence between clinicians regarding strategies to detect sub-optimal performance, and specific instructions on how to feign impairment on particular tests and to present oneself in order to obtain disability benefits. If this information is not sought by the individual, others with a vested interest in the patient appearing impaired may “coach” the individual on ways to present a believable deficit. Youngjohn (1995) for example, reports an instance in which an attorney admitted to coaching a man with mild head injury prior to a neuropsychological evaluation. This willingness within the legal profession to provide such information appears to be widespread – Wetter and Corrigan (1995) surveyed 70 practicing attorneys and 150 law students, most whom believed that they had a responsibility to discuss psychological testing with a client prior to the evaluation. Furthermore, 33% of the law students and 50% of the attorneys believed they should also inform the client of validity scales designed to identify exaggeration or malingering.

In an attempt to determine the effect of coaching on the ability to avoid detection, many studies have included information to participants regarding the symptoms associated with their “condition” and potential strategies to avoid detection. In general, these studies have demonstrated reduced ability to detect participants provided with this knowledge (e.g. Lamb et al., 1994; Martin et al., 1993; Rose, Hall, & Szalda-Petree, 1995; Rose, Hall, Szalda-Petree, & Bach, 1998; Suhr & Gunstad, 2000). For example, the study by Rose and colleagues (1995) compared performance on a computerised version of the Portland Digit Recognition Test (PDRT-C) in coached and uncoached simulating malingers. The uncoached malingers were asked to imagine that they were involved in a car accident in
which they sustained a mild head injury. They were now involved in litigation to receive financial compensation for this injury. The coached malingerers received the same scenario but were also given information regarding the cognitive impairments typical of head injury, such as reduced attentional and learning abilities and a slowing of responses. They were also warned that excessive impairment would be too obvious to the examiner, and easily detected as malingering. Using a combination of test scores and response latency, 86% of the uncoached malingerers but only 47% of the coached malingerers were correctly identified. Additional information in the form of a warning that at least one of the tests participants were about to complete was designed to detect malingering was provided in a study by Gunstad and Suhr (2001). This study demonstrated that warned participants were better at avoiding detection than those who were only given information regarding the likely symptoms following brain injury.

Studies such as these permit researchers to assess the effectiveness of their tools on participants who possess varying levels of information. Unfortunately however, the very publishing of this information raises concerns that it will alert potential malingerers and those involved in coaching to current detection strategies and how to avoid them (Berry, Lamb, Wetter, Baer, & Widiger, 1994). The availability of such information, the apparent willingness of the legal profession to provide it to potential malingerers, and its effect on the ability to detect malingering, presents an obvious challenge for those attempting to identify such behaviour.
2.4 CURRENT STATUS OF TESTS TO DETECT MALINGERING AND FUTURE DIRECTIONS

Despite the increasing range and sophistication of the measures used to detect malingering, there is general agreement that no single test is adequate to discriminate between malingerers and those with genuine impairment, and that multiple indices are required to attain the necessary levels of accuracy (e.g. Bianchini et al., 2001; Cercy, Schretlen, & Brandt, 1997; Haines & Norris, 1995; Lidsky, Schneider, & Karpf, 1998; Nies & Sweet, 1994). Furthermore, the increasing sophistication of malingerers has led to the need for new, more complex or specialised measures to detect feigned impairment (Gunstad & Suhr, 2001; Williams, 1998).

For some, this has meant the inclusion of covert measures in tests of malingering, under the assumption that even coached malingerers may be unaware of, or unable to modify performance on these indices. For example, Rose et al. (1998) combined performance on the PDRT-C with response latency, suggesting that the latter would be more difficult to self-monitor, and less affected by coaching. This proposal was supported by the findings that response latencies of the malingering participants were significantly shorter than the severely head-injured group, and longer than the control group, but did not differ according to whether the malingerers were coached or uncoached. While test scores on the PDRT-C identified 47% of the coached malingerers, this increased to 70% with the addition of response latency measures.

Orr and Pitman (1993) investigated other covert measures of detection in a study comparing 25 Vietnam veterans suffering posttraumatic stress disorder (PTSD) and 18 veterans without the disorder (nonPTSD). Prior to the evaluation, all veterans recounted
their most stressful combat experiences. Thirty-second scripts composed from these were later read to the veterans while heart rate, skin conductance and forehead electromyographic measures were recorded. NonPTSD veterans were instructed to attempt to feign PTSD. The results of this study indicate that the nonPTSD group was unable to simulate the physiological responses of those genuinely suffering from PTSD, with movement in the corrugator muscle of the forehead particularly difficult to feign.

Other researchers suggest that traditional neuropsychological methods of detection need to interface with measures which assess brain function more directly, such as functional magnetic resonance imaging (fMRI) and electroencephalographic measures (Trueblood, 1994). While there appear to be few studies investigating detection of malingering and deception using fMRI (see Lee et al., 2002 for a recent exception), a larger body of literature has examined the utility of event-related potentials as a measure of malingering which may be immune from the effects of coaching. This approach to the detection of malingering will be described in the following chapter.
CHAPTER 3. EVENT-RELATED POTENTIALS IN THE DETECTION OF MALINGERING

3.1 EVENT-RELATED POTENTIALS

The electroencephalogram (EEG) measures the electrical activity of the brain, recorded at the scalp. Particular stimuli or cognitive events are assumed to elicit characteristic patterns of brain activity, which are embedded within the EEG waveform. Event-related potentials (ERPs) reflect that segment of EEG time-locked to the presentation of the stimulus or cognitive event. While the brain activity elicited in response to the stimulus is assumed to be constant, EEG activity not time-locked to the event varies randomly (Coles & Rugg, 1995). Averaging the EEG data in response to a number of these stimulus presentations, therefore, will largely eliminate the random background EEG (or noise) leaving an ERP waveform which reflects the average brain activity elicited by the presentation and processing of the stimulus (Andreassi, 1995).

These ERP waveforms consist of a series of peaks and troughs. Once functional significance has been assigned to these peaks and troughs, they become known as “components”. Components are characterised by their polarity, peak latency, eliciting conditions, amplitude and scalp topography. Components that occur immediately following stimulus presentation (up to approximately 200 milliseconds post-stimulus) are generally thought to reflect sensory processing of the stimulus and have been termed exogenous, since
their characteristics depend on the physical properties of the stimulus\(^1\). These sensory components are obligatory, in that they will be observed in every individual and on every occasion unless the sensory systems involved are impaired. Components that occur later in the waveform have been termed endogenous, as they are thought to reflect cognitive processing – the interaction of the subject with the stimulus – rather than the characteristics of the stimulus itself (Coles & Rugg, 1995).

As the late endogenous ERP components tend to reflect non-obligatory processes, they have been extensively studied in experiments investigating the cognitive operations associated with the storage and retrieval of items from memory. Two endogenous components commonly studied in such investigations are the N400 and P3.

3.1.1 N400

The N400 is a component of the ERP with negative polarity, a latency of approximately 400ms post-stimulus, that is observed to be maximal over centroparietal regions and often with a slightly right-greater-than-left asymmetry (Andreassi, 1995). A number of studies have demonstrated the sensitivity of this component to semantic anomalies (Ainsworth-Darnell, Shulman, & Boland, 1998; Connolly & Phillips, 1994; Kutas & Hillyard, 1980; Kutas, Lindamood, & Hillyard, 1984). For example, ERPs to the terminal word in sentences that concluded with a word congruent with the preceding context (i.e. “George had been fired but he couldn’t tell his wife”) were associated with small N400s, whereas

\(^1\) While these early components are generally thought to reflect sensory processes, a recent study by Woldorff et al. (2002) reports the influence of cognitive processes being apparent as early as 80 msec post stimulus.
those with a semantically incongruent terminal word (“George had been fired but he couldn’t tell his fog”) elicited large amplitude N400s (Kutas et al., 1984). Similar results have been reported for non-terminal incongruous words (“Jill entrusted the recipe to platforms before she suddenly disappeared”) (Ainsworth-Darnell et al., 1998), and for incongruous pairings of category words (i.e. a type of wood: pancake) (Olichney et al., 2000). These studies indicate that the N400 reflects brain activity in response to semantic deviations from expectancy.

Other research has shown that the amplitude of the N400 can be modulated by word or sentence repetition (e.g. Bentin & Peled, 1990; Berman, Friedman, & Cramer, 1991; Olichney et al., 2000; Van Petten, Kutas, Kluender, Mitchiner, & McIsaac, 1991). These studies report attenuation of the N400 when previously-seen items are repeated, although this repetition effect appears confined to studies in which the interval between the study and test phases of the experiment is short (Rugg, 1995). According to Olichney et al. (2000), the sensitivity of the N400 to both semantic and repetition effects reflects “the continued accessibility of representations of recent stimuli for integration with current stimuli” (p.1960) and that the short-lived nature of the repetition effect reflects the optimum span of such a system.

3.1.2 P3

P3 (also known as P300 and P3b) is an ERP component with positive polarity, observed maximally at parietal sites and with a peak latency range of 300-900 ms post-stimulus. The amplitude of this component is influenced by a number of factors. For example, the rarer the event is perceived to be, the larger the P3 (Fabiani, Karis, & Donchin, 1990; Johnson &
Tasks that require participants to make decisions about stimuli elicit a P3 component, while increased confidence in these decisions is associated with higher amplitudes (Cutmore & Muckert, 1998; Rohrbaugh, Donchin, & Ericksen, 1974). Stimuli that are more relevant or significant increase P3 amplitude, with target stimuli eliciting larger P3s than non-target stimuli (Johnson, Miltner, & Braun, 1991). Additionally, P3 amplitude is attenuated in response to target stimuli in a primary task when a secondary task is introduced, suggesting that P300 is sensitive to attention (Mangun & Hillyard, 1990).

The latency of the P3 is thought to reflect the time required to evaluate the stimulus. Tasks in which stimuli are ambiguous, or require complex categorisation or discrimination are associated with increased P3 latency (McCarthy & Donchin, 1981).

Researchers have combined these findings into a model aiming to explain the functional significance of the P3 component. Donchin (1981) for example, proposed that P3 reflects neural events underlying the process of context updating. He stated that the P3 is elicited in response to stimuli that are sufficiently surprising or salient that the subject must modify their current model of the environment. The amplitude of the P3 reflects the degree of modification required. Rare, unexpected or particularly relevant events require greater updating of the model and therefore result in larger P3s. An alternative view is that the amplitude of the P3 reflects context closure (Verleger, 1988). This theory proposes that P3 is elicited when subjects perform highly repetitive, structured tasks while waiting for a particular event or stimulus to occur. Presentation of the awaited stimuli or event causes “closure” or the fulfilment of expectancy, which is reflected in the P3 component.

Another influential theory proposed by Kok (2001) is that P3 reflects event categorisation processes, whereby an external stimulus is judged to either match or differ
from an internal representation of a category or event. This process is mediated by attention, working memory and task difficulty. Low probability, task relevant or highly novel events increase the amount of attention paid to the stimuli, leading to activation of the categorisation networks and a larger P3. In contrast, difficult tasks impose additional loads on working memory, therefore decreasing event categorisation activity and the amplitude of the P3 component.

3.1.3 Assessment of cognitive function using ERPs

ERP components such as the N400 and P3 have been used to assess the integrity of cognitive processes independently of overt behaviour. For example, in a study by Allen, Iacono and Danielson (1992), participants learned two lists of words: one immediately before a recognition memory test and the other around 30 minutes earlier. The memory test consisted of words from both lists, along with words which were new to the experiment. “Yes” responses were required for words shown in the most recently learned list, and “no” responses for new words. In addition, participants were asked to provide “no” responses for items learned in the earlier list, and to try to conceal any electrophysiological indication of recognition for these previously-learned words. Analysis of the ERP data identified five indices (P3 amplitude and four other ERP measures derived from a principal components analysis), which differentiated learned from unlearned items. Combining these indicators in a Bayesian classification analysis, Allen and colleagues were able to correctly identify recognition of the learned items in 94% of the participants, independent of their overt response.
In a follow-up study using a similar test paradigm, van Hooff, Brunia and Allen (1996) excluded the instructions to conceal recognition of the items from the earlier list in order to evaluate the influence of deception instructions on the previous results. Using P3 peak amplitude and mean amplitudes measured over 150 ms epochs extending from 200 to 950 ms post stimulus, the authors obtained similar results to those of Allen et al. (1992), with increased ERP positivity elicited in response to learned compared to unlearned words. These studies by Allen and colleagues thus demonstrated the potential utility of ERPs to assess recognition memory in individuals independent of explicit behavioural identification of the previously-learned items.

Similarly, Connolly, Byrne and Dywan (1995) and Byrne et al. (1999) used the sensitivity of the N400 to semantic incongruence to assess the receptive vocabulary of adults and children in the absence of a behavioural response. These studies used a computer-modified version of a standardised test of receptive vocabulary, the Peabody Picture Vocabulary Test, to enable the recording of ERPs during the test. Ninety pictures from the Peabody test were shown on a computer screen, while two words that either correctly or incorrectly described the picture were heard over headphones. N400 amplitude was greater for incongruous compared to congruous picture-word pairs that were within the individuals’ vocabulary level. These results highlighted the clinical utility of this ERP assessment technique for the evaluation of language ability and vocabulary level in individuals who may not be able to provide a verbal or motor response. This was demonstrated in a study of receptive vocabulary in cerebral palsy (Byrne, Dywan, & Connolly, 1995), a condition in which cognitive assessment is complicated by motor and language impairment that preclude the use of neuropsychological tests requiring behavioural responses. In this study, the
computerised Peabody test was administered to three control participants and an intellectually unimpaired adolescent male with cerebral palsy. In all participants, N400 amplitude was again greater for incongruous compared to congruous picture-word pairs, indicating intact receptive vocabulary in the individual with cerebral palsy.

These studies demonstrate the potential use of ERPs to assess cognitive function in the absence of an overt response, and the clinical application of this data for assessing individuals who are unable to provide a verbal or motor response. In a similar vein, ERPs have been proposed as a means of assessing the integrity of cognitive function in individuals who are unwilling to provide such a response, or whose response is believed to be inaccurate or dishonest. This area of investigation has been extensively studied by Rosenfeld and colleagues, who have utilised the properties of the P3 component in an attempt to detect feigned memory impairment. These studies will be discussed in the following section.

3.1.4 P3 and the detection of malingering and deception

Early studies using the properties of the P3 component (e.g. Farwell & Donchin, 1991; Rosenfeld, Angell, Johnson, & Qian, 1991) attempted to detect deception in paradigms similar to the guilty knowledge tests used in polygraphic evaluations. This technique involves presenting an individual with a series of alternative responses to an event or crime, only one of which is correct. The underlying assumption is that only the guilty person will possess detailed knowledge of the event, and that their recognition of the correct response alternative will be evident in the physiological measures recorded during the evaluation. Thus, in the Rosenfeld et al. study, participants viewed phrases describing antisocial acts, one of which guilty subjects had committed. As expected, larger P3s were elicited in
response to the crime relevant stimuli. Using a four-step algorithm, 89% of participants were accurately classified.

More recently, the focus of this research has turned to the identification of deception involving specific cognitive deficits, such as simulation of amnesia for autobiographical information (Rosenfeld, Ellwanger, & Sweet, 1995). This study instructed 13 participants to fake memory impairment under two sets of instructions. The naïve instructions asked participants to imagine themselves as having been in an accident – although this did not result in memory loss, they were to feign memory impairment to obtain financial compensation. The sophisticated instruction set, included to address issues of coaching, was identical except for the inclusion of information regarding the typical symptoms accompanying brain injury. The test of recognition memory involved presenting each participant with personally relevant information (birthdate, phone number and mother’s maiden name) interspersed with a larger number of similar but irrelevant information. Since P3 amplitude is enhanced to low probability, meaningful stimuli, it was hypothesised that the P3 associated with the “oddball”, i.e. personally-relevant information, would be larger than that to the irrelevant, frequent stimuli. Thus, while behavioural performance was poor (almost all items failed to be recognised in the naïve condition, with 50% correct recognition in the sophisticated condition), the larger P3 in response to the personally-relevant information provided evidence that the participants had in fact recognised this information. Using this technique, Rosenfeld and colleagues were able to identify 92% of those simulating amnesia for their birthdate and phone number, and 77% for their mother’s maiden name.
A more common complaint however, and one thought more likely to be malingered, is the ability to form new memories (Rosenfeld & Ellwanger, 1999). To examine this, Rosenfeld et al. (1996) combined the P3 detection technique with the Hiscock Forced-Choice test. This test involves presentation of a 3-digit number, followed by another number which is either a perfect match or mismatch to that previously shown. Since P3 is enhanced by rare stimuli, the test was modified such that in one block, the probability of a match was 17%, and in another, 33%. In both cases, P3 was greater to the match than the mismatch numbers, however the difference in P3 amplitude was considerably larger in the 17% block than in the 33% block. Classification based on P3 amplitude in the 17% block afforded detection of 70% of the simulators, however classification accuracy in the 33% block was not reported, and was therefore presumably low. More recently, Rosenfeld et al. (1998) obtained almost identical results, detecting 69% of those simulating memory loss.

In a study using newly-learned verbal material, Ellwanger, Rosenfeld, Sweet and Bhatt (1996) asked subjects to learn a list of words, after which followed a recognition memory test with previously-studied (“old”) words interspersed with new words. ERPs elicited by recognition of the subject’s birthdate and the experimenter’s name were also analysed. Using bootstrapping techniques to identify individual subjects, 90% of simulators in the birthdate block were identified, 80% in the experimenter name block, but only 50% in the block containing newly-learned words.

These studies by Rosenfeld and colleagues suggest that the P3 technique is useful for detecting those simulating amnesia for autobiographical information. However, when applied to the more common complaint of anterograde amnesia, the technique is considerably less accurate, with detection of 70 and 50% of individuals simulating amnesia
Allen and Iacono (2001) suggest that the relatively low classification accuracy of these latter studies may be due to their assessment of memory for less well-learned material. It may also be that the limited success of these studies stems from the choice of P3 amplitude as the sole ERP index of simulated recognition memory impairment. Clearly, processes associated with the ability to recognise material contribute to the elicitation of P3. The larger P3 elicited to rare, meaningful stimuli, suggests an ability to recognise the items in order to appreciate their rarity or meaningfulness (Rosenfeld et al., 1996). However, as outlined previously, prior research indicates that the P3 component reflects processes in addition to a subject's ability to recognise information. As an example, participants in the previously-mentioned study (Rosenfeld et al., 1996) gave equivalent behavioural performances on the modified Hiscock forced-choice procedure whether match probability was 17% or 33%, yet P3 amplitudes were significantly different. If P3 was a direct reflection of processes underlying the ability to recognise material, amplitude in response to the matches should be equivalent regardless of their probability of occurrence. The authors of this study (Rosenfeld et al., 1996) note that "the enhanced P3 to the match is very likely not unambiguously due to a subject's psychological response to a match, as opposed to his response to a mismatch, ... [and] ... that stimulus category probability plays an essential role in the success of the method" (p. 177).

As mentioned previously, along with subjective probability and meaningfulness, variables such as confidence in decision-making, the decision-making process itself, difficulty, attention, and the presence of a secondary task also modulate P3 amplitude. It may therefore be difficult to adequately control these variables in order to allow a confident
conclusion that a discrepancy between an individual's averaged P3 amplitude and behavioural response is due to intentions to deceive.

Furthermore, it is possible that the P3 component could be elicited in the absence of conscious awareness in the genuinely impaired (Rosenfeld & Ellwanger, 1999). Rosenfeld and Ellwanger (1999) therefore state that P3 evidence should be used with caution. It would be interesting (but beyond the scope of this thesis) to explore this question in patients with unilateral neglect. An additional potential problem involves the reliance of the P3 technique on the oddball format (i.e. where rare “target” stimuli are presented amongst frequent “standard” or “background” stimuli). This means that a large total number of trials are required in order to obtain sufficient number of trials for ERP averaging. Rosenfeld et al. (1996) recommend 150 total trials to obtain the necessary data. In a clinical situation, where the neuropsychological evaluation may already be lengthy, the addition of such a test may be unwelcome and of considerable difficulty for the genuinely impaired.

In summary, a number of studies by Rosenfeld and colleagues have utilised the P3 component to detect simulated memory deficits, independent of behavioural response. While such ERP techniques hold promise as a method of more directly measuring the brain's response to stimuli, rather than relying on what may be subjective self-report, classification based solely on P3 amplitude may be of limited use. An ERP measure less influenced by other variables and that more directly reflects the processes underlying recognition memory would seem preferable.
3.2 THE ERP OLD/NEW EFFECT AND RECOGNITION MEMORY

Electrophysiological methods by which recognition memory processes are generally studied involve comparing the ERPs evoked by the first presentation of an item, with those evoked by the second presentation. These stimuli are usually presented in a study phase, after which follows a test phase where they are shown again, only this time interspersed with items new to the experiment. Participants are required to discriminate between "old" (previously studied) and "new" (unstudied) items. The well-established finding is that items correctly classified as old generate a more positive ERP relative to items correctly judged new, or old items incorrectly classified as new (e.g. Curran, 1999; Paller & Kutas, 1992; Rugg & Doyle, 1992; Sanquist, Rohrbaugh, Syndulko, & Lindsley, 1980; Smith & Guster, 1993). This difference between ERPs associated with old versus new items is generally known as the “old/new effect”, but in the literature has also been referred to using terms such as the “memory evoked shift” (Smith & Guster, 1993), “ERP repetition effect” (Bentin & Peled, 1990) and the “episodic memory effect” (Friedman & Johnson, 2000).

3.2.1 Early studies of the old/new effect

Early studies of ERPs and recognition memory reported that from around 300-400 ms following stimulus-onset, previously-seen items elicited more-positive waveforms than did unstudied words (e.g. Karis, Fabiani, & Donchin, 1984; Neville, Kutas, Chesney, & Schmidt, 1986; Rugg, 1990; Rugg & Nagy, 1987; Sanquist et al., 1980; Smith & Halgren, 1989). Many of these authors explained the ERP differences between old and new words in terms of modulation of the N400 and P3 components. The old/new effect was thus interpreted according to the established properties of these components rather than as
reflecting cognitive functions more directly underlying retrieval from memory. For example, Karis et al. (1984) interpreted the enhanced positivity associated with old compared to new words as reflecting the relative “targetness” of the old words and the increased confidence in their classification.

The question of whether the old/new effect reflects processes underlying recognition memory, or simply the design and requirements of the task, was addressed by Smith and Guster (1993). In their study, subjects responded to new words that occurred frequently, thus altering the traditional recognition memory paradigm in which old items are usually infrequently occurring targets. Subsequent conditions required responses to high probability old words, low probability old words and low probability new words. During the period over which differences between old and new words emerged, Smith and Guster observed a component typical of the P3 potential. This component was posteriorly distributed with a peaked morphology, positive in polarity, and associated with low probability targets. A second positivity, which was less markedly posterior, less peaked and of longer duration was also observed. Importantly, this positivity was associated with old words independent of their targetness or probability. The authors thus argued that at least some part of the old/new word ERP difference reflects processes related to retrieval from memory, since it was evident regardless of target and probability manipulations. In addition, old and new words did not differ in response classification time or accuracy, or in P3 latency, suggesting that the old/new ERP effect was independent of differences in classification confidence.

Rugg (1990) obtained similar results in a study investigating elicitation of the old/new effect in response to words of varying linguistic frequency. While both high- and low-frequency old words were targets in the recognition task, the magnitude of the effect was
small for the high-frequency words, thus demonstrating the independence of the effect from factors of targetness. In a more recent study (Herron, Quayle, & Rugg, 2003), the ratio of old to new words was manipulated such that old words appeared on either 25%, 50% or 75% of the trials in a recognition memory test. This study reported a reliable old/new effect in the epoch 500-800 ms following stimulus onset, suggesting that unlike the P3 component, the old/new effect was not influenced by the relative probability of the target items.

In summary, while occurring within the time-frame of the N400 and P3 components, these studies of the old/new effect established its independence from factors of targetness, probability, response confidence and the decision-making process, seeming rather to reflect processes directly involved in recognition.

In recent years, much effort has been devoted to the further elucidation and understanding of the old/new effect. These studies have resulted in the dissection of the effect into a family of subcomponents, each of which reflects different processes in the retrieval of information from memory. Three major subcomponents of the old/new effect have been described – the parietal, late right frontal and early frontal old/new effects. Each of these components will be described in the following section.

3.2.2 Parietal old/new effect

This effect is seen as an increased positivity to old compared to new words, maximal over parietal scalp regions, and often over the left compared to the right hemisphere (Neville et al., 1986; Rugg & Doyle, 1992). The effect typically begins approximately 400 ms following the onset of the stimuli, and lasts for around 400-500 ms. The effect is only seen
for correctly-classified old words – words that have been recognised as previously studied. Since it is not evident for unrecognised old words or new words, it has been proposed that this old/new effect indexes processes underlying recognition memory (Rugg, 1995).

Explanations for the parietal old/new effect and its functional significance have largely been posed within the framework of a dual-process theory of recognition memory (Jacoby & Dallas, 1981; Mandler, Goodman, & Wilkes-Gibbs, 1982). This theory suggests that two processes – familiarity and recollection – are involved in the judgement of whether or not an item has been seen before. Recollection refers to recognition based on the conscious retrieval of an item from memory, along with information about the event or context in which it was encountered. Familiarity, on the other hand, refers to the "feeling" that an item has recently been encountered in the absence of memory for the context. Other researchers have used the terms “remembering” and “knowing” to describe similar states of awareness (e.g. Gardiner & Richardson-Klavehn, 2000; Rajaram, 1993).

The ability to dissociate recollection and familiarity suggest that they reflect fundamentally different processes. Rajaram (1993) for example, investigated recognition of items studied under deep (generate semantic associate) or shallow (generate rhyming associate) encoding conditions. During the recognition task, participants were asked to indicate which words they had seen previously, and for these words to also judge whether they distinctly remembered seeing the item, or knew that the item was on the study list without specific recollection of its actual occurrence. The results demonstrated that manipulating the level of processing of stimuli affected recollective (remember) but not familiarity (know) judgements. Similar results were reported by Gardiner, Gregg, Mashru and Thaman (2001) who compared divided vs. undivided attention and shallow vs. deep
processing during the encoding phase. Again, level of processing was shown to influence only those responses that required contextual retrieval of the prior study episode. In contrast, “know” or familiarity-based responses, which do not involve such retrieval, are enhanced by factors that increase the fluency of processing. For example, words which were preceded by a conceptual associate (Rajaram & Geraci, 2000) or a masked prime that was either a match or mismatch of the word (Rajaram, 1993) were shown to selectively increase the proportion of know responses.

Early studies investigating the ERP old/new effect debated the contributions of these two states of awareness to the late positive difference observed between old and new words in recognition memory tests. Rugg and Doyle (1992) observed that while correctly-classified low-frequency words evoked old/new differences, these were not evident for high-frequency words. Although this finding has not been universally replicated (see, for example, Paller & Kutas, 1992; Sanquist et al., 1980), it was taken as evidence that the late positive effect was sensitive to the item's relative familiarity – repetition of a word increases the fluency with which it is identified, and this increase is relatively greater for low- than for high-frequency words. Rugg and Doyle therefore concluded that old/new effects reflect processes associated with the familiarity of a word, rather than conscious recollection of its prior occurrence.

An alternative explanation was suggested by Paller and Kutas (1992) however, who reported that words studied in an imaginal task elicited larger old/new effects than words studied orthographically. Following a "levels of processing" approach, the authors assumed that words from the imagery task were processed more deeply in the study phase than were the words presented in the orthographic task, and were therefore more likely to be
recognised at test. They thus argued that the difference between old and new words could be regarded as an "ERP signature" for the conscious awareness that an item has recently been experienced and therefore reflected recollective processes.

This proposal gained further support from a study by Smith (1993), which asked participants to discriminate between old and new words, and also to differentiate between words that were merely familiar and words that they actually remembered seeing at study. Old words that were accompanied by conscious recollection of information from the study phase elicited more-positive ERPs than words that, although judged familiar, were not accompanied by conscious recollection of the study episode.

In a more direct test of this hypothesis, Wilding, Doyle and Rugg (1995) presented study phase items either auditorily or visually. In the test phase, subjects were asked to discriminate old from new words, and for those words classified as old, to then judge in which modality the words had been presented at study. They observed that ERPs associated with old words correctly assigned to the study modality were more positive than ERPs to correctly-classified new words. In addition, old words correctly identified as old but assigned to the wrong study modality evoked ERPs barely distinguishable from those to new items. Since the old/new effect was only evident for old words that were accompanied by memory for the context in which they were initially presented, these findings strongly suggest that the parietal old/new effect is associated with processes underlying the recollective rather than familiarity component of recognition memory.
3.2.3 Late right frontal effect

These more recent studies involving source judgements revealed the presence of another positive ERP old/new effect. This effect also emerged approximately 400-500 ms post-stimulus but was maximal over frontal scalp sites where it exhibited a right-greater-than-left asymmetry (Mark & Rugg, 1998; Wilding & Rugg, 1996). It was also longer lasting than the parietal effect, persisting for a second or more. Since this effect was also larger for those words which were correctly rather than incorrectly assigned to source (Wilding et al., 1995; Wilding & Rugg, 1996), it too was taken to reflect processes associated with recollection. However, unlike the parietal effect, the emergence of the frontal old/new effect did not depend on successful retrieval of contextual information. In the Wilding and Rugg (1996) experiment, study phase words were presented in two different voices. Subjects were required to respond "old" to words spoken in the same voice as they were in the study phase (targets), but "new" to previously studied words spoken in the other voice (non-targets), as well as to genuinely new words. As expected, a parietal old/new effect was observed for both targets and non-targets, since both judgements involved retrieval of source information. However, the frontal old/new effect was only evident for targets.

These findings of task dissociation and differences in duration and topography led to the proposal that the frontal and parietal old/new effects reflect functionally and neuroanatomically distinct processes (Mark & Rugg, 1998; Wilding & Rugg, 1996, 1997). The parietal effect is thought to reflect hippocampally-mediated retrieval of information of the encoded event from long-term memory. The less obligatory nature and frontal topography of the second effect suggests it may reflect strategic cognitive functions. Mark and Rugg (1998) state that based on studies to date, the frontal old/new effect is likely to
reflect "the engagement of operations that act on the products of retrieval, integrating these into a representation capable of serving goal-directed behaviour" (p. 871).

