ERROR DETECTION IN THE PERFORMANCE OF EVERYDAY TASKS BY PATIENTS WITH FRONTAL LOBE LESIONS

Volume 1: Research and Literature Review

By

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To my father

Antoni Gerhand

1925-2002

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Overview

The research component of this thesis concerns awareness of when an error is made in the performance of an everyday task. It compares a group of patients with lesions involving the frontal lobes of the brain, to a group of patients whose lesions do not affect this area, and a group of healthy controls. A series of tasks was chosen that people are likely to carry out in everyday life, for greater ecological validity, and participants were videoed carrying these out under controlled conditions. A behavioural coding technique was used to keep a record of the errors made, and also whether there was any indication that the participant was aware of when they made an error. Participants were also asked periodically whether they thought they had made any errors, and what those errors might be. Patients with frontal lesions performed more poorly than healthy controls, although non-frontal patients differed significantly from neither group. When awareness of errors was considered, both patient groups differed from controls, but not from each other. A second experiment was conducted, where participants attempted to identify errors whilst watching their own videos. Under these conditions, frontal patients identified significantly less errors than either non-frontal patients or controls. Reasons for this, and the relevance to different theories are discussed. This paper is prepared for submission to *Cognitive Neuropsychology*.

The review paper considers the literature on human error detection in general, and its relevance to clinical psychology. The main research paradigms used in this area of study are considered, and emphasis is given to the idea that the human cognitive system has some kind of in-built system for error detection. The literature on error detection in clinical populations is considered. Although this is a relatively new field of study, evidence is accumulating that certain clinical populations do experience difficulty in error detection, and in some cases, this plays a crucial role in understanding the disorder. Data from both clinical and non-clinical populations is considered, and it is concluded that both sources can be used to shed light on the other. This paper is prepared for submission to *Clinical Psychology Review*.

The clinical volume opens with a formulation essay, looking at the case of a 13-year-old boy with a genetic disorder that was causing him to go blind. He was experiencing panic attacks, and this was formulated from a cognitive and a systemic perspective. This is followed by a case study of a woman with uncontrolled diabetes and high cholesterol levels, who would not take any medication. The case incorporated cognitive-behavioural techniques and motivational interviewing. The third report is a single case experimental design that evaluates the effectiveness of a brief cognitive-behavioural intervention for depression, with a 65 year-old man. This is followed by a small-scale service-related evaluation of a stress management programme implemented with staff working in a residential house for people with learning disabilities. The fifth report was orally presented, and an abstract of the talk is included. This is a case study describing the use of Cognitive-Analytic Therapy with a 65 year-old woman who was experiencing depression during treatment for breast cancer.

Literature Review:

Human error detection and its relevance to clinical psychology.

Abstract

This paper reviews the literature on human error detection, and considers its relevance to clinical psychology. Experimental paradigms used in error detection research are considered, before moving on to how these have been applied to the study of clinical populations. This is followed by a discussion of how clinical data have informed general models of error detection. It is concluded that this is an area where the study of clinical and non-clinical psychology can inform each other. Future implications for clinical psychology are also considered

Aim

This review sets out to summarise the current literature relating to the study of error detection, with an emphasis on how this relates to clinical psychology. Both clinical and non-clinical research is considered, as well as the way the different approaches can be integrated to their mutual benefit. The review begins by discussing why error detection is important, both in the study of general and clinical psychology. A definition of error detection is then considered, before considering the main research paradigms that have been brought to this area. The importance of error detection studies to clinical populations is examined, along with the contribution of clinical populations to the study of error detection. Finally, conclusions are made about the integration and future directions of the area.

1) Why is error detection important?

It is often said that to err is human (e.g. Elton, Band & Falkenstein, 2000). However, the consequences of errors can vary considerably according to whether or not they are detected. Any form of monitoring is dependent upon feedback, and the nature of feedback is error-driven (Reason, 1990). This plays not only a crucial part in correct performance of a particular task, but is also vital to the process of learning. Models have been put forward describing the fundamental role of error detection in the learning of complex motor skills (e.g. Adams, 1971; Anderson, 1982; 1983; Ohlsson, 1996), and a comparison of intended input with delivered output plays a key role in the learning stage of connectionist models that rely upon back propagation (e.g. Rumelhart & Norman, 1981; Sejnowski & Rosenberg, 1987; Seidenberg & McClelland, 1989). Consequently, any form of impairment in error detection will not only affect performance of current skills, but also compromise the acquisition of new ones.

When the ability to detect errors is lost, the consequences can impact upon the individual's ability to function in a range of contexts. There are many reports of diminished awareness of individuals with frontal lobe damage being apparently unconcerned about their deficits, and failing to monitor the social consequences of the their actions (Blumer & Benson, 1975; Luria, 1980). Zaidel (1987) referred to this as a "global error monitoring deficit", which occurs in addition to a lack of awareness of errors in specific cognitive situations. Although the concept of "awareness" with acquired brain injury is not solely a cognitive one (Prigatano, 1999), an error-monitoring deficit is undoubtedly a major component.

Problems with error monitoring have also been linked to forms of disabling mental health problems. For example, one interpretation of obsessive-compulsive disorder is that is represents a hyperactivity in the generation of error signals (Pitman, 1987; Schwartz, 1997), and corrective actions are performed repeatedly in an attempt to try and reduce these error signals. Schizophrenia is also commonly associated with a lack of insight, and disordered thought processes (American Psychiatric Association, 1994), and problems with error detection are featured in some of the most influential models of this disorder (e.g. Frith, 1987; 1992; 1998). One of the key elements of Frith's (1992) model is a deficit in the internal monitoring of intentions, which is considered to be responsible for the positive symptoms. Negative symptoms are related more to problems with goal selection, and the initiation of plans and actions.

Hence, there are not only direct social consequences of an impairment in error detection, but it also features as a major explanatory concept within certain disorders. It can also be seen as a failure of metacognitive thinking. Wells (2000) highlights a distinction between metacognitive knowledge and metacognitive regulation. Monitoring and detection of errors in performance are indicated as aspects of executive function that fall into the category of regulation, along with attention allocation, checking and planning.

2) Definition of error detection

Error detection is an awareness of a discrepancy between intention and consequence. Reason (1990) states that there are three ways in which this can come about: self-monitoring, environmental cues, and being told by someone else. Although most studies concentrate on the first two, it is often not distinguished which of these mechanisms has led to the error being detected.

Response execution verses response selection

When considering the implications of a failure to detect errors, it is first important to give some consideration to precisely what is meant by an error in psychological terms. Reason (1990) highlighted a number of taxonomies of error classification, with considerable areas of overlap. He focussed upon a distinction, previously put forward by Norman (1981), between failures of planning, referred to as "mistakes" and failures of execution, referred to as "slips or lapses". Whilst both error types encompass a discrepancy between intention and consequence, the mechanism whereby that discrepancy arises is crucial. Reason (1990) argues that this distinction leads to three basic error types, each corresponding to a specific performance level (as proposed by Rasmussen, 1986). Slips and lapses represent skill-based errors, whereas mistakes can be classified into those that are rule-based and knowledge-based. This overlaps with a distinction drawn by Schmidt (1988) between errors in response execution and response selection. Most of the clinically-relevant, and laboratory-based, research in this area has tended to concentrate on response execution (Elton, Band, & Falkenstein, 2000).

Ohlsson (1996) draws a distinction between objective and subjective views of errors, whereby the former is dependent upon an external judgement that a particular action is not the best way to attain a particular goal. Subjective errors, however, are defined by comparison of the action to some internal criteria. In reality, there would be some degree of overlap, in that the person's internal criterion is likely to be related to some external criterion of correctness. But it is the subjective error, which will be the focus of this review.

3) Experimental Paradigms used in the study of error detection

Choice reaction time (CRT)

The initial empirical basis for believing that the human cognitive system has some in-built mechanism for error detection, came from experiments using choice reaction times. These have been extensively investigated over a number of decades by Rabbitt and colleagues, whose main focus has been the cognitive effects of ageing (e.g. Rabbitt, 1966;1968;1969; 1979; 1990; Rabbitt & Phillips, 1967; Rabbitt & Vyas, 1970; Maylor &

Rabbitt, 1987;1989). The basic format of these tasks is to present a particular stimuli on a screen (e.g. the letter "A" or "B"), and participants must respond by pressing a corresponding key as quickly as possibly in response to the relevant item. A consistent finding (sometimes now referred to as the Rabbit effect) was that when participants make an error, the first response immediately following this tends to be slowed (Rabbit, 1969), even when they have been instructed to ignore all errors. This suggests that some form of implicit registration of an error takes place, and was observed across age-groups (Rabbitt, 1979) and even when participants had consumed alcohol (Maylor & Rabbitt, 1987; 1989). However, when asked to immediately correct any errors made, participants success rate was only 75-85% (Rabbit, 1978), despite the slowed responses to items immediately following an error still being seen on most of the error-responses that were not corrected. Given the reliability with which the post-error slowing occurs, the question must be raised of whether this apparent capacity for error detection is available to conscious awareness? Rabbitt (1968) included another condition, where participants were asked to signal their awareness of the occurrence of an error by hitting a different hand-key or foot-key. Accuracy on this task fell below that of the error-correction condition, although the slowing of a post-error response was still observed after trials that participants failed to indicate as errors. It was proposed that these response types reflect different places on an automaticity continuum, with error recognition and error detection occurring relatively automatically, and error signalling being more dependent on conscious processing.

This type of paradigm has been extremely influential, and has been used extensively with electrophysiological measures, either in it's pure form, or with slight modifications [e.g. "go/no-go" (Scheffers, Coles, Bernstein, Gehring & Dochin, 1996)].

Electrophysiological measures

Event-related potentials (ERP) and the Error-related Negativity (ERN)

There are a number of techniques for measuring levels of electrical activity in the brain. One of these, the event-related potential (ERP), is based around changes in voltage, measured by macroelectrodes placed on the scalp, that occur immediately after presentation of stimuli. The size of the effect is compared to a baseline, and can therefore be positive or negative. The technique can provide temporally accurate information about electrical activity accompanying particular stimuli, and how this is affected by the individual's response to those stimuli. Most notably, it has enabled the recording of electrical activity during the performance of CRT experiments.

On trials where an incorrect response is made, a characteristic pattern of activity, referred to as an error related negativity (ERN), is observed (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1990; Gehring, Coles, Mayer & Donchin, 1990). The magnitude of the ERN is enhanced when participants are instructed to concentrate on accuracy, and reduced when the emphasis is put on speed (Gehring, Goss, Coles, Meyer & Donchin, 1993). The activity seems to be initiated at the same time as the response, and reaches a maximum about 100 msec later, which indicates that it is not based upon proprioceptive feedback. The size of the ERN is positively correlated with less force being applied to the finger making the erroneous response, a higher probability of self-correction, and the amount of post-error slowing. The ERN appears to be concentrated in the anterior cingulate cortex, and it has been suggested that it occurs only after "slips" of action (Reason, 1990), i.e. after a failed attempt to carry out a correct intention, rather than when the intention itself is incorrect (Dehaene, Posner & Tucker,1994).

Scheffers, et al. (1996) used a task that combined forced choice reaction time, with trials that required no response (a "Go/noGo" task). The ERN was present for both errors involving choosing the incorrect response, and responding when no response was intended. As a result of this, they concluded that the ERN was more closely associated with error detection than correction. Coles, Scheffers & Fournier (1995) also introduced the concept of partial errors, whereby the person initiates an incorrect response, but then responds correctly. Such responses are accompanied by an ERN, indicating that incorrect response has been detected, and corrected, before completion.

Error detection or response competition?

A different interpretation of the ERN was put forward by Carter, Braver, Barch, Botvinick, Noll & Cohen (1998), who suggested that the underlying cognitive process is actually response competition. If this is the case, the magnitude of the ERN should be more sensitive to the degree of mismatch between intended and actual response, rather than expected and actual stimulus. Bernstein, Scheffers, & Coles (1995) had used a 4-choice reaction time task, taken from J. Miller (1982), with participants responding to 4 letters with the index and middle fingers of their right and left hand: the similarities of the letters was also varied. The magnitude of the ERN appeared to be related to the degree of response mismatch (e.g. wrong finger verses wrong hand and finger), and did not appear to be influenced by stimulus characteristics. Gehring & Fencsik (2001) investigated whether this apparent relationship was in some way an artefact of using a task based around the movement of four fingers, by asking participants to respond using either alternative hands or alternative feet. Unlike previous results, this paradigm indicated that the ERN was greatest when the response and error were similar (e.g. left hand/left foot or left hand/right hand, as opposed to a combination such as left hand/right foot): a result consistent with a response competition interpretation.

Error Positivity (Pe) and emotional salience

There is also evidence that the electrical activity associated with errors in CRT has two components. In addition to the negative wave (ERN) which appears to be initiated at the same time as the incorrect response, Falkenstein, Hohnsbein, Hoorman, & Blanke, (1990) described a slow positive wave detectable approximately 300 msecs after an incorrect response; this is referred to as the error positivity (Pe). Although there appears to be agreement that the ERN and Pe represent different aspects of the error monitoring system, the exact nature of the difference remains in debate. One possibility is that the Pe represents a conscious error detection system. In line with this, Nieuwenhuis, Ridderinkhof, Blom, Band, & Kok (2001) found that ERN did not seem to be affected by whether participants were aware that they had made an error, whereas Pe was more pronounced for perceived than unperceived errors. However, Falkenstein, et al. (2000) found that not all participants show a Pe, and argue it is improbable that these participants have no conscious awareness of their errors. They also argued that as both ERN and Pe are reduced in elderly participants, whereas post-error slowing may actually be increased

(Band & Kok, 2000), Pe is unlikely to represent conscious awareness. However, this argument seems to rest upon the assumption that post-error slowing is related to *conscious* error detection, and also that any slowing of post error reaction time is not merely a function of the general cognitive slowing that is associated with ageing (see Salthouse, 1985). Falkenstein et al. (2000) suggest that the Pe may represent some form of emotional/subjective assessment of an event, which is modulated by its individual significance. Errors would therefore be just one of a range of emotionally-salient events detected by this system.

Functional Imaging - fMRI

Although the ERP paradigm is very accurate at specifying the time course of neural activity, it is considerably less precise at attributing to a specific anatomical location. Magnetic resonance imaging (MRI) is highly successful at creating structural images of the brain, based on detection of radiation from hydrogen molecules, which are present in different combinations in different tissues, and allows pictures to be made up of slices of the brain (Carlson, 2000). Functional magnetic resonance imaging (fMRI) uses the same principle to trace the concentration of deoxyhemoglobin, and thus measure cerebral blood flow as an index of neural activity in different cerebral regions.

This technique has been used to investigate certain aspects of error detection highlighted by ERP studies. For example, the probable location of this error monitoring system as the anterior cingulate cortex (Dehaene, et al,1994) has also been suggested by fMRI studies, that have shown this area to demonstrate increased activation during error trials relative to correct trials (Carter, et al., 1998; Kiehl, Liddle & Hopfinger, 2000). Van

Veen & Carter (2000) used fMRI to test a prediction based on the response competition interpretation of ERN (Carter, et al., 1998). According to this interpretation, there should be evidence of response conflict when an incorrect response is prepared but overridden by a correct response. This leads to the prediction that in these cases, activity in the anterior cingulate cortex should be seen *before* the response, whereas in the case of an incorrect response that is carried out, activity should be seen after: this was indeed what was found (van Veen & Carter, 2002).