3.2.4 Frontal old/new effect

Recent studies of recognition memory have reported a further old/new difference that precedes the parietal old/new effect. This effect is maximal over frontal regions, often with a left-greater-than-right asymmetry. Its coincidence with a negative component maximal over frontal sites and with a peak latency of around 400 ms has led to it being dubbed the “frontal N400 effect” (Curran, 1999, 2000; Curran, Schacter, Johnson, & Spinks, 2001).

A number of these studies (e.g. Curran, 1999, 2000; Curran et al., 2001; Mecklinger, 2000; Rugg, Mark et al., 1998) have provided evidence that suggests that this subcomponent of the old/new effect reflects the contribution of familiarity to the recognition process. Curran (1999) for example, reported that this effect was similar for words and pseudowords, but that the parietal old/new effect was enhanced in response to words only. This was interpreted as reflecting early recognition of both words and pseudowords via generalised feelings of knowing (familiarity), with later more-detailed remembering (recollection) restricted to the word stimuli. In a more direct investigation of the role of the frontal old/new effect (Curran, 2000), singular and plural words were shown in a study phase, followed by a test phase consisting of 20 previously-studied and 20 new words, along with 20 words whose plurality was reversed between the study and test lists (“similar” words). Participants were asked to respond “yes” for studied words, and “no” for similar and new words. Curran reported that compared to correctly-identified new words, waveforms elicited in response to old and similar words were more positive, and
were identical to one another. This was interpreted as reflecting familiarity-based recognition, as both previously-studied and similar words would be more familiar than words presented for the first time.

While not all researchers support these interpretations of the functional significance of the early frontal old/new effect (e.g. Finnigan, Humphreys, Dennis, & Geffen, 2002; Toth, 1996; Yonelinas, Kroll, Dobbins, & Lazzara, 1998), there appears to be fairly widespread acceptance that this effect reflects processes underlying familiarity-based judgments.

3.3 SUMMARY OF PREVIOUS CHAPTERS

Malingering imposes significant social and economic costs on society, with a surprisingly large number of people thought to be feigning impairment or exaggerating the severity of their symptoms. Of these, the feigning or exaggeration of impaired memory is considered to be that most commonly encountered by clinicians. Despite the increasing amount of research devoted to detecting malingering of memory disorders, there is general agreement that no single test or strategy is able to accurately identify individuals feigning impairment. In addition, information readily available to potential malingerers regarding the neuropsychological evaluation has led to increased sophistication and the ability to modify performance to avoid detection. As a result, investigators suggest the need for traditional testing procedures to interface with more specialised measures, which may be less susceptible to coaching.

One such technique has been to utilise ERPs as a more direct and covert measure of brain activity and cognitive function. Studies using the P3 component have shown potential for detecting simulated memory impairment, particularly for autobiographical memory.
However, the sensitivity of the component to a wide range of variables not directly related to memory appears to limit its utility. The old/new effect, on the other hand, is an ERP effect thought to more directly reflect processes underlying recognition memory. In particular, the parietal subcomponent of the effect has been shown to reflect processes underlying the conscious retrieval from memory of an item and the context in which it was recently experienced. Unlike the P3 component, the old/new effect is not dependent on subjective probability, targetness or confidence, nor is there the concern that it may be elicited in the absence of conscious awareness. Rather, the evidence suggests that conscious awareness is essential for the elicitation of the parietal old/new effect (Rugg, 1995). Such a measure has obvious potential for the detection of those feigning a recognition memory disorder, with the presence of the old/new effect in the waveform of an individual signalling conscious recollection of the newly-learned information despite behavioural denial of this recognition. The first study in this thesis was therefore an investigation into the utility of the old/new effect as an index of feigned memory impairment.

While the ultimate goal for those involved in malingering research is to discriminate actual or “clinical” malingerers from those with genuine deficits, the contrast groups used in the studies in this thesis were simulating malingerers and normal controls. These groups were chosen in line with recommendations for the early stages of test development (Bianchini et al., 2001), since real or suspected malingerers are largely inaccessible, and it is difficult to obtain a relatively homogenous sample of genuinely impaired individuals in the numbers required for initial test development and assessment. In addition, real or suspected malingerers typically do not admit to non-optimal effort, further complicating any assessment of the effectiveness of a new test or measure.
Following the recommendations for future malingering research (Trueblood, 1994; Williams, 1998), and for ERP studies of specific cognitive processes (Connolly & D'Arcy, 2000; Connolly, Major, Allen, & D'Arcy, 1999), this study utilised a standardised test commonly used in neuropsychological practice – the Warrington Recognition Memory Test. While this test comprises two subtests, recognition of words and recognition of faces, only the Words subtest was used, since prior research using this measure in the detection of malingering demonstrated redundancy of the Faces subtest (Millis, 1994).

The primary hypotheses of this first study was that while participants instructed to feign impairment would perform poorly on the memory test, their parietal old/new differences would be equivalent to those of an honest control group, thus signalling actual recognition of the previously-seen words.
CHAPTER 4. STUDY 1 – DETECTION OF FEIGNED MEMORY IMPAIRMENT USING THE ERP OLD/NEW EFFECT

4.1 INTRODUCTION

The malingering of cognitive deficits appears surprisingly common, with suggestions that 33-60% of patients seen in neuropsychology clinics may be fabricating or exaggerating their disorder (Haines & Norris, 1995; Rogers, 1997). To date, efforts to detect malingerers have focused on neuropsychological test performance. Such tests can only measure cognitive functions indirectly however, and there are growing concerns that malingerers are being coached as to how to present a particular neuropsychological profile, thereby avoiding detection (Lees-Haley, 1992). Rose et al. (1995) demonstrated the dramatic effect of coaching in a study in which test performance enabled correct identification of 86% of uncoached subjects, but only 47% of coached malingerers.

In an attempt to provide a more objective and direct measure of malingered recognition memory, Rosenfeld and colleagues have conducted a series of studies using the properties of the P3 component of the event-related potential (ERP) as an involuntary adjunct to behavioural test performance. Subjects were presented with infrequently occurring, personally relevant or otherwise meaningful stimuli (Rosenfeld et al., 1995; Rosenfeld et al.,

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2 This study has been published as: Tardif, H.P., Barry, R.J., Fox, A.M. and Johnstone, S. J. (2000). Detection of feigned recognition memory impairment using the old/new effect of the event-related potential. International Journal of Psychophysiology, 36, 1-9. The helpful comments of two anonymous referees on a previous version of the article are acknowledged.
1998; Rosenfeld et al., 1996), interspersed with similar but irrelevant material. Since P3 is elicited in response to meaningful stimuli (Johnson, 1988), it was reasoned that while those simulating amnesia may deny recognition of the material, an enhanced P3 would provide independent verification that the simulators had, in fact, recognised the stimuli as being relevant.

Using this technique, Rosenfeld et al. (1995) identified up to 92% of those simulating amnesia for autobiographical information. However, when applied to the more common complaint of anterograde amnesia, and using a forced-choice test format, the P3 technique was considerably less accurate. Up to 70% of subjects feigning recognition memory impairment for numeric stimuli were detected (Rosenfeld et al., 1998; Rosenfeld et al., 1996), decreasing to 50% for newly learned words (Ellwanger et al., 1996).

The limited detection accuracy may stem from the choice of P3 as the sole index of simulated impairment of recognition memory. Clearly, the larger P3 elicited following presentation of rare, meaningful stimuli suggests an ability to recognise the items. However, it is well established that P3 is modulated by a number of other psychological variables, including confidence in decision making, the decision making process itself, difficulty, attention and the presence of a secondary task (Andreassi, 1995). It may therefore be difficult to adequately control these variables in order to allow a confident conclusion that a discrepancy between an individual’s averaged P3 amplitude and behavioural response is due to an intention to deceive.

An ERP measure commonly investigated in studies of recognition memory is the “old/new effect”. Recognition memory test paradigms typically involve discrimination between “old” (previously studied) and “new” (unstudied) items. The well-established
finding is that items correctly classified as old generate a more positive-going ERP relative to items correctly judged new, or old items incorrectly classified as new (e.g. Rugg & Doyle, 1992; Smith & Guster, 1993). The old/new difference typically begins about 300-500 ms post stimulus and is broadly distributed over the scalp. Since the effect is not evident for unrecognised words or new words, it has been proposed that it indexes processes underlying recognition memory (Rugg, Cox, Doyle, & Wells, 1995).

The present study aimed to use the old/new ERP effect to validate test performance in a group of controls and simulating malingerers on the Recognition Memory Test (RMT) (Warrington, 1984). The RMT is a standardised and commonly used neuropsychological test that employs a forced-choice format and involves distinguishing previously-studied words from new words.

While simulators instructed to feign a recognition memory deficit were expected to perform poorly on the RMT relative to the control group, it was predicted that the old/new word ERP differences would be equivalent in the two groups. This would indicate equivalent recognition memory ability in the malingerers, despite test performance that might suggest otherwise.

4.2 METHODS

4.2.1 Participants

Twenty-five undergraduate students enrolled in an introductory Psychology course participated in exchange for partial course credit. One subject was discarded from the final analysis due to excessive EOG artefact. Data from 12 subjects in each group were therefore
analysed. The control group (mean age 23.7, S.D.=6.3) contained 10 females, and the malingering group (mean age 22.7, S.D.=1.73) 8 females. There was no significant difference in age between the groups ($t=0.29, p=0.78$).

4.2.2 Stimuli

Stimuli consisted of items from the Words subtest of the Warrington Recognition Memory Test. This test consists of one hundred words, fifty of which are shown in the study phase (“old” words) and presented again in the test phase, interspersed with 50 new words. The Warrington test presents the words on cards, and in the test phase shows word pairs side by side, with subjects instructed to indicate which of the words had been previously seen. In order to ensure that the diagnostic advantages of using a standardised neuropsychological test were maintained, standard administration of the RMT was followed as closely as possible. However, to enable the recording of the EEG time-locked to presentation and subsequent processing of individual stimuli, certain procedural modifications were required. Words were thus presented on a computer screen one at a time, and after viewing both, participants responded using a button press to indicate which had been presented previously. These words appeared centrally on a computer screen in white letters on a black background. Letters were 1 cm high and 0.5 cm wide. Maximum visual angles subtended were 0.64° (vertical) and 0.32° (horizontal). Words were 3-6 letters in length. A 486 40 MHz IBM-compatible computer controlled stimulus presentation.
4.2.3 Electrophysiological Recording

EEG was recorded using an electrode cap (Electro-cap International) from midline (Fz, Cz, Pz) and lateral scalp sites (F3, F4, C3, C4, P3, P4) referenced to linked ears. Horizontal EOG was recorded from tin electrodes placed beyond the outer canthus of each eye and vertical EOG from electrodes 1 cm above and below the left eye. EOG electrode impedance was kept below 5 kΩ, and cap electrodes below 3 kΩ. Trials where EOG exceeded 100 µV were excluded prior to averaging.

Data were amplified with an EEG and EOG gain of 20,000 and 5,000 respectively, with a time constant of 5 sec, and digitised at a sampling rate of 256 Hz. The ERP epoch length was 1000 ms, adjusted around a 100 ms pre-stimulus baseline.

4.2.4 Procedure

Prior to testing, all subjects were informed that they were to take part in a recognition memory test while ERPs were recorded. Twelve participants were randomly assigned to the control group and encouraged to complete the task to the best of their abilities (see Appendix A). The remaining twelve were assigned to the malingering group and given instructions to feign an accident-related memory deficit (see Appendix B). These instructions were based on the “sophisticated” malingering instructions used by Rosenfeld et al. (1995), which ask participants to feign accident-related memory loss. Information regarding the type and severity of deficits accompanying such an injury was also provided, in order to encourage participants to present a believable deficit. In this and all following
studies, subjects gave written informed consent to participate in the study, which had been approved by the University of Wollongong Human Research Ethics Committee.

Participants were comfortably seated in an upright position 100 cm from a computer screen on which the words were shown. Each study trial commenced with the presentation of a fixation cross in the centre of the screen. Words in the study phase were presented for 500 ms, with a stimulus onset asynchrony (SOA) of 2.5 s. Subjects were asked to remain fixated on the cross, and to make a covert (i.e. subvocal) judgement as to whether each word was pleasant or unpleasant, as in the standardised test format.

The study phase was followed by a test phase in which participants’ recognition of the previously-studied words was assessed. A fixation cross appeared prior to each trial in the test phase. Each trial presented a pair of words, shown individually for 500 ms and separated by an interval of 1000 ms. One word in each pair had been presented in the study phase and the other had not; old/new word order was randomised for each trial. The second word of each pair was immediately followed by a question mark, prompting the subject to indicate via a two-button response-box which of the two words had been seen before, by pressing the button labelled “1” if it was the first word of the pair, or “2” if it was the second. ERPs for each word type were derived from each word in the test phase. Participants were given 2.5 s to respond, and all responses made within this period were included in further analyses.

Studies involving old/new effects typically compare ERPs associated with correctly-recognised old words and new words, with ERPs to incorrectly identified words removed, or analysed separately. In this study however, instructions given to malingerers to feign a deficit made it impossible to determine whether malingering strategies or recognition
failure were responsible for incorrect identifications. Therefore, to enable meaningful comparison of the two groups, the ERPs to words were separated according to their old/new status only.

4.3 RESULTS

4.3.1 Behavioural data

As predicted, the malingering group performed poorly on the RMT (mean 24.6, S.D.=6.3) relative to the control group (mean 42.2, S.D.=4.8), \( t=6.28, \ p<0.0001 \). Of additional interest was comparison of test performance on the computerised RMT relative to performance on the standard version. Table 4-1 compares the scores obtained by subjects in the present study with those obtained in previous studies utilising the standard RMT.

<table>
<thead>
<tr>
<th>The present study</th>
<th>RMT standardisation age-matched sample (Warrington, 1984)</th>
<th>Suspected malingerers (Millis, 1994)</th>
<th>Simulating malingerers (Iverson &amp; Franzen, 1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls</td>
<td>42.2 (4.8)</td>
<td>46.4 (3.5)</td>
<td>24.0 (6.4)</td>
</tr>
<tr>
<td>Malingerers</td>
<td>24.6 (8.4)</td>
<td></td>
<td>24.4 (6.5)</td>
</tr>
</tbody>
</table>

T-tests indicated that the control group’s score in the present study was significantly lower than the mean score of an age-matched group in the RMT standardisation sample \( (t=3.05, \ p<0.05) \). However, the malingeringer’s scores were equivalent to Iverson and Franzen’s (1994) student experimental malingerers \( (t=0.07, \ p=0.94) \). Of additional interest
is the similarity in test scores of the malingers in the present study and Millis’s (1994) suspected malingers ($t=0.24, p=0.82$), indicating performance consistent with that seen in clinical populations.

4.3.2 Electrophysiological data

The grand average ERP waveforms elicited following presentation of old and new words during the test phase for the control and malingering group are shown in Figure 4-1. Consistent with previous research, the waveforms of the control group show a broadly distributed enhanced positivity to old relative to new words, commencing at approximately 450 ms and continuing to the end of the recording epoch. Waveforms for the malingering group also show a broadly-distributed old/new effect, however the onset of the effect appears to emerge earlier, particularly over left and frontal sites.

These effects were quantified by computing the average voltage at each electrode site across two time windows: 0-450 and 450-900 ms post-stimulus onset. The period 450-900 ms was chosen as old/new differences emerged in the control group during this time window and appeared consistent with the old/new effect typically reported in recognition memory paradigms. Examination of the earlier epoch (0-450 ms) allowed further elucidation of the apparent group differences in the onset of old/new word differences.

The data were submitted to a mixed design repeated measures ANOVA, with word (old, new), lateral plane (left, midline and right) and sagittal plane (frontal, central and parietal) as repeated measures, and group (control, malingerer) as a between-subject factor.
Figure 4-1. Grand average ERP waveforms for the control and malingering groups
Planned contrasts within the lateral plane compared the left vs. right regions and the midline vs. the mean of the right and left sites. Within the sagittal plane, frontal vs. parietal regions and central sites vs. the mean of the frontal and parietal sites were compared. These planned contrasts allowed optimal clarification of site effects in the regions examined. As the contrasts were planned and there were no more of them than the degrees of freedom for effect, no Bonferroni-type adjustment to $\alpha$ was necessary (Tabachnick & Fidell, 1989). In addition, Greenhouse-Geisser type corrections were not required since the single degree of freedom contrasts are not affected by violations of symmetry assumptions common in repeated measures analyses. All F tests have (1,22) degrees of freedom.

4.3.2.1 450-900 ms time window

A comparison of the two groups over this time window showed an overall group effect ($F=6.79$, $p<0.05$) with the malingerers exhibiting waveforms that were more negative relative to the control group. A significant lateral effect ($F=23.2$, $p<0.001$) indicated that the mean amplitude of the waveforms was more positive over the right than the left hemisphere, and that the mean of these two regions exceeded the activity at the midline ($F=17.8$, $p<0.001$). These lateral differences were consistent across groups. In both groups, ERP amplitude was more positive at parietal vs. frontal sites ($F=19.0$, $p<0.001$).

The amplitude of the ERPs elicited to old words differed from those elicited to new words ($F=15.4$, $p<0.005$) in the 450-900 ms time-window. This old/new effect was equivalent in both the malingering and control groups ($F=2.49$, $p=0.129$). Group differences in old vs. new word ERPs within the lateral factor approached significance ($F=3.9$, $p=0.06$), indicating a tendency toward an increased old/new effect in the malingerers over the left hemisphere relative to that observed in the control group.
4.3.2.2 0-450 ms time window

In both groups, mean amplitude was more positive over the left than right hemisphere ($F=11.5$, $p<0.005$), with the mean of these regions exceeding the amplitude over the midline sites ($F=9.97$, $p<0.01$). Within the sagittal factor, amplitude at parietal sites was greater than that at frontal sites ($F=10.2$, $p<0.005$).

Significant group differences in old word vs. new word ERPs were observed within the lateral factor ($F=12.9$, $p<0.005$), indicating that the old/new effect in the malingerers was increased relative to the control group over the left hemisphere. Old/new word differences within the sagittal factor approached significance ($F=3.7$, $p=0.067$), suggesting a tendency toward increased old/new word differences at frontal relative to parietal sites. This tendency did not differ between the groups.

The above analysis, along with visual inspection of the ERP waveforms, suggests group differences at left frontal sites. Follow-up statistical analyses were conducted to further explore these early differences. Old/new word differences at left frontal sites (Fz/F3) and over the remainder of the scalp were calculated for each subject. After applying a Bonferroni adjustment, t-tests revealed that the amplitude of the old/new effect at left frontal sites was greater in the malingering relative to the control group (1.90 vs. 0.03 µV: $t=2.45$, $p<0.025$), but that the two groups did not differ over the remainder of the scalp ($t=0.74$, $p=0.467$).
4.4 DISCUSSION

As expected, the malingering group performed poorly on the RMT, relative to an honestly-responding control group. Electrophysiological data revealed that in the control group, old/new word differences emerged at about 450 ms post stimulus onset and continued to the end of the recording epoch. The onset latency, duration and broad distribution of this effect is consistent with the old/new effect described previously (e.g. Paller & Kutas, 1992; Smith & Guster, 1993). While the amplitude of the effect is typically maximal over left parietal sites (Mark & Rugg, 1998; Rugg & Doyle, 1992), significant differences over the hemispheres were not observed for the control group in the present study. As mentioned previously, most studies of old/new word differences compare ERPs elicited to correctly identified old and new items. The logic behind the present study however, meant that words were separated only according their old/new status, irrespective of whether they were correctly or incorrectly identified. The inclusion of incorrectly identified words in the ERP waveforms may have contributed to the failure to observe the typical left-greater-than-right asymmetry over parietal sites.

The first major finding of the present study was that, despite behavioural differences, the magnitude and topography of this old/new effect was equivalent in both the malingering and control group. Thus, while the malingerers in the present study performed poorly on the RMT, they exhibited an old/new effect that did not differ from the honestly-responding control group. Despite test performances suggesting severe memory impairment, the equivalent old/new effect in the malingering group’s ERP waveforms provides independent evidence that they were, in fact, able to recognise the previously-processed material.
The second major finding was the existence of a second old/new effect restricted to the waveforms of the malingerers, which has not previously been reported in studies of simulated memory disorders. This was largest over F3 and Fz scalp sites, and appeared to emerge as early as 100 ms post stimulus onset.

Other researchers have reported old/new effects maximal at frontal sites. In a study of associative retrieval of words from memory, Tendolkar, Doyle and Rugg (1997) observed a left frontal effect that preceded the traditional old/new effect by 100-200 ms. This was interpreted as indicating a role for the prefrontal cortex in episodic memory retrieval processes. Other studies in which subjects were required to distinguish old from new words, and also to report the context in which they were presented at study, have reported right frontal and midline frontal old/new effects, which appear at around the same time as the traditional effect (Mark & Rugg, 1998; Wilding & Rugg, 1996, 1997). It has been proposed that the frontal and traditional old/new effects reflect functionally and neuroanatomically distinct processes, with the former possibly signalling “more strategic, or task dependent, aspects of processing” (Wilding & Rugg, 1997, p.1186).³

Given the well-established relationship between the frontal lobe and strategic cognitive functions, it may be that, relative to the control group, the malingerers engaged a greater range or degree of strategic cognitive functions, not necessarily related to retrieval, resulting

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³ As outlined in Chapter 3 of this thesis, studies have identified a frontally-distributed old/new effect, which has been linked to the familiarity component of recognition memory. However, at the time at which this chapter was written, this link had not been established, and therefore the group differences were not explained in terms of differential engagement of such processes. Even so, the early frontal effect described by others (e.g. Curran, 1999, 2000) onsets around 300 ms following the stimulus, whereas the effect in the present study is evident from around 100 ms post stimulus.
in differential processing of the old words and the earlier emergence of the old/new effect at left frontal sites. This explanation is consistent with suggestions that the task of malingering requires more complex, or additional, cognitive activity (Haines & Norris, 1995; Rose et al., 1998; Rosenfeld et al., 1998). Evidence of these differing or additional requirements in the ERPs of malingerers may have potential as a further index of deceptive responding. Future research with a larger group of participants and an analysis of individual subject data is necessary to determine whether this ERP effect will enable identification of the individual malingering.

The old/new effect appears to have a number of advantages over ERP detection strategies utilising the P3 component. As discussed previously, the old/new effect is considered to directly reflect processes underlying recognition memory. In contrast, P3 amplitude is sensitive to a number of variables. Rosenfeld et al. (1996) note that the success of the P3 detection method relies heavily on the oddball format – previously learned material must appear infrequently relative to new material, with the authors recommending that 150 total trials are required to obtain the necessary data. In practice, the addition of such a test may be unwelcome in what is often an already lengthy neuropsychological examination, and be of considerable difficulty for the genuinely impaired. The old/new effect, in contrast, is not influenced by targetness or probability manipulations (Smith & Guster, 1993), enabling utilisation of existing neuropsychological tests, such as the RMT, without the need for substantial modification.

In addition, Rosenfeld et al. (1995) suggest caution in the use of P3 evidence, due to the possibility that P3 and conscious awareness could become dissociated. The old/new effect, in comparison, is associated with the conscious retrieval of an item from memory.
According to Rugg (1995), “the evidence points strongly to the conclusion that a necessary, if not a sufficient, condition of the emergence of late ERP old/new effects is awareness that an item has recently been experienced” (p.165).

Also of interest were comparisons between performance on the computerised version of the RMT and the standardised version. Connolly and colleagues have computer-modified a number of standardised neuropsychological tests to enable the recording of electrophysiological data (for a review of these studies, see Connolly & D'Arcy, 2000), and note that this modification should not alter behavioural performance associated with the standard version. In the present study, the control group obtained lower scores relative to an age-matched group in the test's standardisation sample. However, examination of individual results revealed that one of the controls obtained a score of only 29 – removal of this score led to comparable performances ($t=1.35, p>0.05$). More recently, the computerised RMT was administered to a larger control group (n=16) without recording ERPs (Fox, Shores, & Tardif, 2000). In that study, the control group obtained scores (M=47.2, S.D.=4.1) that did not differ from those reported by Warrington (1984) in an age-matched sample ($t=0.78, p>0.05$), suggesting that the computerisation of the test, necessary for the recording of psychophysiological measures, did not alter behavioural response.

Additional support for the relationship between the two tests was seen in the similar performances of the simulators in the present study and that of experimental (Iverson & Franzen, 1994) and suspected (Millis, 1994) malingers in previous research. Similarly positive correlations between scores on the standard Hiscock forced-choice procedure and a computerised version were reported by Rosenfeld et al. (1996), and taken to indicate that both tests were identifying the same simulating behaviour.
In summary, the results of the present study indicate that the ERP old/new effect has potential as an objective measure to detect feigned recognition memory impairment on a standardised neuropsychological test. The inability to suppress an electrophysiological response signalling recognition of newly-learned material, coupled with poor test results, warrants suspicion of the validity of a subject’s behavioural performance. In addition, the early old/new differences evident only in the waveforms of the malingering group may have additional potential for the electrophysiological identification of those feigning a recognition memory deficit.
CHAPTER 5. STUDY 2 – AN INVESTIGATION OF ERPS IN SIMULATED AMNESIA: A WITHIN-SUBJECT STUDY

5.1 INTRODUCTION

An increasing range of methods to detect feigned memory impairment has been investigated recently. The majority of these use scores on existing neuropsychological and specifically-designed tests to screen for non-optimal performance. However, test scores have been shown to be highly sensitive to coaching strategies, which provide participants with information on how to present a believable deficit and thus avoid detection (Gunstad & Suhr, 2001; Lamb et al., 1994; Orr & Pitman, 1993; Rose et al., 1998; Suhr & Gunstad, 2000; Youngjohn, Lees-Haley, & Binder, 1999). As a result, an increasing number of researchers are now investigating other, more covert, measures to distinguish honest from feigned performance. For example, significant differences in overall response latency have been reported between malingering, control and head-injured groups, but not between coached and uncoached malingerers (Rose et al., 1998). Other studies have suggested the value of event-related potentials (ERPs) as a means of detecting feigned deficits. These studies have predominantly focussed on the P3 component of the ERP, and have demonstrated equivalent recognition of target stimuli in control and malingering subjects,

4 This study has been published as: Tardif, H.P., Barry, R.J. and Johnstone, S.J. (2002). Event-related potentials reveal processing differences in honest versus malingered memory performance. International Journal of Psychophysiology, 46,147-158. The helpful comments of two anonymous referees on a previous version of the article are acknowledged.
despite reduced test performance in the malingerers suggestive of memory loss (e.g. Ellwanger, Tenula, Rosenfeld, & Sweet, 1999; Rosenfeld et al., 1995; Rosenfeld et al., 1998).

The previous study in this thesis reported that another ERP measure, the old/new effect, may also be useful in the detection of those simulating memory deficits. The old/new effect refers to the more-positive waveform elicited in response to previously-encountered (“old”) items relative to that associated with “new” items. Studies have shown that this effect consists of a number of subcomponents reflecting functionally-distinct processes involved in the recognition of previously-studied items. For example, an old/new effect predominant over parietal scalp sites evident around 500-800 ms following stimulus onset is thought to reflect conscious recollection of an item and the context in which it was seen (Curran, 1999, 2000; Wilding, 2000). Study 1 in this thesis demonstrated that a similar effect did not differ in size or topography between subjects feigning a deficit or responding honestly, indicating actual recognition in the simulating subjects despite poor test performance. In addition, and unexpectedly, an early old/new effect confined to the waveforms of the simulators was also observed, evident in the 0-450 ms period following stimulus onset. This was interpreted as reflecting the more complex, or additional, processing required in the simulating task. This early effect does not appear to have been previously reported in studies of feigned impairment. One of the major aims of the present study, therefore, was to replicate the results of the previous work and demonstrate the reliability of this early malingering effect.

The predominant focus of malingering research over the last decade has been on the use of Symptom Validity Tests (SVTs) – a range of tests which present stimuli in a forced-choice format (for a review, see Bianchini et al., 2001). Consistent with this line of
research, the previous study presented words in pairs, with subjects discriminating previously-studied words from distractor items. In contrast, ERP studies of recognition memory typically require that subjects make recognition judgements for each word presented in the test phase, in either a “yes-no” (e.g. Rugg, Schloerscheidt, & Mark, 1998; Wilding, 2000) or “continuous” (e.g. Berman et al., 1991; Dietrich et al., 2001) format. Despite the widespread use of forced-choice tests in behavioural studies of recognition memory (e.g. Aggleton & Shaw, 1996; Keane, Verfaellie, Gabrieli, & Wong, 2000) and simulated impairment, there do not appear to be any studies examining the electrophysiological correlates of recognition memory in this paradigm, and how these may differ from those typically reported in the yes-no and continuous formats. For example, an anonymous reviewer of the previous study speculated that the forced-choice format might permit differential processing of each word in the pair – presentation of the first word may be sufficient to make an old/new judgement, thus reducing the need to attend to the second word. Further, attention to, or analysis of, the second word might differ between the control and malingering groups. A further aim of the present study, therefore, was to address these issues with a more-detailed analysis of the electrophysiological response than was used in the previous study. This involved using a principal component analysis (PCA) to define the components underlying the ERP waveform, and separating ERPs to words not only as a function of their old/new status, but also according to whether they were presented as the first or second word in the pair. This allowed investigation of differential processing of the stimuli as a function of presentation order and to compare this in honestly-responding and simulated-impairment conditions.
The present study also utilised a within-subject design in order to provide confirmatory evidence that any differences between the control and malingering conditions were task-rather than subject-related.

5.2 MATERIALS AND METHODS

5.2.1 Participants

Twenty-two undergraduate students from the University of Wollongong participated in the study as one means of satisfying a course requirement. Three subjects were discarded from the final analysis – one due to equipment problems, one with insufficient artefact-free trials, and another who failed to adhere to task instructions (see comments in the Procedure section). The average age of the remaining 19 subjects (16 females) was 26.4 years (S.D.=8.9 years).

5.2.2 Stimuli

Stimuli were two blocks of 100 words each. The first block consisted of the items from the Words subtest of the Warrington Recognition Memory Test (Warrington, 1984). Block 2 contained words matched for length (3-6 letters) and frequency (mean 130 occurrences per million) to the Warrington test words, chosen from the Kucera and Francis (1967) corpus. For each block, 50 words were shown in the study phase, and presented again in the test phase, paired with a word new to the experiment. Words were presented centrally on a computer screen in white letters on a black background. Letters were 1 cm high and 0.5 cm
wide, with maximum visual angles subtended being 0.64° (vertical) and 0.32° (horizontal). A 486 40 MHz IBM-compatible computer controlled stimulus presentation.

5.2.3 Electrophysiological Recording

The procedure for recording the electrophysiological data was identical to that outlined in Study 1 (Section 4.2.3), with the exception that the EEG was recorded from 17 scalp locations. However, to facilitate clarity of presentation and comparability with data from Study 1, only data from nine sites (Fz, Cz, Pz, F3, C3, P3, F4, C4, P4) were analysed in this and all subsequent studies. These sites adequately cover all peaks of interest in this thesis, and reflect common usage in the field.

5.2.4 Procedure

The task was identical to that of the previous study (outlined in Section 4.2.4) with the exception that participants in the present study were instructed to respond as quickly as possible during the test phase. ERP studies typically include such instructions to ensure responses are made within the epoch time-locked to the onset of the stimuli. Therefore, while the standard administration of the Warrington RMT is not paced during the test phase, instructions to respond as quickly as possible were included in this and all following studies in order to maximise the number of trials in the analysis.

Each subject completed one block of the experiment as a control subject, and the other after being given instructions to feign accident-related memory loss (see Appendix A and B). These instructions were again based on the “sophisticated” malingering instructions used by Rosenfeld et al. (1995) and included information regarding symptoms typical of
such impairment in order to encourage subjects to produce a believable deficit. Block order was counterbalanced over subjects and conditions. Subjects completing the first block as controls were unaware that they would be asked later to simulate impairment. These subjects were simply asked to perform Block 1 to the best of their abilities, and were informed of the malingering task prior to beginning Block 2. The remaining subjects were given malingering instructions prior to Block 1, and then prior to Block 2, were encouraged to perform to the best of their ability.

After completing both blocks, participants were questioned regarding their compliance with the malingering instructions, and the strategies used to simulate impairment. One participant failed to follow instructions, reporting that he did not look at the words, only responded infrequently and randomly, and sang to himself during the study and test phases. This subject’s data were therefore excluded from analysis.

5.2.5 Data analysis

Reaction time data were analysed using a repeated-measures ANOVA, with Condition (control vs. malingering), and Response Accuracy (correct vs. incorrect) as factors. To investigate any effects arising from counterbalancing the malingering and control conditions, Counterbalance Order (control condition first vs. control condition second) was included as a between-subject factor.

ERP studies of recognition memory typically separate correct from incorrect responses. In this and the previous study however, correct and incorrect responses were analysed together, for the following reasons. The task of feigning impairment requires subjects to knowingly provide incorrect responses on a proportion of trials. It is therefore impossible to
determine whether incorrect responses are due to malingering strategies, or to genuine recognition failure. For example, in the present study, test scores indicated that participants in the control condition failed to recognise approximately 10% of the previously-studied words. It seems reasonable to assume that, along with intentional provision of incorrect responses, a similar percentage of old words was also genuinely not recognised in the malingering condition. While it is acknowledged that inclusion of incorrect responses is not standard technique, removal of such trials from one condition but not the other may present difficulties in terms of group or task comparisons in studies of feigned impairment. Having said this however, performance level in the control condition in the present study was relatively high, suggesting a small number of genuine recognition failures that would be expected to have only limited influence on the overall waveforms. As a check on this assumption, control condition waveforms including all responses were compared to those excluding incorrect responses. This analysis revealed a significant large correlation between the two data sets ($r=0.985$, $p<0.0001$).

Initial analysis of the ERP data was conducted over two broad time windows as in the previous study, using a repeated-measures ANOVA with Word (old, new), Condition (control, malingering), Lateral (left, midline, right) and Sagittal plane (frontal, central, parietal) as the factors. A more detailed analysis of the components underlying these broad effects, including the effects of word order, was then carried out using Principal Components Analysis (PCA) to define the components. This was performed on the covariance matrix, with a Varimax rotation. Cases in the analysis consisted of the conditions (2), word type (2), order of word presentation (2), electrode sites (9) and subjects (19). The variables were 128 time points, obtained by averaging every two sequential data
points in the original 1000 ms (256 time point) epoch. The factor loadings were used to identify non-overlapping epochs which best represented the extracted components. Separate ANOVAs were conducted on mean amplitudes from each of these PCA-defined epochs with Word (old, new), Word Order (first, second), Condition (control, malingering), Lateral (left, midline, right) and Sagittal plane (frontal, central, parietal) as within-subject factors, and Counterbalance Order (control first, control second) as a between-subject factor.

In all ERP analyses in this and the following studies, interactions involving the factors of Word, Condition and Order with topography are reported only if they remained significant after normalisation based on the vector-scaling procedure (McCarthy & Wood, 1985). Planned contrasts were identical to those carried out in the previous study (outlined in Section 4.3.2). As before, since the contrasts were planned and there were no more of them than the degrees of freedom for effect, no Bonferroni-type adjustments to $\alpha$ were necessary (Tabachnick & Fidell, 1989), except where complex interactions of the factors with topography necessitated subsidiary analyses. All F tests have (1, 18) degrees of freedom.

A direct discriminant function analysis was performed using significant group differences revealed in the above analyses as predictors of honest vs. feigned performance.

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5 PCA is most reliable when the number of cases exceeds the number of variables (van Boxtel, 1998). In this and all following studies, sequential time points were averaged in order to achieve a variable-to-case ratio of between 1:8 and 1:10.

6 There were no statistically significant main effects or interactions involving Counterbalance Order in either the behavioural or electrophysiological analyses. The results are therefore discussed for combined group data.
Classification accuracy in this and all following studies was cross-validated using the “leave one out” function in the SPSS (version 10.0.1) statistical package. Also known as a U-procedure, this entails omitting one of the cases from the original data set and using this group to derive a discriminant function. This function is then used to classify the omitted case. This process is repeated, successively leaving out each case in the data set. The hit rates for each successive classification are averaged, and a single measure reflecting the ability to classify new cases is obtained. It should be noted however, that classification of an entirely new group of subjects might be expected to result in lower hit rates than those obtained with the “leave one out” method of cross-validation.

5.3 RESULTS

5.3.1 Behavioural data

Mean reaction times and test scores are shown in Table 5-1. Test performance was significantly better in the control than the malingering condition ($F=172.60, p<.0001$). Responses were slower when feigning memory impairment, compared to performing the task honestly ($F=5.31, p<.05$). An interaction between Condition and Response Accuracy ($F=28.12, p<.0005$) reflected task-related differences in the time taken to make correct relative to incorrect judgements. This was due to faster responses for correct vs. incorrect trials in the control condition (correct approximately 340 ms faster than incorrect), while in the malingering condition, there was little difference in the time taken to make correct and incorrect decisions.
Table 5-1. Mean recognition performance and response latency by condition (standard error in brackets).

<table>
<thead>
<tr>
<th></th>
<th>Control condition</th>
<th>Malingering condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy (%)</td>
<td>89.7 (1.3)</td>
<td>51.3 (2.9)</td>
</tr>
<tr>
<td>Reaction Time (ms)</td>
<td>1300.4 (94.0)</td>
<td>1443.0 (87.9)</td>
</tr>
<tr>
<td>- correct responses</td>
<td>1131.3 (69.9)</td>
<td>1469.5 (123.7)</td>
</tr>
<tr>
<td>- incorrect responses</td>
<td>1467.4 (90.4)</td>
<td>1418.6 (100.3)</td>
</tr>
</tbody>
</table>

5.3.2 Electrophysiological Data

Figure 5-1 shows the averaged waveforms for the two conditions as a function of word. The mean number of trials contributing to these ERPs was 42.0 and 40.7 for old and new words respectively in the control task, and 44.1 and 42.5 for old and new words in the malingering condition. Visual inspection of the waveforms shows clear separation of responses to old and new words in both conditions, with old-word ERPs more positive than ERPs to new words. As in the previous study, these old/new word differences emerged 200-300 ms earlier when feigning impairment.

The waveforms in this and the previous study have a similar morphology, showing an early positive deflection, an N400-like component, and a late positive component. In the present study however, the peak latency of these components is approximately 50-100 ms earlier than in Study 1. A likely reason for this is that in the present study, participants were instructed to respond as quickly as possible, whereas no such instruction was given in the first study. With regard to old/new word differences, the present results were compared with those of the previous study by conducting an analysis over identical time windows: 450-900 ms to analyse the traditionally-reported late parietal effect, and 0-450 ms to explore task differences in the early old/new effect.
Figure 5-1. Grand mean waveforms for the control and malingering conditions shown as a function of Word.
5.3.2.1 450-900 ms.

Previously-studied words were associated with more positive amplitudes than new words (1.92 vs. 0.47 $\mu$V: $F=13.68$, $p<0.01$). There were no statistically-significant effects of Condition, indicating that old/new differences over this period did not differ according to whether subjects were answering honestly, or feigning a recognition-memory deficit.

5.3.2.2 0-450 ms.

A main effect of Condition nearing significance ($F=4.38$, $p=0.051$) suggested that the task of malingering was associated with more positive waveforms in general than the control task. An interaction of Word with Condition reflected task differences in response to old and new words, with old/new word differences evident in the malingering (1.06 $\mu$V) but not the control condition (0.13 $\mu$V) ($F=4.80$, $p<0.05$).

5.3.3 Principal component analysis of electrophysiological data

The results of these analyses replicate the major findings of the previous study, showing firstly, a late old/new word difference that did not differ according to whether subjects were answering honestly or feigning a recognition-memory deficit, and secondly, an old/new effect in the early epoch, evident only in the ERPs of subjects feigning memory impairment.

In a more-detailed analysis, the ERP data were examined using PCA-defined epochs. A scree test suggested the extraction of 4 factors (illustrated in Figure 5-2), which explained 74.2% of the variance in the data. The component scores for each of the four factors were multiplied by the original waveforms to form a graphical representation of each factor
overall, as a function of order of word presentation, word type and condition (see Figures 5-3 to 5-6).\textsuperscript{7}

Time windows best representing the four components were calculated using the Kaiser-normalised factor loadings (see Figure 5-2). These were 0-190, 190-320, 320-585 and 585-900 ms. The significant results of ANOVAs conducted on the mean amplitudes during each of these epochs are outlined below.

![Figure 5-2. Varimax-rotated components showing the epochs over which they were analysed.](image)

\textbf{5.3.3.1 0-190 ms.}

The waveform during this epoch (see Figure 5-3) was characterised by a negative deflection peaking at 100 ms (N100) followed by a positive deflection with a peak latency of around 150 ms (P150). This early complex is likely to reflect sensory activity in response

\textsuperscript{7} In these and all other figures showing PCA-derived components, the scale on the $y$-axis has been kept constant to allow a comparison of the relative magnitude of the components.
to the onset of each word. Results of the ANOVA revealed that words presented first in the pair elicited more-positive waveforms relative to second words ($F=4.9$, $p<0.05$). There were no significant effects involving the factors of Word or Condition, providing further support for the sensory nature of these components, and indicating that participants paid similar attention to the stimuli in both simulating and control conditions.

5.3.3.2 190-320 ms.

Waveforms during this epoch (Figure 5-4) showed a positive deflection peaking at around 200 ms after stimulus onset. This component was labelled as “P2” and was maximal over the midline compared to the hemispheres ($F=6.5$, $p<0.05$).

More positive waveforms were associated with words presented first in the pair compared to those presented second ($F=12.0$, $p<0.005$), and with the malingering compared to the control condition ($F=5.4$, $p<0.05$). Responses to old words were generally more positive than those to new words ($F=4.7$, $p<0.05$). An interaction of all five factors pointed to more complex task-related differences, followed up in separate analyses within each condition for first- and second-presented words. Four subsidiary analyses were therefore carried out, with $\alpha$ adjusted to 0.0125. These revealed significant old/new word differences only in the malingering task in response to words presented as the second in the pair. These differences were widely distributed over all recording sites ($F=7.74$, $p<0.0125$, old-new=1.52 $\mu$V).
Figure 5-3. The N100-P150 complex (Factor 4), analysed over the 0-190 ms epoch. In this and the following figures, factors are illustrated as a function of task, old/new status and presentation order.
Figure 5-4. The P2 component (Factor 3), analysed over a 190-320 ms epoch following stimulus onset
This epoch was represented in the plots (Figure 5-5) as a negativity with a peak latency around 400 ms. The amplitude of the component was maximal over left and midline sites (left vs. right, $F=23.8$, $p<0.0005$; midline vs. left/right, $F=18.0$, $p<0.0005$) and frontocentral regions (frontal vs. parietal, $F=22.9$, $p<0.0005$; central vs. frontal/parietal, $F=24.0$, $p<0.0005$).

Waveforms during this epoch were more positive for the malingering than the control task ($F=7.6$, $p<0.05$), old vs. new words ($F=9.2$, $p<0.01$) and words presented first compared to those presented second ($F=5.2$, $p<0.05$).

An interaction of all five factors was followed up as before, with separate analyses within the factors of Condition and Order. These revealed that in the control condition, differences between old and new words became evident only after presentation of the second word in the pair, with this old/new difference maximal over frontal scalp regions (Word x frontal vs. parietal: $F=8.3$, $p<0.0125$, old-new=1.16 µV). In the malingering task, second words also elicited old/new differences, evident over all scalp sites ($F=10.80$, $p<0.005$, old-new=1.93 µV) but with a midline maximum (Word x midline vs. left/right: $F=14.24$, $p<0.001$, old-new=2.25 µV).
Figure 5-5. Waveforms for Factor 2, showing the frontocentral N400 component which was analysed over the 320-585 ms epoch.
5.3.3.4 585-900 ms.

The amplitude of the waveform during this epoch (Figure 5-6) was greater over the right than the left hemisphere ($F=9.2, p<0.01$), and was maximal at midline posterior sites (frontal vs. parietal, $F=21.8, p<0.0005$; midline vs. left/right x frontal vs. parietal, $F=13.5, p<0.005$). This component was labelled a late positive component (LPC).

Waveforms associated with words presented second in the pair were more positive than for those presented first ($F=61.0, p<0.0001$). Old words elicited more positive waveforms than new words, with this difference maximal over the midline sites (Word x midline vs. left/right: $F=8.8, p<0.01$).

An interaction of the five factors followed up with separate analyses as for the previous epochs indicated that significant old/new word differences in the control condition again only emerged after presentation of the second word in the pair, and were maximal over right frontocentral scalp sites (Word x left vs. right x frontal vs. parietal: $F=7.74, p<0.0125$; Word x left vs. right x central vs. frontal/parietal: $F=8.95, p<0.01$). In the malingering task, reliable and broadly distributed old/new word differences were evident for both first- ($F=12.40, p<0.005$, old-new=1.38 µV) and second-presented words ($F=8.71, p<0.01$, old-new=2.14 µV).
Figure 5-6. The LPC (Factor 1), measured over the 585-900 ms epoch
5.3.4 Classification of simulated and honest performance

The results revealed a number of differences between honest and simulated recognition memory performance. Behaviourally, participants simulating impairment obtained considerably lower scores on the recognition test than when responding honestly, and failed to demonstrate response latency differences for correct compared to incorrect responses. Analysis of the ERP data revealed that the primary difference between the tasks was that recognition-related processes occurred earlier in the simulating compared to control condition, associated with enhanced positivity to old words in the LPC time window for words presented first in the pair, and P2 window for second words (see Table 5-2).

Table 5-2. Presence of old/new word differences in response to first and second words in the control and malingering conditions

<table>
<thead>
<tr>
<th></th>
<th>First words</th>
<th></th>
<th>Second words</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>190-320</td>
<td>320-585</td>
<td>585-900</td>
<td>190-320</td>
</tr>
<tr>
<td>Control condition</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Malingering condition</td>
<td>×</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Since reaction time and electrophysiological measures are considered to be under the conscious control of the test taker to a lesser extent than are test scores, the variables entered into a direct discriminant function analysis were (1) the difference in reaction time for incorrect and correct responses, (2) the average difference between old vs. new word responses over all scalp sites during the LPC epoch for first-presented words, and (3) the difference in responses to old vs. new words during the P2 epoch for second-presented
words, again averaged over all scalp sites. The resulting discriminant function was significant \( \text{Wilks’ lambda}=0.54, \chi^2=21.40, p<0.0001 \), indicating that the variables effectively distinguished honest from feigned performance. This function successfully classified 81.6% of the sample: sixteen of the nineteen cases of simulated performance and fifteen of the nineteen instances of honest responding. Cross-validated classification accuracy decreased slightly to 78.9%, with one additional control case misclassified as malingering.

5.4 DISCUSSION

The present study examined behavioural and electrophysiological measures of honest and feigned memory performance on a forced-choice recognition memory test. The behavioural results indicated that subjects instructed to simulate impairment claimed to recognise only 51% of the words they had previously studied. The same subjects, when asked to perform the task to the best of their abilities, recognised nearly 90% of the studied words.

Typically, in studies of recognition memory, subjects take longer to make old/new word judgements on trials on which an incorrect response is given (e.g., Donaldson & Rugg, 1998; Wilding, 2000). This pattern was evident in the present study in those answering honestly, however subjects simulating memory loss took approximately the same time to make correct and incorrect judgements. A similar result has been reported in a study utilising the Stroop test to detect simulated cognitive performance (Osimani, Alon, Berger, & Abarbanel, 1997). This well-known test presents the names of colours written in congruent or incongruent coloured ink. The Stroop effect refers to the increased time taken
to name the colour of the word in the incongruent relative to the congruent condition. Osimani et al. (1997) reported a reversed or absent Stroop effect in those feigning a deficit, despite training the participants in the use of the test, and providing information regarding preservation of the effect in the cognitively impaired. While Osimani and colleagues provide no specific explanation for their observations, it could be that elimination of the typical pattern of response latencies in that and the present study reflects response inhibition – the subject knows the correct answer, yet suppresses it in order to plan or consider the response to be given.

Detailed assessment of the ERP data was performed via analysis of PCA-defined epochs, with an examination of the effect of word order on stimulus processing. These analyses revealed that processing of the words was associated with early sensory components (N100-P150), and a P2, N400 and late positive component. The amplitude of the early sensory components varied according to whether words were presented first or second in the pair, but did not differ with Condition. That differences between the control and malingering tasks only became evident in later ERP components rules out the automaticity of any malingering-related processing, suggesting instead that these differences were cognitively driven.

The later components showed both task- and recognition-related processing effects. In the control condition, differences between old and new word ERPs did not emerge until the second word was shown. Old/new differences evident in the 320-585 ms epoch following presentation of the second word were distributed over frontal regions, and associated with a negative component peaking at around 400 ms. The difference between old and new words became right-frontally dominant in the later 585-900 ms epoch.
Many studies of recognition memory employing a yes-no or continuous format also report a frontal old/new effect with a latency of around 300-500 ms, and have linked this effect to the familiarity component of recognition memory (Curran, 1999; Henson, Rugg, Shallice, & Dolan, 2000; Mecklinger, 2000; Rugg, Allan, & Birch, 2000). Familiarity refers to recognition based on a general “feeling” that an item has been recently experienced, without specific memory for the context in which it was seen. Most other studies also report a late parietal old/new effect, occurring around 500-800 ms following stimulus onset (Curran, 1999; Mecklinger, 2000; Wilding, 2000; Wilding et al., 1995). In contrast to the frontal old/new effect, the late parietal effect is thought to reflect processes underlying the recollective component of recognition memory, in which there is conscious recollection of the item along with the context in which it was shown. Some studies also report a late right frontal effect evident around 500-1500 ms, which has been linked to monitoring or evaluation of the retrieved information (Allan, Wilding, & Rugg, 1998; Rugg et al., 2000; Rugg, Fletcher, Frith, Frackowiak, & Dolan, 1996; Wilding & Rugg, 1996).

The differing pattern of old/new differences in the control condition in the present study compared with these other studies suggests differential processing in forced-choice compared to yes-no and continuous formats. For example, forced-choice tests are thought to rely on the familiarity rather than recollective component of recognition memory – participants are able to make recognition decisions based on a comparison of the relative familiarity of the two words, without specifically recalling information from the study phase (Keane et al., 2000; Parkin, Yeomans, & Bindschaedler, 1994). This seems consistent with the pattern of old/new differences observed in the present study, with a frontal effect evident at around 400 ms and relatively small parietal effect in the later epoch, suggesting
discrimination based on familiarity without conscious retrieval of information from the study episode. The right-frontally distributed old/new word difference evident in the later epoch may share a common function with the right-frontal old/new effect described by others, indicating monitoring processes following identification of the previously-seen word. That old/new word differences did not emerge until after the second word was presented also provides support for the proposal that discrimination in forced-choice tests involves predominantly comparative processes – the first word in the pair may be simply “registered”, with old-new discrimination delayed until the second word is presented.

When asked to simulate memory loss, responses to old and new words differed from those obtained in the control condition. Discrimination between previously-studied and new words began earlier, following presentation of the first word in the pair. This finding of earlier identification of old from new words is consistent with the results of the previous study, which reported an early old/new word difference confined to the waveforms of those simulating impairment. The more-detailed analysis employed in the present study indicated that this differential processing of old and new words began around 600 ms after presentation of the first word in the pair, and grew steadily in magnitude over the 900 ms following presentation of the second word. The earlier discrimination of old from new words in this and the previous study in those feigning memory loss suggests that it may reflect a reliable difference between honest and simulated performance.

Interestingly, old/new word differences in the malingering condition did not have a specific topographical distribution as was evident in the control task, or reported in other studies of recognition memory. This broadly-distributed positivity associated with previously-seen words suggests the recruitment of multiple cortical regions, or alternatively,
activity in subcortical brain structures. The functional significance of this sustained positivity is not clear, but could possibly reflect processes including inhibition of the response to previously-seen words, followed by planning processes related to the provision of a task-appropriate response. Slow positive activity has been associated with the load imposed on working memory (Rösler & Heil, 1991) and therefore, in the present study, could reflect processes related to maintaining a mental tally of previous responses in order to present a believable deficit. That such processes were elicited to old rather than new words implies that the old words were the targets for poor performance in the malingering task. Future studies, which utilise a test format that permits assessment of bias in responding, will enable evaluation of this proposal.

ERP data reflecting the earlier discrimination of old from new words, along with the other major finding of the present study, that the time taken to make correct and incorrect responses did not differ in simulators, were used in a discriminant function analysis to distinguish honest from simulated performance. This function successfully classified 84.2% and 78.9% of the instances of simulated and honest performance, respectively (84.2% and 73.7% after cross-validation). These measures point to additional or more-effortful processing on the part of those feigning memory loss. This is an important observation for investigations of non-optimal performance. Intuitively, it might be thought that subjects would attempt to avoid detection by using such strategies as not paying attention to the stimuli, or of having no intention to retrieve information. Such strategies might be reflected in the malingerers’ data as quantitative decrements in the effects observed in non-malingering subjects. The present study provides evidence suggesting that this is not the case. Rather, participants malingering impairment demonstrated qualitative differences in
the processing of the stimuli which may have potential as a means of detecting non-optimal performance in the clinical situation.
CHAPTER 6. STUDY 3 – ERPS AND DETECTION OF FEIGNED MEMORY IMPAIRMENT USING LOW-FREQUENCY WORD STIMULI

6.1 INTRODUCTION

Terms including “insufficient”, “incomplete” and “non-optimal” have been used to describe performance and motivation of suspected and simulating malingerers on tests of cognitive ability (Bierley et al., 2001). The behavioural results of the previous studies in this thesis are consistent with these descriptions, with participants instructed to feign impairment performing poorly on tests of recognition memory, relative to control participants. The electrophysiological data presents a different picture however, demonstrating that simulating impairment involves more active and effortful processing of the test material. For example, comparison of the event-related potentials associated with previously studied (old) versus new words revealed that old/new word differences emerged earlier in simulating relative to control subjects. This “early malingering effect” was taken to reflect enhanced cognitive processing in those asked to feign impairment.

The additional analyses included in Study 2 allowed a more-detailed investigation of this effect, and indicated that in the forced-choice recognition memory format, control participants made decisions after both words in the pair had been presented. In comparison, when asked to simulate impairment, participants made recognition judgements earlier, following presentation of the first word. Along with reaction time
differences, ERP measures reflecting this earlier recognition were shown to have reasonable specificity and sensitivity in discriminating feigned from honest performance.

One of the primary aims of the present study was to determine whether these measures of malingered impairment vary with the linguistic frequency of the stimuli. Numerous studies have demonstrated differential processing of verbal stimuli according to their frequency of occurrence. For example, the “word frequency effect” refers to the well-established finding that low-frequency words are more accurately recognised than high-frequency words (e.g. Jacoby & Dallas, 1981; Mandler et al., 1982; Rugg et al., 1995). According to Lockhart, Craik and Jacoby (1976) and Rao and Proctor (1984), this effect is due to high-frequency words having more meanings and associations with other items in memory, resulting in easier encoding without the need for extensive processing. Low-frequency words, in contrast, have fewer associations and are more distinctive relative to other items in memory, and therefore involve more extensive and elaborative processing during encoding. The varying levels of encoding of the two classes of words influence the processes by which they are later recognised: the elaborative encoding of a low-frequency word enhances memory for the item and the encoding event, leading to a higher proportion of recollective- or “remember”-based decisions, while a high-frequency word is associated with a higher proportion of familiarity or “know” responses, whereby the item is recognised without specific memory for the encoding episode (Balota, Burgess, Cortese, & Adams, 2002; Gardiner et al., 2001; Rajaram, 1993; Reder, Angstadt, Cary, Erickson, & Ayers, 2002).

The previous studies in this thesis utilised words with an average frequency of 130 occurrences per million (Kucera & Francis, 1967), considered as high-frequency words.
Consistent with the findings of Rao and Proctor (1984) and Lockhart et al. (1976), it is possible that the words were encoded shallowly by the control participants in our previous studies, leading to recognition based on familiarity judgements. This is further supported by the frontal distribution of the ERP differences between old and new words, which have previously been shown to reflect familiarity-based recognition judgements (e.g. Curran, 2000; Maratos, Allan, & Rugg, 2000; Mecklinger, 2000). In contrast, instructions to simulate impairment may have induced an enhanced state of arousal, attention or motivation in the malingering participants, for example, which in turn resulted in more extensive processing of the high-frequency words during encoding, and the earlier recognition of these words at test. Therefore, the early malingering effect observed in the previous studies may be due to the comprehensive processing of words that generally receive only shallow encoding.

Presentation of low-frequency words in the current study may therefore enable further elucidation of the functional significance and independence of the early malingering effect. For example, if the effect is related to depth of encoding, it is anticipated that the control and malingering participants would show similar early recognition of the low-frequency words since these would be elaboratively encoded by both groups. Alternatively, if the early malingering effect relates more specifically to the malingering task itself (perhaps reflecting additional strategic processing, planning or motivation), it would be expected to remain evident in the waveforms of the simulators only, regardless of the linguistic frequency of the stimuli.
6.2 METHODS

6.2.1 Participants

Twenty-two undergraduate students from the University of Wollongong participated in the study as one means of satisfying a course requirement. These were largely the same individuals used in the previous study – the participant who contributed insufficient artefact-free trials in the previous study was included in this study, while another individual’s data were removed from further analysis due to contributing less than 16 artefact-free trials in the present study. Therefore, three participants were discarded from the final analysis – one due to equipment failure, one with insufficient artefact-free trials, and another who failed to adhere to task instructions. All subjects completed the study and test phase of the previous study before beginning the present study. The reason for this was that the primary aim of Study 2 was to replicate the results of Study 1. If presentation of the stimuli in this and the previous study had been counterbalanced, factors such as practice effects may have confounded the replication. The 19 participants in the present study were randomly allocated to either a malingering or control task. The average age of the control participants (10 subjects, 8 females) was 28.5 years (S.D.=11.0 years), and the simulators (9 subjects, 8 females), 23.8 years (S.D.=5.8 years). The age difference between the groups was not significant ($F(1,17)=1.33$, $p=0.27$).
6.2.2 Stimuli

Stimuli were 100 low-frequency words (1-7 occurrences per million) (Kucera & Francis, 1967), 4-6 letters in length. Fifty words were shown in the study phase, and presented again in the test phase, paired with a word new to the experiment. The physical characteristics and mode of presentation of the words were identical to that of the previous studies (detailed in Section 5.2.2).

6.2.3 Electrophysiological Recording

EEG data was recorded using the procedure outlined in the previous studies (see Section 5.2.3).

6.2.4 Procedure

The procedure followed was identical to that of the previous studies (see Section 4.2.4). At the beginning of the experiment, ten participants were encouraged to complete the task to the best of their abilities (control group). The remaining nine were given instructions to feign an accident-related memory deficit (malingering group).

6.2.5 Data analysis

Reaction time data were analysed using an ANOVA, with Group (control vs. malingering), and Response Accuracy (correct vs. incorrect responses) as between- and repeated-measures factors, respectively. This analysis was based on the data of 17 participants, since two controls did not misclassify any stimuli.
Analysis of the ERP data was carried out using Principal Components Analysis (PCA), performed on the covariance matrix, with a Varimax rotation. The cases in the analysis consisted of the word type (2), order of word presentation (2), electrode sites (9) and participants (19). The variables were 85 time points, obtained by averaging every three sequential data points in the original waveform of 256 points. A matrix comprising 684 cases and 85 variables was therefore formed. The factor loadings were used to identify non-overlapping epochs over which the extracted components were best represented. Separate ANOVAs were conducted on mean amplitude data from each of these PCA-defined epochs with Word (old, new), Order (words presented first in the pair, words presented second), Lateral (left, midline, right) and Sagittal plane (frontal, central, parietal) as repeated measures, and Group (control, malingering) as a between-subject factor.

The same planned contrasts used in Study 1 were used in the present study. All F-tests of electrophysiological data have (1,17) degrees of freedom.