A dissociation in the type of activity seen for different conditions of a Stroop-based task (Stroop, 1935) was also seen by McDonald, Cohen, Stenger & Carter (2000). They used event-related fMRI to demonstrate greater activity in the left dorsolateral prefrontal cortex during colour naming, and greater activity of the anterior cingulate cortex when responding to incongruent stimuli. The most popular interpretation of the interference effect is that it represents a form of response competition (MacLeod, 1991), which would be consistent with activity in the anterior cingulate being a neural correlate of such activity.

There has also been a suggestion that the function of the anterior cingulate area should be subdivided further. Menon, Adleman, White, Glover, & Reiss (2001) and Kiehl et al. (2000) proposed that fMRI data indicated activation of the caudal anterior cingulate cortex during correct conflict trials, but that error trials involved the additional activation of a more rostral anterior cingulate area. However, van Veen & Carter (2002) explained this as a function of the limited temporal resolution of the fMRI technique, and suggested that the activity these studies had observed in the more rostral area in response to errors was in fact the slow positive wave, described by Falkenstein et al. (1990): the error positivity (Pe), which is detectable approximately 300 msecs after an incorrect response.

Thus fMRI and ERP studies are able to compliment each other, and provide an integrative source of data to guide theories. Although most of the studies have concentrated on non-clinical populations, both ERP and fMRI were techniques developed for clinical purposes. They therefore both provide examples of how methods of clinical research have been applied to non-clinical populations in the study of error detection.

Behavioural coding

Although there has been an immense development in the use of electrophysiological and imaging techniques in the last decade, there are certain limitations on the type of tasks that can be studied using these techniques. A major problem is movement, as fMRI requires the participant's head to remain relatively still, and ERP recording equipment can be quite physically restrictive. Consequently, these techniques are currently restricted to laboratory-based settings, and not appropriate for use in the study of more ecologically-valid, everyday tasks. A technique that has been developed for use in these instances is behavioural coding.

This stems directly from work done on rehabilitation after stroke and head injury, that attempts to code errors made in the performance of naturalistic action tasks (Schwartz, Montgomery, Fitzpatrick-DeSalme, Ochipa, Coslett, & Mayer, 1995; Schwartz, Reed, Montgomery, Palmer, & Mayer, 1991), and focuses on the performance of everyday tasks, such as making a cup of tea, or a cheese sandwich. Initially, a coding system was devised to identify different error types from watching a video of the patient performing the task. This was followed by a second coding system for identifying behavioural cues as to whether patients were aware of each error (Hart, Giovannetti, Montgomery & Schwartz 1998; Giovannetti, Libbon, & Hart, 2002). Instances of self-correction, and behavioural cues such as gestures, hesitations, and verbal exclamations are considered to be indicators of awareness. As yet, this approach does not distinguish between errors that are detected by some form of internal monitoring system, and those that are signalled by some external cue (e.g. realising a stamp has not been stuck on an envelope by seeing it still lying on the table), which may prove to be quite an important distinction (Reason, 1990), but one which is difficult to implement in practice. The results of these studies will be discussed further when we come to consider action errors in further detail.

4) Contribution of error detection to studies of clinical populations

a) *Action errors*

Acquired brain injury (ABI)

The study of awareness of action errors in neurological conditions has focussed on both acquired brain injury (ABI) (Forde & Humphreys, 2000; Hart et al., 1998; Humphreys & Forde, 1998), and dementia (Giovannetti et al., 2002). Hart et al.(1998) looked at ABI patients' awareness of errors in the performance of naturalistic action tasks. Using a behavioural coding system, they analysed videos of patients carrying out these tasks under controlled conditions, and compared total number of errors made to the number of errors of which patients demonstrated some awareness. Even though the patients selected did not differ from controls in their total number of errors made, they demonstrated a lower overall level of awareness. Hart et al. (1998) speculated that this difference in awareness might be related to the different type of errors made by the two groups: the most common form of patient error involved missing out a stage in the task (e.g. not adding coffee to the cup), whereas controls were far less likely to do this. However, they did not actually consider awareness of errors of omission as part of their study. They also used a questionnaire to measure awareness, but found that these scores did not correlate with error detection.

Forde & Humphreys (2000) employed the same behavioural coding system as part of a case study on a patient who was severely impaired in the performance of routine, everyday tasks after a stroke that involved the frontal lobes. This patient frequently demonstrated some awareness of the fact that he was making an error, yet did not appear to be able to act upon that information. On some occasions this appeared to indicate a lack of awareness of what the error actually was, but on others appeared to indicate a dissociation between being able to verbalize a goal and implementing the actions to achieve it. A similar dissociation had been evident in other patients (Humphreys & Forde, 1998), and may also be related to the distinction drawn by Ohlsson (1996) between procedural and declarative knowledge of an error.

Dementia

A lack of awareness in dementia is something that is widely accepted, and evidence has been provided by a number of questionnaire-based studies (e.g. DeBettignies, Mahurin & Pirozzolo, 1990; McGlyn & Kasniak, 1991; Mangone, Hier, Gorelick, Ganellen, Langenberg, Borman & Dollear. 1991; Neuendorfer, 1997; Duke, Seltzer, Seltzer, &

Vasterling, 2002). The only study published so far that has a more behavioural focus was carried out by Giovannetti, Libon and Hart (2002), who looked at awareness and correction of naturalistic action errors. Utilising the same behavioural coding methodology as Hart et al. (1998), they compared 54 dementia patients to 10 healthy controls on the performance of everyday tasks. Overall, the dementia group demonstrated lower levels of awareness of errors than controls, and also self-corrected a smaller proportion of errors for which they demonstrated awareness. Participants demonstrated a lower level of awareness for omission errors, perseverative errors, and errors that involved additional steps. However, the level of error detection was not related to the number of errors each individual made, their level of awareness as measured by a self/other rating questionnaire, neuropsychological test results, or dementia severity. This may reflect a lack of more severely demented people in their sample, or perhaps is an indicator that error monitoring is something that is affected badly from the very early stages of dementia.

Therefore it would appear that lower levels of error detection in neurological patients are at least partly related to the types of errors made, in that certain errors may be more difficult to detect than others.

Models based on non-clinical populations

Theories of motor learning have been greatly influential in the development of subsequent models of error detection, with possibly the most important being Adams' (1971) closed loop theory. The original basis of this was a comparison of actual and intended limb trajectories. Learning is based upon the build-up of a series of *perceptual* *traces*, which are representations of previous movements and response-based feedback. This feedback is compared to information about the success of the movement in terms of environmental goals. This procedure, referred to as *subjective reinforcement* leads to the long-term capability to detect ones own errors. The basic principle of comparing output to some internal representation of what was intended has become fundamental to later models of motor learning (e.g. Schmidt,1975; Norman , 1981; Sellen & Norman, 1992). Ohlsson's (1996) model of complex skill acquisition draws on the distinction between procedural knowledge (knowing how to) and declarative knowledge (knowing that), with evaluation of outcome being based upon the latter.

A closed-loop theory of error detection makes a clear prediction regarding error type: errors of omission (i.e. leaving out a stage in the sequence) should be more difficult to detect, as they may come about through a lack of intention to perform the act. As omission errors appear to be the most common form of error type seen in neurological patients (Schwartz et al., 1998; Giovannetti, Libon, Buxbaum & Schwartz, 2002), this may provide some insight into the lower level of error detection seen in those patients (Hart et al.,1998; Giovannetti et al., 2002). Thus the study of patients provides data that may be applicable to non-patient populations regarding the detection of different error types, and a model developed to explain normal error detection can contribute to our understanding of error detection deficits in neurological disorder.

Models developed from the study of patients

The model of control of action that has had the biggest impact on clinical psychology must be the Supervisory Attention System and Contention Scheduling

(Norman & Shallice, 1986; Shallice & Burgess, 1996; Cooper & Shallice, 2000), which categorises control human action into three levels. At the most basic level, action schemas (Schmidt, 1975; Arbib, 1985) are organised representations of knowledge about how to carry out a particular action. Which schema become activated is determined by a system of contention scheduling, whereby schemas compete for activation on the basis of environmental contingencies and "source" schemas. This process occurs relatively automatically, but when a novel situation is encountered, requiring conscious control, the Supervisory Attention System comes into play. Schemata are goal-directed, and each schema has a number of subgoals, the execution of which is monitored. This monitoring proceeds on the basis of purely proprioceptive feedback. Although Cooper & Shallice (2000) state that subgoals are "ticked off" as they are achieved by the system, and that the Supervisory Attention System carries out more sophisticated procedures for monitoring and correction, it appears that these aspects of the model are not as fully developed as other components. As this is achieved by the action of a closed loop system, it is an example of a model derived on the basis of clinical findings that draws upon theories from a non-clinical population.

Another theory developed from studies of patients is the reduced cognitive resources model (Schwartz et al., 1998; 1999). Although not specifically developed to address error detection, this theory suggests that a deficit in performing everyday tasks is related to a global reduction in cognitive abilities, rather than any specific, measurable cognitive deficit. Hart et al. (1998) suggest that it could also account for a deficit in error detection, as more resources are now needed for previously routine, automatic tasks. Consequently, there is an even greater reduction in the resources available to carry out performance monitoring. On the basis of this, Giovannetti et al., (2002) predicted a relationship between error detection and dementia severity: this was not found. Evidence is therefore currently lacking to support this theory. The theory also states that the type of errors made by patients are not qualitatively different from those made by non-clinical populations under certain conditions, such as fatigue. Consequently, the general cognitive resources must also apply to non-patients, and a relationship might also be expected with I.Q. This has yet to be investigated.

b) *Neurological conditions and a general error detection system*

Although there has been a large amount of work on the neural basis of error detection, using physiological measures, most of these data have been collected from non-clinical populations. However, some researchers have now also started to use this technology with neurological patients.

Parkinson's disease is often referred to as a subcortical dementia, although cognitive impairment is often seen (Hart & Semple, 1990). Falkenstein, Hielscher, Dziobek, Schwarzena, Hoormann, Sundermann & Hohnsbein (2001) looked at ERNs in Parkinson's patients performing a variety of tasks. Although they did find evidence of a reduced ERN, this was only for tasks requiring a relatively high cognitive load. However, rather than implicating the anterior cingulate area, they concluded that this represented impaired function of the basal ganglia, an area that has also been suggested to play a role in error monitoring (Holyrood, Dien, & Coles, 1999).

Gehring & Knight, (2000) compared ERNs in a group of patients with lateral prefrontal damage to a group of age-matched controls, and a group of young controls on a letter-discrimination task. For controls, error trials generated greater ERN activity than correct trials, however in patients with lateral prefrontal damage, a difference in ERN activity between correct and error trials was not seen. Although this was taken as further evidence of a frontally-based monitoring system, a comparison was not made with a lesion control group, i.e. patients with cortical lesions that did not involve the frontal lobes. This study therefore only addresses a lesion / non-lesion comparison.

Following on from this, Ullsperger, von Crammon, & Műller (2002) included several different groups for comparison: patients with unilateral dorsolateral lesions, patients with bilateral orbitofrontal lesions, patients with unilateral temporal lobe lesions, an elderly healthy control group, and a young health control group. They also investigated a further possibility that, although the error monitoring mechanism may still be functioning in patients with frontal lesions, what may be impaired is the accompanying emotional response. This prediction was based on the finding that frontal lobe lesions produce an irregularity in the ability to experience reward and punishment (Bechara, Damasio, Tranel, & Damasio, 1997; Damasio, 1998). Consequently, they looked for differences in ERN and Pe, which has been targeted as some form of emotional response to the error (Falkenstein et al., 2000). In the group with dorsolateral lesions, the ERN was abolished and the Pe reduced. Other groups did not differ significantly from controls. Although this study used fairly small samples (seven dorsolateral patients, and six in each of the other groups), it provides possibly the strongest evidence, based on group data, that patients with a specific type of lesion will experience impaired error monitoring.

Thus information derived from non-patient populations can be used to make predictions about how particular neurological patients will perform, and provide further insight into their impairments.

c) Errors in speech

There is evidence for a highly active error detection and correction system operating as part of normal speech production. Nooteboom (1980) found that sixty-four per cent of errors in a corpus of over 8,000 slips of the tongue and pen were corrected by the speaker, and Nakatani & Hirschberg (1994) found that roughly ten per cent of all utterances contain some sort of revision. There have been several models of speech production that incorporate a capacity for revision, in all of which feedback plays a crucial role. Postma (2000) distinguishes three forms of control that feedback can serve: directive, tuning and corrective. It is the third of these that is highlighted as being most pertinent to models of speech monitoring.

Degenerative disorders

Whilst everyone experiences some failure of error detection in speech production at some time, a permanent impairment has been noted to occur in certain neurological conditions. For instance, a common finding is that one of the early signs of Alzheimer's disease is a difficulty in word finding (McKhann, Drachman, Folstein, Katzman, Price, Emanuel, & Stadlan, 1984; Capitani, Della Sala & Spinnler, 1986). McNamara, Obler, Rhoda, Durso & Albert (1992) looked at monitoring of speech errors in the reading of a passage by patients with Alzheimer's disease, Parkinson's disease and healthy elderly controls. Error monitoring ability was assessed by comparing the total number of speech errors made to the number of corrected errors. Whilst healthy controls corrected 72-92% of their errors, Alzheimer's and Parkinson's patients corrected only 24% and 25% of errors respectively. Forbes, Venneri & Shanks, (2001) compared performance of patients with very early stage Alzheimer's to mild Alzheimer's patients and healthy elderly controls, on a complex and simple picture description task. Even patients with very early stage Alzheimer's disease differed from healthy controls in their error detection ability, indicating that it is one of the first aspects of language function to be impaired in the disease.

Aphasia

The literature on aphasia indicates that an unawareness of deficit is commonly associated with a disruption of phonemic perception (Alajouanine, 1956; Benson & Geschwind, 1985), particularly in the case of jargon aphasia (Lebrun, 1987) where the patients seems unaware that their speech output is scattered with neolgisms, and unintelligible to the listener. It would appear that the loss of ability to perceive speech sounds also impairs ability to monitor ones own speech production. By contrast, awareness of deficit appears to be relatively preserved in conditions where phonemic perception is not disrupted (Benson, 1972; Zaidel, 1987). Although this lack of awareness is widely accepted, it is based largely upon clinical observation rather than controlled studies of error detection. Most experimental data has been based on non-clinical populations, along with the development of models. However, such models can still generate testable predictions that are applicable to clinical populations.

Models of normal error detection in speech

The most influential model of error detection in speech is Levelt's (1989; Levelt, Roelofs & Meyer,1999) perceptual loop model. Error detection in one's own speech is carried out by individual's speech comprehension system; the same system that detects errors in the speech of others. The model features three loops, starting with the conceptual loop, which monitors the appropriateness of what the speakers intends to say at a pre-verbal conceptual level. Error detection is performed primarily by the inner loop, which monitors internal speech (at a phonemic level) prior to articulation, and also by the auditory/postarticulatory loop, which monitors speech after it has become overt.

A different model was put forward by Mackay (1987; 1992a;1992b) based around connectionist principles and called the node structure theory (NST). In this, error detection is crucially linked to awareness, which corresponds to prolonged activation of one or more nodes within a network. This occurs only when the formation of new connections to an unconnected node is called for simultaneously by two or more existing nodes. In contrast to the perceptual loop theory, NST sees error detection as being a distributed process, rather than occurring at only one or two places in the hierarchy.