6.3 RESULTS

6.3.1 Behavioural data

As expected, there was a significant difference between the two groups’ scores on the memory test (controls: 90.0% correct, malingers: 47.3%, $F=37.17$, $p<.0005$). There were no group differences in overall response latency (controls: 1147.9 ms, malingers: 1048.4 ms, $F<1$). However, a Group x Response Accuracy interaction ($F=10.92$, $p<.01$) revealed that the control participants made correct judgements more rapidly than incorrect judgements (correct approximately 280 ms faster than incorrect), while the simulators
showed almost no difference in response latency as a function of accuracy (correct approximately 7 ms faster than incorrect).

6.3.2 Electrophysiological data

Averaged waveforms for the two groups are shown in Figure 6-1. In both groups, responses to old words were more positive than to new in the latter half of the recording epoch. In the control group, the effect emerged earliest over the right hemisphere, at around 250-300 ms post-stimulus, whereas in the malingering group, the effect was evident as early as 100 ms, over the left hemisphere.

Principal component analysis of the data suggested the extraction of 4 factors, explaining 80.1% of the variance. The Kaiser-normalised loadings from these components are shown in Figure 6-2. These loadings were used to identify time windows best representing the four components: 0-175, 175-340, 340-660 and 660-900 msec. The significant results of ANOVAs conducted on mean amplitudes from each of these epochs are outlined below. Figures 6-3 through 6-6 show plots of each component as a function of Group, Word and Order of presentation, obtained by multiplying the factor scores for each component by the original waveforms.
Figure 6-1. Grand mean waveforms for the control and malingering groups.
Visual inspection of the grand mean waveforms (Figure 6-1) and factor plots (Figure 6-3) shows a negativity (peak latency around 100 ms) followed by a positive deflection (peaking at around 150 ms). This factor appears to be an N1-P1 complex, probably reflecting early sensory processing of the stimuli. The amplitude of this complex was more positive over posterior regions, where it was maximal over the hemispheres compared to the midline (midline vs. left/right x frontal vs. parietal: $F=7.32, p<0.05$). In the control participants, the amplitude was more positive over the right than the left hemisphere, with the opposite in the malingering group (Group x left vs. right: $F=5.69, p<0.05$).
Figure 6-3. The N1-P1 complex (Factor 4), which was analysed over a 0-175 ms epoch following stimulus onset. In this and the following figures, factors are illustrated as a function of group, old/new status and presentation order.
Words presented as the first in the pair elicited more positive waveforms than those presented second ($F=5.07, p<0.05$), with this difference maximal at central sites (Order x central vs. frontal/parietal: $F=5.18, p<0.05$). No other word order effects were evident in this period, or differences due to the old or new status of the words.

6.3.2.2 175-340 ms

Waveforms during this epoch (Figure 6-1 and Figure 6-4) depict a positivity with a peak latency of around 250 ms, similar to the P2 component observed in the previous study. The amplitude of this component was more positive over the hemispheres relative to the midline ($F=5.63, p<0.05$). A main effect of Order was due to the more positive waveforms elicited in response to first- relative to second-presented words ($F=11.30, p<0.005$). This difference was enhanced over the midline and right hemisphere regions (Order x left vs. right: $F=12.20, p<0.005$; Order x midline vs. left/right: $F=9.33, p<0.01$).

An interaction of Word, Group and the lateral dimension (left vs. right, $F=14.47, p<0.005$) was due to new words eliciting more positive waveforms over the left hemisphere in the control group (1.21 vs. 0.47 µV), while responses to old words were more positive than new over these sites in the malingering group (2.59 vs. 1.71 µV). These differences in the responses to old and new words did not interact with their order of presentation.

6.3.2.3 340-660 ms

This component was represented as a negativity with a peak latency of 400-450 ms (see Figure 6-1 and Figure 6-5).
Figure 6-4. The P2 component, measured over the 175-340 ms epoch
Effects within the lateral and sagittal planes reflected the enhanced negativity of the component at left and midline sites (left vs. right: $F=14.69$, $p<0.005$; midline vs. left/right: $F=8.63$, $p<0.01$) and frontocentral regions (frontal vs. parietal: $F=25.47$, $p<0.001$; central vs. frontal/parietal: $F=8.95$, $p<0.01$). The latency and topography of this component was very similar to the frontocentral N400 component identified in the previous study.

Differences between first- and second-presented words were greatest over the right hemisphere, with words presented as the first in the pair eliciting the more positive waveforms (Order x left vs. right: $F=30.99$, $p<0.0001$).

Across the scalp, old words elicited more positive waveforms than new words ($F=17.56$, $p<0.005$, old-new=1.44 $\mu$V). Interactions of Word with the lateral and sagittal site factors indicated that the old/new word difference was greatest over parietal regions (Word x frontal vs. parietal: $F=7.09$, $p<0.05$) and at the vertex (Word x midline vs. left/right x central vs. frontal/parietal: $F=4.93$, $p<0.05$). The enhanced positivity to old words was evident in both groups, regardless of the order in which the words were presented in the pair. At central sites however, old/new word differences were maximal over right hemisphere regions in the control group, and over the left in the malingerers (Group x Word x central vs. front/parietal x left vs. right: $F=5.54$, $p<0.05$).

An interaction of Word, Order and topography (left vs. right x frontal vs. parietal: $F=6.16$, $p<0.05$) revealed that responses to the first word of the pair were associated with old/new effects maximal over right compared to left parietal sites (1.98 vs. 1.46 $\mu$V). However, following presentation of the second word, this effect became enhanced over left relative to right parietal regions (right: 2.06 $\mu$V, left: 2.46 $\mu$V).
Figure 6-5. Factor 2 waveforms, showing the frontocentrally-distributed N400 component, analysed over the 340-660 ms time window
6.3.2.4   660-900 ms

Figures 6-1 and 6-6 indicate that this factor represents a late positive component (LPC). During this epoch, waveforms were more positive over parietal (frontal vs. parietal: $F=22.85$, $p<0.0005$), and right hemisphere regions (left vs. right: $F=5.39$, $p<0.05$). Over parietal regions, the amplitude of the component was more positive over the midline (midline vs. left/right x frontal vs. parietal: $F=18.80$, $p<0.0005$).

Responses to words presented as the second in the pair were more positive than to those presented first ($F=21.36$, $p<0.0005$), with this difference maximal over the left hemisphere (Order x left vs. right: $F=10.74$, $p<0.005$). Old word responses were more positive than those to new words ($F=5.22$, $p<0.05$, 3.14 vs. 1.91 $\mu$V). This effect was larger over right parietal sites for words presented first, and left parietal regions for second-presented words (Word x Order x left vs. right x frontal x parietal: $F=12.45$, $p<0.005$).

Group differences were evident in more-positive waveforms over the vertex in the control relative to the malingering participants (Group x midline vs. left/right x central vs. frontal/parietal: $F=8.07$, $p<0.05$). In addition, the old/new effect during this epoch was greater over the left hemisphere in the malingering group, and over the right in the control group (Group x Word x left vs. right: $F=8.28$, $p<0.01$).
Figure 6-6. The LPC (Factor 1) analysed over the 660-900 ms epoch
6.3.3 Classification of honest and feigned memory performance

As in the previous study, the present experiment observed (1) group differences in the time taken to classify correct and incorrect responses, and (2) that ERP differences signalling recognition of previously-studied words were evident earlier in the malingering compared to control group. These differences were maximal over left hemisphere regions in the epoch associated with the P2 component. These measures (reaction time for incorrect minus correct responses, and the difference in response to old vs. new words during the P2 epoch over the left hemisphere) were used as variables in a direct discriminant function analysis. The resulting function was significant (Wilks’ lambda = 0.48, $\chi^2=11.80$, $p<0.005$), accurately classifying 89.5% of the 19 participants (9 of the 10 controls, and 8 of the 9 malingerers). This accuracy remained constant after cross-validation.

6.4 DISCUSSION

Consistent with the results of the previous studies in this thesis and the work of others (e.g. Ellwanger et al., 1999; Iverson & Franzen, 1998), participants instructed to feign memory impairment performed significantly worse on the memory test compared to those performing to the best of their ability. Control participants took less time to recognise words they successfully classified as old or new, a finding often reported in studies of recognition memory (e.g. Donaldson & Rugg, 1998; Wilding, 2000). In contrast, the malingerers showed almost no difference in the time taken to respond to the items, regardless of whether they were correctly or incorrectly classified. A similar result was
observed in Study 2 of this thesis and interpreted as reflecting response inhibition. The reliability of this deviation from the typical response pattern confirms its potential as an index of feigned impairment.

Control participants in the present study recognised 90% of the studied words. In the previous study, in which high-frequency words were shown, 89.7% of the words were correctly identified. This is at odds with the well-established “word frequency effect” which demonstrates more-accurate recognition of low- compared to high-frequency words. The reason for this discrepancy may be the forced-choice format of the test phase, which is generally considered to be easier than the “yes-no” procedure more commonly used in ERP recognition memory paradigms. The relative ease of the tests may have meant that ceiling levels were reached, thus masking the expected differences in test scores. This interpretation should be confirmed by replicating the study using a yes-no test paradigm.

Despite the lack of behavioural confirmation, the ERP results support the proposal of differential processing according to word frequency. In the previous study, which utilised high-frequency words as the stimuli, old/new word differences in the control condition did not emerge until after the second word in the pair had been shown. This was interpreted as reflecting familiarity-based recognition – participants compared the relative familiarity of the two words in order to make an old/new judgement. The frontal distribution of the ERP old/new differences, linked to familiarity-based recognition judgements, further supported this interpretation. In the present study however, recognition-related ERP effects were evident in the waveforms of the control participants during the 340-660 and 660-900 ms epochs, regardless of whether the studied word was presented as the first or second word in the pair. This ability to distinguish old from new words without the need to see both
words in the pair suggests that information regarding the words’ prior presentation was used as the basis for recognition. Furthermore, the ERP recognition effects were distributed over parietal rather than frontal regions. This parietal old/new difference may have functions in common with the well-documented late parietal old/new effect described by others (e.g. Curran, 2000; Mark & Rugg, 1998; Rugg et al., 1995; Rugg, Schloerscheidt et al., 1998; Wilding, 2000). This effect usually occurs in a period 500-800 ms following stimulus onset, and has been associated with the recollective component of recognition memory, whereby there is specific and conscious memory for the item and the context in which it was seen. If the old/new word differences in the present and previous study do reflect similar functions as the frontal and late parietal effects reported by others, these results would lend electrophysiological support to the proposal that low-frequency words are recognised using recollective processes, while high-frequency words are recognised on the basis of familiarity.

The finding of parietal old/new differences also has implications for interpretations made in Study 2 of this thesis. In that study, the frontal old/new differences in the waveforms of the control condition were explained as being due to the forced-choice format of the test, which provides the opportunity to base judgements on the relative familiarity of the two words. The results of the present study, however, which report parietal rather than frontal old/new differences in a forced-choice format, suggest that the topographical distribution of these differences may be more a function of the linguistic frequency of the word stimuli than the format of the test, or alternatively, an interaction of the two.
As in the control group, the waveforms of the malingerers were also characterised by ERP old/new differences that were evident following presentation of the first word in the pair, and maximal over parietal scalp sites. This suggests similar processing in the two groups, again, perhaps reflecting recollective-based recognition of the studied words.

One of the primary aims of this study was to investigate the influence of depth of encoding on the early malingering effect. As outlined in the Introduction (Section 6.1), it was suggested that the effect observed in the previous studies might have arisen through differential processing of the high-frequency words at study, with more-elaborative encoding by malingerers leading to rapid recognition of the items. This proposal would gain support if the early malingering effect was absent in response to low-frequency words, which should be elaboratively encoded by both control and malingering participants. The findings of the present study clearly indicate that depth of encoding influences the time taken to recognise previously-studied items – in both the control and malingering groups, low-frequency words were recognised more rapidly than were the high-frequency words in the previous study. However, as in the previous studies, recognition occurred earlier in the malingering compared to control group, with ERP old/new differences in the waveforms of those simulating impairment evident in the epoch encompassing the P2 component. These results support the previous proposal of more effortful processing by those simulating impairment. However, they do not permit any firmer explanation for the processes underlying the effect – these could reflect processes specific to the malingering task, such as strategic planning, or alternatively, still-deeper levels of encoding, regardless of the linguistic frequency of the stimuli. Future studies, which directly compare ERPs recorded during the initial presentation of the words in the
study phase, may shed further light on the processes underlying this early malingering effect.

Although these processes remain unclear, the reliability of the early malingering effect suggests it may be a useful index of simulated performance. As in the previous study, an ERP measure reflecting the effect, along with the other major finding of this and the previous study – the similar response latency in classifying correct and incorrect decisions – were shown via discriminant function analysis to accurately classify the majority of honest and malingering participants. In this and the previous study, 89.5% and 79% of participants, respectively, were correctly classified on cross-validation. The superior classification accuracy in the present study, along with the inclusion of only one ERP measure of early recognition, suggests that the use of low-frequency words may provide an easier and more accurate measure by which to detect those simulating impairment.

Another, unexpected, group difference was observed in the waveforms of the participants in the present study. In the control group, the difference between old and new words was larger over the right hemisphere, while in the malingering group, these were maximal over the left hemisphere. These hemispheric differences were evident in the epochs associated with the P2, frontocentral N400 and LPC components, as well as the early sensory components. In the previous study, no task-related differences were observed in similar early components, with this finding used to support the notion that the later-emerging differences between the control and malingering tasks were not reflective of automatic, but rather, cognitively-driven processes. The early group disparity evident in the present study is inconsistent with this, suggesting that low-frequency words may introduce automatic processing differences, with control and malingering participants
utilising distinct brain regions in the processing of the stimuli. This asymmetry may be an additional measure of effortful processing in simulators. For example, Henson et al. (2000) reported that more-confident decisions elicited activity in left-lateralised brain regions, while Ito (2001) demonstrated coarse vs. fine semantic coding in the right vs. left hemisphere, and more accurate left-hemisphere discrimination of targets from distractors. Further studies will determine the reliability and usefulness of this asymmetry as a measure of simulated impairment.

In summary, the present study demonstrated the reliability of the results reported in Study 2 of this thesis, in a test using low-frequency word stimuli. Specifically, these were the disruption of the typical pattern of response latencies, and ERP indications of earlier recognition of studied items in those simulating impairment. This study also demonstrated the influence of depth of encoding on the recognition process, with deeper levels of encoding leading to faster, recollective-based recognition. The following study in this thesis will directly examine ERPs recorded during the encoding of stimuli in the hope that this might provide further insight into the significance of the earlier recognition of stimuli in those asked to simulate impairment.
CHAPTER 7. STUDY 4 – IDENTIFICATION OF FEIGNED IMPAIRMENT USING HIGH-FREQUENCY WORD STIMULI IN A “YES-NO” TEST OF RECOGNITION MEMORY

7.1 INTRODUCTION

The ability to remember an item or event is influenced by the way it is initially processed. This has been demonstrated in numerous studies that manipulate the depth to which items are encoded. Craik and Tulving (1975), for example, instructed participants to make orthographic, phonemic or semantic judgements regarding a series of words. When memory for these words was tested, they observed a linear increase in recognition performance with increasing cognitive complexity during encoding. Other studies have reported similar effects on memory using less explicit processing instructions, and demonstrated that a range of other factors, such as mood, (Eich, 1995), arousal level (Hamann, Ely, Grafton, & Kilts, 1999), attention (Mangels, Picton, & Craik, 2001) and prior knowledge (Kimball & Holyoak, 2000) affect initial processing of an item. Electrophysiological studies manipulating the level of processing during encoding have also reported differing ERP effects according to encoding task instructions (e.g. Duzel, Vargha-Khadem, Heinze, & Mishkin, 2001; Otten & Rugg, 2001; Rugg et al., 2000).

Similarly, the results of Study 3 of this thesis suggested that depth of processing during encoding may be responsible for ERP group differences evident during the retrieval phase of a recognition memory test. Specifically, these group differences included the earlier emergence of ERP correlates of recognition in participants asked to feign memory
impairment compared to those answering to the best of their ability. Through manipulation of the linguistic frequency of the stimuli, Studies 2 and 3 demonstrated that depth of encoding influenced the speed at which words were recognised, with deeper levels of processing leading to more-rapid discrimination in a forced-choice test format. It was therefore proposed that depth of encoding may explain the early malingering ERP effect reported in the previous studies in this thesis: instructions to feign impairment may have led participants to process the words more elaboratively at initial presentation, leading to their earlier recognition at test.

One of the primary goals of the present study was to further investigate the role of encoding processes in the simulation of impairment. Based on the research of others (Lockhart et al., 1976; Rao & Proctor, 1984), the previous studies have assumed that manipulation of word frequency influenced depth of encoding. However, without directly analysing electrophysiological data from the study phase, it is not possible to be sure that group differences were due to differential encoding rather than differences occurring during the retrieval phase. For example, in the study utilising high-frequency words (Study 2), it may have been that depth of processing at encoding was equivalent in the two conditions, but that the forced-choice format of the test phase allowed the controls to perform at a high level simply by comparing the relative familiarity of the two words, without the need for contextual retrieval. In contrast, the additional demands required of those simulating a deficit might have meant that a more active and effortful approach to retrieval was necessary, with this additional effort indexed by the early malingering effect. Analysis of electrophysiological data recorded during encoding will thus permit more definite
conclusions regarding the contribution of encoding to the elicitation of this effect and other group differences evident during the retrieval phase.

A second aim of the present study was to examine whether the behavioural and ERP effects reported in the previous studies, which employed a forced-choice paradigm, are also apparent in the “yes-no” test format. This paradigm is more commonly used in ERP studies of recognition memory, with words presented one at a time in the test phase, and instructions to make an old or new judgement in response to each word. Using this or similar paradigms (such as the continuous recognition format), researchers have reported a “family” of old/new effects, occurring under fairly well-defined conditions, with consistent latencies and topographies and generally well-established functional interpretations. Although effects with similar latencies and distributions were reported in the previous studies, the differences in test paradigm meant that any relationships between the two were necessarily tentative. Using the yes-no format in the present study may therefore permit more confident functional interpretations of any ERP differences between old and new words evident in the two groups.

As in Studies 1 and 2, the present experiment utilised high-frequency words as the stimuli, with the following study investigating words with a low-frequency of occurrence.

7.2 METHODS

7.2.1 Participants

Forty-eight undergraduate university students participated in the study as one means of fulfilling a course requirement. Eight participants were discarded from the final analysis
due to excessive EOG artefact. Of the remaining 40, 17 participants completed the task to
the best of their ability (control group – 14 females), and 23 were asked to feign injury-
related memory loss (malingering group – 20 females). The average age of the control
group was 23.8 years (SD=8.8), with a mean of 22.3 years (SD=5.7) for the malingering
group.

7.2.2 Stimuli

Stimuli consisted of items from the Words subtest of the Warrington Recognition
Memory Test (Warrington, 1984), which were computer-modified to enable recording of
physiological measures. The test consisted of one hundred words, fifty of which were
shown in the study phase and presented again in the test phase (“old” words), randomly
interspersed with 50 new words. Words were presented centrally on a computer screen in
white letters on a black background. The physical characteristics of the words and their
mode of presentation were identical to that outlined in Study 1 (Section 4.2.2).

7.2.3 Electrophysiological recording

Electrophysiological data were recorded as in Study 2 (Section 5.2.3).

7.2.4 Procedure

Prior to testing, participants were informed that they were to take part in a recognition-
memory test while ERPs were recorded. The instructions to control and malingering
participants were identical to those used in the previous studies.
Participants were seated 100 cm from a computer screen on which the word stimuli were shown. The study phase commenced with the presentation of a fixation cross in the centre of the screen, shown for 500 ms. Words were presented for 500 ms, with each word followed by a 1500 ms interval, giving a stimulus onset asynchrony (SOA) of 2.0 s. After viewing each word, participants were asked to decide whether the word was pleasant or unpleasant, following the standardised Warrington test instructions. Participants were not required to vocalise or record these judgements.

The test phase also began with presentation of the fixation cross for 500 ms. Words were again shown for 500 ms with a SOA of 2.0 s. Using a two-button response box, participants were asked to indicate, as rapidly as possible, whether each word was new to the experiment or had been previously seen in the study phase. Participants were given 1.5 s to respond, and all responses made within this period were included in further analyses.

7.2.5 Data analysis

Reaction time data were analysed using a mixed-design ANOVA, with group (control, malingrere) as a between-subjects factor, and Word (old, new) and Response Accuracy (correct vs. incorrect responses) as repeated measures. This analysis was based on the responses of 39 participants, since one of the simulators did not misclassify any new words.

Analyses of the ERP data were carried out on test and study phase data using principal components analyses, performed on the covariance matrix, with a Varimax rotation. The cases in the analysis of the test phase data consisted of the word type (2), electrode sites (9) and participants (40). The variables were 64 time points, obtained by averaging every four sequential data points in the original waveform of 256 points. For the study phase analysis,
the cases were electrode sites (9) and participants (40). The variables were 32 time points, obtained by averaging every 8 sequential data points in the original waveform. The factor loadings were used to identify non-overlapping epochs capturing the extracted components. Separate ANOVAs were conducted on mean amplitude data from each of these PCA-defined epochs. For the test phase, Word (old/new), Lateral (left, midline, right) and Sagittal (frontal, central, parietal) planes were within-subject factors, and Group (control, malingering) the between-subject factor. The study phase analysis did not include the factor of Word.

The peak amplitude and latency of the components were also determined using a peak-picking program and analysed with ANOVAs using the same factors as those outlined above. These data are reported in the present study only where it was considered necessary to supplement the mean amplitude analyses. ERP effects within regions were examined using the same planned contrasts outlined in Study 1. All F tests of ERP data have (1, 38) degrees of freedom.

7.3 RESULTS

7.3.1 Behavioural data

Reaction times and test scores for the two groups are shown in Table 7-1. As expected, the malingerers claimed to recognise significantly fewer words than the controls on the recognition memory test. Measures of response bias for each group were calculated using the method outlined by Snodgrass and Corwin (1988), whereby:
An index less than 0.50 indicates a conservative bias, with participants tending to answer that the words have not been previously seen. In contrast, values greater than 0.50 indicate a liberal bias, where “yes” responses are over-endorsed. In the present study, the bias index ($B_i$) of the control participants (0.46) was not significantly different from 0.5 ($F=0.75$, $p>0.05$) indicating a neutral bias. In the malingering group however, the index of biased responding was 0.40, a value significantly less than 0.50, ($F=7.76$, $p<0.05$), suggesting that the poor scores obtained by this group were predominantly achieved through misclassification of old words.

Table 7-1. Accuracy and response latency measures for the control and malingering groups showing means, and standard error of the means in brackets

<table>
<thead>
<tr>
<th></th>
<th>Controls</th>
<th>Malingers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Accuracy (%)</td>
<td></td>
</tr>
<tr>
<td>Correct</td>
<td>78.76 (2.54)</td>
<td>54.26 (1.67)</td>
</tr>
<tr>
<td>Hits</td>
<td>77.41 (3.45)</td>
<td>46.87 (3.09)</td>
</tr>
<tr>
<td>Misses</td>
<td>21.65 (3.38)</td>
<td>48.99 (3.70)</td>
</tr>
<tr>
<td>False alarms</td>
<td>19.18 (3.33)</td>
<td>36.52 (4.00)</td>
</tr>
<tr>
<td>Correct rejections</td>
<td>80.47 (3.27)</td>
<td>63.39 (3.84)</td>
</tr>
<tr>
<td>Bias</td>
<td>0.46</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>Reaction Time (ms)</td>
<td></td>
</tr>
<tr>
<td>Old words</td>
<td>819.87 (42.55)</td>
<td>765.07 (37.41)</td>
</tr>
<tr>
<td>- correct</td>
<td>789.30 (42.12)</td>
<td>761.23 (37.03)</td>
</tr>
<tr>
<td>- incorrect</td>
<td>749.44 (41.57)</td>
<td>784.74 (36.54)</td>
</tr>
<tr>
<td>New words</td>
<td>829.16 (45.30)</td>
<td>737.71 (39.82)</td>
</tr>
<tr>
<td>- correct</td>
<td>850.44 (45.27)</td>
<td>768.92 (39.79)</td>
</tr>
<tr>
<td>- incorrect</td>
<td>899.01 (53.73)</td>
<td>769.83 (47.23)</td>
</tr>
</tbody>
</table>

Overall reaction times did not differ between the groups ($F(1,37)=0.94$, $p=0.34$), however, an interaction between Response Accuracy and Group ($F(1,37)=12.10$, $p<0.001$).
reflected faster responses for correct relative to incorrect trials in the control condition (correct approximately 90 ms faster than incorrect), while the opposite occurred in those simulating impairment, with participants taking longer to respond on trials in which a correct response was made (correct approximately 20 ms slower than incorrect).

7.3.2 Electrophysiological data

7.3.2.1 Test phase data

Figure 7-1 shows grand average waveforms for the two groups as a function of word. Responses to old words were generally more positive than to new words. This old/new effect became evident approximately 400 ms after stimulus onset in the control group, and at around 200 ms post-stimulus in the malingering group. In addition, old/new word differences evident at frontal sites in the control group were largely absent in the malingering group. The negativity peaking at around 400 ms in the control participants’ waveforms appears substantially reduced in those feigning impairment.

Four factors were extracted in the PCA (shown in Figure 7-2) and together explained 82.9% of the variance in the data. Factor scores for each component were multiplied by the original waveforms to give plots of each factor (Figures 7-3 to 7-6). The Kaiser-normalised loadings from these components were used to determine time windows encompassing the four components. These were 0-290, 290-520, 520-720 and 720-900 ms. The significant results of ANOVAs conducted on each of these epochs are outlined below.
Figure 7-1. Grand average waveforms for the control and malingering group recorded during the test phase, showing responses to old and new words.
Figure 7-2. Varimax-rotated components for the test phase data, showing the epochs over which they were analysed.

7.3.2.1.1 0-290 ms.

Visual inspection of the waveforms during this early epoch (see Figures 7-1 and 7-3) showed a positive component with a peak latency around 150 ms post-stimulus, a negativity maximal over parietal sites with a peak latency of 200 ms, followed by a positive deflection peaking at about 250 ms.

An interaction of all four factors (Group x Word x midline vs. left/right x frontal vs. parietal: \( F=7.46, p<0.05 \)) revealed that in the control condition, new words were more positive than old words, with this difference maximal over midline parietal scalp sites. In the malingering condition however, old words were more positive than new, with this difference also maximal over midline parietal sites.
Figure 7-3. Early components (Factor 4), measured over the epoch 0-290 ms following stimulus onset. In this and the following figures, factors are shown as a function of Word and Group.
As noted above, this early epoch appears to contain a number of components. In order to determine the effect of Group and Word on these components individually, data obtained from a peak identification program were also analysed. The first peak identified was a positive component with a right-midline parietal distribution, and peak latency of 140 ms. This was followed by a negative deflection, with a peak latency of 195 ms, and a parietal distribution, maximal over lateral sites. There were no statistically-significant differences in the amplitude of these early components as a function of Group or Word.

The third component within this early epoch was a positivity that was maximal over parietal sites, with a peak latency of 250 ms. An interaction of Group and Word within the sagittal plane (frontal vs. parietal: $F=6.64, p<0.05$) revealed that at parietal sites, responses to new words were more positive than old in the control group, while responses to old words were more positive than new in the malingering group. This confirms the results of the mean amplitude analysis of the first ERP factor, and isolates the differences between the groups and the effect of word type to this P2 component.

7.3.2.1.2 290-520 ms

Visual inspection of the waveforms during this epoch (Figures 7-1 and 7-4) revealed a negative deflection at approximately 400-450 ms post stimulus onset. This component was maximal over frontal and central scalp sites (frontal vs. parietal: $F=16.50, p<0.0005$; central vs. frontal/parietal: $F=13.31, p<0.001$), showing an onset latency and topography consistent with the frontal N400-like component described by others (e.g. Curran, 1999; Duzel et al., 2001). An interaction of Group with the sagittal plane (frontal vs. parietal: $F=4.75, p<0.05$) was due to the markedly reduced amplitude of the component at frontal sites in the malingering group.
Old words elicited more positive waveforms than new words during this epoch ($F=5.60$, $p<0.05$), a pattern evident in the waveforms of both control and malingering participants.

**Figure 7-4.** The frontocentral N400 (Factor 2), analysed over the 290-520 ms epoch
7.3.2.1.3 520-720 ms

Figure 7-5 reveals a predominantly positive deflection of the waveform during this epoch, enhanced over parietal sites, and with a peak latency of approximately 600 ms post-stimulus.

The amplitude of this late positive component (LPC) was enhanced over posterior compared to frontal sites ($F=37.22, p<0.0001$), and over central sites relative to the average of the front and posterior regions ($F=12.55, p<0.005$), revealing a centroparietal distribution. Over parietal regions, amplitude was greater over the midline relative to the hemispheres ($F=26.03, p<0.0001$). Interactions with Group revealed that control group waveforms were more negative at frontal sites and positive at posterior sites than were those of the malingering group (frontal vs. parietal: $F=8.87, p<0.001$). In addition, at frontal sites in the control group, LPC amplitude was more negative over midline relative to lateral sites, whereas the opposite was true in the malingering group (midline vs. left/right x frontal vs. parietal: $F=4.34, p<0.05$)

A main effect of Word reflected a broadly distributed increased positivity to old relative to new words ($F=10.50, p<0.005$). There were no statistically-significant interactions of Group with Word during this epoch.

7.3.2.1.4 720-900 ms

The plots of this factor (Figure 7-6) show a predominantly positive deflection enhanced over parietal relative to frontal regions. The long duration of this component is suggestive of a positive slow-wave component.
Figure 7-5. Factor 3 waveforms showing the LPC, measured in the 520-720 ms time window
Figure 7-6. The positive slow wave (Factor 1), analysed over the 720-900 ms epoch
Interactions within the lateral and sagittal planes showed that overall, amplitude was maximal over central regions, and midline parietal sites (central vs. frontal/parietal: \(F=31.29, p<0.0001\); midline vs. left/right x frontal vs. parietal: \(F=14.26, p<0.001\)). An interaction of Group, Word and the sagittal plane (frontal vs. parietal: \(F=15.66, p<0.0005\)) was due to old/new word differences at frontal sites, with old words more positive than new in the control but not the malingering group.

7.3.2.2 Study phase data

The ERPs recorded from the two groups during the study phase are shown in Figure 7-7. These show a more positive waveform in the malingering relative to the control group. Specifically, a positive component peaking at around 250 ms was enhanced in the malingering group, while a negativity with a peak latency of approximately 400 ms was dominant in the control group, and markedly reduced in the malingering waveforms.

As in the test phase data, a PCA was conducted, and 3 factors explaining 83.9% of the variance in the data were extracted. The factor loadings are shown in Figure 7-8, and individual factor plots in Figures 7-9 – 7-11. The Kaiser-normalised loadings were used to identify epochs best representing these components: 160-290, 290-675 and 675-900 ms. The results of ANOVAs conducted on each of these epochs are detailed below.
Figure 7-7. Grand average waveforms for the control and malingering group recorded during the study phase

Figure 7-8. Varimax-rotated components for the study phase, showing the epochs over which they were analysed
7.3.2.2.1 160-290 ms

Figure 7-9 shows a positive deflection with a peak latency of approximately 250 ms, similar to the P2 evident in the test phase data. This component was more positive over the midline relative to the hemispheres (midline vs. left/right: $F=9.16$, $p<0.005$), and over central relative to frontal and parietal sites (central vs. frontal/parietal: $F=24.11$, $p<0.0001$). An interaction within the lateral and sagittal planes reflects greater amplitude over right compared to left parietal sites (left vs. right x frontal vs. parietal: $F=4.50$, $p<0.05$). A Group main effect ($F=4.86$, $p<0.05$) reflected the more positive waveform of the malingering (4.26 $\mu$V) relative to the control group (2.40 $\mu$V) during this epoch.

Figure 7-9. The P2 component (Factor 3), analysed over the 160-290 ms epoch and shown as a function of Group
Figure 7-10 depicts a negative component with a peak latency of approximately 400 ms and frontal distribution (frontal vs. parietal: $F=24.11$, $p<0.0001$). There was an overall difference in the amplitude of the waveform between the two groups, with the control group more negative than the malingering group (-1.66 vs. 0.84 µV: $F=5.07$, $p<0.05$). Interactions with the lateral and sagittal planes revealed that this group difference was greatest over left and central scalp sites (left vs. right: $F=7.34$, $p<0.05$; central vs. frontal/parietal: $F=6.69$, $p<0.05$).

**Figure 7-10.** The frontal N400 component (Factor 1) recorded during the study phase, and measured over the 290-675 ms epoch.
The plot of this later epoch (Figure 7-11) shows a positive deflection most evident at frontal and central scalp sites. The long duration of this component is suggestive of a slow wave component. Amplitude was greater over the midline relative to the hemispheres (midline vs. left/right: $F=6.48$, $p<0.05$). A Group main effect nearing significance ($F=3.64$, $p=0.06$) reflected a tendency towards more positive waveforms in the malingering relative to the control group (3.29 vs. -0.13 µV) during this epoch.

Figure 7-11. The slow wave component (Factor 2) for the control and malingering group, analysed over the 675-900 ms time window.
7.3.2.3 Analysis by response accuracy

Control participants from previous studies in this thesis have performed at high levels on the recognition memory tasks, achieving scores around 90%. In the present study however, the group obtained an average score of 79%, reflecting the more difficult combination of less memorable high-frequency words presented in a yes-no test of recognition. The higher number of incorrect responses in the present study thus permits a preliminary analysis of ERPs according to response accuracy. Plots of these are shown for the two groups in Figure 7-12. In the control condition, words which were recognised from the study phase elicited the most positive waveforms, evident from around 400 ms post stimulus onset over parietal sites, and 300 ms at frontal sites. Over sites in which the late parietal old/new effect is generally largest (i.e. left parietal), the positivity is graded from old correct>new correct>old incorrect>new incorrect. This mirrors the pattern of response latency and therefore could reflect factors such as response confidence. Also notable in the control waveform plots is the marked negativity to incorrectly classified new words, which is present to a lesser extent to incorrectly classified old words.

In the malingering groups’ waveforms, old correctly identified words were also more positive than those to the other categories of response. This difference appears to emerge earlier in the malingering group, at around 300 ms over frontal regions and 200 ms at parietal sites. The enhanced negativity also appears to be absent in the waveforms of the malingering group.
Figure 7-12. Grand average test phase waveforms for the control and malingering group as a function of response accuracy.
The 520-720 ms epoch analysed previously appeared to encompass this negativity. To investigate group differences in this region, a further ANOVA on this epoch was conducted using the factors described for the test phase analyses, but separating responses to old and new words according to the accuracy of their classification. Only control subjects who contributed more than 15 incorrect response trials (misses plus false alarms) to the ERP were included in this analysis. The average number of incorrect trials in the averaged ERPs of these 10 participants was 12.8 (misses) and 12.9 (false alarms). All 23 malingering participants were included in this analysis, contributing an average of 22.0 and 15.4 trials to the miss and false alarm ERPs. F-tests have (1,31) degrees of freedom.

A main effect of Accuracy reflected the more positive waveforms for correctly-identified words \((F=10.13, \ p<0.005)\). An interaction of Group and Accuracy with topography (midline vs. left/right x frontal vs. parietal: \(F=5.59, \ p<0.05\)) was due to an enhanced negativity maximal over midline frontal sites associated with incorrect responses, which was confined to the waveforms of the control group. A 5-way interaction of the analytic factors prompted subsidiary analyses comparing hit, miss, false alarm and correct rejection responses in the two groups as a function of topography. Alpha levels were adjusted accordingly to 0.0125.

Waveforms in response to hits were positive over parietal compared to frontal sites \((F=19.80, \ p<0.0005)\) and at central sites relative to the mean of frontal and parietal regions \((F=7.69, \ p<0.01)\), reflecting a centroparietal distribution. There were no significant differences according to whether participants were responding honestly or feigning impairment.
Misses were associated with ERPs that were more positive over parietal compared to frontal sites \((F=11.80, p<0.005)\) and at central sites relative to the mean of frontal and parietal regions \((F=9.63, p<0.005)\), again reflecting a centroparietal distribution. Interactions of the lateral and sagittal dimensions were due to the enhanced amplitude of the waveform over midline relative to lateral parietal scalp sites, a pattern which was not evident over frontal \((\text{midline vs. left/right x frontal vs. parietal: } F=23.80, p<0.00005)\) or central \((\text{midline vs. left/right x central vs. frontal/parietal: } F=7.71, p<0.01)\) scalp sites. Again, there were no interactions with Group.

Waveforms associated with correct rejections were more positive over posterior sites \((\text{frontal vs. parietal: } F=20.17, p<0.0001)\), where they exhibited a midline maximum \((\text{midline vs. left/right x frontal vs. parietal: } F=10.95, p<0.005)\). Again, the responses of the two groups did not differ significantly.

False alarm ERPs were negative over frontal sites and positive over posterior regions \((F=15.13, p<0.0005)\). Waveforms over posterior sites were more positive over the midline compared to the hemispheres \((\text{midline vs. left/right x frontal vs. parietal: } F=13.29, p<0.001)\). An interaction of Group with topography \((\text{midline vs. left/right x frontal vs. parietal: } F=9.51, p<0.005)\) was due to the enhanced negativity of the waveform at midline frontal sites in the control relative to the malingering group.

7.3.3 Classification of malingering and control participants

As in the previous studies, the present study demonstrated a significant difference in the time taken to make correct and incorrect recognition judgements, and also earlier recognition in the malingering compared to control group, with an old/new effect evident in
the epoch encompassing the P2 component. In addition, this study reported several other differences in the group as a whole, which may have potential as discriminators of feigned from honest performance. In the test phase, these included an enhanced frontocentral N400 component and a late frontally-distributed old/new effect evident in the control group waveforms. In the study phase, malingering group waveforms were more positive in relation to the P2 and frontal N400 component, and tending towards enhanced positivity in a slow wave component.

A direct discriminant function analysis including the equivalent measures used in previous studies (reaction time differences between correct and incorrect responses, and measures of the early emergence of the old/new effect, in this case, over the Pz electrode site in the P2 epoch) correctly classified 72.5% of all cases before and after cross-validation (Wilk’s lambda=0.69, $\chi^2=13.57, p<0.005$). However, closer inspection indicated that the function accurately identified 82.6% of the simulators but only 58.8% of the instances of honest performance. In an attempt to improve classification accuracy, all the significant group effects identified in the study were entered as variables. In addition to the variables entered in the previous discriminant function analysis, these were: N400 amplitude measured over the frontal sites in the test phase; differences between old and new words over frontal sites in the 720-900 ms epoch of the test phase; P2 amplitude measured over all electrode sites in the study phase; N400 amplitude measured over the left hemisphere in the study phase; and the N400 amplitude measured over central sites in the study phase. This marginally improved prediction accuracy (Wilk’s lambda=0.52, $\chi^2=22.48, p<0.005$), with 82.6% of malingerers and 64.7% of controls correctly classified after cross-validation. The relative utility of these predictors was examined in a stepwise discriminant function. With
an F to enter of 0.2, the variables included in the analysis were reaction time differences and the amplitude of the N400 component over central sites recorded during the study phase (Wilk’s lambda=0.64, $\chi^2=16.45$, $p<0.0005$). This function correctly classified 77.5% of the cases, 75% following cross validation. Again, however, this accurately identified 20 of the 23 malingerers (87%) but only 10 of the 17 control participants (58.8%).

ERP group differences at Fz in the response to false alarms was also reported in the analysis which compared correct and incorrect responses in 10 of the 17 control participants to those of the malingering group. Entered into a discriminant function analysis, this variable alone correctly classified 72.7% of the 10 controls and 23 malingerers before and following cross-validation. When applied to the entire group, 77.5% of cases were correctly classified after cross-validation, and with the addition of differences in reaction time, 82.5% correct classification was achieved following cross-validation (87% of malingerers and 76.5% of controls).

7.4 DISCUSSION

One of the primary aims of this study was to examine whether the behavioural and ERP effects effectively discriminating honest performance from simulated impairment reported in the forced-choice paradigm were also apparent in the “yes-no” test format. The results of the present study indicate that these group differences are reliable across test paradigms and confirm their potential as indices of simulated impairment.

Firstly, participants instructed to feign impairment gave behavioural performances on the memory test suggestive of severe memory loss. Those responding honestly recognised 79% of the previously-studied words, while simulators claimed to recognise only 54%. The
relative difficulty of the yes-no test was evident in the lower scores achieved by the control participants compared to those obtained in the previous studies using high-frequency words (1 and 2), in which identical stimuli were presented in a forced-choice format. In those studies, control participants correctly identified 85-90% of the studied words. This difference in the difficulty of the two paradigms was not reflected in the test scores of malingering subjects, who claimed to recognise approximately 54% of the words in the yes-no task, but 51% in the previous forced-choice tests.

Secondly, while control participants took less time to recognise words they successfully classified as old or new, there was almost no difference in latency according to accuracy in the malingering group. Although the response latency analysis did not show a significant group difference in the accuracy of old and new word categorisation, the data indicate that the largest difference in reaction time for the malingering group were for correct vs. incorrect classifications of previously-studied words (see Table 7-1). In contrast, there was little difference in the time taken to classify new words. This observation provides some support for the proposal made in the previous study that old words are the target items for poor task performance. Further support for this comes from the analysis of response bias in the two groups. Intentional poor performance in the malingering task could be achieved by responding that previously-studied words were not recognised, or by claiming to recognise words that had not been seen. In the present study, the simulating participants displayed a conservative response bias, indicating that poor performance was primarily achieved by claiming not to recognise the previously-studied words. This also indicates that participants adopted a specific response strategy, as simply guessing or responding randomly would have resulted in a neutral bias.
Thirdly, ERP differences between old and new words once again emerged earlier in the waveforms of the malingering group. As in the previous study, this was evident in the epoch encompassing the P2 component. The reliability of this early malingering effect confirms its utility as a marker of simulated memory impairment.

The present study also revealed a number of other differences between honestly-responding and simulating participants, in both the study and test phases of the experiment.

7.4.1 Test phase analysis

Group differences were evident in an anteriorly-distributed N400 component during the retrieval phase of the test. Similar components have been described in other studies of memory, and related to processes including novelty detection (Tsivilis, Otten, & Rugg, 2001), and lexical (Osterhout, Bersick, & McKinnon, 1997), semantic (Maratos, Dolan, Morris, Henson, & Rugg, 2001) and conceptual (Mangels et al., 2001) processing of words. In the present study, this component was pronounced in the waveforms of the control group, and strikingly reduced in those simulating impairment. A similar, although less marked, result was observed in Study 2 of this thesis, suggesting that amplitude differences in this component reflect differential task-related processing, rather than factors related to test format or individual differences.

Other researchers have also reported modulations in the size of similar negative components in both normal and clinical populations. For example, studies of age-related ERP effects have shown reduced N400 amplitude in elderly participants (Joyce, Paller, McIsaac, & Kutas, 1998; Mark & Rugg, 1998; Swick & Knight, 1997), interpreted by Swick and Knight (1997) as due to greater effort required in the elderly patients in order to
complete the task. Kayser et al. (1999) also reported a reduced negative component in the waveforms of a schizophrenic relative to a control group during a recognition memory task. Although this component had an earlier peak latency of 330 ms, and was maximal over parietal sites, the negative component was also markedly reduced at frontal and central sites, as in the present study. This group difference was interpreted as reflecting a deficit in the allocation of conceptual resources in the patient group, and the need to rely on later, more-elaborative cognitive processes. Furthermore, Dunn, Dunn, Languis and Andrews (1998), reported larger frontal N400 amplitude in low compared to high recallers. They interpreted this as reflecting short-term semantic feature selection and less use of long-term memory resources in the low recalling participants. These functional interpretations of N400 amplitude are consistent with the proposal developed in the previous studies in this thesis linking more effortful, elaborative processing to the task of simulating impairment.

Further group differences were evident in the 720-900 ms epoch, with frontal old/new word differences confined to the waveforms of the control group. Other researchers have also reported late frontally-distributed old/new effects. These have most often been reported as having a right hemispheric dominance, although others have also reported left-lateralised effects (Rugg, Fletcher, Chua, & Dolan, 1999; Schloerscheidt & Rugg, 1997) and bilateral effects which precede the typical right frontal effect (Donaldson & Rugg, 1998; Johansson, Stenberg, Lindgren, & Rosen, 2002; Wilding & Rugg, 1997). It is generally agreed that this late frontal activity in response to old words is related to post-retrieval monitoring of the studied items (Allan et al., 1998; Rugg et al., 1996; Wilding & Rugg, 1996). The amplitude of the effect is larger when items are encoded shallowly (Rugg et al., 2000) and when recognition is based on familiarity assessments (Henson et al., 2000). In these instances,
recognition decisions are assumed to be less confident, and with more monitoring of the information therefore required. Although this component of the old/new effect is typically measured over a longer epoch, the late frontally-distributed difference between old and new words in the present study may reflect the engagement of similar processes. That the effect was confined to the waveforms of the control participants may indicate that these individuals engaged in more monitoring of the retrieved information than the simulators, possibly reflecting relatively less-confident decisions resulting from shallower processing of the high-frequency words. In contrast, the absence of the late frontal effect in the malingerers may reflect deeper levels of processing and fewer requirements for post-retrieval monitoring of the words.

In both malingering and control groups, old/new effects associated with the frontal N400 and LPC were broadly distributed across the scalp. This finding is at odds with many other studies, which report old/new effects in corresponding epochs with more defined topographical distributions. However the majority of those studies used low-frequency words as the stimuli, with the broadly distributed effects reported here possibly reflecting differential processing of words with a high-frequency of occurrence. Similarly broad effects in the malingering task were reported in Study 2, associated with the retrieval of high-frequency words and interpreted as reflecting more effortful or additional processing and the engagement of multiple cortical regions. In contrast, old/new word differences in the control task of that study were largely confined to frontal regions, and interpreted as reflecting less-effortful, familiarity-based judgements, permitted by the relatively easy forced-choice format. In Study 3, the deeply encoded low-frequency words gave rise to activity in defined regions in both groups. It is possible that, in the present study, the more
difficult recognition of high-frequency words combined with the increased difficulty of the
test format may have led to additional processing in both groups, indexed by broadly
distributed old/new word differences.

7.4.2 Study phase analysis

The second primary aim of this study was to examine whether instructions to simulate
impairment influence processing during the encoding of the stimuli. The results indicated
that there were indeed significant differences between the malingering and control group in
the initial processing of the words. In particular, compared to the control group, the
waveforms of the malingerers were characterised by a larger P2 and attenuated frontal N400
component. Interestingly, the morphology of these study phase waveforms was very similar
to that obtained in the test phase. The similarity of these components in both study and test
phases within each group is consistent with theories which propose that processes utilised at
encoding are reinstated at test (see Allan, Robb, & Rugg, 2000 for a more-detailed
description of these). For example, in the present study, given the proposed functional
significance of the frontal N400 outlined previously, participants in the control task
appeared to engage in short-term semantic or conceptual processing of the study words.
During the test phase, similar processing of the words occurred. The relative absence of this
component in the malingering group suggests that these participants employed qualitatively
distinct strategies or methods of processing the stimuli in both study and recognition phases,
seemingly involving processes more closely related to the P2 component. Positive
components with a similar latency and topography have been associated with cognitive
functions including attention to, and selection of, task-relevant stimuli (Mangels et al.,
2001), early retrieval of information from memory (Dunn et al., 1998), the amount of effort used in word evaluation (Herning, Jones, & Hunt, 1987) and short-term memory storage (Chapman, McCrary, & Chapman, 1981; Salustri, Chapman, Chapman, & McCrary, 1993). The study phase waveforms of the malingering group also showed a tendency for enhanced positive slow wave activity. According to Mangels et al. (2001) the first 400 ms of stimulus encoding involves perceptual and conceptual processing to a level that enables recognition on the basis of familiarity. Elaborative processing however, as indexed by slow wave activity, is required for conscious recognition of an item.

Based on the electrophysiological results of the present study, the following sequence of task performance in control and malingering participants is proposed, with the associated ERP measure in brackets. During the initial encoding of high-frequency word stimuli, participants in the control task process the words according to their semantic or conceptual features (frontal N400). Similar processing is reinstated during the retrieval phase (frontocentral N400). However, the relatively shallow encoding of the words in the study phase means that participants are less confident about their old or new status, and additional monitoring of the words is required prior to making a recognition decision in the test phase (late frontal old/new effect). In contrast, instructions to simulate memory impairment result in a different strategy of processing during the study phase, possibly involving enhanced attention, evaluative effort or storage of the words in memory (P2) and elaborative associative processing (slow wave activity). At test, processes related to the P2 are reinstated and the enhanced elaborative encoding results in earlier discrimination of old from new words (early malingering effect, evident in the P2 epoch). These early processes may attenuate or make redundant the later processing proposed to occur in the control
group, such as semantic or conceptual processing and post-retrieval monitoring, resulting in a reduced frontocentral N400 and absent late frontal old/new effect.

Utilising these group differences to distinguish simulating from honest individuals gave only mixed success however. Using reaction time differences and the ERP measure of early recognition, 72.5% of participants were correctly classified. This is considerably lower than the rates of 79% and 89.5% achieved in the previous studies. In addition, while sensitivity was high, specificity was not, with honest performance correctly classified at around chance levels only. A stepwise discriminant function analysis using all the significant differences between the groups retained reaction time differences and N400 amplitude during the study phase as predictors. As in the previous analysis, this function showed good sensitivity but poor specificity, classifying controls with only 58.8% accuracy. These results suggest that the cognitive processes underlying the functions were reliably and consistently used by those simulating impairment, but were more variable in the control participants. For example, the task of malingering may reliably elicit high levels of attention and effort, whereas these are important in the performance of some controls but not others.

Finally, the present study also identified group differences in the amplitude of a negative component with a peak latency of 600-650 ms. This frontocentrally-distributed negativity was seen in response to incorrectly classified words, and was particularly large to words incorrectly judged as old. Other researchers have also reported accuracy-related ERP effects. For example, the error-related negativity (ERN) is a component thought to reflect the realisation that one has given an incorrect response (Coles, Scheffers, & Holroyd, 2001; Falkenstein, Hoorman, Christ, & Hohnsbein, 2000). According to Coles et al. (2001), the ERN reflects an error-processing system, whereby the correct response is compared with the
one that is actually made, with the ERN signalling the detection of a mismatch. Although the ERN is generally studied in response- rather than stimulus-locked waveforms, the topography of the late negativity observed in the present study, along with its relationship to response accuracy, suggests that it may share features in common with the ERN. Interestingly, this negativity was absent or substantially reduced in malingering participants, particularly over midline frontal sites. According to Coles et al. (2001), errors are the result of fast guessing or impulsive responding, and can be avoided through further processing of the stimulus. It is possible that in the present study, the reduced or absent negativity in the waveforms of the malingerers may indicate careful or additional processing in these participants relative to the controls.

In a study by Dikman and Allen (2000), a reduced amplitude ERN was reported in a group of low-socialised individuals on a simple decision-making task. In this study, half of the trials rewarded correct responses with a financial incentive, while a loud tone punished incorrect responses on the remaining trials. The authors found that the ERN on the punished trials was reduced in the low-socialised group, relative to reward trials and to the error responses of the high-socialised participants. These results were interpreted as reflecting the reduced salience and concern for the implications of an error in the low-socialised individuals. Similarly, the reduced negativity in the malingering compared to the control group in the present study may be due to differences in the implication of erroneous responses in the two tasks. While the controls were instructed to perform at their best, the task of malingering required that participants include a proportion of errors in their responses. The differing electrophysiological response to incorrect recognition judgements may therefore be due to these being deliberate actions rather than “errors” in the
malingering participants. Although a relatively small number of error trials contributed to the ERPs in this analysis, differences between controls and malingerers in this ERP effect may prove a fruitful avenue for future research.

7.4.3 Summary

In summary, the results of the present study demonstrate the reliability of the early malingering effect and patterns of response latency in a group of participants simulating memory impairment. The presence of these measures in a yes-no test of recognition memory indicates that they are robust across test formats. In addition, this study observed group differences in a number of ERP components, in particular, enhanced amplitude of the P2 and attenuation of an anterior N400 in malingering participants. Analysis of study phase ERPs suggested that differential encoding strategies in the two groups influenced retrieval phase ERPs and may play a role in the elicitation of the early malingering effect. Once again, the behavioural and ERP group differences were consistent with more-effortful processing in the malingering compared to the control participants. However, while these processes appeared to be reliably elicited in malingering participants, they (or their absence) were less consistent in those responding honestly. If these measures are a sign of additional or more-effortful processing, this result may reflect the increased difficulty of the recognition test utilised in the present study, combining words which tend to be recognised based on their relative familiarity with a test format which depends more on recollection of specific details from the study episode. Therefore, while the malingering task requires greater effort regardless of test format, similar effortful processing may have been required in a proportion of the honestly-responding participants in order to complete the task. This
would suggest that easier tasks, perhaps utilising a forced-choice format, might maximise the ability to discriminate between control and malingering individuals.

The following experiment aims to complete this series of studies manipulating word frequency and test format, by presenting low-frequency words as the stimuli in a yes-no test of recognition memory. Classification accuracy in the previous low-frequency word study (Study 3) was high, and it is hoped that the specificity of the measures of feigned impairment will improve relative to those obtained in the present study.
CHAPTER 8. STUDY 5 – AN ERP STUDY OF SIMULATED AMNESIA USING LOW-FREQUENCY WORDS IN A “YES-NO” TEST OF RECOGNITION MEMORY

8.1 INTRODUCTION

The previous studies in this thesis have demonstrated reliable behavioural and electrophysiological differences between control and simulating groups in their processing of word stimuli in tests of recognition memory. For example, consistent differences in the patterns of response latency between the two groups have been reported, with controls taking longer to respond to words that were incorrectly compared to correctly classified, while the response latency of malingerers did not differ with accuracy. In addition, electrophysiological analyses revealed that the enhanced positivity elicited in response to previously-studied words emerged earlier in simulating compared to control participants. This early emergence was interpreted as reflecting processes related to the additional demands of the malingering task, such as strategic planning, attention, evaluative effort, or early retrieval of information from memory.

While the functional significance of this early malingering old/new effect remains speculative, the results of the previous studies implicate encoding strategy as a potential influence. Specifically, Study 3 presented low-frequency words as stimuli – words that are assumed to be deeply and elaboratively encoded. The results of that study demonstrated that old/new ERP differences emerged earlier in both groups compared to the latency of the effect when high-frequency words were the stimuli. This suggested that deeper levels of
encoding of the stimuli in those simulating impairment may be a factor in the early emergence of the effect. This was investigated more directly in Study 4, with an analysis of study-phase waveforms. The results of that analysis confirmed the presence of group differences consistent with more elaborative encoding in the malingering compared to the control group.

One of the primary aims of the present study was to investigate whether the early malingering effect and response latency differences reported in the previous studies are also apparent when low-frequency words are presented in a yes-no format. As these effects appear robust over test-format and word-frequency manipulations, it is predicted that they will also be evident in the present study. If this is the case, and given the apparent relationship between depth of encoding and latency of retrieval, it is also predicted that the study phase waveforms of the two groups will differ, with the malingering group showing evidence of deeper levels of encoding. Furthermore, classification of individuals was superior when low-frequency words were used in the forced-choice format (Study 3), and it is anticipated that employing this class of word will improve the specificity of classification relative to that obtained in the previous study using the yes-no paradigm.

8.2 METHOD

8.2.1 Participants

Forty-six subjects participated in the study, and were randomly assigned to either a control or simulating group. Due to excessive eye movements, four participants failed to contribute sufficient ERP trials to the group average (< 16) and were therefore excluded.
from further analysis. Of the remaining 42, there were 20 control participants (15 females, average age 22.25 years, SD=6.44) and 22 malingerers (19 females, average age 24.91 years, SD=10.58).

8.2.2 Stimuli

The stimuli were 100 low-frequency words (1-7 per million), 4-8 letters in length, selected from the Kucera and Francis corpus (1967). As in the previous study, fifty of these words were shown in the study phase, and were presented again in a test phase, interspersed with 50 new words. During the test phase, participants were asked to indicate whether the words had been previously seen in the study phase (old words) or were new to the experiment.

8.2.3 Electrophysiological recording

Electrophysiological data were recorded as described in Study 2 (Section 5.2.3).

8.2.4 Procedure

The procedure employed was identical to that outlined in Section 7.2.4

8.2.5 Data analysis

Reaction time data were analysed using a mixed-design ANOVA, with Group (control, malingerer) as a between-subject factor, and Word (old, new) and Response Accuracy (correct vs. incorrect responses) as repeated measures. This analysis was based on the responses of 35 participants, since one control did not misclassify any old or new words,
another any old words, and four controls and one simulator did not misclassify any new words.

Analyses of the ERP data were carried out on test and study phase data using PCA. These were performed on the covariance matrix, with a Varimax rotation. The cases in the analysis of the test phase data consisted of the word type (2), electrode sites (9) and participants (42), and for the study phase analysis, electrode sites (9) and participants (42). The variables for the test phase were 64 time points, obtained by averaging every four sequential data points in the original waveform of 256 points. For the study phase, every 6 sequential data points were averaged, giving 42 variables. The factor loadings were used to identify non-overlapping epochs capturing the extracted components. Separate ANOVAs were conducted on mean amplitude data from each of these PCA-defined epochs. For the test phase, Word (old/new), Lateral (left, midline, right) and Sagittal (frontal, central, parietal) planes were within-subject factors, and Group (control, malingerer) the between-subject factor. The study phase analysis excluded the factor of Word. ERP effects within regions were examined using the same planned contrasts outlined in Study 1. All F tests of ERP data have (1, 40) degrees of freedom.

8.3 RESULTS

8.3.1 Behavioural data

There was a significant difference in the test scores of the two groups (\(F(1,40)=197.9, p<0.0005\)), with control participants recognising 91.4% of the previously-studied words compared to the malingerering group, who claimed to recognise only 53.7%.
Reaction times as a function of accuracy for the two groups are shown in Figure 8-1. As in previous studies, an interaction of Group and Accuracy ($F(1,33)=4.39$, $p<0.05$) reflected rapid responses to correctly compared to incorrectly classified items in the control participants (710.4 vs. 769.6 ms), whereas in the malingering group there was little difference in reaction time with response accuracy (correct: 799.9 ms vs. incorrect: 805.2 ms). An interaction of Group, Word and Accuracy ($F(1,33)=10.308$, $p<0.005$) was primarily due to group differences in the time taken to classify previously-studied words: compared to honestly-responding participants, malingers took longer to correctly identify previously-studied words (hit), and less time to misclassify these words as being new (miss).

Figure 8-1. Response latencies for the control and malingering groups as a function of word type and accuracy

Analysis of response bias revealed a tendency for the control group to respond conservatively ($B_r=0.391$, $t=-2.026$, $p=0.057$), that is, to respond that they hadn’t seen a
previously seen word when unsure. In the malingering group, this bias was more marked
($B_x=0.3141$, $t=-4.910$, $p<0.0001$), suggesting a strategy of answering incorrectly in response
to old rather than to new words.

8.3.2 Electrophysiological data

8.3.2.1 Study phase data

Figure 8-2 presents the grand mean waveforms for both groups recorded during the
study phase of the task. The PCA conducted on the study phase data identified four factors
with eigenvalues exceeding one (shown in Figure 8-3), which together explained 85.7% of
the variability in the data.

![Figure 8-2. Study phase waveforms for the control and malingering groups](image-url)
The component scores for each of the factors were multiplied by the grand mean waveforms to form plots of each factor for the two groups (Figures 8-4 to 8-7). As in previous studies, factor loadings were used to define non-overlapping epochs best representing each of the factors. These were 155-295, 295-595, 595-625 and 625-900 ms. However, the 595-625 ms epoch appears inadequate to properly represent Factor 4, which seems to reflect a late positive component (LPC). Visual inspection of the factor plots led instead to analysis of 595-700 and 700-900 ms epochs, which seemed to better encompass the LPC, while retaining the region of greatest activity in the slow wave which follows. The results of ANOVAs conducted on the mean amplitudes of each of these epochs are outlined below.
Figures 8-2 and 8-4 depict waveforms during this epoch as encompassing a positive component with a peak latency of approximately 250 ms, similar to the P2 component observed in the previous study. The amplitude of this component was generally enhanced over the midline relative to the hemispheres ($F=4.95$, $p<0.05$) and over central regions relative to the average of frontal and parietal sites ($F=8.46$, $p<0.01$). Interactions within the lateral and sagittal planes revealed that amplitude was maximal over right parietal scalp regions (right vs. left x frontal vs. parietal: $F=6.44$, $p<0.05$), and at the vertex (midline vs. left/right x central vs. frontal/parietal: $F=6.50$, $p<0.05$). There were no statistically significant differences between the control and malingering group waveforms during this epoch.