Clinical implications of models of speech monitoring

Whilst this was a model derived to explain detection of errors in normal speech, the Perceptual Loop model of error detection (Levelt, 1989) has clear implications for clinical populations. As error detection is carried out by the speech comprehension system, patients with deficits within that system should show accompanying deficits in error detection. An impairment in speech monitoring accompanying a comprehension deficit might also be predicted from Mackay's (1992a) model, albeit in a weaker form (Postma, 2000). However, the clinical populations so far observed have not demonstrated this pattern. Nickels & Howard (1995) looked at the production of phonological errors in a group of aphasic patients, focussing on their level of self-correction as an index of error monitoring. However, the level of self-correction appeared to be unrelated to the severity of their auditory comprehension deficits. McNamara et al. (1992) looked at self-correction of speech errors in a group of patients with Parkinson's disease. Whilst they found evidence for a reduction in this ability, it was not accompanied by any evidence of a deficit in language comprehension. In fact, a double dissociation appears to be demonstrated in the case of an aphasic patient with reduced awareness of speech errors, but relatively unimpaired comprehension (Maher, Rothi & Heilman, 1994), and a patient with severe auditory agnosia, impaired auditory comprehension, but good self-correction of phonemic errors in speech (Marshall, Rappaport, & Garcia-Bunuel, 1985). These studies are not consistent with the idea that speech monitoring is dependent on an in-tact speech comprehension system, but would be more in line with an argument put forward by Schlenk, Huber & Wilmes (1987) for dissociable production and perception monitors. Most evidence from cognitive neuropsychology tends to indicate separate input and output lexicons within the language system (Ellis & Young, 1988), which is something that neither the perceptual loop nor the NST model seems to incorporate.

Therefore the study of clinical populations has provided empirical tests of models of normal speech production, which in turn attempt to explain clinical phenomena. The implications of error detection in rehabilitation have also been investigated by Franklin, Buerk & Howard (2002), who used Levelt's (1989) perceptual loop model as the theoretical background for a single case experiment using multiple baselines. Their patient, MB, was an 83 year-old woman with reproduction conduction aphasia, which is characterised by the production of phonological errors in all tasks requiring spoken output. After an intervention based around improving MB's perceptual processing and monitoring skills, they reported an improvement in all output modalities, with evidence of generalisation to words that had not been used in therapy.

d) *Error detection and mental health disorders*

Obsessive-compulsive disorder

Obsessive-compulsive disorder is characterised by repetitive thoughts or images, which cause marked anxiety or distress (American Psychiatric Association, 1994), accompanied by compulsions, which are behavioural or mental responses to these thoughts, aimed at reducing the distress. It has been suggested that people with this condition have some irregularity in their monitoring system. People with OCD have hyperactive error signals, and repeatedly perform corrective actions in an attempt to reduce these error signals (Pitman, 1987; Schwartz, 1997). In their review article of the function of the orbital frontal cortex, Zald & Kim (1995) speculated on the basis of animal data, that hyperactivity of error detection cells in this region might lead to the feeling that acts have been performed inadequately. So far, only one study appears to have focussed on this particular patient group, which used the paradigm of measuring ERPs whilst performing a CRT task. Gehring, Himle, & Nisenson (2000) compared a group of nine patients with OCD to a group of nine age, sex and education-matched controls, and found the ERN to be enhanced in the OCD group. The level of this enhancement was also found to correlate with symptom severity (although the small numbers here seriously restrict the validity of correlational data). Again, analysis of where the ERN was most pronounced was consistent with an anterior cingulate location.

Schizophrenia

Another disorder in which impaired error detection has been implicated is Schizophrenia. This is commonly associated with a lack of insight, disordered thought processes, hallucinations and delusions (American Psychiatric Association, 1994). Problems with error detection might be expected in this population, and are featured in some of the most influential models of this disorder (e.g. Hoffman, 1986; Frith, 1987; 1992; 1998). One of the key elements of Frith's (1992) model is a deficit in the internal monitoring of intentions, which is considered to be responsible for the positive symptoms. Negative symptoms are related more to problems with goal selection, and the initiation of plans and actions.

There are some empirical data to support this model, although it has not always been consistent. Leudar, Thomas & Johnson (1992) looked at speech errors in schizophrenics and controls. Although a fairly high rate of speech errors was found in the schizophrenic group, they did not differ from controls in the frequency with which errors were detected and repaired. In a follow-up study, Leudar, Thomas & Johnson (1994) looked at performance on the reporter test (DeRenzi & Vignolo, 1962), which features the participant describing a series of actions being carried out by the experimenter. In this study, they differentiated between within-word repairs and repairs immediately after the error word. The latter type of repair is made before the word has been completely articulated, and must therefore be a response to monitoring of an internal (phonetic) code rather than an external (acoustic) one. When this distinction was made, the schizophrenic group were found to demonstrate internal error detection only half as often as controls. Although this is consistent with Frith's (1992) proposal that schizophrenics have a deficit in internal monitoring of action plans, Leudar et. al. (1994) found that the apparent reduction in internal monitoring was present for schizophrenics with negative symptoms as well as those experiencing auditory hallucinations. Frith's model proposes an internal monitoring deficit as an explanation specifically for auditory hallucinations, so this finding is not entirely consistent.

Focussing on a different form of error detection, Rossell & David (1997) carried out a study, which involved training schizophrenic patients and controls on a number of variants of the Wisconsin Card Sorting Test (Heaton, 1981) in order to ascertain which element of the task was proving most difficult. This task consists of matching stimulus cards to source cards according to particular dimensions, and is one of the most well-known measures of executive dysfunction. The manipulation, which produced the greatest improvement in the performance of schizophrenic participants was asking them to provide a running commentary of what they were doing. The rationale was that this would help participants pace themselves and provide additional opportunity for error checking. However, some aspects of the methodology used in this study appear curious. For instance, the control group were made up of elderly participants living in residential homes, and it is unclear upon what criteria these participants were matched. Also, there were eight conditions, and only twenty-four participants, which amounts to only three participants per condition: a rather low case-to-variable ratio.

The role of event-related potentials in the error monitoring of schizophrenic patients has also been investigated. Kopp & Rist (1999) first reported a reduced ERN in the performance of a CRT task by schizophrenic patients. Mathalon, Fedor, Faustman, Gray, Askari, & Ford (2002) looked at (ERN) and correct-response-related negativity (CRN) in a picture-word verification task. In this, a picture is presented briefly, followed by a word, which may or may not match the picture; participants must decide if the word and picture match. Compared to controls, schizophrenic patients had smaller ERNs and larger CRNs, which they concluded was consistent with a dysfunction in self-monitoring, and implicating the anterior cingulate and dorsolateral prefrontal cortices. A similar set of results were obtained by McNeely, Christensen and West (2002), using a computerized version of the Stroop colour-naming test. They also concluded that there is deficit in error monitoring possibly due to some form of dysfunction of the anterior cingulate area.

Carter, Mintum, Nichols, & Cohen (1997) looked at cerebral blood flow during the performance of the Stroop task (Stroop, 1935), using PET scanning. During the colour-incongruent condition, which is likely to elicit the most response conflict, schizophrenic patients exhibited lower anterior cingulate activity than controls. However, the authors pointed out that these patients were all medicated, and antipsychotic medication has been shown to decrease blood flow and metabolism in this area. A slightly different result was found by Nordahl, Cameron, Salo, Kraft, Baldo, Salamat, Robertson & Kusubov (2001), who performed a PET scan study, looking at cerebral metabolism in unmedicated patients diagnosed with paranoid schizophrenia, whilst performing a computerised version of the Stroop task. Schizophrenic patients made a higher number of errors than controls in the colour-interference condition, which correlated with a higher level of glucose metabolism in the anterior cingulate area. Curiously, a correlation between error rate and anterior cingulate metabolism was not seen in controls. Although the authors concluded that this was evidence that error monitoring is preserved in unmedicated paranoid schizophrenics, this is based upon the assumption that the increased metabolism in this area is an index of monitoring. If that were the case, it seems strange that no such relationship was seen in controls, unless, of course, their error rate were too low, which would suggest that what was seen here is in fact a floor effect, which may explain this apparently inconsistent result.

Carter, MacDonald, Ross, &. Stenger (2001) returned to the CRT methodology, in a study that used event-related fMRI with schizophrenic patients and healthy controls. The schizophrenic group differed from controls in that they failed to demonstrate error-related activity in the anterior cingulate area, and also showed less reaction time slowing in the trials following an error.

Overall, there appears to be a growing body of evidence to suggest that a reduced capacity for error monitoring is a feature of schizophrenia. Along with OCD, this provides an example where a deficit in error detection is actually incorporated into the model in order to explain the condition. Information from, and paradigms developed with, non-clinical populations can therefore be useful in explaining clinical conditions. Normal models of error detection can perhaps be of most use to clinical psychology when used this way.

5) Contribution of clinical populations to the study of error detection

Localisation

The evidence accumulated from studies on ERN in non-clinical populations suggested that error detection systems may be localised to specific anatomical regions, in particular the anterior cingulate cortex (Gehring et al, 1990; Dehaene, et al. 1994). Further evidence has been provided by the use of fMRI (Menon et al., 2001; Kiehl et al., 2000). Although these techniques provide evidence for neural activity accompanying cognitive tasks, the question always remains of whether activity in that area is *necessary* for the occurrence of a cognitive process, or whether it is some form of artefact. The approach of traditional neuropsychology has been to relate patterns of cognitive impairment to sites of lesion location (e.g. Broca, 1865; Luria, 1973; Wernicke, 1874): if damage to a particular brain region results in an impaired ability to carry out a cognitive process, then the functional integrity of that region is considered necessary for that process. Hence to draw firm conclusions about localisation of function, the contribution of human lesion data is required. The studies carried out looking for ERN in patients have provided converging evidence that damage to regions of the frontal lobes does indeed produce a reduction, or even abolition, of the ERN (Gehring & Knight, 2000; Ullsperger, et al., 2002). This data further strengthens the case for a frontally-based system for error detection.

Lateralisation

There is also evidence that there may be some form of hemispheric specialisation for error detection. Kaplan & Zaidel (2001) looked at performance of the lexical decision task, a paradigm involving deciding if strings of letters presented on a computer screen are real words or non-words (Rubenstein, Lewis & Rubenstein, 1973). This version incorporated visual feedback presented selectively to either visual field. Negative feedback to the right hemisphere appeared to cause a decrease in error rate, whereas the same feedback to the left hemisphere increased latency on the following trial. They concluded that this indicated a right hemisphere advantage for error detection. However, this result may reflect the functioning of a slightly different system to that examined in many other studies, as this was a form of *explicit* monitoring, of which the participant was, by definition, fully aware. Error-related slowing, as reported by Rabbit (1969), was not seen in this task, which the authors suggest was due to the presence of a scrambled control stimulus after each task. Feedback was also presented 225msecs after the response, by which time any cognitive process corresponding to the ERN would already have occurred.

Swick & Jovanovic (2002) used two single case studies to demonstrate a dissociation of function according to which part of the anterior cingulate cortex was lesioned. They used a version of the Stroop task with patients D.L., who had a right anterior cingulate lesion, and patient R.N., who had a left hemisphere anterior cingulate lesion. The performance of each patient was compared to that of age-matched controls. If the anterior cingulate cortex monitors for response conflict, as suggested by Carter et al. (2000), then damage to this area should result in a high error rate in the incongruent condition. Patient D.L, with a right hemisphere lesion performed at a level with controls, whereas patient R.N., whose lesion was left-hemisphere-based, showed an increased level of errors in this condition. Although the authors point out that their results cannot distinguish whether this represents an impairment in conflict monitoring, or cognitive control, it certainly seems inconsistent with Kaplan & Zaidel's (2001) claim for a right hemisphere advantage. Thus in relation to hemispheric differences, data from patients questions the conclusion drawn from a non-clinical population.

Age, I.Q. and learning disabilities

In his body of research looking at the effects of ageing on CRT, Rabbit (1968; 1978; 1990) also considered error correction. Rabbitt (1968) included a condition where participants were asked to signal their awareness of the occurrence of an error by hitting a different hand-key or foot-key, as well as a condition where participants were asked to correct their errors. Accuracy on this task fell below that of the error-correction condition, although the slowing of a post-error response was still observed after trials that participants failed to indicate as errors. It was proposed that these response types reflect different places on an automaticity continuum, with error recognition and error detection occurring relatively automatically, and error signalling being more dependent on conscious processing. Error recognition and error correction were compared across 4 different age cohorts, and found to remain stable, whereas error signalling decreased (Rabbitt, 1990)[although an increase post-error slowing in elderly participants has been reported elsewhere (Band & Kok, 2000)]. It would therefore appear that the ability to consciously detect errors decreases with age. Across all age-groups, Rabbit (1990) also looked for effects of I.Q., and found that performance in all three conditions improved with I.Q. score.

A different paradigm was used by Marshall, Elias, & Wright (1985), who looked at error detection and correction abilities on a simple motor task in young, middle aged and elderly participants. They were taught a particular movement, and were then required to give a confidence rating for whether subsequent movements were the same as the earlier one. Both elderly and middle aged participants demonstrated poorer performance than the younger participants.

Although Rabbitt (1990) suggests a relationship between error detection and I.Q., which would predict a poorer level of error detection in individuals with learning disabilities, this prediction has yet to be tested. Several studies have approached the issue by looking at detection of errors in text (Hannah & Shore, 1995), encouraging checking whilst teaching arithmetic (Laird & Winton, 1993), and looking out for errors made by a puppet performing a counting task (Porter, 1998). Porter (1999) did find that mental age, as estimated by the British Picture Vocabulary Scale (Dunn, Dunn, Whetton & Pintilie, 1982), was found to be the best predictor of performance on both a straightforward counting task and monitoring the puppets counting. Whilst this is consistent with I.Q. and error detection being related, no studies have yet looked at learning disabled participants ability to detect their own errors.

Conclusions

Although this was formerly an area of research on which few empirical studies had been conducted (Reason, 1990), the last decade has seen a large surge of interest. This has undoubtedly been spurred by the advent of new technology that has allowed the neural basis of error detection to become clearer, and there is now evidence to back up views regarding the role of error detection in clinical populations. Techniques that have evolved as part of the discipline of experimental technology have been applied to the study of clinical populations, and methods of clinical investigation have been used to illuminate the processes that underlie error detection in the normal population. In order to understand what happens when a process breaks down, it is necessary to understand how that process is normally carried out, and models can be tested on the basis of their ability to predict what will happen when that process breaks down. In the case of some mental health conditions, that breakdown has been shown to be fundamental in explaining the condition itself.

As the study of error detection is relatively new, there are still many areas to be developed. For example, there has not been a great focus on the implications of error detection for rehabilitation, despite a long-standing recognition of the need to do so (e.g. Prigatano, 1999). Error detection, I.Q. and learning disabilities is also an area that is clearly under-researched. One thing that is clear is that this is an area that is made richer by converging evidence from the wide range (both clinical and non-clinical) of approaches.

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Appendix: Search History

This literature review was compiled using the following databases: PsycLit, Medline, and BIDS. The main terms used as key words were "error detection", "error monitoring", and "metacognition". Across the three databases, this produced a list of 1,686 items (including the term "awareness" produced 48,005 items). Items were then excluded if they were not written in English, were based on non-human populations, or were a form of publication other than journal articles, book chapters, or books. Two historically significant non-English-language articles were still referred to. This reduced the number to 1,318. A list was drawn up of potentially relevant items, by scanning these. 254 titles were selected by this method, and selection proceeded on the basis of information contained within the abstract. Some articles and book chapters were also sourced as a result of being references in other items. Articles were gathered by sourcing the University of Birmingham library, and applying for inter-library loans via the library at the Queen Elizabeth Psychiatric Hospital, Birmingham. The final review took account of 93 journal articles, 20 books, and 10 book chapters.