![Waveform Diagram]

**Figure 8-4.** The P2 component (Factor 3) for the control and malingering group, analysed over the 155-295 ms epoch
8.3.2.1.2 295-595 ms

The predominant feature of waveforms during this epoch (Figures 8-2 and 8-5) was a negative component peaking at around 425 ms following stimulus onset. The amplitude of the component was more negative at frontal relative to parietal sites ($F=31.41, p<0.00001$). This component was similar to that described in previous studies in this thesis and by others (e.g. Curran, 1999; Duzel et al., 2001), and labelled a frontal N400 component.

![Figure 8-5. Frontal N400 component (Factor 1), analysed over a 295-595 ms epoch following the onset of the stimulus](image)

Over central regions, the amplitude of the component was more negative over the midline relative to the lateral sites, a pattern not apparent over frontal and parietal scalp sites (midline vs. left/right x central vs. frontal/parietal: $F=6.51, p<0.05$). An interaction of Group with the sagittal plane reflected the enhanced negativity of this frontal N400 at...
frontal sites in the malingering relative to control participants (frontal vs. parietal: $F=7.77$, $p<0.01$).

8.3.2.1.3 595-700 ms

Visual inspection of the waveforms during this epoch (Figs. 8-2 and 8-6) show a positive deflection peaking at around 650-700 ms. As mentioned previously, this component appears to represent a late positive component (LPC). The component was generally more positive over the midline relative to the hemispheres ($F=21.23$, $p<0.00005$), with an interaction of the lateral and sagittal dimensions indicating that this was predominantly the case over parietal sites (midline vs. left/right vs. frontal/parietal: $F=8.52$, $p<0.01$).

![Waveforms showing the LPC (Factor 4), analysed over the 595-700 ms time window](image)

**Figure 8-6.** Waveforms showing the LPC (Factor 4), analysed over the 595-700 ms time window
The plots of this component show that it was broadly distributed in the control participants, apparent at frontal, central and parietal regions. In the malingers however, the component was largely absent over frontal scalp sites. This was supported by an interaction of Group with topography, revealing markedly less-positive waveforms over right frontal sites in the malingering relative to the control group (left vs. right x frontal vs. parietal: $F=6.74, p<0.05$) and a tendency towards significant group differences over frontal sites in general (frontal vs. parietal: $F=3.62, p=0.06$).

8.3.2.1.4 700-900 ms.

Figures 8-2 and 8-7 reveal a positive deflection of the waveform during this epoch. The long duration of this component is suggestive of a positive slow wave. The amplitude of the slow wave was enhanced over midline (midline vs. left/right: $F=8.26, p<0.01$) and central scalp sites (central vs. frontal/parietal: $F=5.61, p<0.05$). An interaction of Group with the sagittal plane, closely approaching significance (frontal vs. parietal: $F=4.05, p=0.051$), indicated that the differences between the groups tended to be largest over frontal regions, with more positive waveforms in the control compared to the malingering group. An interaction of Group with the lateral and sagittal planes (left vs. right x frontal vs. parietal: $F=6.74, p<0.05$) was due to differences at parietal scalp regions: amplitude was similar over right hemisphere sites, but markedly more positive in the control group over the left hemisphere.
8.3.2.2 Test phase data

The grand mean waveforms for the two groups are shown in Figure 8-8. Old/new differences are apparent in both groups at all recording sites, but appear to emerge earlier in the control compared to the malingering group. The waveforms also appear markedly more positive in the control group.

The PCA extracted six factors with eigenvalues exceeding one (Figure 8-9), which together explained 91.1% of the variability in the data.
Figure 8-8. Test phase grand average waveforms for the control and malingering groups
Figure 8-9. Varimax-rotated component for the test phase, illustrating the epochs over which the components were analysed

The component scores for these were multiplied by the grand mean waveforms to form plots of the six factors as a function of Word, Group and topography (Figures 8-10 – 8-15). Visual inspection of these revealed a remarkable similarity in Factors 5 and 6 (Figures 8-14 and 8-15), and their similarity to Factor 1 (Figure 8-10). Early differences (i.e. around 350 ms) between Factors 5 and 6 suggest that they represent subdivisions of elements of the later slow wave component (Factor 1). The similarity of the first four factors to those extracted in the previous studies, along with the small contribution of Factors 5 and 6 to the explained variance (3.8%), suggested further analysis of the first four factors only. Factor loadings were used to define non-overlapping epochs best representing each of these four factors:
90-170, 170-300, 300-605 and 605-900 ms. ANOVAs were conducted on each of these epochs, with the results outlined below.

8.3.2.2.1 90-170 ms

This factor (Figures 8-8 and 8-10) represents a negativity peaking at around 125-150 ms, maximal over frontal regions, followed by a positivity maximal at parietal sites with a peak latency of 150-175 ms. Similar early components have been identified in previous studies and related to early sensory processing of the stimuli. The amplitude of this complex was more positive over the hemispheres relative to the midline sites ($F=7.44$, $p<0.01$), and over parietal compared to frontal regions ($F=18.73$, $p<0.0001$). At central sites, amplitude was more negative over the midline relative to the hemispheres (midline vs. left/right x central vs. frontal/parietal: $F=8.13$, $p<0.01$), reflecting the increased amplitude of the negative component over this region. At parietal sites, the amplitude of the complex was enhanced over the right relative to left and midline regions (right vs. left x frontal vs. parietal: $F=4.18$, $p<0.05$); midline vs. left/right x frontal vs. parietal: $F=7.26$, $p<0.05$). There were no differences in amplitude or topography as a function of word type or task during this epoch.

8.3.2.2.2 170-300 ms

This factor was depicted as a positive component with a peak latency of around 220-250 ms, accompanied by a negativity evident at parietal sites peaking at approximately 200 ms (see Figures 8-8 and 8-11). This factor is hereafter referred to as an N200-P2 complex.

In both groups, the amplitude of the complex at frontal and parietal sites was more positive over the right compared to the left hemisphere, whereas at central sites, amplitude was more positive over the left hemisphere (left vs. right x central vs. frontal/parietal:
In the control group, the amplitude was most positive over frontal regions, while in those malingering impairment, amplitude was enhanced parietally (Group x frontal vs. parietal: $F=7.02, p<0.05$). This seems to be due both to attenuation of the negative component in the malingering group over parietal regions, and the enhanced amplitude of the positive component over frontal sites in the control group. There was no difference in the waveforms according to whether the words were new or had been previously studied.

8.3.2.2.3 300-605 ms

The waveforms during this epoch (Figures 8-8 and 8-12) show a negative deflection maximal over frontal and central sites, and peaking at around 400 ms, followed by a positive deflection enhanced over parietal sites with a peak latency of approximately 575-600 ms. Interactions within the lateral and sagittal dimensions reflected enhancement of the negativity over midline frontocentral sites and positivity over midline parietal sites (midline vs. left/right x frontal vs. parietal: $F=6.63, p<0.05$; midline vs. left/right x central vs. frontal/parietal: $F=10.94, p<0.005$). An interaction of topography with Group however, revealed that these midline maxima were most evident in the control group (group x midline vs. left/right: $F=8.19, p<0.01$).

Overall, responses to old words elicited more positive waveforms relative to new words ($F=41.27, p<0.00001$). This difference was maximal over sites closest to the midline (midline vs. left/right: $F=10.46, p<0.005$), and parietal relative to frontal regions ($F=5.4, p<0.05$). The old/new word difference was greater in the control compared to the malingering group (old minus new: controls – 3.14 µV, malingerers – 1.39 µV: $F=6.20, p<0.05$).
Figure 8-10. Early components (Factor 4) analysed over the 90-170 ms epoch following the onset of the stimulus
Figure 8-11. The N200-P2 complex (Factor 3) measured over the 170-300 ms time window
Figure 8-12. Factor 2 waveforms showing the frontocentral N400 component, analysed over the 300-605 ms epoch
8.3.2.2.4  605-900 ms

Plots of this factor (Figures 8-8 and 8-13) depict a positive, followed by a negative deflection. The positivity of this complex appears very similar to that measured in the previous epoch, while the negative deflection may represent a return to baseline following resolution of the processes underlying the earlier positivity, or alternatively, a negative slow wave component.

The waveforms of the control group during this epoch were more positive than those of the malingerers ($F=5.74$, $p<0.05$). An interaction of Group with the sagittal plane indicated that this was particularly so over central scalp regions (central vs. frontal/parietal: $F=4.90$, $p<0.05$). Old words elicited more positive waveforms relative to new words ($F=17.72$, $p<0.0005$), with this difference largest over parietal compared to frontal scalp sites ($F=8.35$, $p<0.01$). An interaction of Word with the lateral and sagittal dimensions reflected a reduction in the size of the old/new effect at right relative to left central sites (left vs. right x central vs. frontal/parietal: $F=9.30$, $p<0.005$). There were no differences in the size or topography of the old/new word differences as a function of group membership.
Figure 8-13. Factor 1 waveforms (measured over the 605-900 ms epoch) for the control and malingering groups.
Figure 8-14. Waveforms for Factor 5 for the two groups. This factor was interpreted as representing a subdivision of Factor 1, and statistical analyses of this component were not conducted.
Figure 8-15. Factor 6 waveforms for the control and malingering groups. As for Factor 5, this component was seen as a subdivision of Factor 1 and was not analysed further.
8.3.3 Classification of simulated and honest performance

This study identified a number of differences in the performance of simulating and control participants. As in the previous studies, there was a group difference in the time taken to make correct and incorrect recognition judgements. Furthermore, discrepancies between the groups were greatest in the classification of previously-studied compared to new words. Relative to the control group, the study phase ERPs of the malingerers showed an enhanced frontal N400 component, and more negative waveforms right-frontally in the 595-700 ms epoch, and left-parietally in the 700-900 ms epoch. In the test phase, malingering group waveforms associated with an N200-P2 complex were more positive over parietal sites and negative frontally. In the 605-900 ms epoch, their waveforms were less positive over central sites. Across the scalp, old/new word differences evident in the 300-605 ms epoch were also smaller in the malingering group.

As in the previous study, these eight significant group differences were entered into a direct discriminant function analysis. This function correctly classified 63.6% of all cases after cross-validation (Wilk’s lambda=0.59, $\chi^2=19.34$, $p<0.05$). The relative utility of the predictors was examined in a stepwise discriminant function. With an F to enter of 0.2, the variables included in the analysis were differences in reaction time to hits versus misses, and the amplitude of the N200-P2 complex at frontal versus parietal sites (Wilk’s lambda=0.62, $\chi^2=18.87$, $p<0.0001$). This function correctly classified 73.8% of the cases, before and after cross validation (75.0% of controls and 72.7% of malingerers).
8.4 DISCUSSION

The primary aim of the present study was to demonstrate the robustness of behavioural and electrophysiological measures obtained in previous studies in this thesis in a yes-no recognition test using low-frequency words as the stimuli. Despite the similarity of a number of the findings, the overall pattern of results suggests that the interaction of less-common words and the yes-no paradigm bring about group differences in processing not evident in the previous studies.

Results that were consistent with those previously reported were related to behavioural performance. Firstly, malingering participants scored poorly on the recognition memory test compared to those performing honestly. Secondly, while controls responded more rapidly to correctly compared to incorrectly identified words, no such pattern was evident in the responses of the malingerers. Thirdly, malingerers again showed a significant bias towards claiming not to have seen words from the study phase. This bias was reflected in the time taken to classify the words, with the shortest response times associated with misclassification of old words. In addition, the longest response latencies occurred when old words were correctly identified, suggesting the need to inhibit the response bias on these trials. Similar results were reported in Study 4, and provide further evidence to suggest that poor behavioural performance in malingering participants is predominantly achieved by claiming not to recognise words from the study phase.

While the behavioural results support the hypothesis of robust group differences across test format and word frequency, the electrophysiological findings do not. The previous studies in this thesis have consistently shown that old/new word differences emerge earlier in participants malingering a deficit compared to those responding honestly. In the previous
study utilising a yes-no test format (Study 4), this effect was associated with a parietally-distributed P2 component. That study also reported an enhanced P2 component in the waveforms of the malingerers during initial encoding, suggesting a relationship between processes engaged at study and the early malingering old/new effect. Contrary to expectations, this early old/new effect was not evident in either the malingering or control group in the present study. In addition, there were no group differences in the amplitude of the P2 component during encoding of the stimuli.

Along with the absence of the early malingering effect, further unexpected ERP group differences were evident during both the encoding and retrieval phases of the test. For example, during the initial encoding of the stimuli, malingering participants showed enhanced frontal N400 amplitude and reduced frontal positive slow wave activity relative to the control group. These results are in direct contrast to those obtained in the previous study, which presented words with a high linguistic frequency. In that study, the larger frontal N400 and attenuated slow wave in the controls were interpreted as reflecting semantic or conceptual processing of the words with little further elaborative processing. Another unexpected difference in the present study was the attenuated parietal old/new word difference in the malingering group’s waveforms recorded during retrieval. Wilding (2000) related the size of the parietally-distributed old/new effect to the quality and amount of information retrieved from the study phase, and observed that when more information was retrieved, the effect was larger. These results appear to indicate that while both groups recognised the words using recollective-based processes (as evidenced by the predominantly parietal distribution of the old/new effect), the control group demonstrated deeper levels of
encoding, and more efficient recognition of the studied items compared to those asked to simulate impairment.

The electrophysiological results of the present study therefore appear to be at odds with those of the previous studies, which had suggested that it was the malingering rather than the control participants who adopted the more-effortful processing strategies. In particular, when compared to Study 4, the results suggest a task-related reversal in the processing of words according to their linguistic frequency: low-frequency words were processed more-effortfully in control compared to malingering participants, whereas the opposite pattern of results occurred for high-frequency words. Consistent with the extant literature, the pattern of results for the control participants is likely to be due to differential encoding of low- and high-frequency words, with low-frequency words processed more elaboratively at initial presentation than high-frequency words (Lockhart et al., 1976; Rao & Proctor, 1984). The more effortful processing of high- than low-frequency words in the malingering condition may be a result of the additional requirements of this task. For example, knowledge that one will be asked to simulate impairment in the test phase may encourage additional encoding strategies that will facilitate later recognition of the words. Since high-frequency words are less distinctive relative to other items in memory, malingerers may have had to utilise more-effortful cognitive processing in order to make these items distinctive and therefore memorable. This proposal is consistent with the interpretation of differences in the pattern of subsequent memory effects for high- and low-frequency words in a study by Fernández et al. (1998). That study observed two dissociable subsequent memory effects, one of which occurred for high-frequency words only. According to the authors, that effect may be due to
the additional organisational strategies and specific item information required for the successful encoding of the less distinctive high-frequency words.

In the previous study therefore, it is possible that the early stages of this additional or more effortful processing was reflected in the P2 component, with larger amplitudes indexing processes such as elaboration or enhanced attempts at storage of information in memory. At test, this enhanced processing was revealed as old/new word differences in the P2 component, reflecting early retrieval of the studied items from memory. In contrast, in the present study, the inherent memorability of the low-frequency words may have required relatively less elaborative effort by the malingering group. It is also possible that the more complex conceptual or semantic nature of the low-frequency words attenuated or delayed the early processes reflected in the P2 component. For example, it has been proposed that the P2 may signal attempts at early storage of the items in memory. While the relatively simple and inherently familiar high-frequency words may be easily encoded and stored in memory in motivated participants, the complexity of the low-frequency words may necessitate additional processing before such processes can occur.

This explanation for the difference between control and malingering participants in processing of low- and high-frequency words is complicated however by the results of Study 3, in which low-frequency words were presented in a forced-choice format. In that study, an early old/new effect was found to reliably distinguish honest from simulating individuals. This finding suggests that processes adopted by those simulating impairment may be subject to the combined influence of test format and word frequency. For example, forced-choice tests require that participants sequentially view a pair of words, and make a recognition decision after both words have been shown. The increased evaluation time in
this format may allow for earlier discrimination of studied vs. unstudied words in motivated subjects, or allow other cognitive processes to play a role in the task of simulating impairment. Furthermore, the absence of study wave analyses in that study did not allow comparisons between the control and malingering groups’ encoding strategies.

A discriminant function, which used as variables the significant response latency and ERP group differences reported in this study, successfully classified 63.6% of cases. A stepwise discriminant analysis determined that of these eight major group differences, only reaction time difference to hits compared to misses, and the topography of the N200-P2 complex elicited during the test phase reliably differentiated the two groups (73.8% correctly classified after cross validation). The latter has not been reported in previous studies in this thesis, but reflected the larger N200 component at parietal sites and P2 at frontal sites in the control group, and attenuated posterior N200 and enhanced parietal P2 in the malingering group (see Figure 8-11). In the control group, the latency and topography of these components is consistent with the N2b and P2a components described by Potts and colleagues (Potts, Liotto, Tucker, & Posner, 1996; Potts & Tucker, 2001) and proposed to reflect processes supporting target detection and evaluation. In those studies, the posterior N2b was related to detection of the physical attributes of the stimuli, while the frontal P2a supported functions such as attention, working memory and evaluation of task relevance. However, in the present study there was no difference between the amplitude of either component to old (targets) compared to new words, so a functional interpretation similar to that described in the Potts et al. studies seems unlikely. An alternative explanation is that the frontal component represents the novelty P3a, however if this were the case it would also be expected that the amplitude would be reduced in response to old words compared to
words seen for the first time. Another possibility is that the posterior compared to frontal P2 in the malingerers compared to controls shares functions in common with those reported in a study of recall by Dunn et al. (1998). In that study, participants recalling fewer words had a large frontal P2 component, while high performing participants instead exhibited a posteriorly-distributed P2. It was proposed that the posterior distribution of this component might reflect partial or complete word retrieval from long-term memory. Again however, if this were the case in the present study, one would expect differences in old compared to new word ERPs.

In summary, in the context of the previous studies, the present study provides evidence indicating that control participants and those asked to simulate memory impairment differentially process word stimuli depending on their linguistic frequency and the format in which they are presented. Unexpectedly, the early malingering old/new effect and other measures suggestive of more-effortful processing in those simulating impairment were not evident when low-frequency words were presented in a yes-no test format. The next study in this thesis will attempt to integrate the findings of this and the previous studies, in order to more directly compare the behavioural and electrophysiological measures of control and malingering participants across frequency and format paradigms.
CHAPTER 9. OVERVIEW OF THE PREVIOUS STUDIES

9.1 INTRODUCTION

The previous studies in this thesis have examined behavioural and electrophysiological measures of recognition memory in control groups and in participants asked to feign memory impairment. These studies have systematically manipulated the linguistic frequency of the stimuli and the format in which the words were presented at test. Studies 1 and 2 presented high-frequency (HF) words in a forced-choice format, Study 3, low-frequency (LF) words in a forced-choice format, and Studies 4 and 5 utilised HF and LF words respectively, in a yes-no recognition paradigm.

Within each of these studies, the results demonstrated differing performance in control and malingering participants. The aim of the present chapter is to integrate and compare the results of the preceding studies to enable a more complete description of the effects of linguistic frequency and test format on performance in malingering and control tasks.

Data from studies 2, 3, 4 and 5 were used in this analysis. Studies 1 and 2 presented HF words in a forced-choice format, using between- and within-subject designs, respectively. However, Study 1 did not include reaction time data or analyses based on the order of presentation of words in the pair. In addition, for the reasons discussed in Study 2, the peak latencies of ERP components in the first study differed from those observed in the following studies. Data from Study 2 will therefore be used in the following analyses, using only the first block from each participant to ensure compatibility with the other between-subject
studies. The Study 2 data set in the present analysis thus comprises nine malingering and ten control participants.

9.2 BEHAVIOURAL MEASURES

Test scores and reaction time measures for the malingering and control participants in the four studies are shown in Table 9-1 below.

Table 9-1. Behavioural measures for the control and malingering groups for Studies 2-5. Note that due to the presentation of paired old and new words in the forced-choice studies, hit and false alarm rates, measures of bias and reaction times as a function of word status and accuracy could not be assessed.

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<th>Test format</th>
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<th>Test score (% correct)</th>
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<th>M</th>
<th>C</th>
<th>M</th>
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<td>5</td>
<td>Yes-no</td>
<td>Low frequency</td>
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| C=control, M=malingeringer.

These data reveal that format and word frequency combined to influence test scores in the control groups. In the yes-no tests, recognition was more accurate for LF vs. HF words,
consistent with the “word frequency effect”, described by others (e.g. Jacoby & Dallas, 1981; Mandler et al., 1982; Rugg et al., 1995). However, recognition of HF and LF words was equivalent in the forced-choice test, indicating that the relative ease of this test format enabled accurate recognition regardless of linguistic frequency. There was little difference in the control groups’ scores for LF words across test paradigms, suggesting that these words were accurately recognised regardless of test format.

The test scores for the malingerers indicate that in all studies, simulating instructions were successful, with behavioural performance suggesting severe memory loss. Despite the use of “sophisticated” instructions however, which were designed to assist participants present a believable deficit, as a group, the malingerers in all studies performed at around chance levels. Analyses of measures of bias indicated that these chance-level scores were not simply due to random responding: in both studies in which these measures were analysed (Studies 4 and 5), a conservative response bias was evident, suggesting an over-endorsement of negative responses to both previously-studied and new words. Such a bias typically results in a lower proportion of hits and false alarms, however Table 9-1 shows that while the proportion of hits was reduced compared to those of the control group, there were a larger number of false alarms. This finding, together with the response bias results, indicates that while malingerers responded more often than controls that they had seen the new words, poor task performance was predominantly achieved through claiming not to recognise previously-studied words.

In both control and malingering participants, reaction times were faster for the yes-no compared to the forced-choice formats. This is likely due to the longer response deadline in the forced-choice (2.5 s) compared to the yes-no studies (1.5 s). In all studies, control
subjects took less time to respond to correctly vs. incorrectly classified items, a result reported by many others (e.g. Donaldson & Rugg, 1998; Sanquist et al., 1980; Wilding, 2000). In contrast, the malingerers showed equivalent response times to correct and incorrect judgements. More specifically, data from Studies 4 and 5 reveal that malingerers were slowest to correctly identify previously-seen words but responded most rapidly to old words which they misclassified as new. This short latency associated with miss responses is consistent with the response bias of these participants, while the long latency associated with correct classification of old words suggests the requirement to inhibit this bias on a proportion of the trials.

In summary, the behavioural results from the four studies indicate that malingerers performed consistently poorly on the recognition test, regardless of word frequency and test format. The more detailed results obtained in Studies 4 and 5 provide evidence that participants simulated impairment by claiming not to recognise previously-seen words, as seen in the conservative response bias and the rapid misclassification of old words.

9.3 ELECTROPHYSIOLOGICAL MEASURES

9.3.1 Test format

To investigate the effect of test format on electrophysiological measures, ERP data from the test phase of the forced-choice studies (2 and 3) were combined and compared to the combined data from the yes-no studies (4 and 5). The results of this comparison are shown in Figure 9-1.
Figure 9-1. Waveforms for the control and malingering participants showing ERPs for the forced-choice compared to the yes-no test formats averaged over old and new words.
Disregarding old and new word status, this figure shows that the ERP components in the yes-no studies were generally larger in amplitude and better defined than those in the forced-choice test formats. This appears to be related in part to the order of presentation of the words in the forced-choice test, as illustrated in Figure 9-2. This figure shows control group waveforms separated according to first vs. second presentation of the words in the pair, and compares these to ERPs from the yes-no studies. Differences between first- and second-presented words are clearly evident, as is the similarity of second word responses to those elicited in the yes-no test paradigm.

Figure 9-2. Waveforms for the control group comparing responses to first and second words in the forced-choice format to yes-no format ERPs.
This is consistent with the proposal made in Study 2 that first words are registered, but more active cognitive processing and recognition decisions are delayed until presentation of the second word.

Regardless of word order however, the plots show enhanced amplitude of the frontal N400 component in the yes-no compared to the forced-choice format. Mangels et al. (2001) linked a similar frontally-distributed component with processes underlying conceptual rather than perceptual evaluation. In the present comparison, the difference in frontal N400 amplitude may therefore reflect greater involvement of semantic or conceptual processing in the yes-no compared to the forced-choice format. It is possible for example that, in the relatively easy forced-choice studies, recognition occurred simply through a comparison of the perceptual familiarity of the two words. According to Keane et al. (2000), in forced-choice tests where the stimuli are visually dissimilar (i.e. sofa/died, compared to similar stimuli such as lied/died), the ease of these tasks means that there is “little room for performance to be influenced by explicit memory for words from the prior list” (p.329). Thus, control participants may have based recognition judgements on measures of perceptual familiarity whereas those in the yes-no study retrieved semantic or conceptual information established during initial encoding of the stimuli.

Also obvious from the control group waveforms in Figure 9-1 is the attenuated LPC in response to words in the forced-choice test format. Examination of Figure 9-2 indicates that this difference was again largely due to differences in the processing of first- compared to second-presented words, with second word ERPs almost equivalent in amplitude to those evident in the yes-no study. This indicates that decision-making processes, similar to those influencing the P3 component, may influence the amplitude of this positivity.
In those simulating impairment (see lower panel of Figure 9-1), the amplitude of the frontal N400 component was also larger in the yes-no compared to forced-choice format, although this difference appears less marked. In addition, and unlike the control groups, the amplitude of the LPC was very similar in both formats, due primarily to a relatively small response in the yes-no tasks. Why this is so is not clear, although other researchers have also reported an attenuated positive component with a similar latency in subjects simulating memory impairment. For example, in studies of simulated autobiographical memory loss, Rosenfeld et al. (1995) and Miller, Rosenfeld, Soskins and Jhee (2002) reported a reduced P3 component in their malingering groups and related this to the sensitivity of this component to divided attention and the dual task requirements of simulating a deficit.

Figure 9-3 compares old minus new word difference waveforms for the two groups in the yes-no (Studies 4 and 5) and forced-choice (Studies 2 and 3) paradigms. This shows that in the control group, the old/new effect emerged approximately 100 ms earlier in the yes-no compared to the forced-choice test (250-300ms vs. 350-450 ms). In addition, old/new effects were larger in this format. This appears consistent with a more passive approach to recognition in the forced-choice compared to the yes-no task. In contrast, the difference plots for the malingering groups show that old/new effects emerged earlier in the forced-choice (apparent almost from stimulus onset) compared to the yes-no study (~ 250 ms), particularly over left hemisphere central and parietal sites. This may reflect additional effort or processing on the part of the malingerers, with Study 2 proposing that malingerers attempted recognition judgements following presentation of the first word in the pair.
This could result in cueing, or expectation of the status of the second word, leading to the very early old/new effects apparent in the forced-choice format.

Figure 9-3. Difference waveforms (old minus new words) for the control and malingering groups in the forced-choice and yes-no test formats.
In summary, in control participants, the forced-choice format appears to permit recognition based on perceptual familiarity of the two items, as evidenced by the small frontal N400 and differences in response according to order of word presentation. Along with differences in the latency and amplitude of the old/new effects, these results are consistent with the proposal that forced-choice tests permit a more passive approach to recognition compared to tests that require a recognition judgement for each word. In contrast, the malingering group waveforms were more similar across test format and showed an earlier emergence of the old/new word differences in the forced-choice tests. These results suggest differential processing in the two groups, and that the malingerers adopted a relatively more-active approach to the force-choice tests compared to the control participants.

9.3.2 Word Frequency

9.3.2.1 Study Phase Data

ERP data from the study phase of the recognition tests were collected in Studies 4 and 5. To examine the effect of word frequency on encoding in the two groups, difference waves (low- minus high-frequency words) were computed and are shown in Figure 9-4. In the control group, LF word waveforms were generally more positive than high, with this positivity associated in particular with an attenuated frontal N400, enhanced slow wave component evident at all electrode sites, and a somewhat larger frontal P2. It has been proposed that LF words receive enhanced encoding relative to HF words (e.g. Lockhart et al., 1976; Rao & Proctor, 1984). The control task test scores support this proposal, and the study phase ERP data therefore indicate that this deeper encoding involves processes
underlying the P2 and slow wave component. In contrast, an enhanced frontal N400 appears associated with shallower encoding. The P2 component has been suggested to reflect processes such as the amount of effort used in word evaluation (Herning et al., 1987), early storage of items in memory (Chapman et al., 1981; Salustri et al., 1993), salience (Potts & Tucker, 2001) and attention to and selection of words (Mangels et al., 2001). Slow wave activity is associated with elaborative processing enabling the formation of a durable trace of an item or its representation in memory (Mangels et al., 2001).

Figure 9-4. Difference waveforms for the control and malingering groups during the study phase, showing low- minus high-frequency words
This suggests that in control group participants, responses to LF words involved early processes reflected in the P2, possibly including enhanced attention, evaluation, selection and storage of these items in memory, followed by elaborative encoding strategies as indexed by the slow wave activity. In contrast, these processes were absent, or engaged to a lesser degree, in response to HF words which instead appeared to be processed in terms of their conceptual or semantic features.

Difference waveforms for the simulating participants showed the opposite pattern of results to those observed in the control task, with more positive ERPs associated with HF compared to LF words. These word frequency differences were predominantly associated with an enhanced frontal P2 and reduced frontal N400. Differences in the slow wave component were less marked and largely confined to right frontal regions. Mangels et al. (2001) described two slow wave components important for successful retrieval of studied information: a posterior negativity thought to index the sustained activation of a word or its representation in memory, and a frontal positivity which reflects elaborative, associative encoding. The difference waveforms for the malingering group therefore suggest early stages of encoding consistent with deeper or more active processing of HF vs. LF words (as seen in the enhanced P2 and reduced frontal N400), equivalent processing in terms of the parietal slow wave, but enhanced elaborative processing of the HF words.

A possible explanation for this group difference in the processing of HF and LF words given in Study 5 was that simulators processed HF words with increased effort in an attempt to increase their memorability. This additional cognitive requirement may be perceived during the early stages of encoding, leading to increased involvement of processes underlying the P2, thus attenuating or making redundant those reflected in the frontal N400.
In contrast, the inherently more memorable LF words did not require this additional effort or level of processing, leading to the relatively smaller P2 and enhanced frontal N400.