Research Paper:

ERROR DETECTION IN THE PERFORMANCE OF EVERYDAY TASKS BY PATIENTS WTH FRONTAL LOBE LESIONS

ABSTRACT

Two studies are reported that compared error detection in a group of 14 patients with frontal lobe lesions, 8 patients with lesions not involving the frontal lobes, and 12 healthy controls, in the performance of naturalistic action tasks. In study 1, which used a behavioural coding system similar to that devised by Hart et al. (1998), frontal patients made more total errors than healthy controls. Non-frontal patients did not differ from either frontal patients or controls. When looking at awareness of errors both patient groups differed from controls, but not from each other. In study 2, a comparison was made of the ability to detect errors whilst watching a video of themselves performing experiment 1. The pattern here was closely related to the number of errors made, with frontal patients identifying a smaller proportion of their own errors than either non-frontals or controls. The data are considered in the context of an anatomically-based error-detection system, and the reduced cognitive resources model of naturalistic actions (Schwartz et al., 1998).

INTRODUCTION

A major factor that has been highlighted as a barrier to successful outcome from rehabilitation after head injury is a lack of awareness (e.g. Cavallo, Kay, & Ezrachi, 1992; Ezrachi, Ben-Yishay & Kay, 1991; Lam, McMahon, Priddy & Gehred-Schultz, 1988), which has come to be associated particularly with damage to the frontal lobes of the brain (Prigitano, 1991). Although the main method of investigating this has tended to be by use of questionnaires (e.g. Prigitano, Fordyce, Zeiner, Roueche, Pepping & Wood, 1986; Ranseen, Bohaska & Schmitt, 1990), there have been recent developments in the use of a behavioural coding system for use in the performance of everyday tasks (Hart, Giovannetti, Montgomery & Schwartz, 1998; Giovannetti, Libon & Hart, 2002). This study incorporates a similar approach, comparing the performance of a group of patients with lesions to the frontal lobes, with that of a group of patients with lesions that did not involve the frontal lobes, and a group of healthy controls.

Naturalistic Action Tasks

The performance of everyday tasks, or naturalistic action tasks, by individuals with acquired brain injury (ABI) has been studied extensively by Schwartz and colleagues (Schwartz, Buxbaum, Montgomery, Fitzpatrick-DeSalme, Hart, Ferraro, Lee & Branch-Coslett, 1999; Schwartz, Fitzpatrick-DeSalme & Giovannetti, 1995; Schwartz, Montgommery, Buxbaum, Less, Carew, &. Coslett, 1998; Schwartz, Montgomery, Fitzpatrick-DeSalme, Ochipa, Coslett, & Mayer, 1995; Schwartz, Reed, Montgomery, Palmer. & Mayer, 1991). Commonly the studies assess tasks performed in everyday life, involving multiple components, which can often break down after ABI; examples would include making a sandwich, toast, or a cup of coffee. A coding system was developed which broke each task down into a number of components, which are routinely performed in a set order (Schwartz et al., 1991). When a deviation is made, the precise point at which it occurred can be carefully documented, and the nature of the deviation classified according to a finite number of error categories.

There are a number of theories as to why this breakdown should take place. Initial interpretations were in terms of the Norman & Shallice (1986) model of executive function, which explains routine tasks being carried out in a fairly automated fashion by the selection of relevant action schemas. The selection procedure, referred to as contention scheduling, is based upon activation via environmental cues (Cooper & Shallice, 2000). Performance of non-routine tasks involves a degree of conscious control, which is governed by the Supervisory Attention System (SAS). This latter system is associated with the function of the frontal lobes. Evidence suggests that a deficit in semantic knowledge of how to carry out the tasks in itself cannot explain the breakdown in performance (Buxbaum, Schwartz, & Carew, 1997; Humphreys & Forde, 1998; Sirigu, Zalla, Pillon, Grafman & Dubois, 1996), and that an impairment in both routine action schemas and the SAS is necessary for a breakdown in the performance of routine actions (Schwartz & Buxbaum, 1997). This might be expected, as everyday action skills usually contain both routine and non-routine components (Schwartz et al., 1999).

However, Schwartz et al. (1998) considered some predictions based on the Norman & Shallice (1986) model. They used a paradigm referred to as the Multi-level Action Test (MLAT), which varied the complexity of the tasks, by including semantic distractors and a dual-task condition, where two tasks must be performed in any order, without time limits. A second dual-task condition necessitated also searching a drawer for necessary items. They predicted that patients should not differ from controls on the simplest most routine versions of the tasks, and also that errors seen should be primarily errors of commission, as target responses should lose their advantage over competing responses in the more complex conditions. The finding that these predictions were not supported by the data, and that error score was associated with clinical severity (based on a rating scale consisting of 13 items relating to motor function, and 5 items relating to cognitive function), led them to propose an alternative explanation for the pattern of breakdown.

Reduced cognitive resources

The alternative explanation for errors in everyday action demonstrated by patients with acquired brain injury is based around limited capacity resources (Schwartz et al., 1998; 1999). Rather than linking action errors with specific cognitive functions, it is considered that they arise as a result of a reduction in general cognitive resources. The deficits seen after ABI and in dementia are not qualitatively different to errors made by normal participants, and represent points along a continuum (Schwartz et al., 1998). These are the same errors that commonly occur in people with no neurological impairment, under conditions such as fatigue (Norman, 1981; Norman & Shallice, 1986). The implication is that this occurs under these conditions because cognitive resources are reduced. The difference is that in cases of ABI and dementia, this state of reduced resources is not transient. The cognitive resources appear to be a fairly generalised concept, and are not related to specific domains of cognition, such as executive processing (Norman &

Shallice, 1986), or specific modules of attention (Posner & Peterson, 1990; Robertson & Frasca, 1992). Significantly, the breakdown of naturalist actions is not localised to the frontal lobes (Schwartz et al., 1999).

The evidence for the different theories is currently inconclusive. Schwartz et al., (1998) looked at performance on the MLAT task in a group of 30 unselected patients with closed head injury. Once clinical severity had been taken into account, the presence/absence of an anatomically-defined frontal lesion did not significantly affect the number of errors made. In a study of 54 dementia patients, Giovannetti et al. (2002) found that dementia severity [as measured by the Mini Mental State (Folstein, Folstein & McHugh, 1975)] was the only significant predictor of the number of errors made. Tests related to specific cognitive function were not significant predictors. However, this conflicts with evidence from Buxbaum, Schwartz & Carew (1997), who found that an executive impairment with little semantic impairment was associated with compromised ability in the performance of these tasks by a dementia patient. A second patient, with impaired semantic knowledge but intact executive function performed well. Also Schwartz, Fitzpatrick-Desalme & Giovannetti (1995) reported significant correlations between naturalistic action impairments and tests of executive function in patients with closed head injury. Other evidence for dissociations in types of error (e.g. perseverations) also goes against a simple, single resource account (Humphreys & Forde, 1998). Consequently, the relative importance of executive processing and resource limitation in the performance of naturalistic actions remains unclear.

The role of error detection

One factor that has not been considered in any great detail in the study of everyday action is the contribution of error detection and awareness. It is possible that an impairment in monitoring acts as a contributory factor in the breakdown of performance. The studies which have considered this aspect will be discussed shortly, but first we will consider evidence for the existence of an error detection system.

A generic error detection system

Evidence for the existence of some form of generic error detection system began to emerge from studies using choice reaction times (Rabbitt, 1969;1979; Maylor & Rabbitt, 1987; 1989). It was found that reaction times were slowed on the trials that followed an incorrect response, which appeared to indicate that at some level the cognitive system was registering its occurrence. The notion of a neural system specifically for error detection gained impetus with the discovery of a characteristic form of Event-Related Potential (ERP), that appeared to occur when participants made an incorrect response (Falkenstein, Hohnsbein, Hoormann, & Blanke, 1990; Gehring, Coles, Mayer & Donchin, 1990). This was referred to as the Error Related Negativity (ERN), and its size appeared to correlate with Rabbit's (1969) post-error slowing, and decreased if the task emphasized speed over accuracy (Gehring, Goss, Coles, Meyer & Donchin, 1993). There is a growing body of evidence that suggests the ERN is localised to the frontal lobes, in particular the anterior cingulate cortex (Dehaene, Posner & Tucker, 1994; Carter, Barver, Barch, Botvinick, Noll & Cohen, 1998; Kiehl, Liddle & Hopfinger, 2000). However, there is some debate as to what the ERN actually represents. It has been proposed that it only occurs after slips of action (Reason, 1990), which is when the correct task is intended, but there is a problem in its execution: it is not evident when an incorrect response is selected (Dehaene et al., 1994). There is also a suggestion that it represents the registering of response competition (Carter et al., 1998). In line with this, there appears to be increased activity in the anterior cingulate region during incongruent conditions of the Stroop task, as opposed to an increase in the left dorsolateral prefrontal cortex during colour naming (McDonald, Cohen, Stenger & Carter, 2000). If the system that these data describe really is a generic error monitoring system, then it would follow that the site of the lesion may be important for error detection in a range of tasks, including naturalistic action tasks.

Error detection in patients

Although there is an accumulation of evidence for the existence of a neural system, which specifically functions to detect errors in task performance (Bernstein, Scheffers & Coles, 1995), localised to the anterior cingulate cortex (Miltner, Braun, & Coles, 1997), very little work has been carried out on patients' awareness of their own error rates. Gehring and Knight (2000) used a letter discrimination task to compare ERNs in patients with frontal lesions and healthy controls. In line with the theory of a frontally-based error monitoring system, controls demonstrated a difference in ERN's between correct and incorrect trials, which was absent in the patient group. However, the absence of a condition with patients whose lesions did not involve frontal regions makes it difficult to rule out the possibility that a similar effect might not be observed with damage to other cortical, or subcortical, areas. Ullsperger, Von Crammon and Műller (2002) compared patients with unilateral lesions in the lateral frontal cortex, bilateral lesions involving the orbital cortex, and unilateral temporal lobe lesions on a computer presented speeded flanking task. This involved pressing a right button in response to arrows pointing to the right, and a left button in response to arrows pointing to the left. Whereas the ERN was still present in the orbital and temporal lobe groups, it appeared to have been abolished in patients with lesions involving the lateral frontal cortex.

One difficulty with the ERP-based paradigm is that it imposes certain limitations upon the type of task in which error detection may be considered. The physical restrictions of recording an ERP mean the tasks used tend to be fairly simple reaction time experiments, and quite removed from the type of complex everyday task studied by Schwartz et al. (1998). This has led to the development of a different means of investigation based around behavioural coding.

Error detection in the performance of everyday tasks

Hart, Giovannetti, Montgomery & Schwartz (1998) used the same sample of patients and controls as Schwartz et al. (1998) to look at participants' awareness of when they made an error. They devised a coding system for rating when a participant was aware of an error, which produced the following categories: verbal acknowledgments of errors, audible nonword gestures, one of three facial expressions (smiling, grimacing, surprise), head shaking, or manual gestures. This was then used to calculate a percent aware score by adding the number of corrected errors to the number of uncorrected errors of which the participant showed some awareness, and dividing this by the total number of errors made. Although patients and controls were matched for the overall number of errors made, controls detected an average of 74 % of their errors, whereas patients with closed head injury detected only 47.7%. Although their data did not address reasons for this discrepancy, they speculated that the reduced cognitive resources theory (Schwartz et al., 1998) might account for the differences, in that after acquired brain injury, performance of routine tasks would require more attentional resources. Therefore, less resources would be available for error monitoring, and the efficiency of the system would suffer accordingly. However, when Giovanetti, Libon & Hart (2002) used the same system in a study of error detection in 54 dementia patients, they found that awareness did not correlate with the number of errors made, or dementia severity, nor was any relationship found with any specific neuropsychological tests. This is not consistent with a reduced processing resources account.

The studies by Hart et al., (1998) and Giovannetti et al. (2002) raise a number of interesting questions. For instance, Hart et al. (1998) considered only errors of commission, whereas previous studies have shown that patient errors are primarily omissions (Forde & Humphreys, 2000; Schwartz et al., 1998; 1999). This raises the question of whether certain error types are more difficult to detect than others. Forde & Humphreys (2000) found some indication that their patient, HG, had insight into some of his errors, but not others, and in particular was not aware of his semantic errors. Giovannetti et al. (2002) found that semantic errors (substitution errors in their coding system) and sequence errors were detected *more* frequently than omissions, perseverations and additions. There is also the question of whether a verbal awareness will translate into a behavioural one. For instance, Humphreys & Forde's (1998) patient HG was prone to perseveration errors, and yet would verbally acknowledge that he was doing something wrong whilst continuing to behave incorrectly.

Hart et al.'s (1998) data suggest that a failure in error monitoring will reliably distinguish individuals with closed head injury from healthy controls. However their closed head injury patients were an unselected group, so it remains unclear whether this will also distinguish frontal patients from patients without any frontal involvement.

Aims of the current study

This study sets out to further examine a number of questions that have been raised by previous research. The first set of questions relate to the total number of errors made. Will frontal patients differ from non-frontal patients in terms of the number of errors made? An anatomically-based model might predict this (e.g. Gehring et al., 1993), whereas the attentional resource theory (Schwartz et al, 1998: 1999) would not. Secondly, would frontal patients differ from non-frontal patients in the types of error made? Thirdly, what variables might predict the number of errors?

The second set of questions relates to patients and controls awareness of the errors that are made. Will frontal patients differ from non-frontal patients in terms of their awareness of errors? The attentional resources theory (Schwartz et al., 1998; 1999) would not predict such a difference, whereas a model based around an anatomical site for error detection might (e.g. Gerhring et al., 1993; Gehring & Knight, 2000). If a difference is seen, is this due to qualitatively different types of error being made? For example, a closed loop theory of error detection (e.g. Adams, 1971; Norman, 1981; Sellen & Norman, 1992), in which an internal representation of the desired state is compared to the state of the external environment, would predict that omission errors would be less likely to be detected. Errors are far more likely to be detected if they involve poor performance of an intended action. A question that will also be addressed is whether there is a pattern for different error types to be more difficult to detect. Also, the reduced attentional resources theory would not predict that poor performance will be related to scores on any specific neuropsychological tests. But if error detection is linked to a deficit in executive ability, that is measurable by one of the conventional tests of executive function, a relationship should be apparent.

Experiment 2 will focus on the ability of participants to detect errors whilst watching a video of themselves performing Experiment 1. If differences are apparent between the groups in their awareness of errors as measured by a behavioural coding system, will this be reflected in their ability to explicitly recognise errors on video? Will particular error types be more difficult to detect under this condition? Finally, what variables will predict patients' level of error detection whilst watching their videos?

EXPERIMENT 1

METHOD

Participants

Patients were recruited from a number of neuroscience outpatient services, and rehabilitation centres throughout the West Midlands. Full ethical approval was obtained via the West Midlands Multi-Centre Research Ethics Committee (MREC). Lesion location was determined by CT or MRI scan. Exclusion criteria were a) a history of psychiatric disorders, b) evidence of progressive neurological disorders, c) major visual impairment or agnosia, d) inability to follow and understand task instructions [screening was carried out using the Sheffield Aphasia Battery (Snyder, Body, Parker & Body, 1993)], e) inability to maintain arousal and behaviour control adequate for a 45-minute testing session, f) and insufficient sensorimotor function to perform the tasks.

A post hoc power analysis based on results shown in Table 2, the current study presents a power of 0.51. To achieve a power in excess of 0.80, a sample size of approximately 63 individuals would have been required. However, the final sample size was greatly restricted by the number of suitable patients available. Patients with lesions that did not involve the frontal lobes were particularly difficult to acquire. Data were initially collected from 30 patients. Of these, two asked to withdraw, one was excluded due to comprehension problems, one was excluded due to high anxiety levels, and four were excluded because of uncertainty over their lesion location. The final sample consisted of 14 patients with lesions involving the frontal lobes (13 male, 1 female), and 8 patients with lesions that did not involve the frontal lobes (4 male, 4 female). All patients were at least a year post occurrence, and neurologically stable.

The aetiologies of the frontal group consisted of eight patients with stroke, three patients with head injury, one patient with carbon monoxide poisoning, and one patient with herpes simplex encephalitis. Although all of these patients had evidence of damage to the frontal lobes of the brain, their lesions generally extended beyond these areas. Of these, three patients had a hemi-paresis, and one more was mildly dyspraxic. To our knowledge, only one patient was prone to seizures, which were controlled with medication. The criteria for non-frontal patients was that their lesion site, as evidenced by CT or MRI, did not encroach on either frontal cortical areas or subcortical areas. The non-frontal group consisted of one patient with head injury, five patients with stroke and two patients who had undergone surgery for removal of posterior fossa tumours. There were no instances of hemi-paresis in this group, although one patient was mildly dyspraxic. None were prone to seizures, and none were taking anti-convulsant medication. Background neuropsychological screening was performed on all participants, and a summary of their characteristics is shown in table 1. A non-lesion control group was also tested, which was made up of 12 participants (4 male, 8 female) from the same geographical area as the patients. The 3 groups were well matched on age, and years of education, but not gender distribution. However, previous studies suggest that error rates for males and females are similar (e.g. Schwartz et al., 1998; 1999).

Procedure

A variation on the "2x3" action test (Buxbaum, Schwartz, & Carew, 1997) was developed in pilot studies, using 12 normal adults, and 4 patients prone to action errors. This task involves 3 everyday tasks, each of which must be performed twice. The aim was to develop a form of the test that would be unlikely to be performed at ceiling (i.e. no errors) by controls, but would be still be manageable by neurological patients.

The experimental set-up was similar to the "dual-basic" condition of the MLAT, where the participant performs a primary and a secondary task, in any order. Here, participants were required to perform 3 tasks, twice. An additional set of rules was also included, based upon the logic of the Modified 6 Elements task (Shallice & Burgess, 1991; Wilson et al., 1996), which was intended to create the potential for "executive", or rule-based errors. These were that no two versions of the same task should be carried out consecutively, each task should be finished before moving on to the next one, and that any items that were going to be needed again should be left open ready for use (e.g. milk bottle, tea-bag box).

Everyday Tasks

From a range of tasks, 6 were selected, which were administered in two sets of three. The choice of which tasks would be administered together was partly determined by the range of items necessary to perform each task. This enabled the presence of semantic distractors, and also the opportunity to create an extra level of difficulty in that participants needed to take into account not only whether they had finished using an item for the purpose of the current task, but also whether they would need it in the following task. The final selection of task was as follows:

1) making a cup of tea with milk and sugar; preparing a bowl of cereal with milk and sugar; preparing a Christmas card for posting, including a gift voucher.

2) Making two slices of toast with butter and jam; making a cheese sandwich and putting it in a lunchbox; gift-wrapping a book, including a decorative bow.

Scoring sheets are included in appendix 11.

A number of other tasks were considered in the pilot stage, but rejected for a number of reasons, e.g. painting a piece of wood was considered to have too few components, brushing teeth is something not usually performed at a table.

Patients were sat in front of a table, with the necessary items arranged before them in a set order. They were first asked to identify what each of the objects were. For those patients with a naming impairment, this was done by a spoken-word / object matching procedure. The rules of the task were explained to them, and they were given a set of written instructions, which they could refer to at any time. Participants were asked to repeat these instructions before beginning, and were allowed to supplement their output with gestures, where expressive aphasia was present. Participants were asked to indicate when they considered that they had finished the task. Items on the table were then replaced by those necessary to perform the second 2x3.

After performance of 3 tasks, patients were asked if they thought they had made any errors, and what those errors might have been. Performance was videotaped, and coded according to detailed criteria, described later. Participants performed both 2 x 3's in a single, one-hour session. Although three participants required more than one session, their slow performance was attributable to motor problems, rather than cognitive deficits.

Scoring

Detailed scoring sheets were devised by asking 12 individuals, who did not take part in any other aspects of the research, to generate scripts for the performance of each of the tasks used. The resulting scripts were then classified into stages of each task, and subcomponents, which correspond to the A1 and A2 units identified in the action coding system devised by Schwartz et al., (1991). Each stage was listed on the form, accompanied by a box to tick correct performance, and a series of boxes indicating each possible error category. In addition, the scoring system developed by Hart et al., (1998), for identifying awareness of errors was also incorporated. For each error that was identified, it was also noted whether the person self-corrected, either during performance of that error, or afterwards. For errors that were not self-corrected, it was considered that the participant was aware if they made one or more of the following behavioural cues: verbalisations, audible nonword exclamations, head shaking, or manual gestures. After the performance of three tasks, participants were asked if they had made any errors, and what they were. This made it possible to take account of occasions where participants had been aware of an error, which had not been picked up from scoring the video.

As the focus of this study was specifically error detection, the error coding system differed in a number of ways from those used before. Most importantly, the category of sequence error was not used, for two reasons. For a number of the tasks, the sequence in which actions are performed is largely arbitrary, and also subject to regional variation. For example, it is common practice in some parts of the country, but not others, to add the milk to the cup first when making a cup of tea. Also, for the majority of tasks where the order of performance was not arbitrary, it did not seem possible to realistically distinguish a sequence error from a corrected omission error. Step omissions and tool omissions were also condensed into one omission category. The error categories finally used were:

• semantic errors – a task was performed using an inappropriate object.

• perseveration – a particular step was not discontinued at the appropriate time, e.g. continuing to add sugar to tea

• omission – particular step was left out, e.g. not adding milk or sugar to tea

• commission – performing an additional step, e.g. removing the crusts from bread before making toast

• executive – not following one of the rules of the task, e.g. not finishing one task before starting the next

• quality – performing a task poorly, e.g. dropping jam on the table

The videos were scored by two trained coders. Inter-rater reliability was assessed on a subset of eight videos, which gave an agreement rate of 85% across all error types. This is similar to the rates that have been reported in previous studies (e.g. Giovannetti, et al., 2002; Hart et al., 1998; Schwartz et al., 1998; 1999).

RESULTS

Neuropsychological tests

The mean scores for the neuropsychological tests are shown in table 1. There was a significant difference between the groups in Hayling Profile [$F(2, 31) = 12.3, p < .01$], Brixton Scaled Score [$F(2, 31) = 10.3, p < .01$], cognitive speed [$F(2, 30) = 17.6, p < .01$], NART error score [$F(2, 31) = 10.1, p < .01$], digits forwards [$F(2, 30) = 6.2, p < .01$], digits backwards [$F(2, 31) = 6.1, p < .01$], prospective memory (RMBT) [$F(2, 31) = 5.9, p < .01$], HADS depression [$F(2, 31) = 7.5, p < .01$], Zoo map [$F(2, 28) = 6.4, p < .01$], Modified 6 Elements [$F(2, 31) = 15.8, p < .01$], telephone search [$F(2, 24) = 17.7, p < .01$], telephone search whilst counting [$F(2, 24) = 6.5, p < .01$], figure recall [$F(2, 30) = 4.5, p < .01$], and story recall [$F(2, 31) = 11.6, p < .01$].

Post hoc analysis with Tukey HSD ($p < .05$) indicated that both patient groups differed from controls, but not from each other, on cognitive speed. Frontal patients differed from non-frontals and controls on Prospective Memory and the Modified 6 Elements. Non-frontal patients also showed higher levels of depression than the frontal group or the control group (although all were below the cut-off for clinical depression). For all other tests, the pattern was for frontal patients to score lower than controls, but for non-frontal patients to differ significantly from neither.

Characteristic	Frontal (n = 14)		Non-frontal (n = 8)		Control (n = 12)	
	M	**SD**	**M**	**SD**	**M**	**SD**
Age	48	15.2	41.6	10.9	46.2	13.8
NART errors (Nelson, 1982)	30.1	11.5	22.9	13.4	11.8	5.8
Executive						
Modified 6 (profile)	2.1	1.2	2.8	1.0	3.8	.5
Action plan (profile)	3.4	1.3	4	0	3.9	.3
Zoo map (profile)	1.5	1.1	1.6	1.2	3.1	.9
(BADS, Wilson et al., 1996)						
Hayling (profile)	2.4	1.7	3.9	1.4	5.6	1.6
Brixton (scaled score)	2.9	1.8	4.1	2.4	6.3	1.7
(Burgess & Shallice, 1997)						
Memory						
AMIPB story recall (raw score)	22	14.2	29.1	9.9	42.47	6.4
AMIPB figure recall (% recalled)	62.2	30.0	60.9	16.5	86.5	12.1
(Coughlan & Hollows, 1985)						
RMBT prospective Memory (raw score) (Wilson et al., 1989)	3	2.4	5.6	.5	4.9	1.6
Attention						
TEA telephone(scale)	5.5	2.1	4.8	2.2	9.5	1.5
TEA combined(scale)	7.6	3.5	10.8	3.9	12.8	2.7
(Robertson et al., 1994)						
Digit forward	5.1	1.5	6	1.2	7	1.3
Digit backwards	3.3	1.4	4.3	2.1	5.3	1.2
(longest correct; Wechsler, D., 1981)						
Cognitive speed						
AMIPB speed info. proc. (adjusted)	38.2	25.5	60.0	8.8	89.1	21.9
Mood						
Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983)						
HADS anxiety	5.6	4.9	9.6	3.5	6.2	4.7
HADS depression	3.8	2.7	6.1	2.9	1.9	1.4

Table 1: Summary statistics for characteristics of the three participant groups

The data were analysed first according to the number of errors made, and then by looking at the percentage of errors of which participants demonstrated some awareness.

Total number of errors

The greatest number of errors was made by the frontal group, and the least number by the control group. The means for this are displayed in table 2. The pattern for error types indicated that the most common form of errors were omissions (662), followed by executive errors (291) and quality errors (155). Commission errors (88) and semantic errors (22) were less common. Perseverative errors (6), were the least common, and were only observed in the frontal group.

Group	total number of errors		
	Mean	S.D.	range
Frontal (n=14)	49.4	27.5	7 - 104
Non-frontal (n=8)	34.5	22.2	11 - 78
Control	17.2	14.9	3 - 50

Table 2: Mean number of total errors made by each participant group

A 3 x 6 mixed design ANOVA was conducted, using participant group as a between-participants variable, and error type as a repeated-measures variable[1]. There was a significant main effect of participant group [$F(2, 31) = 10.31, p < .01$]. Post hoc analysis

[1] Strictly speaking, it could be argued that this analysis violates a strict interpretation of between factors, as each incorrect response could theoretically fall into more than one category, e.g. it may be possible to perseverate whilst spreading jam with a spoon. However, it has been included because the likelihood of such an occurrence seems remote. A similar analysis was also reported by Schwartz et al. (1998).

used a Tukey HSD ($p < .05$) revealed a significant difference between frontal patients and controls; non-frontal patients did not differ significantly from either. The main effect of error type was also significant [$F(5, 31) = 30.38, p < .01$]. Post hoc analysis using Tukey HSD revealed there were significantly more omissions than any other error type. There were also more executive errors than perseverations, commissions and semantic errors. The interaction between participant group and error type was significant [$F(10, 31) = 3.5$, $p < .05$]. Analysis of simple main effects indicated that the difference in the number of errors made between the groups was significant for omission errors [$F(2, 31) = 22.9, p < .01$], and executive errors [$F(2, 31) = 5.6, p < .01$], but not for perseverations [$F(2, 31) = .99$], commissions [$F(2, 31) = .62$], semantic errors [$F(2, 31) = .21$], or quality errors [$F(2, 31) = .51$]. The means for this interaction are displayed in figure 1. In order to see if the differences between error types was consistent in the different groups, a series of separate pair-wise comparisons were carried out. The results of these can be seen in table 3.

It can be seen that the greatest amount of variation was seen in the frontal patients. They made significantly more omission errors than perseveration, commission, semantic or quality errors, and significantly more executive errors than perseveration, commission, semantic or quality errors. The third most popular error type was quality, of which there were significantly higher levels than semantic errors. The number of perseveration, semantic and commission errors did not differ significantly from each other. For non-frontal patients, the only significant differences were between executive and perseverative errors, and executive errors and semantic errors. For controls, executive errors differed from perseverative and semantic errors. There was also a difference between semantic and quality errors.

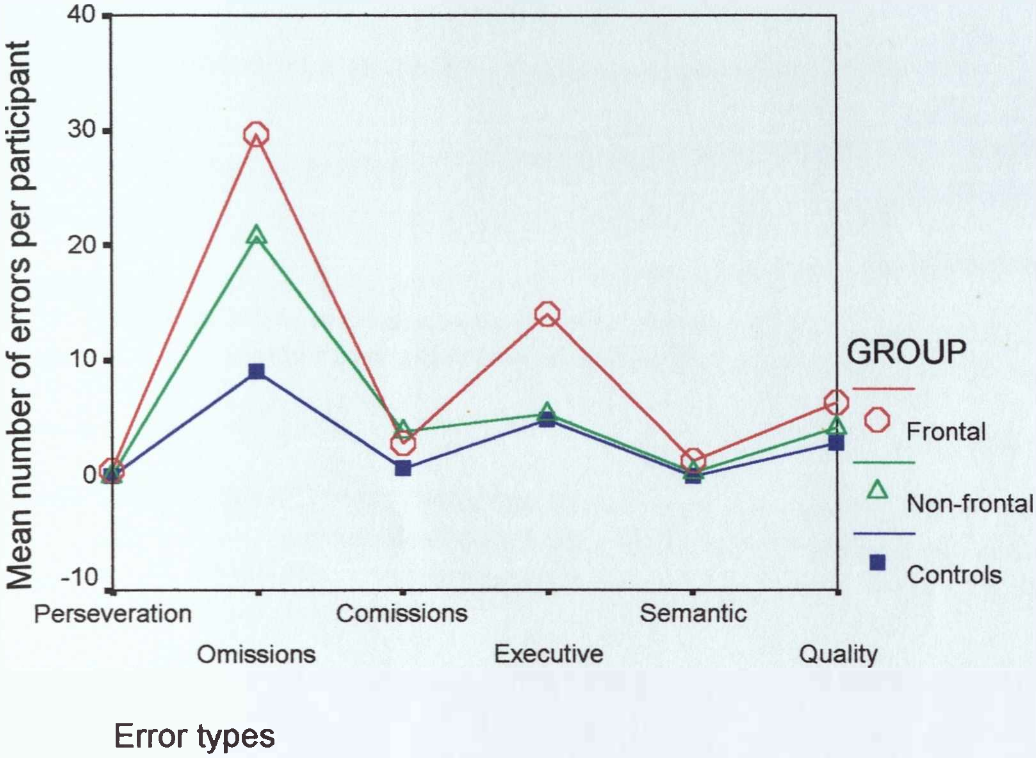

Figure 1: Mean number of different error types made by participants in each group

Frontal group

Error type	omis	comm	exec	sem	quality
Perseveration	**	-	**	-	**
Omission		**	-	**	*
Commission			**	-	-
Executive				**	**
Semantic					*

Non-frontal group

Error type	omis	comm	exec	sem	quality
Perseveration	-	-	*	-	-
Omission		-	-	-	-
Commission			-	-	-
Executive				*	-
Semantic					-

Controls

Error type	omis	comm	exec	sem	quality
Perseveration	-	-	*	-	-
Omission		-	-	-	-
Commission			-	-	*
Executive				*	-
Semantic					**

Table 3: Pair-wise comparisons (Bonferonni) on differences between error types for the different groups. ** $p < .01$, * $p < .05$.