9.3.2.2 Test Phase Data

Plots comparing ERPs for LF (Studies 3 and 5) and HF words (Studies 2 and 4) for the control groups are shown in the top panel of Figure 9-5. Collapsed over word type (old, new) and relative to HF words, LF word waveforms were associated with a less negative frontal N400 component, and more positive LPC. The enhanced amplitude of the frontal N400 component for HF compared to LF words may be explained in terms of the account provided in Study 4. In this study, it was proposed that controls processed high-frequency words according to their semantic or conceptual properties, and did not engage in further elaborative processing. At test, these processes were reinstated, resulting in the large frontal N400. In contrast, and as shown in Study 5, the distinctiveness of LF words meant they were processed more elaboratively at encoding, enabling recognition on the basis of features other than conceptual properties, leading to a smaller frontal N400.

In the malingering group (lower panel of Figure 9-5), HF word waveforms were associated with a larger P2 component, later slow positivity and smaller frontal N400 relative to the LF words. These differences appear maximal over frontal and central scalp regions. These data are consistent with the effects observed in the study phase, and support proposals that processes engaged during encoding are reinstated at retrieval, and that malingers more-effortfully process HF words.
Figure 9-5. High vs. low-frequency ERPs for the control and malingering groups, averaged over old and new words.
Figure 9-6 illustrates the old minus new word differences for the two groups as a function of word frequency. In the control task, old/new effects were evident earlier for LF compared to HF words, at around 250 vs. 400 ms following stimulus onset. The magnitude of the effect was also larger in response to LF words, associated with the N400 and LPC components. The centroparietal distribution of the latter indicates that LF words were recognised largely using recollective-based recognition. There was considerably less difference in parietal vs. frontal old/new effects in response to HF words, possibly reflecting a relatively greater contribution of familiarity-based judgements in this task.

In the malingering group, old/new word differences were evident from about 200 ms for HF words, and approximately 300 ms for the LF words. This reversal of the pattern of results observed for the control subjects is consistent with enhanced processing of HF words in those simulating impairment.
Figure 9-6. Difference waveforms (old minus new words) for the two groups as a function of word frequency
9.4 SUMMARY

The aim of the present analysis was to compare and integrate the results from the previous studies which manipulated the test format and frequency of the stimuli used in a test of recognition memory.

In these studies, performance in those responding to the best of their abilities was consistent with that which would be expected based on results reported by other researchers. These participants generally scored highly on the recognition tests. Lower scores were obtained when high- compared to low-frequency words were presented in a yes-no format, consistent with the word frequency effect (Jacoby & Dallas, 1981; Mandler et al., 1982). Control participants responded more rapidly on correct compared to incorrect trials (Donaldson & Rugg, 1998; Wilding, 2000). The electrophysiological data revealed that earlier and larger old/new effects were elicited to low- compared to high-frequency words (Rugg et al., 1995; Rugg & Doyle, 1992). The amplitude of ERP components was also consistent with more elaborative encoding of low- vs. high-frequency words (Lockhart et al., 1976; Rao & Proctor, 1984). The results also provided evidence for differential processing in the forced-choice compared to yes-no format. Although there appear to be few studies examining ERPs in the former paradigm, the results of the studies in this thesis, in which old/new effects were smaller and emerged later in control participants, suggest a more passive approach to retrieval in this easier form of the test.

Participants asked to simulate memory impairment showed a pattern of performance that differed from the controls in a number of ways. Firstly, test scores were at chance levels regardless of word frequency or test format, suggesting that they adopted a similar response strategy in each study. Secondly, incorrect responses were made more rapidly than correct
responses. Thirdly, old/new effects were evident earlier for HF words and in the forced-choice format.

These results have a number of implications for future malingering research. Most importantly, the greatest electrophysiological differences between the groups exist in those tests which utilise a forced-choice format, and in which the stimuli are high-frequency words. These group differences appear to be due to the relative ease of these tests. For example, it is possible that while the forced-choice test appears to permit accurate performance in honestly-responding participants with little apparent effort, those simulating impairment may be utilising the ease of the test to engage additional cognitive processes required for feigning a deficit. In contrast, the yes-no tests, which require more-rapid responses and rely to a greater extent on retrieval of information from the study phase, may not permit the same differentiation of processing in the two groups. Similarly, it may be the familiarity of the high-frequency words and their subsequent ease of encoding which permits the malingerers to process these words in ways that differ from that of the control participants. This suggests that the easier the test, the less cognitive processing honestly-responding participants will use, and the more this will allow additional cognitive operations or strategies to be engaged by those simulating impairment.

While this may indicate that high-frequency words in a forced-choice format would be the optimal test for distinguishing malingerers from honestly-responding individuals, the yes-no test format also contributes useful information. For example, more data regarding behavioural performance can be gained through this format, permitting analysis of bias and more-detailed response latency measures. In addition, the increased difficulty of the yes-no test in which high-frequency words were used resulted in considerably lower scores in
control participants. This permitted analysis of ERPs associated with incorrect trials, and presented preliminary evidence that responses to incorrect trials may be a useful discriminator of feigned from honest performance. Future research will need to determine the optimal combination of linguistic frequency and test format enabling the most accurate discrimination based on a number of measures.

This overview of the previous studies revealed therefore, that simulating participants performed poorly on the recognition memory tests, regardless of the linguistic frequency of the stimuli or the format in which they were presented. This poor performance was achieved largely through the misclassification of previously-studied words. The ERP data of the control participants suggested they adopted a relatively passive approach to test performance in the forced-choice paradigm, and in response to high-frequency words. In contrast, these words and the forced-choice format appeared to elicit additional effort or cognitive processes in those simulating impairment.
CHAPTER 10. STUDY 6 – AN INVESTIGATION OF THE RELATIONSHIP BETWEEN ENCODING AND RETRIEVAL PHASE ERPS IN SIMULATED IMPAIRMENT

10.1 INTRODUCTION

A number of recent studies have shown that behavioural and electrophysiological measures of recognition memory performance differ in honestly-responding and simulating individuals. For example, Rosenfeld et al. (1998) and Miller et al. (2002) reported test scores that were significantly lower in malingering relative to control tasks, as well as task-related differences in the topography of the P3 component. The previous studies in this thesis have also demonstrated differences between control and simulating participants: in particular, the first four studies reported that ERP effects associated with recognition of previously-studied items occurred earlier in participants simulating impairment compared to those responding to the best of their abilities.

These previous studies have also provided evidence that appear to support a relationship between this ERP early recognition effect and strategies adopted during the initial encoding of the stimuli. In Study 4 for example, the study phase waveforms were consistent with more-effortful or additional processing in the malingering compared to the control group, as seen by an enhanced P2 and slow wave component, and reduced frontal N400. In this study, an early recognition effect associated with the P2 component was evident in the retrieval phase waveforms of the malingering group. In contrast, the results of Study 5 failed to demonstrate early differences in the study phase waveforms consistent with
effortful processing in the malingering group – and early recognition of words in these subjects were not evident during the test phase. Strategies employed at study therefore appear to markedly influence retrieval phase ERPs and, importantly in the identification of the simulat...
phase will help determine whether this early malingering effect is a function of differential encoding in the two groups, or alternatively, differences in the processes occurring at retrieval.

10.2 METHOD

10.2.1 Participants

Twenty-two undergraduate psychology students participated in the study, and were randomly assigned to either a control or simulating group. Two participants were discarded from the final analysis due to excessive EOG artefact. Of the remaining 20, there were 10 control participants (8 females, average age 27.4 years, SD=8.3) and 10 malingerers (8 females, average age 23.5 years, SD=5.6). The age difference between the two groups was not significant \(F(1,18)=1.65, p>0.05\)

10.2.2 Stimuli

The stimuli were 100 low-frequency words, identical to those used in Study 3 of this thesis.

10.2.3 Electrophysiological recording

Data were recorded as in the previous studies (detailed in Section 5.2.3)
10.2.4 Procedure

Prior to testing, participants were informed that they were to take part in a recognition memory test while ERPs were recorded. Following electrode application, participants were comfortably seated in a sound attenuated air-conditioned room, approximately 100 cm from a computer screen on which the words were presented. The study phase was identical for all subjects, and commenced with the presentation of a fixation cross in the centre of the screen. Fifty words followed, each presented for 500 ms, at a rate of one every 2.5 s. Participants were asked to covertly judge whether each word was pleasant or unpleasant, in order to ensure attention to the stimuli. Participants were not required to record these judgements.

The study phase was followed by a test phase in which participants’ recognition of the previously-studied words was assessed. Prior to beginning the test phase, half of the group were encouraged to complete the task to the best of their abilities (control group). The remainder were given instructions to feign an accident-related memory deficit (malingering group), using the “sophisticated” instructions as in the previous studies.

The procedure for the test phase was identical to that employed in the previous forced-choice studies, as described in Section 4.2.4.

10.2.5 Data analysis

Reaction time data were analysed using an ANOVA, with Group (control vs. malingering), and Response Accuracy (correct vs. incorrect responses) as between- and repeated-measures factors, respectively. This analysis was based on the data of 16 participants, since four controls did not misclassify any stimuli.
Analysis of the study and test phase ERP data was carried out using PCA, performed on the covariance matrix, with a Varimax rotation. The cases in the study phase analysis consisted of electrode sites (9) and participants (20). The variables were 21 time points, obtained by averaging every 12 sequential data points in the original waveform of 256 points. A matrix comprising 180 cases and 21 variables was therefore formed. For the test phase, the analysis included word type (2), order of word presentation (2), electrode sites (9) and participants (20). The variables were 85 time points, obtained by averaging every three sequential data points, and forming a matrix comprising 720 cases and 85 variables. The factor loadings were used to identify non-overlapping epochs over which the extracted components were best represented. Separate ANOVAs were conducted on mean amplitude data from each of these PCA-defined epochs with Word (old, new), Order (words presented first in the pair, words presented second), Lateral (left, midline, right) and Sagittal plane (frontal, central, parietal) as repeated measures, and Group (control, malingering) as a between-subject factor. The study phase analysis omitted the factors of Word and Order. Planned contrasts were the same as outlined in Study 1. All F tests of electrophysiological data have (1,18) degrees of freedom.

10.3 RESULTS

10.3.1 Behavioural data

There was a significant difference in the test scores of the two groups ($F(1,18)=41.63, p<.0005$), with control participants recognising 93.4% of the previously-studied words compared to the malingering group, who claimed to recognise only 50.0%.
Reaction times overall did not differ between the control and malingering group (1123.65 vs. 1195.10 ms: $F(1,14)=0.16, p>0.05$). However a Group x Response Accuracy interaction ($F(1,14)=6.50, p<0.05$) revealed that the control participants made correct judgements more rapidly than incorrect judgements (correct approximately 250 ms faster than incorrect), while there was much less difference in the responses of the simulators (correct around 36 ms faster than incorrect).

10.3.2 Electrophysiological data

10.3.2.1 Study phase data

Figure 10-1 presents the averaged waveforms for both groups recorded during the study phase of the task.

![Waveforms](image)

Figure 10-1. Study phase waveforms for the control and malingering group
The PCA conducted on the study phase data extracted three factors (shown in Figure 10-2), which together explained 83.9% of the variability in the data.

Figure 10-2. Varimax-rotated components for the study phase, illustrating the epochs over which they were analysed

The component scores for each of the factors were multiplied by the grand mean waveforms to form plots of each factor for the two groups (Figures 10-3 through 10-5).

As in previous studies, factor loadings were used to define non-overlapping epochs best representing each of the factors. These were 180-310, 310-490 and 490-900 ms. The results of ANOVAs conducted on the mean amplitudes of each of these epochs are outlined below.
10.3.2.1.1 180-310 ms

The plots of this factor (Figure 10-3) show a positive component, similar to the P2 observed in the previous studies, with a peak latency of approximately 250 ms. This component showed a midline maxima, with the amplitude greater over central sites compared to the average of frontal and parietal regions ($F=9.25$, $p<0.01$). There were no differences between the two groups during this epoch.

![Waveforms showing the P2 component (Factor 3) for the two groups recorded during the study phase and measured over the 180-310 ms epoch](image)

**Figure 10-3.** Waveforms showing the P2 component (Factor 3) for the two groups recorded during the study phase and measured over the 180-310 ms epoch

10.3.2.1.2 310-490 ms

This epoch (Figure 10-4) appears to encompass a frontocentrally distributed N400 component similar to that observed in the previous studies. The waveform was negative over frontal and positive over parietal regions ($F=8.04$, $p<0.05$). Over central regions, the
amplitude of the component was enhanced over the midline compared to the hemispheres: this distribution was not evident at the average of frontal and parietal regions ($F=6.53$, $p<0.05$). There were no significant group differences during this epoch.

![Figure 10-4. The frontocentral N400 (Factor 2) measured over the 310-490 ms time window](image)

10.3.2.1.3 490-900 ms

This factor (Figure 10-5) shows a LPC with a peak latency of around 700 ms. Interactions within the lateral and sagittal dimensions were due to the more positive amplitude of the component over midline parietal scalp sites (midline vs. left/right x frontal vs. parietal: $F=17.28$, $p<0.001$; midline vs. left/right x central vs. frontal/parietal: $F=21.21$, $p<0.0005$). Again, there were no group differences in the amplitude or topography of this component.
Figure 10-5. Factor 1 waveforms showing the LPC, which was analysed over the 490-900 ms epoch

10.3.2.2 Test phase data

Averaged waveforms for the control and malingering group recorded during the test phase are shown in Figure 10-6. As in the previous studies, these show enhanced positivity in response to old words, evident from approximately 400 ms in the control group. These differences appear to emerge earlier in the malingering condition, from approximately 300 ms. A PCA performed on the data extracted eight factors with eigenvalues greater than one: the first four of these were similar to those identified in previous studies and together explained 79.1% of the variability in the data (Figure 10-7). As in the study phase, component scores for each of these four factors were multiplied by the grand mean waveforms to form plots of each factor for the two groups (Figures 10-8 through 10-11).
Figure 10-6. Averaged waveforms for the control and malingering groups showing responses to old and new words, recorded during the test phase.
Factor loadings then enabled definition of non-overlapping epochs encompassing each of the factors. These were 0-170, 170-310, 310-630 and 630-900 ms. Separate ANOVAs were conducted on the mean amplitudes of each of these epochs, with the results described below.

10.3.2.2.1 0-170 ms

Plots of this factor (Figure 10-8) depict a negativity with a peak latency of approximately 100 ms, followed by a positivity peaking at around 150 ms. This complex was more positive over parietal than frontal regions ($F=15.62$, $p<0.001$), and over the average of frontal and parietal compared to central regions ($F=10.16$, $p<0.005$), reflecting a predominantly parietal distribution. Words presented first in the pair elicited more-positive waveforms than did second-presented words ($F=4.83$, $p<0.05$). An interaction of Order...
with Group and topography was due to the enhanced positivity of second-presented words over the hemispheres compared to the midline in the control group ($F=5.37, p<0.05$).

**Figure 10-8.** Early components (Factor 4) in the control and malingering group, measured over the 0-170 ms epoch.
10.3.2.2.2 170-310 ms

Factor 3 (Figure 10-9) represented a component similar to the P2 evident during the study phase and in previous studies in this thesis. The amplitude of the component was enhanced over right parietal (left vs. right x frontal vs. parietal: $F=5.45$, $p<0.05$) and right central (left vs. right x central vs. frontal/parietal: $F=4.67$, $p<0.05$) regions. First-word waveforms were again more positive than those elicited in response to second-presented words ($F=7.00$, $p<0.05$). An interaction of Order and topography was due to differences over parietal regions: first-word ERPs were more positive over the midline whereas those in response to second words were maximal over the hemispheres (midline vs. left/right x frontal vs. parietal: $F=6.81$, $p<0.05$). Waveforms during this epoch did not vary according to old/new status or group membership.

10.3.2.2.3 310-630 ms

This epoch encompassed a negative deflection (see Figure 10-10), similar to the frontal N400 component reported in the previous studies in this thesis. The amplitude of this component was most negative over left (left vs. right: $F=14.17$, $p<0.001$), midline (midline vs. left/right: $F=10.78$, $p<0.005$) and frontocentral regions (frontal vs. parietal: $F=29.76$, $p<0.00005$; central vs. frontal/parietal: $F=20.78$, $p<0.0005$). The left > right asymmetry of this negative component was particularly evident over central sites (left vs. right x central vs. frontal/parietal: $F=8.66$, $p<0.01$).

Old/new word differences became evident during this epoch, tending to be larger for second- relative to first-presented words ($F=4.13$, $p=0.057$). This effect was significantly larger over central regions (Word x central vs. frontal/parietal: $F=22.99$, $p<0.0005$), and
over midline sites compared to the hemispheres ($F=5.21$, $p<0.05$). As in the previous epoch, there were no differences in the waveforms of simulators and controls.

**Controls**

**Malingerers**

Figure 10-9. Topographical distribution of the P2 component (Factor 3), analysed over the 170-310 ms time window
Figure 10-10. The frontocentral N400 component (Factor 2), measured over the 310-630 ms epoch
10.3.2.2.4  630-900 ms

Figure 10-11 indicates that this factor represents a LPC. This component was more positive over the right hemisphere compared to the left ($F=8.26, p<0.01$), and over centroparietal regions (frontal vs. parietal: $F=25.71, p<0.0001$; central vs. frontal/parietal: $F=10.67, p<0.005$). Second-presented words were more positive than those presented first in the pair ($F=12.34, p<0.005$).

Old words elicited more positive waveforms than did new words ($F=8.55, p<0.01$). This difference was maximal over central scalp sites for words presented as the second in the pair (central vs. frontal/parietal: $F=8.75, p<0.001$). An interaction of Word and Order with topography was due to differences in the magnitude of this effect at parietal sites: for first presented words, old/new word differences were largest over the right hemisphere, but equivalent over the hemispheres for words presented as the second in the pair (left vs. right x frontal vs. parietal: $F=8.12, p<0.05$).

Group differences were evident during this epoch, with an attenuated parietal LPC in response to first words in the malingering group (frontal vs. parietal: $F=5.63, p<0.05$). An interaction of Word, Order and Group with topography (left vs. right x central vs. frontal/parietal: $F=11.35, p<0.005$) was due to differences over central scalp sites for second-presented words: in the control group the old/new word difference was small over the left compared to the right hemisphere whereas in the malingering group it was equivalent across the hemispheres.
Figure 10-11. Factor 1 waveforms showing the LPC as a function of Group, Word and Order, analysed over the 630-900 ms epoch.
10.4 DISCUSSION

The aim of this study was to further investigate the contribution of processes engaged during encoding to the ERPs of simulating and control participants during recognition of previously-studied words. In an attempt to minimise differential task-related encoding, all participants in the present study were given identical instructions prior to the study phase – to view each word and make a judgement as to its pleasantness. Only prior to the test phase, in which recognition of the words was assessed, were participants asked to either perform at their best or to simulate impairment.

Not surprisingly, the study phase waveforms of the two groups did not differ significantly, since all subjects had received the same instructions at this stage of the task. Importantly however, waveforms recorded during the retrieval phase also differed little, despite half of the group receiving instructions to simulate impairment. In particular, in both groups, old/new word differences emerged during the epoch encompassing a frontally-distributed N400 component, suggesting that recognition of the old words occurred at approximately the same time in the honestly-responding and simulating participants.

These results contrast with the proposal developed earlier in this thesis, that on forced-choice tests of recognition memory, ERP effects associated with recognition emerge earlier in participants simulating impairment. This contrast is most evident when the present study is compared to Study 3. These two studies were identical in terms of stimuli and test format and used a similar number of participants (19 in Study 3 and 20 in the present study). The crucial difference between the two was that instructions to simulate impairment were given before the words were encoded in Study 3, and after encoding in the present study. In the latter, there was no evidence of ERP differences signalling earlier recognition in the
malingering group, whereas in Study 3, an early malingering effect associated with the P2 component reliably differentiated malingering from control participants. This result confirms the importance of differential encoding strategies to the results reported in the earlier studies in this thesis, and provides support for a relationship between the early malingering effect and strategies utilised during encoding of the stimuli. More specifically, it appears that instructing participants to malinger prior to the commencement of the study phase encourages or permits additional or deeper levels of encoding, which then influence recognition during the retrieval phase.

The behavioural results of the present study are consistent with those reported in previous studies, with the control participants accurately discriminating old from new words, while the malingerers claimed to only recognise approximately 50% of the previously-studied words. Similarly, the other group difference shown to be reliable across test format and word frequency – response latency differences according to response accuracy – was also evident, with the controls responding more rapidly to words that were correctly compared to incorrectly assigned to study status, while the malingerers showed little difference in response latency according to the accuracy of their recognition judgements.

The presence of this response latency effect in the absence of the ERP early malingering recognition effect demonstrates a dissociation between the two. While the early malingering effect appears to rely on processes engaged during encoding, the response latency effect is evident regardless of whether task instructions are provided before or after the study phase commences. This dissociation suggests that the processes underlying these two effects are independent.
This independence may prove advantageous in the detection of simulated impairment. For example, a study by Ellwanger et al. (1999) compared the accuracy of neuropsychological test scores and ERP measures to discriminate honest from simulated performance. When used individually, these measures differentially classified the malingering individuals. However, all of the simulators were accurately identified by one of the two measures. This result indicated that the processes underlying the test scores and ERPs were independent, with each therefore contributing differing information in the classification of the individuals. According to the authors, while an individual malingerer may adopt a strategy that permits successful avoidance of detection on one measure, he or she may be unable to do the same on another that assesses a differing aspect of performance. Similarly, the ERP measures and response latency effects reported in the studies in this thesis appear to measure differing facets of malingering behaviour, and together may be of considerable use in the detection of those simulating amnesia.

In summary, when task instructions prior to initial processing of word stimuli were held constant, retrieval phase ERPs differed little between participants who were later asked to perform to the best of their abilities and those instructed to feign memory impairment. In the context of the previous studies in this thesis, this indicates that instructions to simulate impairment result in differential encoding of the stimuli, and further supports the relationship between encoding strategies and the early malingering effect evident in the waveforms of the simulating participants, reported in earlier studies in this thesis.
11.1 INTRODUCTION

Neuropsychologists are becoming increasingly concerned that potential malingerers may have detailed knowledge of the tests and measures used to identify sub-optimal performance. This knowledge appears to be readily available on the internet (Ruiz et al., 2002), in magazines and newspapers (Lees-Haley, 1992) and from members of the legal profession who have an interest in their client appearing impaired (Wetter & Corrigan, 1995; Youngjohn, 1995). Awareness of this growing sophistication has led researchers to investigate the vulnerability of a range of tests to malingering by individuals who receive varying levels or types of information. In general, these studies have shown that individuals who are “coached” as to the particular profile to present, or given specific details of the assessment procedure, are better able to avoid detection than uncoached malingerers (e.g. Gunstad & Suhr, 2001; Lamb et al., 1994; Martin et al., 1993; Rose et al., 1995; Rose et al., 1998; Suhr & Gunstad, 2000).

Despite the increasing amount of research devoted to assessing the effect of coaching on the ability to detect feigned impairment, relatively few studies have investigated the strategies used by individuals to simulate impairment, and how these might differ in malingerers who are successful in avoiding detection. One exception (Edens et al., 2001) addressed this issue in an analysis of 540 participants asked to simulate psychosis, mood or anxiety disorder, or cognitive impairment. After completing the task, the participants
answered a questionnaire assessing the strategies used. Malingerers who were unsuccessful in avoiding detection endorsed very bizarre or unusual items on the test, exaggerated on most or all of the items and tried to appear “crazy”. In contrast, those malingerers who were able to present believable symptoms and avoid detection gave complex, thoughtful responses, basing these on their own personal experience and selectively endorsing symptoms consistent with the complaint.

Another recent study (Lee et al., 2002) questioned 95 students about how they planned to respond when asked to feign memory impairment on a forced-choice task. While some stated that they would simply respond randomly to the stimuli, others reported that they planned to consciously manipulate the proportion of correct and incorrect responses in order to appear impaired. Lee et al. (2002) went on to investigate whether differences in neural activity corresponding to the more “astute” strategy of consciously manipulating correct and incorrect responses could be distinguished from a condition in which participants responded honestly. Six participants underwent functional magnetic resonance imaging, which revealed significantly greater activation in prefrontal, parietal and subcortical regions in the simulating compared to honest condition. The authors interpreted this as reflecting the additional effort and cognitive processing required of simulators who adopted strategies of deliberately manipulating responses, which might include selection of retrieval strategies, the simultaneous processing of information relating to primary and secondary goals, calculation of responses and performance monitoring.

The aim of the present study was to identify and compare malingerers who portrayed a believable recognition memory impairment with those whose performance was less plausible. Consistent with the studies of Edens (2001) and Lee et al. (2002), it was
hypothesised that faking a believable deficit would involve a thoughtful or considered approach to the task, which in the context of a recognition memory test might involve cognitive processes related to strategic planning, monitoring of performance, and calculation of the proportion of correct and incorrect responses. Furthermore, these processes would not be expected to feature in the performance of malingerers who were less convincing. It was therefore predicted that this differential cognitive processing would be evident as electrophysiological differences between the two groups of malingerers.

11.2 METHOD

11.2.1 Participants

Participants were selected from the previous studies in this thesis, with the exception of Study 1 for the reasons outlined in Section 5.3.2. They were initially assigned to one of three groups based on whether their test scores were below, above, or within the range of chance level performance. In forced-choice, two alternative tests, chance level performance equates to scores of between 40 and 60% correct (Iverson & Franzen, 1994).

Twelve malingerers in Studies 2 to 6 obtained scores on the recognition memory test that were below the level of chance. These participants appear to have adopted a naïve strategy of deliberately choosing the incorrect answer. Such individuals would be easily identified as malingering by their test score alone, since consistently endorsing the incorrect response signals the ability to recognise the correct one. As a result, this group’s data were not analysed further in this study.
Malingerers who scored above the levels of chance were assigned to a “high performing” (HP) malingering group. The scores of these individuals were more typical of genuinely head-injured patients – low compared to the honestly-responding unimpaired controls but still above the level of chance performance (Iverson & Franzen, 1998). There were five HP malingerers in both Studies 4 and 5, four in Study 2 and two each in Studies 3 and 7. Due to the small numbers in Studies 3 and 7, only data from Studies 2, 4 and 5 were analysed further.

The third group comprised malingering participants who scored within the range of chance on the memory test. According to Lockhart (2000), determination of chance level performance must also take into account the contribution of an individual’s response bias. For example, a tendency to over-endorse “yes” responses when uncertain might lead to a high hit rate of 0.8, but also a high false alarm rate, where new words are also incorrectly judged to be previously studied. Therefore, despite the high number of old words correctly identified, an equivalent false alarm rate would indicate failure to discriminate previously studied from new words. The ability to discriminate between old and new words can thus be determined by calculating the difference between the false alarm and hit rate. Therefore, malingerers from Studies 4 and 5, for which hit and false alarm rate data was available, were assigned to this group if they obtained test scores of between 40 and 60% and a discrimination index close to zero. Malingerers from Study 2 were assigned to this group based on chance level performance only. This group was labelled the “poor performing” malingerers (PP): despite receiving “sophisticated” malingering instructions, used to encourage believable deficits, they presented a deficit so severe as to be unlikely in the
genuinely memory impaired. There were four of these malingerers in Study 2, seven in Study 4 and six in Study 5.

11.2.2 Data analysis.

The behavioural responses of the 14 high- and 17 poor-performing malingerers were analysed using an ANOVA with Group (HP, PP) as a between-subject factor, and Response Accuracy (correct, incorrect) as a within-subject factor. For the subset of 23 subjects who participated in the yes-no studies (10 HP, 13 PP), this analysis was repeated with the additional within-subject factor of Word (old, new).

Analysis of the ERP data was carried out by conducting mean amplitude analyses over epochs of interest. These epochs were chosen such that they were consistent with the epochs analysed in the studies from which the present data were drawn, and also to accurately encompass the ERP components evident in the combined data of the present study (see Figure 11-1). Separate ANOVAs were conducted on data from each of these epochs with Word (old, new), Lateral (left, midline, right) and Sagittal plane (frontal, central, parietal) as repeated measures, and Group (PP, HP) as a between-subject factor.

The same planned contrasts outlined in Study 1 were used in the present study, and all F tests in the ERP analyses had (1, 29) degrees of freedom.

11.3 RESULTS

11.3.1 Behavioural data

The behavioural data for the two groups are shown in Table 11-1 below.
Table 11-1. Test scores, reaction time and response rates for the poor- and high-performing malingerers (standard deviations in brackets).

<table>
<thead>
<tr>
<th></th>
<th>High-performing malingerers</th>
<th>Poor-performing malingerers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test score</td>
<td>66.50 (4.54)</td>
<td>48.88 (2.57)</td>
</tr>
<tr>
<td>Reaction time (ms)</td>
<td>921.50 (265.00)</td>
<td>888.31 (544.90)</td>
</tr>
<tr>
<td>- correct</td>
<td>938.86 (249.35)</td>
<td>919.52 (562.14)</td>
</tr>
<tr>
<td>- incorrect</td>
<td>947.98 (295.64)</td>
<td>893.96 (526.03)</td>
</tr>
<tr>
<td>Hit ratea</td>
<td>0.53</td>
<td>0.46</td>
</tr>
<tr>
<td>False alarm ratea</td>
<td>0.22</td>
<td>0.42</td>
</tr>
<tr>
<td>Discrimination indexa</td>
<td>0.32</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Note. * these measures were calculated for the subset of 23 participants in the yes-no format studies.

The two groups differed in the number of items they answered correctly ($F(1,29)=185.14, \ p<0.00001$), with the HP group scoring significantly higher on the recognition memory test. A further breakdown of response according to word type and accuracy was performed for the 23 participants in the yes-no studies. This revealed that the hit rate was equivalent in the two groups ($F(1,21)=3.51, \ p>0.05$), and indicated that both groups correctly classified approximately half of the previously-seen words. However, the false alarm rate differed significantly between the HP and PP groups ($F(1,21)=10.78, \ p<0.005$), suggesting that while new words were also classified correctly on approximately half of the trials in the PP group, the HP group correctly classified the majority of new words. These results are also reflected in the discrimination index for the two groups: the PP group failed to distinguish between new and previously-studied items, while the index for the HP malingerers indicates that task performance for these participants did involve discriminating old from new words.