Consideration of covariates

A series of ANCOVA's follow, which attempt to evaluate the differences between the groups when the means are adjusted to take into account differences between the neuropsychological profiles of the groups. The criterion for choice of covariate was that it must address a theoretical issue, e.g. "do the groups still differ in the total number of errors made, once differences in executive ability are controlled for?". The manner in which the groups differed on the covariates chosen is displayed in table 4. The Action Plan was not included as a covariate of executive function, as none of the groups differed significantly on it.

Variables on which both patient groups differed from controls

AMIPB speed of information processing

Variables on which frontal patients differed from controls

Executive	*Attention*
Modified 6 Elements (profile)	Telephone search
Zoo map (profile)	Telephone search whilst counting
Hayling (profile)	*Memory*
Brixton (scaled score)	AMIPB story recall
AMIPB story recall	AMIPB figure recall
AMIPB figure recall	

Variables on which frontal patients differed from both non-frontal patients and controls
RMBT prospective memory

Table 4. List of variables that were entered as covariates, listed according to how the groups systematically varied on them

Contribution of other variables

In order to assess the contribution of executive function to the total number of errors made, an ANCOVA was performed, using the participants scores on the four significant executive tests as covariates. The effect of participant group was no longer significant [$F(2, 26) = 1.17, p = .33$]. However, when the analysis was repeated entering these covariates individually, the effect of participant group failed to reach significance only with the raw score of the Modified 6 Elements entered as covariate [$F(2, 30) = 1.32, p = .28$]. When the analysis was repeated, cognitive speed, figure recall, story recall and telephone search whilst counting (raw score) as covariates, the main effect of participant group was marginally significant [$F(2, 19) = 3.51, p = .05$][2]. However, when this was repeated using the prospective memory score from the RMBT instead of figure and story recall, the effect of participant group just failed to reach significance [$F(2, 19) = 3.01, p = .08$].

Differences between the number of participants making each error type

For those error categories where the overall number of errors made by each participant was low, a further analysis was conducted, looking at how many participants in each group made each type of error. As frontal patients differed from healthy controls, but not from non-frontal patients, this analysis combined non-frontals and controls into one group. 4/14 (29%) frontal patients made perseverative errors, which were not seen in the

[2] When NART error score was also entered as a covariate, the effect of group just failed to reach significance [$F(1, 18) = 3.3, p = .06$]. However, as some of the frontal group had expressive language difficulties, the validity of the NART as an estimate of premorbid ability could have been compromised.

other two groups. This difference was significant (Fishers exact = 6.5, $p < .05$). Commission errors were made by 12/14 (86%) frontal patients, 7/20 (35%) of the other groups. This difference was significant (Fishers exact = 8.5, $p < .01$). Semantic errors were made by 8/14 (57%) frontal patients, and 2/20 (10%) of the other participants. This difference was significant (Fishers exact = 8.53, $p < .01$). Quality errors were made by 14/14 frontal patients, 18/20 (90%) of the other participants. This difference was not significant.

Prediction of errors

A regression analysis was performed to determine which, if any, of the neuropsychological test data predicted the number of errors made by *patients only*. Neuropsychological data were selected, if they correlated significantly with total errors. A stepwise multiple regression was performed using the total number of errors made as the dependent variable, and action plan raw score ($r = -.47, p < .05$), figure recall ($r = -.56$, $p < .01$), and prospective memory (rmbt) ($r = -.51, p < .05$), as the independent variables. The model for total errors accounted for 33% of the variance [$F(1,18) = 10.5, p = .005$] and had prospective memory as the only significant predictor ($\beta = -.61, p = .005$).

Awareness of errors

In line with the scoring procedure adopted by Hart et al. (1998), and Giovannetti, et al. (2002), an awareness index was calculated by dividing the number of errors coded as "aware"(corrected and uncorrected) by the total number of errors made, and multiplying this figure by 100. Overall, the frontal group demonstrated the lowest level of awareness, followed by the non-frontal group; controls demonstrated the highest level. The mean percentages are displayed in table 5.

Participant group	M	SD
Frontals (n = 14)	32.5%	16.0
Non-frontals (n = 8)	44.6%	16.9
Controls (n = 12)	78.9%	19.1

Table 5: Group means and standard deviations for awareness index for total number of errors scores

A oneway ANOVA was conducted on the awareness index scores for the total number of errors per group. This difference was significant [$F(2, 31) = 23.9, p < .01$]. Post hoc analysis using Tukey HSD indicated that both frontal and non-frontal patients differed significantly from controls, but not from each other. Although the awareness index scores correlated significantly with total number of errors made ($r = -.64, p < .01$), the effect of participant group remained significant when total errors was entered as a covariate [$F(2, 30) = 12.4, p < .01$]. This effect was robust, even when Hayling, Brixton, action plan, zoo map and modified 6 elements were entered as additional covariates [$F(2, 22) = 4.5, p < .05$].

Contribution of other variables

In order to assess the contribution of general cognitive resources, total number of errors was entered as a covariate, and cognitive speed. The difference between groups still remained significant [$F(2, 28) = 4.96, p < .05$]. Pairwise comparisons on the adjusted means indicated that patient groups still differed from controls, but not from each other.

Awareness for different error types

In order to see whether there was a difference in the type of errors most recognised across the groups, and 3 x 3 mixed ANOVA was carried out, looking at the three most common error types: omission, executive and quality. Across the groups, the average awareness index was 45% for omissions, 48% for executive errors, and 67% for quality errors. This difference was significant [$F(2, 56) = 4.4, p<05$], as was the effect of participant group [$F(2, 28) = 17.5, p < .01$]. The interaction between group and error type was not significant [$F(4, 56) = 1.7, p = .15$]. Pairwise comparisons indicated that the proportion of errors which people were aware of was significantly less for omission errors than for quality errors. Awareness of executive errors did not differ significantly from omissions, and differed only marginally from awareness of quality errors ($p = .054$).

Prediction of awareness scores

A regression analysis was performed to determine which, if any, of the other factors predicted the awareness index score of patients only. Items were selected which correlated significantly with the awareness score. In addition, prospective memory was included as its correlation only just missed significance ($r = .43, p = .055$). A stepwise multiple regression was performed entering the total number of errors made ($r = .58, p < .01$), action plan profile score ($r = .43, p < .05$), modified 6 elements profile score ($r = .44, p < .05$), and prospective memory (rmbt) as the independent variables ($r = .43, p =$

.06). The model for the awareness index accounted for 34% of the variance [$F(1,19) = 9.9, p = .005$] and had total errors as the only significant predictor ($\beta = -.59, p = .005$). [3]

Number of errors corrected

A further index score was calculated for the percentage of errors that participants were aware of that were corrected. A oneway ANOVA indicated that there was no significant difference across the groups [$F(2, 33) = .67, p = .52$]. The percentage of errors corrected did not correlate significantly with the total number of errors made ($r = -.30, p = .09$).

DISCUSSION OF EXPERIMENT 1

In summary, the results indicated that frontal patients differed from controls in terms of the number of errors made. Non-frontals performed at a level between these two groups. The fact that this effect remained robust when cognitive speed was covaried, but not when the Modified 6 Elements was covaried, suggests this difference between frontal patients and controls is more closely related to a difference in executive ability, than a general level of cognitive resource. However, the results of the stepwise regression indicated that the biggest predictor among patients was actually prospective memory.

When awareness of errors was considered, the two patient groups differed from controls, but not from each other. The levels of awareness demonstrated by our control group and non-frontal group indicated they were aware of a similar proportion of errors to that reported by Hart et al.'s (1998) patients (79% verses 74%, and 45% verses 48%). In contrast, our frontal group were aware of a considerably smaller proportion (33%),

[3] A stepwise regression performed on both patients and controls yielded a quite different set of results, with group being the only significant predictor of awareness.

although the difference between frontals and non-frontals was not significant. Even though there was a relationship between the total number of errors made, and the percentage of which participants were aware, this difference in awareness was still apparent when total number of errors was entered as a covariate. It therefore seems unlikely that the lower levels of awareness demonstrated by the two patient groups could be simply due to the greater number of errors affording more opportunity to miss instances. However, the fact that the frontal group did not differ from the non-frontal group is not a result that would be predicted on the basis of a model which places an error detection system within the frontal lobes. If the difference in error detection were due to a difference in general cognitive resources, entering cognitive speed as a covariate might also be expected to remove the difference in awareness: this prediction was also not supported by the data.

The stepwise regression performed on patients did indicate that, for patients, the strongest predictor of awareness was actually the number of errors that patients made. The lower levels of awareness would appear to be related to the higher error rate affording more opportunities to miss instances, even if this cannot explain the differences in awareness seen between the groups.

EXPERIMENT 2

The aim of this experiment was to determine whether patients differ from controls in their ability to detect errors they made when watching the video of themselves taking part in experiment 1.

METHOD

Participants

Experiment 2 used exactly the same participants (patients and controls) that took part in Experiment 1.

Procedure

The video of each participant was transferred onto VHS format. Participants were shown the video on either a portable television, or their own television at home. They were reminded of the task instructions, and the three rules that they had to remember. Their instruction this time was to watch the video carefully, and identify anything that they considered might be an error. They were told that this was to include doing something that they were not intended to do, not doing something they were intended to do, not doing a task particularly well (this was illustrated with the example of spilling something), or breaking one of the rules of the task. Participants were asked to describe what they considered the error to be, and patients with expressive dysphasia were asked to point at the screen whenever they identified an error, and use gestures to indicate what the error might be. If participants appeared not to be attending to the video, they were prompted with the question "do you think there have been any errors yet?", or "have you seen any more errors?".

Scoring

Participants responses were noted down verbatim, and then compared to the completed scoring sheets for Experiment 1. Errors identified by participants were then checked off against the errors identified by the scorers, and a percentage figure worked out for each participant.

RESULTS

Explicit awareness of errors

Comparison to experiment 1

Patients with frontal lobe lesions identified the least number of errors, and controls identified the most. The means for the different groups are shown in table 6. None of the participants who made perseveration or semantic errors identified them from watching the video.

Participant group	M	SD
Frontals (n = 14)	11.6%	9.4
Non-frontals (n = 8)	36.6%	28.9
Controls (n = 12)	49.9%	27.5

Table 6: Group means and standard deviations for percentage of errors participants identified whilst watching videos of themselves performing Experiment 1.

When these scores were compared to the awareness scores from Experiment 1, participants were aware of a smaller proportion of their errors. This difference was significant [$F(1, 31) = 13.9, p < .01$]. There was also a significant effect of participant group [$F(2, 31) = 26, p < .01$]. Post hoc analysis using Tukey HSD indicated that all three groups differed significantly from each other. The interaction between task and group was not significant [$F(2, 31) = 1.2, p = .32$].

Awareness of errors on video

Although an ANOVA was initially carried out on just the scores for Experiment 2, the data yielded a significant result on Levene's Test of Equality of Error Variances [$F(2,31) = 7.4, p < .01$], which indicated that the data violated the assumptions for ANOVA. Therefore the analysis was conducted on a $\log_{10}(1+x)$ transformation of the data, which did not give a significant result on Levene's test [$F(2, 31) = .3, p = .72$]. There was a significant difference between the groups [$F(2, 33) = 14.2, p < .01$]. Post hoc analysis with Tukey HSD indicated that the frontal group differed significantly from both non-frontals and controls. The difference between non-frontals and controls was not significant. The effect remained significant when total errors was entered as a covariate [$F(2, 33) = 6.4, p < .01$]. However, when cognitive speed was added as an additional covariates, the effect was only marginal [$F(2, 32) = 2.73, p = .08$], and the adjusted marginal means now placed the non-frontal groups awareness levels above that of the control group. Pair-wise comparison using the Least Significant Difference method indicated that the frontal group now differed significantly from non-frontals, but not from controls.

Prediction of awareness scores

When the control group was excluded, the only variables which correlated significantly with percentage errors recognised were total errors made ($r = -.56, p < .01$), participant group ($r = .56, p < .01$), and prospective memory ($r = .51, p < .05$). A stepwise multiple regression was performed using total errors and prospective memory as independent variables, which indicated that the best model accounted for 29% of the variance [$F(1, 20) = 7.7, p = .01$], and had only prospective memory ($\beta = 5.38, p = .01$) as a significant predictor.

Awareness for different error types

A further analysis was conducted, separating out the different error types. As none of the participants who made perseverative or semantic errors picked these out whilst watching the tapes, these error types were not included in the analysis. A 3 x 4 mixed design ANOVA was conducted, looking at omissions, commissions, executive and quality errors. Participants recognised fewest commission errors (15.7%), closely followed by omissions (19.0%). The highest recognition rate was for executive errors (47.7%), then quality errors (35.6%). This difference was significant [$F(2, 31) = 8.4, p <.01$]. Planned comparisons indicated that recognition of executive errors was significantly better than recognition of omissions. The effect of group was also significant [$F(2, 31) = 10.26, p<.01$]. Post hoc testing with Tukey indicated frontals showed significantly lower levels of recognition than non-frontals or controls. There was also a significant interaction seen between group and error type [$F(6, 31) = 3.39, p<.01$. Analysis with simple main effects indicated that there was a significant effect of group for executive errors [$F(2, 31) = 15.75, p < .01$], and for commission errors [$F(2, 31) = 3.46, p < .05$]. The effect of group was not significant for omission errors [$F(2, 31) = 2.1, p = .13$], or for quality errors [$F(2, 31) = 1.7, p = .19$].

If the interaction is considered in terms of the effect of error type, this was significant for control patients [$F(3, 31) = 11.6, p < .01$], who recognised a higher percentage of executive errors, and the least number of commissions. The effect was also significant for non-frontals [$F(3, 31) = 2.9, p < .05$], for whom executive errors were the most recognised, followed by quality, commission and omission errors. There was no significant effect of error type for frontal patients [$F(3, 31) = 1.0, p = .41$]. The means for this interaction are displayed in figure 2.

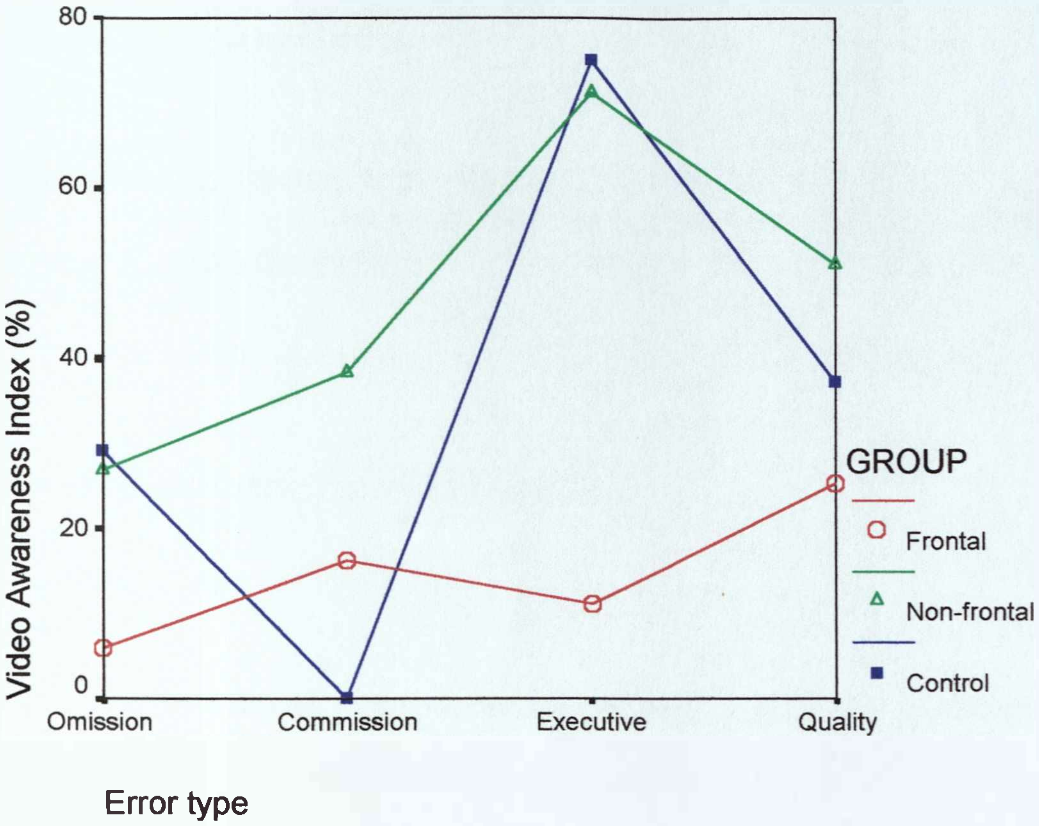

Figure 2: Mean video awareness values for the interaction between participant group and error type.

Sex differences

Although the different sex distributions across the groups made a direct statistical comparison difficult, scores were further broken down according to the sex of each participant. The mean scores can be seen in table 7. Overall, it can be seen that there was a trend towards females making fewer total errors.

Group	**Frontal** (13 male, 1 female)	**Non-frontal** (4 male, 4 female)	**Controls** (4 male, 8 female)
Experiment 1:Total number of errors			
Male	50.54	44.25	21.25
Female	35.00	24.75	15.13
Experiment 1: Awareness of errors			
Male	32.28	44.75	72.50
Female	34.00	44.50	82.13
Experiment 2: Awareness of errors whilst watching video			
Male	9.31	25.25	58.00
Female	36.00	49.50	49.63

Table 7: Mean total number of errors, %awareness scores and %awareness of errors whilst watching video, for male and female participants.

Due to the uneven sex distribution across groups, Oneway ANOVA's were performed simply comparing male to female participants, which indicated significant differences on total number of errors [$F(1, 32) = 8.40, p < .01$], awareness of errors[$F(1, 32) = 8.09, p < .01$], and awareness of errors whilst watching the video [$F(1, 32) = 8.10, p < .01$].

DISCUSSION OF EXPERIMENT 2

In summary, when watching videos of themselves performing Experiment 1, frontal patients identified significantly fewer of their errors than either non-frontals or controls. This result is perhaps surprising given the results of Experiment 1, where both patient groups differed from controls. However this may be a function of task difficulty, as all groups identified a significantly smaller proportion of errors in this task. This is perhaps unsurprising, as a considerable amount of practice was required for the coders scoring the videos to reach an acceptable level of inter-rater reliability. Patients did not have the benefit of such practice. As the effect remained when total number of errors was entered as a covariate, the difference, like that seen in Experiment 1, cannot be explained simply by a greater number of errors affording more opportunities to miss instances.

One other factor to be considered might be a difference between explicit and implicit error detection. Experiment 1 relied heavily on nonverbal reactions to signal detection of an error, some of which may well have represented implicit processing. By contrast, experiment 2 clearly required an explicit judgement to be made. As frontal damage is most closely associated with conscious, reflective judgements, patients with frontal lesions may have been particularly disadvantaged under this constraint.

When the different error types were considered, it was apparent that frontal patients were poor at identifying all error types. A difference between error types did appear to be important for non-frontals and controls, with executive errors being recognised more consistently than other error types. This is perhaps surprising as executive errors were the second most common error type, and provides firm evidence against the argument that the most common errors are detected less due to the greater opportunity to miss them.

The other surprising aspect of these data is that controls were worse than the other groups at identifying errors of commission. This was perhaps related to the low frequency of these types of errors, but most probably also reflects that on the occasions these types of responses were observed, they may well have been intentional. A closed-loop theory of error detection (Adams, 1971) would predict a lesser salience of such responses, or put simply, if the participant intended to do something, they would be less likely to classify it as an error.

GENERAL DISCUSSION

Number of errors and awareness

As the current study is under powered, the results should be treated with caution. The frontal group made more errors than either the non-frontal group or the controls. As the difference between groups remained when age and cognitive speed were covaried, but was removed by covarying the Modified 6 Element scores, it appears these errors are more closely related to executive ability than to a general limitation in cognitive resources. However the different pattern seen for awareness, of both patient groups differing from controls, suggests a difference in the mechanism underlying the two functions. The number of errors made appeared to be strongly related to executive ability, and also prospective memory, neither of which influenced implicit awareness.

Our data did show a relationship between the number of errors made, and the awareness score, which had not been reported previously. Hart et al. (1998) compared a patient and control group that were matched for the number of errors made, and Giovannetti et al. (2002) found no relationship between the two in dementia patients. However, the difference in awareness between patients and controls was a robust effect over and above the relative number of errors made. The picture was less clear when both patient groups were considered separately from the controls in a stepwise regression. Here, the total number of errors did indeed appear to be the only significant predictor of awareness. But this would seem to suggest something quantitatively different between patients and controls, whereas one might logically expect them to lie on a continuum. As always with correlational data, it is not possible to deduce causality of the basis of a relationship. Whilst it is plausible that a greater number of errors means more opportunity to miss examples, the relationship may work the other way around, with a greater number of errors made as a result of a reduction in the capacity to monitor them. Another slightly surprising finding was that none of the groups differed in their level of error correction. The key factor would therefore appear to be that groups differed on their ability to detect their errors, rather than their ability to self-correct the ones they do detect.

Anatomical considerations

The data do not support the existence of a generic, anatomically-based error detection system. Although patients differed from controls in terms of the percentage of errors detected, the predicted difference between frontals and non-frontals was found only in Experiment 2. There may be a number of factors at play here. For instance, the type of task typically used when "frontal" effects have been isolated are ERP studies (Falkenstein et al., 1990; Gehring et al., 1990) and this has often been necessarily less complex than the paradigm used here. If the system that generates the ERN is primarily based around response competition (Carter et al, 1998), this raises the question of the extent that response competition might play in the types of errors seen here. Dehaene et el. (1994) suggested that the ERN would be most likely to be seen with errors based around response performance rather than response selection. If this is the case, we might expect that omission errors, where the participant does not intend to perform a particular step, would not register on this system.

The question must also be raised of the difference between errors that are detected by an internal monitoring system, and those that are signalled by environmental cues. For example, one patient omitted the step of removing the lid from the milk container when making a cup of tea. The point at which he registered, and corrected this, was when he attempted to pour some out. Would such a realisation result in the generation of an ERN? The relative importance of error detection via internal monitoring verses external cues is a question that has yet to be addressed, and one that may have important implications for rehabilitation. However, it remains to be seen whether it is possible in practice to reliably distinguish these two sources of awareness.

Another consideration is that we have treated all patients with frontal lesions as a homogenous group, whereas evidence suggests that there is a marked functional dissociation between different regions within the prefrontal cortex (Roberts, 1998). Ullsperger et al. (2002) reported that a reduced ERN for patients with lateral frontal damage which was not seen in patients with damage to frontopolar regions. It would be desirable (although perhaps difficult in practice) to compare patients with focal lesions to different prefrontal areas.

Awareness of different error types

A question that has been raised (Hart et al., 1998; Giovannetti et al., 2002) is whether differences in error detection were related to the type of error made. As the most frequent form of errors made by patients appears to be the omission error, is it simply the case that omission errors are more difficult to detect? Our findings were that omission errors were more common among both patients and controls, which differs to previous studies (Schwartz et al., 1998;1999). Part of this no doubt reflects differences in the coding system used, as their system only allowed for omission errors if the step was never performed: therefore corrected omission errors could not exist by definition. Accordingly, the lowest level of awareness was also seen for omission errors. However, it seems unlikely that the type of error made by the different groups can entirely explain the different awareness levels. In total, over twice as many omissions were made as executive errors, and yet the mean awareness scores for omission and executive errors were fairly similar (45% and 48%).

Omission errors were also least frequently detected by participants watching the videos of themselves performing Experiment 1. This is consistent with predictions derived from closed loop theories of error detection (e.g. Adams, 1971), and may also go part of the way to explaining why frontal patients performed so poorly, having made the largest number of these types of errors. However, one puzzle is why a difference should emerge between frontals and non-frontals on this task, when the data from Experiment 1 suggested they did not differ significantly in terms of their awareness whilst performing the tasks. Presumably, when watching a video, action schemas are less active than when actually performing the tasks, and there are less cues available to sustain that activation. Frontal patients may be particularly disadvantaged as a result. This may also relate to the distinction between implicit and explicit error detection highlighted earlier.

Reduced cognitive resources

Schwartz et al. (1998; 1999) proposed that poor performance of naturalistic action tasks is related to a general reduction in cognitive resources, rather than a specific cognitive ability. This was based upon their finding that clinical severity was the strongest predictor of performance. However, an overall reduction such as this should be detectable in a fairly non-specific task such as cognitive speed. Although this variable correlated significantly with both the awareness score when performing the task and when watching the video, and both patient groups differed from controls on this variable. Entering cognitive speed as a covariate did not remove the effect when performing the task, and still left a trend on participants awareness when watching their videos. This suggests that awareness of errors is not adequately explained by a general resource theory.

Although the relationship between semantic memory and naturalistic errors has been investigated (Buxbaum et al. 1997; Humphreys & Forde, 1998; Forde & Humphreys, 2000), the relationship between semantic memory and error detection has not. Giovannetti et al. (2002) found that individuals with dementia demonstrated impaired awareness of errors, but as this was not linked to dementia severity, their data did not support the reduced processing resources hypothesis. However, they, like the present study, did not look at the patients' semantic knowledge of performing these particular tasks. It has been suggested elsewhere, that a breakdown in naturalistic action task performance is caused by a semantic *and* executive deficit (Schwartz & Buxbaum, 1997), and that neither are sufficient on their own to bring about such a breakdown. Perhaps clinical severity also reflects the probability of having impairments in both of these areas of cognition. The inability to monitor one's own performance may result from an inability to keep action schemas and rules sufficiently active to allow a comparison to take place with intended and actual outcomes.

Our data also did not include anything equivalent to the simpler conditions of the MLAT. As the focus of the study was to compare error detection across the three groups, a task format was necessary that would not allow any of the groups to perform at ceiling. The importance of executive ability in this task doubtlessly reflected the fact that a format was chosen with a significant executive component. It was curious though, that although patient groups did not differ significantly in terms of the number of errors made, the factor which appeared to predict the number of errors made was in fact their prospective memory score: one of the few psychometric measures on the which the groups differed.

Discussion of sex differences

The apparent sex differences in all dependent variables must be interpreted with caution, particularly in the context of previous research not having shown any evidence for this (Schwartz et al., 1998; 1999). Although it appears to indicate that men showed higher error rates and lower levels of awareness, it should be noted that there were nearly twice as many men as women, and that the male participants were concentrated in the frontal group, whereas there was a higher proportion of women in the control group. Any apparent disadvantage shown by the male participants in this study may therefore reflect that fact that they were more likely to have a frontal lesion.

The possibility does however remain that there is a difference between the sexes, which may be attributable to practice effects on the particular tasks chosen. Is it the case that the frequency with which tasks such as making a cup of tea, making a sandwich and wrapping a gift are performed in everyday is greater for women than for men? The possibility that such a difference may exist, and represent a possible confound, would certainly make this a suitable topic for systematic investigation in future research.

Contribution of emotional responses

One slightly unusual aspect of Experiment 2 is that it required participants to evaluate themselves from a perspective that they would not normally consider. Few people watch themselves on video, and for most of the patients, this would certainly have been their first opportunity to do so since acquiring their injury. This raises the question of what their response to the experience was. First it should be kept in mind that the general demands of the experiment were made clear to all potential participants at the time of recruitment, which in most cases meant a period of not less than two weeks for them to consider whether they wished to proceed. Indeed, concerns over the potential impact of watching the video was given by one participant as a reason for withdrawing. Those participants who did watch themselves had therefore all made an informed decision about their participation.

Participants generally indicated that they found the experience interesting, and enlightening. Although three participants did indicate that they not previously been aware of the amount of time they took to perform the tasks, nobody reported finding the experience in any way distressing. It cannot be ruled out entirely that there may have been some under-reporting of errors, particularly from the frontal patients, if they were indeed distressed by their level of performance. Some mechanism such as "denial" could conceivably have contributed to those patients' awareness scores when watching the video being so much lower than their "implicit" awareness scores in Experiment 1. However, such concepts are notoriously difficult to evaluate with an experimental methodology, so this must remain for the present as speculation.

CONCLUSIONS

The main finding of this study was that frontal patients differed from controls, but not from non-frontal patients, in terms of the total number of errors made. However, non-frontals performed closer to frontals in terms of the percentage of errors of which they were aware. This suggests that both differences are unlikely to simply be a result of a general reduction in processing resources. The data also did not support the prediction that frontal patients would be particularly poor at error detection, although this was the pattern seen when they watched their own videos.

A number of questions are raised which are currently left unanswered by these data. For instance, what is the key element that left frontal patients so disadvantaged when monitoring their performance on video? We know of no other study that has used this approach, so this remains a question for further research. Also, how would each patient fare watching the same video of someone else performing a set of similar tasks? Is there a quantitative difference between patients and controls, or do they represent different points on a continuum? In terms of rehabilitation, the implications appear to be that error detection rather than error correction is the key variable, and should be a focus for future research.

Clinical relevance

There is an increasing body of evidence that awareness is a major predictor of recovery from acquired brain injury. For instance, Sherer, Boake, Levin, Silver, Righolz, & High (1998) found that measurements of impaired awareness was a stronger predictor of employment outcome than a whole range of more traditionally recognised predictors. One of the main clinical implications of this study is that awareness of errors may be a crucial determinant of someone's ability to perform an everyday task. The difference appeared to be the level of error detection itself, rather than ability to act upon that information. A programme of rehabilitation that includes training on error detection and performance monitoring may therefore be capable of producing greater gains. A reduced ability to detect errors is also likely to be a fairly general problem, and so any intervention that successfully targets this could potentially produce gains that generalise, and are not task-specific. If patients with frontal lesions have an implicit level of error detection that exceeds their explicit ability, this may be the area that needs to be addressed.

Also the use of videos of patients performing tasks is an area that has not been extensively explored in a rehabilitation setting. Many of the patients in this study expressed that they found the experience enlightening, and that in itself had increased their general awareness of their ability levels. In particular, several patients commented on the time it took them to perform tasks: something of which they appeared to previously have little insight. This is perhaps an area which could be explored further.

Finally, this study has confirmed the relationship between awareness and error type. In particular, omission errors appear to be the most common error type seen in patients, and the error type for which the lowest levels of awareness are seen. An increased focus on error detection would therefore be expected to reduce the level of these types of errors, and improve performance as a whole. Thus, this information provides an indication for a potentially promising route for intervention.

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Appendix 1: Description of neuropsychological measures used.

• National Adult reading Test (Nelson , 1982)

This test is used as an estimate of premorbid I.Q. It consists of a list of 50 irregular words, which are read aloud, and the number of errors totalled.

• Modified 6 elements (BADS: Wilson et al., 1996)

This test consists of 3 tasks; dictations, picture naming and arithmetic. Each task has two subcomponents: part A and part B. The patient has 10 minutes to perform some of each of the subtasks, but they are instructed not to try to complete any one task, and not to attempt any two subcomponents of the same task consecutively. It therefore measures their ability to divide the 10 minutes optimally.

• Action plan (BADS: Wilson et al., 1996)

The patient must work out how to remove a cork from a tube using some water.

• Zoo map (BADS: Wilson et al., 1996)

A map of a zoo is presented, through which a route must be devised in order to visit certain attractions.