Response latencies did not differ between the HP and PP participants in either overall reaction time, or in the time taken to make judgements on trials that were correct compared to those that were incorrect (all $F$-values <0.5).
11.3.2 Electrophysiological data

The ERP waveforms of the HP and PP participants are shown in Figure 11-1. These show a larger and earlier old/new effect in the waveforms of the HP group, particularly over parietal scalp regions. As in the previous studies, the predominant components evident in these plots were a P2, frontocentral N400 and late positive component (LPC). Mean amplitude data for each of these components was analysed over the following epochs: 150-350, 350-550 and 550-900 ms respectively.

11.3.2.1 150-350 ms

The amplitude of the P2 component was greater in the HP compared to the PP group ($F=4.17, p<0.05$). A main effect of Word ($F=5.50, p<0.05$) was due to more positive waveforms associated with old compared to new words. The magnitude and topography of this effect differed with performance level (Word x Group x frontal vs. parietal: $F=7.05, p<0.05$) – while the effect was equivalent in the two groups over frontal regions (HP: 1.09 µV, PP: 0.93 µV), it was large over parietal sites in the HP group (1.96 µV) but almost absent over these sites in the PP participants (0.22 µV).

11.3.2.2 350-550 ms

During the epoch encompassing the frontocentral N400, old word ERPs were significantly more positive than those in response to new words ($F=9.69, p<0.005$). The size of this effect was statistically equivalent over all scalp sites, and did not differ according to performance level ($F=2.31, p=0.14$).
Figure 11-1. Average waveforms for the poor- and high-performing malingerers shown as a function of Word.
11.3.2.3 550-900 ms

As in the previous epochs, a main effect of Word reflected more positive LPC waveforms associated with old compared to new words ($F=6.10$, $p<0.05$). Despite what appear to be large, widely distributed group differences in the size of this old/new effect (see Figure 11-1), only differences over the vertex were reliable, where the effect was larger in the HP compared to the PP participants (2.79 vs. 0.77 $\mu$V: Word x Group x midline vs. left/right x central vs. frontal/parietal: $F=6.77$, $p<0.05$).

11.3.3 Summary of results

The results of these analyses reveal a number of differences between the poor and high-performing simulators. The hit and false alarm rates suggest that the latter participants attempted to manipulate the proportion of correct and incorrect responses, misclassifying previously-studied words on approximately half of the trials, while correctly classifying the majority of new words. The electrophysiological results reveal a larger P2 component in the waveforms of the high-performing malingerers, along with the earlier emergence of old/new word differences over parietal sites in the epoch associated with this component. In addition, a larger old/new effect was evident in the epoch encompassing the LPC in the high-performing malingering group.

Another important finding from this analysis relates to reaction time as a function of response accuracy. In all previous studies in this thesis, control participants took longer to make old/new word judgements on trials on which an incorrect response was given. In contrast, the data from the malingering groups consistently showed response latencies that did not differ with the accuracy of their judgements. The present study failed to show a
difference between the high- and poor-performing malingering groups on this measure, suggesting that the effect may be a function of the malingering task itself rather than the manner or skill with which the impairment is portrayed.

Interestingly, the differences between poor- and high-performing malingerers reported in this study were similar to those reported between control and malingering participants in the previous studies in this thesis. In particular, the group differences in the P2 component reported here were interpreted in previous studies as reflecting more cognitive effort in malingering compared to control participants, involving processes such as enhanced attention, evaluative effort and early retrieval of words from memory.

These results also suggest that the malingerers in the previous studies who presented less-believable deficits may have “diluted” the group differences reported between control and malingering participants. This means that the ability to discriminate the typically difficult-to-identify high-performing malingerers may increase if the less credible malingerers are removed from the analysis. In order to investigate this possibility, the discriminant function analyses from Studies 2, 4 and 5 were each revisited to assess whether accuracy of identification improves if only the high-performing malingerers are compared to the control group.

11.3.4 Classification of control and high-performing malingerers in Studies 2, 4 and 5

11.3.4.1 Study 2.

In Study 2, three predictors were entered into a direct discriminant function analysis: reaction time for correct vs. incorrect words, the old/new effect for first-presented words in the LPC epoch, and for second-presented words in the P2 epoch. This function achieved
78.9% correct classification after cross-validation. With only the four high-performing malingerers compared to the control participants however, classification increased to 89.5% (Wilks’ lambda = 0.44, $\chi^2=12.57$, $p<0.01$), and did not change after cross-validation. Importantly, all of the high-performing malingerers were accurately identified. When these variables were entered in a stepwise analysis, only reaction time differences and the old/new effect during the P2 epoch were retained (Wilks’ lambda = 0.62, $\chi^2=9.23$, $p<0.05$). Classification rates for this stepwise analysis were identical to that for the direct analysis.

11.3.4.2 Study 4.

The discriminant function analysis used in Study 4 identified the old/new effect over midline parietal sites during the P2 epoch and reaction time differences as significant predictors of group membership, classifying 72.5% of honest and malingered performance. If just the five high-performing malingerers were compared to the control participants however, classification accuracy increased to 95.5% (Wilks’ lambda = 0.31, $\chi^2=22.28$, $p<0.0001$) with 100% of the astute malingerers identified and only one control participant misclassified. These rates of classification compare favourably with those obtained previously in Study 4, in which a significant proportion of malingerers but only about half of the controls were accurately identified.

11.3.4.3 Study 5.

Study 5 was the first in this thesis that failed to demonstrate early ERP old/new differences between control and simulating participants. To investigate whether these differences were in fact evident in the high-performing malingerers but masked by the performance of the malingerers who did not present a believable deficit, old/new differences
over parietal sites in the P2 epoch were computed and used as a variable in a discriminant function analysis, along with reaction time differences. This function failed to discriminate between the controls and high-performing malingerers (Wilks’ lambda = 0.96, \( \chi^2=99, p=0.32 \)), correctly classifying 68% of participants after cross-validation (70% of controls and 60% of malingerers). The other significant ERP group differences identified in Study 5 were also entered in a stepwise discriminant function, but none were retained as significant.

11.4 DISCUSSION

Significant behavioural and electrophysiological differences were observed between malingerers who presented a believable profile of impairment and those whose performance was less credible. Specifically, the behavioural analysis revealed that the less-convincing malingerers failed to discriminate between studied and unstudied words, incorrectly classifying both old and new items on approximately half of the trials. This pattern of performance appears to indicate that these participants were responding randomly to the stimuli. The more-convincing malingerers, on the other hand, correctly classified the majority of new words, and selectively feigned memory loss for the previously-studied items. This finding is consistent with proposals made previously in this thesis, which suggested that poor test scores in those simulating impairment were predominantly achieved through the misclassification of old words. The present results indicate, however, that this manipulation of correct and incorrect responses according to the word’s old or new status was most evident in the malingerers whose impairment was plausible.

The present study also suggests that within a group of simulators, individuals may adopt differing approaches or strategies in order to present a profile of impairment. Consistent
with the findings of Lee et al. (2002), for some participants in the previous studies these appeared to involve a less-active approach, showing little or no attempt to discriminate old from new words, while others appeared to employ the more-effortful strategy of manipulating the proportion of correct and incorrect responses.

The behavioural analysis also revealed, as outlined in the Summary section (Section 11.3.3), that regardless of the credibility of the performance, the simulators failed to show the typical pattern of response latency observed in honestly-responding participants, whereby less time is taken to make correct compared to incorrect recognition judgements. The reliability of this finding confirms its potential as an indicator of simulated amnesia.

The electrophysiological analysis revealed an enhanced P2 component and a larger and earlier-emerging old/new effect in the waveforms of the high- compared to the poor-performing malingerers. These ERP group differences provide support for the main hypothesis of this study, which claimed that the task of presenting a believable deficit requires additional or enhanced cognitive processing, and that this would be evident as electrophysiological differences between the believably and less-credibly impaired. Furthermore, these ERP group differences were similar to those observed between control and malingering participants in the previous studies in this thesis. That these ERP effects were magnified in the malingerers who presented a more-believable deficit lends support to the proposal developed earlier in this thesis that they signal enhanced or additional cognitive processing.

These electrophysiological findings prompted a reanalysis of the discriminant functions of the previous studies, in which similar ERP effects were used as variables to distinguish between controls and malingerers. In the studies that demonstrated more effortful
processing in the malingering participants (i.e. Studies 2 and 4), this reanalysis permitted highly accurate discrimination of the high-performing malingerers from the honestly-responding participants.

These results highlight a specific role for the use of ERP techniques in the detection of simulated amnesia. Malingerers who are able to portray a believable deficit present the greatest challenge for researchers and clinicians. These individuals may be educated or coached as to the performance typical of genuinely brain-injured people, and may therefore be able to manipulate their responses and level of performance in such a way as to present a profile indistinguishable from the genuinely impaired. It seems logical to assume that the presentation of a believable deficit requires active involvement in the assessment procedure, possibly more than would be necessary in control or head-injured individuals. For example, on a test of recognition memory, the presentation of a believable deficit might require processes including the inhibition of a learned or usual response, conscious manipulation of the proportion of correct and incorrect answers and keeping a mental tally of responses made on previous trials – cognitive processes that are not required in honestly-responding individuals. The findings of the present study, taken in the context of those preceding it, indicate that this additional effort or processing may be identifiable in the ERPs of malingerers who are able to present a believable behavioural profile of impaired memory.

It should be noted however, that the “high performing” malingerers identified in this study obtained average scores on the recognition memory test of just 66.5%. While these were significantly higher and more representative of believable impairment than the chance and below chance scores of the other malingerers, when compared to the genuinely head injured, these scores may still be suspiciously low. For example, in a review of performance
on the Warrington Recognition Memory test (a computerised version of which was used in Studies 1 and 2), Iverson and Franzen (1998) reported that patients with genuine head injuries and memory loss averaged scores of over 70%. Therefore, despite the use of “sophisticated” malingering instructions, which were used to encourage the presentation of believable deficits, only a small percentage of the total number of malingerers scored at above chance levels. These low scores are not unprecedented, with Martin et al. (1993) for example, reporting that on a forced-choice test, coached student malingerers performed at chance levels, while the uncoached malingerers scored well below chance. The sophisticated instructions used in this thesis provided information regarding the typical symptoms following a head injury. Other studies (e.g. Gunstad & Suhr, 2001; Lamb et al., 1994) have shown however, that coaching is most effective when it includes information regarding the test protocol itself, strategies to avoid detection or a warning that the assessment may include measures to detect malingering. In fact, a recent study by Dunn et al. (2003) reported that malingerers provided only with information about brain injury obtained worse scores than malingerers who were given no coaching at all.

Future studies could therefore provide more-detailed instructions to malingerers, perhaps suggesting the use of specific strategies or a particular level of performance to aim for. A study by Rosenfeld et al. (1998) for example, successfully manipulated performance level by instructing malingerers to obtain test scores of either 75-80% or 85-90%. Such instructions may allow malingerers to present a behavioural profile indistinguishable from genuinely memory-impaired individuals. At the same time however, these additional or more specific instructions might be expected to increase the level of engagement of the malingerer in the task, and the extent to which additional cognitive processing is necessary.
The results of the present study suggest that this increasingly sophisticated behavioural performance may be associated with still larger ERP effects, indexing the greater effort or processing required.

In summary, the results of this study confirm the potential of ERP data in the detection of simulated impairment, and suggest it may be of particular use in the identification of the astute malingering who is able to avoid detection on the more-commonly used neurobehavioural measures of malingering.
CHAPTER 12. SUMMARY AND FUTURE DIRECTIONS

The purpose of this thesis was to examine event-related potentials in individuals who were asked to complete a recognition memory test to the best of their abilities, and in those instructed to feign memory impairment. The aim of the present chapter is to summarise the main results of these studies and to suggest avenues for future research.

Previous studies investigating ERPs and malingering have focussed predominantly on the P3 component. The main aim of a number of these studies (e.g. Rosenfeld et al., 1995; Rosenfeld et al., 1996) has been to demonstrate that P3 amplitude in response to previously-studied or well-learned information, compared to new or irrelevant information, did not differ in control and simulating participants. Supportive evidence was taken to indicate that the simulators were as able to recognise the previously-learned material as the controls. The first study in this thesis began in a similar vein, but aimed to demonstrate equivalence of the old/new effect, rather than the P3, in control and simulating participants. As outlined in Chapter 3, the old/new effect is commonly investigated in studies of recognition memory, and thought to more directly reflect recognition processes. The results of this first study showed that the parietally-distributed old/new effect did not differ in size or topography in control and simulating groups, indicating that the simulators were able to identify the old words despite behavioural denial of this knowledge.

In addition, Study 1 revealed an earlier emerging old/new effect, evident only in the waveforms of the malingering group. This finding was of particular interest – while the equivalence of the parietal old/new effect assumed similar processing in the two groups, the early effect provided evidence indicating that the malingering group differed from the
controls in some aspect of their response to the stimuli. As such, this was seen as a potential measure by which to discriminate feigned from honest performance.

As early old/new differences had not been reported previously in studies of simulated amnesia, Study 2 was conducted to test the reliability of this early malingering recognition effect. This study extended the previous one with a within-subject design, and a more detailed examination of the data, using a principal components analysis to define the underlying components of the waveform. The results replicated those of Study 1, again showing ERP evidence of earlier recognition when participants feigned impairment. Consistent with proposals that malingering presents a more challenging task than responding honestly (Haines & Norris, 1995; Rose et al., 1998; Rosenfeld et al., 1998), these results were interpreted as reflecting additional or enhanced cognitive processing of the stimuli, leading to earlier recognition of the studied words. The replication of this finding also suggested that the earlier discrimination of previously-studied from new words reflects a reliable difference between honest and simulating individuals.

In line with the recommendations made by other researchers (e.g. Connolly et al., 1999; Suhr & Gunstad, 2000; Trueblood, 1994), these first two studies had examined electrophysiological activity using a standardised and commonly-used neuropsychological test. This test, the Warrington Recognition Memory test, presents words in a forced-choice format, with word stimuli that have a high frequency of occurrence in the language. Typically, however, ERP studies of recognition memory present stimuli in a yes-no or continuous format, where an old or new judgement is made for each word, rather than the identification of one of a pair of words as in the forced-choice paradigm. In addition, numerous studies have demonstrated a recognition advantage for low- compared to high-
frequency words (e.g. Jacoby & Dallas, 1981; Mandler et al., 1982), and that the former are associated with larger old/new effects (Rugg et al., 1995; Rugg & Doyle, 1992). As a result, studies investigating the old/new effect typically present low-frequency words as the stimuli. The following three studies in the thesis manipulated these factors in order to examine whether the group differences obtained in the previous studies were reliably elicited in tests of varying format and stimulus frequency.

Study 3 investigated the use of low-frequency word stimuli in a forced-choice test of recognition memory. This study again demonstrated ERP effects signalling earlier identification of the previously-seen words in the malingering group. This early effect was shown to be associated with the P2 component.

Studies 4 and 5 completed this series of manipulations, with an examination of responses to high- and low-frequency words, respectively, in a yes-no test of recognition memory. In addition, these studies analysed electrophysiological activity recorded during the study phase of the tests, thereby extending previous research investigating ERPs in malingering, which has predominantly focussed on retrieval processes. Study 4 replicated the results of the previous studies, reporting an early malingering recognition effect, this time in response to high-frequency words presented in the yes-no test paradigm. This effect was again associated with the P2 component. In the control group, the study phase waveforms were dominated by a large amplitude frontal N400. In contrast, those of the malingers were characterised by enhanced P2 amplitude, and a tendency for increased slow wave activity. A similar pattern of ERPs were evident during the test phase: the controls showed a large frontal N400 and additionally, a late frontally-distributed difference between old and new words, while the malingering group waveforms showed an enhanced
P2 with which the early malingering effect was associated. In line with the extant literature, these results were interpreted as reflecting relatively shallow encoding of the high-frequency words in the control participants, leading to less-confident recognition and more post-retrieval monitoring during the test phase. In the malingering group however, the results were consistent with elaborative and effortful encoding of the words, leading to their earlier recognition at test. The similarity of the study and test phase waveforms within each group suggested that processes engaged during the encoding of the stimuli were reinstated during retrieval. The differences in the waveforms between the two groups however, indicated that these processes differed according to whether the individual was answering honestly or feigning impairment.

These proposals linking additional effort to the task of simulating impairment were challenged by the results of Study 5, which examined the responses of malingerers and controls to low-frequency words in a yes-no test of recognition. Unlike the previous studies, there was no evidence in either the study or test phase waveforms of ERP group differences signalling additional processing in the malingering group. Furthermore, the early malingering recognition effect was absent.

These discrepancies were addressed in Chapter 9, which presented an overview of the results of Studies 2 to 5 in terms of the ERP outcomes of varying word frequency and test format. Previous research has shown that compared to highly familiar words, low-frequency words tend to be elaboratively encoded, leading to their earlier and more accurate subsequent recognition (Lockhart et al., 1976; Rao & Proctor, 1984). In addition, it has been suggested that yes-no tests require more-active cognitive processes, relying heavily on retrieval of information from the study phase, whereas the easier forced-choice test permits
accurate recognition based on the relative familiarity of the two items (Hanley et al., 2001). Furthermore, the analyses conducted in this thesis suggest that in a forced-choice test, recognition judgements may be delayed until the second word of the pair has been presented. The results for the control participants were consistent with these findings, with the old/new effect emerging earlier when the words were of low linguistic frequency, and when they were presented in a yes-no format. In contrast, the electrophysiological data for the malingering participants indicated that recognition occurred earlier in the forced-choice format and for high-frequency words. This differing pattern of results obtained for the two groups across frequency and format manipulations suggested that tasks which require active processing of the stimuli (such as elaborative encoding of the low-frequency words, and retrieval of information from the study phase in the yes-no formats), elicit similar cognitive activity in participants regardless of task instruction. However, the cognitively less-challenging tasks (such as those involving highly familiar words and a forced-choice format), may enable additional processing or planning in malingering participants – processes which are not required by individuals responding to the best of their ability. This suggested that these easier forms of the recognition memory test, in which the electrophysiological differences between the groups are maximised, may be preferable in future studies aiming to detect the simulation of amnesia.

These findings also indicate that the Warrington Recognition Memory test, enhanced with ERP analysis, may be an effective tool in the detection of malingering. Such a test combines the advantage of high-frequency words and a forced-choice format, factors that, as mentioned above, appear to permit greater electrophysiological discrimination between honest and malingering participants. In addition, this test has the advantage of combining a
normed and commonly used test of recognition memory with a specialised measure which interfaces more directly with brain function, and is less influenced by coaching. The clinician could thus detect non-optimal performance if it is present, and obtain information regarding the cognitive abilities of the client if it is not.

The first five studies in the thesis were followed up with two additional analyses. The first of these further investigated the apparent link made in previous studies between strategies adopted during the initial encoding of the stimuli and the early malingering recognition effect. In Study 4 for example, waveforms recorded during encoding were consistent with more-effortful or additional processing in the malingering compared to the control group, as seen by an enhanced P2 and slow wave component. In this study, an early recognition effect associated with the P2 component was evident in the retrieval phase waveforms of the malingering group. In contrast, Study 5 failed to demonstrate early differences in the study phase waveforms consistent with effortful processing in the malingering group – and early recognition of words in these subjects was not evident during the test phase. Study 6 therefore attempted to remove task-related differences in encoding by assigning individuals to either a control or malingering group after completion of the study phase in which the words were encoded. The results showed that, as expected, the two groups did not differ in their processing of the words during the study phase, and importantly, the early malingering recognition effect was absent from the test phase waveforms. These results suggested that the ERP effect indexing earlier recognition of previously-studied words in the simulating group in previous studies of the thesis arose from differential processing during the initial encoding of the stimuli.
The final study in this thesis aimed to investigate whether differences in the behavioural depiction of amnesia were reflected as differential patterns of electrophysiological activity. Based on measures of test score and response bias, Study 7 compared malingering individuals in Studies 2, 4 and 5 who performed at chance levels (thus indicating a total lack of discrimination between old and new words) with malingerers whose simulated deficit was more believable. This study revealed that ERP effects interpreted previously as reflecting more effort in the processing of the stimuli, in particular, the early malingering recognition effect associated with the P2 component, were larger in the simulators who presented the plausible impairment.

Taken together, the major electrophysiological findings obtained in the studies in this thesis suggest that (1) individuals simulating recognition memory impairment use more active or additional cognitive processing during task performance compared to those who respond honestly, (2) this enhanced effort is most reliably evident as an earlier positivity in response to previously-studied compared to new words, suggesting that recognition occurs earlier in these participants despite behavioural denial of their ability to remember the items, and (3) this earlier recognition appears to be the result of more elaborative encoding of the stimuli. However, these task-related processing differences seem to be evident only in tests that use highly familiar words and/or a forced-choice format, suggesting that the use of these easier forms of the test may be preferable in the detection of simulated impairment. Finally, the results also indicate that the ERP effects proposed to signal greater cognitive effort were associated with more “sophisticated” malingering. That is, malingering participants who presented a plausible profile of recognition memory impairment showed a larger early recognition effect than malingerers whose performance was less credible.
These findings suggest that ERPs could play an important role in the detection of malingering: while the chance level test scores of the less astute malingerers may be sufficient to detect their sub-optimal effort, ERP data may be of particular value in detecting individuals whose superior knowledge of the assessment procedure, or of the condition to be faked, makes their behavioural performance difficult to distinguish from that of individuals with genuine amnesia. This clearly has implications for those who receive coaching regarding the particular profile required in order to appear impaired. While this coaching may enable the individual to escape detection based on his or her behavioural scores, the increased cognitive effort required to present the desired profile may be evident in the waveforms of the individual.

A related issue concerns the apparent link between response manipulation and the elicitation of the ERP effects signalling enhanced processing. These effects were maximal in the high-performing malingerers identified in Study 7, whose behavioural data suggested that they consciously manipulated the proportion of correct and incorrect responses according to whether the word was previously-studied or new to the experiment. In contrast, these effects were not evident in individuals whose performance would not be expected to involve response manipulation – controls, and the malingerers scoring at chance levels whose behavioural data suggested that they responded randomly to the stimuli. This finding may address the concerns expressed by a number of researchers (e.g. Bierley et al., 2001; Haines & Norris, 1995; Rees et al., 2001) that unconscious processes, such as those occurring in depressed individuals, could affect test scores and lead to an inaccurate assessment of malingering. The apparent association between conscious response manipulation and the ERP effects proposed to reflect additional processing suggests that the
ERP identification procedure could be effective in identifying purposeful and deliberate deception, but would not incorrectly classify as a malingerer an individual for whom there are unconscious effects or influences on test performance.

Along with the electrophysiological data showing differences between the malingering and control groups, the studies in this thesis also demonstrated a reliable difference in the time taken by each group to accurately classify the words. While the controls were quicker on trials on which they correctly judged the words to be old or new, this difference was absent or markedly reduced in the malingering participants. This was taken to reflect concealment of information, with the simulators having to suppress a behavioural response that would signal actual recognition of the words. This task-related difference was observed in each of the studies that recorded reaction time data, showing that it reflects a robust difference between honest and simulated performance, elicited regardless of test format, word frequency, encoding processes or the credibility of the malingering performance. Furthermore, its presence in conditions where the early malingering recognition effect was not evident (Study 5) indicates that the two reflect differing facets of malingering behaviour, which together may form a reliable indicator of simulated amnesia.

The results of this thesis suggest a number of avenues for future research. Study 4 provided preliminary evidence to suggest that honest and simulating participants differentially respond to errors. In this study, an enhanced negativity at about 600 ms was observed in the waveforms of the honest individuals in response to incorrect classification of words, but was absent in those simulating impairment. This was interpreted as reflecting the differing requirements of the malingerers, whereby providing the incorrect answer on a proportion of trials was essential for successful task performance. Their “errors” were
therefore deliberate rather than genuine, and as such did not elicit the negativity often reported to follow an incorrect response (e.g. Coles et al., 2001; Falkenstein et al., 2000). This differential response to errors may have potential as another measure to detect individuals simulating impairment, and would appear to be to relatively immune from the effects of coaching. While the analysis in Study 4 was limited by a small number of error trials, future investigations should aim to increase the number of these in order to assess the reliability of this effect. This could be achieved by increasing the total number of stimuli, reducing the presentation time of the stimuli, or extending the period between the study and test phase.

In line with the recommendations for the early stages of test development (Bianchini et al., 2001), the participants used in the studies in this thesis were individuals who were asked to feign amnesia. These participants were undergraduate psychology students, a group unlikely to be representative of the population in which brain injury and malingering typically occurs. Although research has shown that students tend to be skilful malingerers and are particularly difficult to identify (Haines & Norris, 2001), future research should use participants from the general community, forensic settings, and psychiatric patients. Investigating both honest and simulated performance in these individuals would enable assessment as to whether the task-related differences evident in the university students used in this thesis are also evident in individuals from the wider community.

Also crucial is the study of genuinely memory-impaired individuals. As Bianchini et al. (2001) note, “the critical diagnostic question in malingering research is whether a pattern of impaired performance is due to brain injury or to purposeful dysperformance, not whether one can differentiate malingered from normal performance” (p.34). Therefore, future
research should also investigate the utility of the ERP technique in individuals with documented memory loss, to determine whether simulated impairment can be reliably distinguished from genuine amnesia.

Studies of patients with amnesia do indicate however, that the measures identified in this thesis may have the potential to distinguish feigned from genuine memory loss. For example, behavioural studies have shown that memory-impaired patients show the typical pattern of response latencies, making correct judgements faster than incorrect judgements (Duzel et al., 2001; Lalouschek et al., 1997). In contrast, the similarity of reaction times regardless of response accuracy was identified as a reliable characteristic of feigned impairment in this thesis. Memory-impaired individuals also have a liberal (Lalouschek et al., 1997) or normal (Snodgrass & Corwin, 1988) response bias, whereas the simulators in this thesis demonstrated a conservative bias. Finally, studies of amnesia generally find a reduced or absent ERP difference in responses to old and new words (Munte & Heinze, 1994; Olichney et al., 2000; Rugg, Roberts, Potter, Pickles, & Nagy, 1991), consistent with behavioural performance suggesting a deficit in the ability to differentiate between studied and unstudied items. The pattern of results obtained for simulators in the present thesis – poor test scores accompanied by ERP indications of early and enhanced recognition of the studied items – would seem unlikely to occur in those with genuine amnesia. This early malingering recognition effect appears to hold considerable potential for the identification of individuals who deliberately feign memory loss, and confirms the potential use of electrophysiological data in future strategies to detect malingering.
REFERENCES


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APPENDIX A – INSTRUCTIONS TO CONTROL PARTICIPANTS

Background

Neuropsychological tests are used to identify the effects of brain dysfunction on behaviour and abilities. Assessment using these tests usually depend however, on the person tested being able to provide a behavioural response – a verbal answer or an appropriate movement for example. These tests cannot therefore be used with people unable to give the desired response, such as individuals who cannot speak, or those with impaired movement.

There has been considerable recent interest in examination of the brain’s electrical activity (ERPs) as a method of assessing brain function. The present study attempts to identify the characteristic ERPs that are elicited during performance on a recognition memory test. This technique may enable determination of brain function independent of behavioural measures, and thus enable accurate assessment of those unable to respond appropriately.

Procedure

You will be asked to read a series of words and decide whether the word is “pleasant” or “unpleasant”. Later you will be shown another set of words and will be asked to indicate which words were in the earlier list. The electroencephalogram (EEG) will be recorded while performing the task described above. The EEG provides a non-invasive measure of the electrical activity of the brain recorded at the scalp. The procedure involves fitting an
elastic cap, similar to a bathing cap, over your head and placing a small amount of salt water paste between the surface of the scalp and small metal discs (electrodes) inserted at various locations in the cap. Eye movement will be monitored by taping electrodes 1 cm above and below the left eye, and on the outer canthus of each eye. The procedure should cause no discomfort.

The experiment lasts for approximately 1 hour. Participation in the project is voluntary and you may discontinue participation at any time without penalty.
APPENDIX B – INSTRUCTIONS TO MALINGERING

PARTICIPANTS

Background

Neuropsychological tests used in clinical practice typically depend on the client providing behavioural responses that truthfully reflect their abilities. For various reasons however, certain people may provide responses that underestimate their actual abilities. The present study attempts to determine whether electrical activity in the brain, elicited while performing a memory test, will enable the detection of such people, regardless of their test performance.

Instructions

You are about to undergo a memory test. Some individuals who have accidents are normal, or unharmed, following their accidents, but nevertheless may fake injury to obtain financial awards. We want to know what this type of faked memory performance looks like.

Although you are, of course, normal and have NOT suffered memory loss, your goal during this test is to play the role of a head-injured individual who has suffered traumatic brain injury. In other words, you are to try to act as though you have suffered memory loss due to brain damage from an accident. For your information, people with brain injury often have memory problems, concentration problems and difficulty thinking. Most brain-injured individuals have measurable memory loss, ranging from mild to severe. The majority of patients have some residual memory ability, but may learn new information more slowly and may forget the information more quickly than normal individuals. It would be very
unusual after an accident not to be able to learn anything new, or to forget everything learned.

Your goal is to produce the most severe disability that you can, in such a way that the examiner would not know you are faking or pretending. If you were caught faking a memory disorder in real life, it would be considered a crime and you could be prosecuted.

**Procedure**

You will be asked to read a series of words and decide whether the word is “pleasant” or “unpleasant”. Later you will be shown another set of words and will be asked to indicate which words were in the earlier list. The electroencephalogram (EEG) will be recorded while performing the task described above. The EEG provides a non-invasive measure of the electrical activity of the brain recorded at the scalp. The procedure involves fitting an elastic cap, similar to a bathing cap, over your head and placing a small amount of salt water paste between the surface of the scalp and small metal discs (electrodes) inserted at various locations in the cap. Eye movement will be monitored by taping electrodes 1 cm above and below the left eye, and on the outer canthus of each eye. The procedure should cause no discomfort.

The experiment lasts for approximately 1 hour. Participation in the project is voluntary and you may discontinue participation at any time without penalty.
APPENDIX C – DATA AND STATISTICAL ANALYSES

See the attached CD-ROM for details of the data and statistical analyses for Studies 1 to 7.