• Hayling test of sentence completion (Burgess & Shallice, 1997)

Participants are read a sentence with the last word missing. In the first condition, they must provide a word that fits the sentence. In a second condition, they are read a second list of sentences, again with the last word missing. However, this time, they are required to provide a word, which does not fit the sentence. The time taken to provide each response is measured. A profile score is derived on the basis of how long they take to respond in both conditions, and how many responses in the second condition are related to the sentence.

• Brixton test of spatial anticipation (Burgess & Shallice, 1997)

The participant is presented with a page featuring ten circles in two rows, one of which is coloured. Each time the page is turned, the coloured circle moves according to certain rules. The task is to work out the rules, in order to predict where the coloured circle will appear on the next page.

• AMIPB story recall (Coughlan & Hollows, 1985)

A short story is read aloud. The participant repeats the story in as much detail as possible.

• AMIPB figure recall (Coughlan & Hollows, 1985)

The participant copies a complex figure. They then attempt to draw it from memory. Their score is worked out as a percentage of the score they achieved when copying.

• RMBT prospective memory (Wilson et al, 1989)

The experimenter asks the participant if they can borrow one of their possessions, which they place somewhere. The participant is told to ask for it back at the end of the test session. A timer is also set, and when it goes off, the participant must ask when their next appointment will be.

• TEA telephone search (Robertson et al, 1994)
Participants scan a mock page from a telephone directory, and identify entries with 2 matching symbols.

• TEA combined telephone search while counting (Robertson et al., 1994)
Participants scan a telephone directory, whist simultaneously counting auditory tones played on a tape.

• Digits forward (Wechsler, D. 1981)
Strings of digits are read aloud, which participants repeat.

• Digits backwards (Wechsler, D. 1981)
Strings of digits are read aloud, which participants repeat in reverse order.

• Cognitive speed (Coughlan & Hollows, 1985)
Rows of 5 x 2-digit numbers are presented. The participant scans the rows, and crosses out the second highest number in each row: as many as possible in four minutes. They then cross out rows of number 11's in 20 seconds. A figure is then calculated that adjusts the number crossed out in the first condition according to how many were crossed out in the second condition.

• Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983)
This is a self-completed questionnaire containing 6 items relating to anxiety, and 6 items relating to depression.

Appendix 2: Public Domain Paper

Thesis title

ERROR DETECTION IN THE PERFORMANCE OF EVERYDAY TASKS BY PATIENTS WITH FRONTAL LOBE LESIONS

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June, 2003

Summary

The aim of this thesis was to look at the importance of error detection and the clinical implications when this ability is impaired. The literature review looked at models of error detection derived from non-clinical populations, and consideration of the implications of these for clinical populations. Emphasis was given to how research on non-clinical populations informs the study of clinical populations, and vice versa. Data from forced choice reaction time tasks initially uncovered a phenomena known as post-error slowing, or the "Rabbitt" effect (Rabbitt, 1966), where reaction times on trials immediately following an incorrect response are slowed down. With the development of increasingly sophisticated techniques for measuring neural activity, a characteristic pattern known as the error-related negativity (ERN) was discovered (Gehring, Coles, Meyer & Dochin, 1990), which appears to occur when incorrect response are made. It appears to originate in a part of the frontal lobes of the brain, known as the anterior cingulate cortex (Dehaene, Posner & Tucker, 1994). A reduction in the level of this ability has been reported in a number of clinical populations (e.g. schizophrenia, obsessive-compulsive disorder, head injury), which may indicate that a general reduction in the ability to monitor errors is implicated in a range of disorders. This is an area where clinical research has drawn on data and theories from non-clinical populations, and vice versa.

The research paper focussed on the performance of everyday tasks, such as making a cup of tea, or wrapping a Christmas present, by individuals with acquired brain injury. The particular emphasis was on their awareness of any errors that were made during the performance of these tasks. This was assessed by videoing their performance on these tasks, and coding the videos for behavioural evidence of awareness (e.g. self-corrections, hesitations, verbal exclamations). A second experiment involved people watching their own videos to try and identify errors.

As a lack of awareness is something that is frequently associated with damage to the frontal lobes of the brain (Prigatano, 1991), a group of patients with damage to these regions were compared to a group of patients with acquired brain injury that did not

encroach on these areas, as well as a group of healthy controls. When awareness of errors was considered on the basis of cues given when performing the tasks, frontal patients did not differ from non-frontal patients. However, both of these groups differed from healthy controls. When attempting to identify their errors from watching their own videos, frontal patients performed worse than either non-frontal patients or controls. These results may indicate a difference between implicit and explicit awareness, with frontal patients being particularly disadvantaged at the latter.

Background

One problem often encountered after acquired brain injury involving the frontal lobes is a difficulty in the performance of routine, everyday tasks (Schwartz, Reed, Montgomery, Palmer & Mayer, 1991), which Luria (1966) originally described as "frontal apraxia". He considered that verification of activity, and the ability to identify when an error is made are crucial to performing such tasks: hence any form of brain damage that reduces awareness would also impair the ability to perform everyday tasks. A relationship between frontal lobe damage and a diminished sense of awareness has been reported frequently (Prigitano, 1991). Subtle forms of unawareness have been reported over the years (for review see McGlynn & Schacter, 1989), and have been cited as one of the major factors which impede rehabilitation. Most models of frontal lobe function specify that they play some kind of role in monitoring and regulating performance, however the precise way in which this is achieved is often not specified. Also, there have been few studies which set out to directly test whether an inability to monitor one's own performance is something which is particularly impaired by damage to the frontal lobes.

As performance of everyday tasks can fail in a number of ways, a coding system was developed by Schwartz et al. (1991), which breaks down complex actions into smaller units. When Schwartz, et al. (1995) compared 15 patients and 14 controls on the performance of six everyday tasks, they found that patients' errors consisted mainly of leaving steps out, or performing steps in the wrong order (sequence errors). Controls made mainly sequence errors. There was also a different distribution of errors across tasks, even when overall error rate was roughly equivalent. Hart et al. (1998) went on to develop a second form of coding system to identify whether participants were aware of the errors they made. They compared awareness in a group of patients and controls whose overall error rates were similar, and found that controls detected an average of 74 % of their errors, whereas patients with closed head injury detected only 47.7%. However, only errors of commission were considered, whereas previous studies have shown that patient errors are primarily omissions (Forde & Humphreys, 2000; Schwartz et al., 1998; 1999). Also, the closed head injury group were an unselected sample, so this study does not specifically address the role of the frontal lobes in error monitoring. Finally, there was no indication of whether certain errors types are more difficult to detect than others. Forde & Humphreys (2000) found some indication that their ADS patient, HG, had insight into some of his errors, but not others, and in particular was not aware of occasions where he used an incorrect items to perform a task (semantic errors).

A further question relates to the mechanism may underlie differences in awareness. Schwartz et al (1998; 1999) proposed that a general reduction in cognitive resources, rather than a specific cognitive deficit, is responsible for poor performance on everyday tasks. Hart et al. (1998) speculated that this might also underlie the differences in awareness. However, study by Giovanetti et al. (2000) looking at dementia patients failed to find a relationship between dementia severity and awareness. The current study also attempted to look at this, by including a measure of speed of processing as an index of general cognitive resources.

Details of the study

Participants

The participants were 14 patients with lesions involving the frontal lobes, 8 patients with non-frontal lesions, and 12 healthy controls. Patients were recruited from a number of neurosciences outpatient clinics, rehabilitation services, and stroke services throughout the West Midlands. Participants were excluded if they had major visual impairments, visual agnosia, language comprehension problems or difficulty sustaining attention. The groups did not differ significantly in age.

Method

Data collected can be divided into three categories:

- *Neuropsychological tests*

Participants were given a broad neuropsychological assessment, which included an extensive range of executive tests.

- *Experiment 1*: 2 x 3

They were then videoed carrying out a range of everyday tasks. These were: making a cup of tea, preparing a bowl of cereal, writing a Christmas card, wrapping a Christmas present, making two piece of toast with bread and jam, and making a cheese sandwich. Each of these tasks had to be performed twice, whilst observing certain rules: each task must be completed before starting the next, two versions of the same task were not to be carried out consecutively, and items that were going to be used again should be left open ready to use. Videos were scored by two observers, and participants were periodically asked whether they had made any mistakes, and what those mistakes may have been.

- *Experiment 2*: watching the video

After a delay of at least one week, participants were shown the video of themselves performing experiment 1, and asked to identify any errors might have made.

Results

Patients with frontal lobe lesions made significantly more errors than controls. Patients with non-frontal lesions did not differ significantly from either frontal patients or healthy controls. . A series of analyses of covariance (ANCOVA's) were used to evaluate the contribution of other variables to these differences. The effects remained robust when these were added, with the exception of one executive test: the Modified 6 Elements.

However, the pattern was slightly different for awareness of errors, in that both groups of patients differed significantly from controls, but not from each other. The total awareness of errors correlated significantly with the total number of errors made. However, entering this as a covariate did not remove the difference between groups. The effect remained when speed of processing and various executive measures were also entered.

When watching the videos of experiment 1, frontal patients identified significantly less of their errors than either non-frontals or controls. However, when number of errors and cognitive speed were entered as covariates, the effect was removed.

Implications and future directions

This study suggests that patients with acquired brain injury are less aware of their errors than controls, when performing everyday tasks. There was a difference in the levels of awareness shown, rather than the ability to act on that awareness. Frontal patients appeared to be particularly disadvantaged, especially when watching their videos. Reasons for this could be related to the overall level of cognitive resources, or may be related to a distinction between implicit and explicit awareness. Experiment 1 used mainly behavioural indices of awareness, whereas asking people to identify their own errors on video requires an explicit awareness. This would be consistent with the notion that frontal lobe lesions particularly affect conscious, non-automatic processing.

A future direction for research would be to investigate what implications this might have for rehabilitation. Evidence seems to suggest that cognitive rehabilitation is effective for improving performance on specific tasks. However, the effects seldom generalise to other areas of function. A rehabilitation programme that focuses on improving general levels of error monitoring and detection may well produce improvements that generalise beyond the individual task.

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Appendix 3: Letter of ethical approval from West Midlands Multi-Centre Research Ethics Committee

NHS

West Midlands Multi-centre Research Ethics Committee

Our Ref: MT/AB/MREC/01/7/90/approval
(Please quote in all correspondence)

Directorate of Public Health and Policy Development
Birmingham Health Authority
St Chad's Court
213 Hagley Road
Birmingham
B16 9RG

Tel: [redacted]
Fax:
Email: [redacted]

Dr Simon Gerhand
Doctoral Training Programme in Clinical Psychology
School of Psychology
University of Birmingham
Edgbaston
B15 2TT

7 January 2002

Dear Dr Gerhand

<u>Research Protocol Title: Error monitoring in the performance of everyday tasks by patients with frontal lobe lesions</u>

The West Midlands MREC reviewed your application on 21st November 2001. The paperwork that has been approved is as follows:

Patient Information Sheet, version 2, dated 21st December 2001
Control Patient Information Sheet, version 1 dated 21st December 2001
Consent Form, version 2 dated 21st December 2001
Application Form, dated 29th October 2001
Protocol, undated
GP/Consultant Letter/Information Sheet
Questionnaire: Dex
Questionnaire: Hospital Anxiety and Depression Scale
C.V for Principal Researcher, undated

The members of the MREC present agreed that there is no objection on ethical grounds to the proposed study. I am, therefore, happy to give you our approval on the understanding that you will follow the conditions of approval set down below. A record of the review undertaken by the MREC is contained in the attached MREC Response Form. The project must be started within three years of the date on which MREC approval is given.

While undertaking the review of your application the MREC noted the research involves the establishment of a new disease or patient database for research purposes with no patient contact. **For this reason you are not required to notify any LRECs when undertaking this research.**

MREC Conditions of Approval

- The protocol approved by the MREC is followed and any changes to the protocol are undertaken only after MREC approval.
- If projects are approved before funding is received, the MREC must see, and approve, any major changes made by the funding body. The MREC would expect to see a copy of the final questionnaire before it is used.
- You must complete and return to the MREC the annual review form that will be sent to you once a year, and the final report form when your research is completed.

Legal and Regulatory Requirements

It remains your responsibility to ensure in the subsequent collection, storage or use of data or research sample you are not contravening the legal or regulatory requirements of any part of the UK in which the research material is collected, stored or used. If data is transferred outside the UK you should be aware of the requirements of the Data Protection Act 1998.

ICH GCP Compliance

The MRECs are fully compliant with the International Conference on Harmonisation/Good Clinical Practice (ICH GCP) Guidelines for the Conduct of Trials Involving the Participation of Human Subjects as they relate to the responsibilities, composition, function, operations and records of an Independent Ethics Committee/Independent Review Board. To this end it undertakes to adhere as far as is consistent with its Constitution, to the relevant clauses of the ICH Harmonised Tripartite Guideline for Good Clinical Practice, adopted by the Commission of the European Union on 17 January 1997. The Standing Orders and a Statement of Compliance were included on the computer disk containing the guidelines and application form and are available on request or on the Internet at http://www.corec.org.uk

Yours sincerely

[redacted]

Maureen Thrupp
Administrator, MREC West Midlands

Enclosures *MREC Response Form*

Appendix 4: Letter of Ethical Approval from Birmingham University School of Psychology Ethics Committee

THE UNIVERSITY
OF BIRMINGHAM

School of Psychology

Edgbaston
Birmingham B15 2TT
United Kingdom
Telephone 0121 414 4932
Fax 0121 414 4897

Head of School
Professor G. W. Humphreys
PhD FBPsS CPsychol
Email [redacted]

Direct Line [redacted]

JO/DT

16 January 2002

Simon Gerhand
Clinical Psychology Trainee
School of Psychology
University of Birmingham

Dear Simon,

Re: Error monitoring in the performance of everyday tasks by patients with frontal lobe lesions

Thank you for the further information which seems to answer all points raised in my letter of 20 December. I am therefore pleased to be able to give you our committee's approval.

Good luck with your research.

[redacted] Yours sincerely,

[redacted]

[redacted] Jim Orford
Chair: School Human Research Ethics Committee

copy to: Prof G W Humphreys

Appendix 5: Consent form

Consent Form: Version 2, 21.12.01

Awareness of errors in the performance of everyday tasks

Researcher: Simon Gerhand, University of Birmingham

Please initial boxes

I have read the information sheet concerning this study, dated December 2001, and have had the opportunity to ask questions.

I understand that by consenting to participate in this study, I will be asked to

a) carry out some tests that will examine memory, attention, planning and organising skills and language skills ☐

b) carry out some tasks that I may already do in my everyday life, such as make a snack. ☐

I agree to the testing sessions being videotaped and understand that the video will be deleted after the whole study is completed. I know that the tapes will not be viewed by anyone who is not working directly on the study. ☐

I am aware that I can withdraw from the study at any time before January 2003 without giving a reason. If I decide to do this, all information held about me will be destroyed and removed from the study. ☐

I understand that the results of neuropsychological tests which I have already carried out may be looked at by the researchers from the University of Birmingham and I give permission for these individuals to access those results. I understand that I will be asked before a consultant is approached for any results. ☐

I understand that sections of my medical notes may be looked at by the researchers where it is relevant to my taking part in the research. I give permission for these individuals to access my records. ☐

I give permission for .... (give name) to be approached to fill in the DEX questionnaire, giving their view of difficulties they think I may experience. I have seen a copy of the questionnaire and understand what it entails. ☐

I agree to take part in the study described on this consent form and the accompanying information sheet.

Name .... Date: ....

Signed (participant) ....

Name .... Date: ....

Signed (relative/ professional) ....

Name .... Date: ....

Signed (researcher) ....

Appendix 6: Patient information sheet

Patient Information Sheet.
Version..........................2
Date................................21-12-2001

Title: Awareness of errors in the performance of everyday tasks

Invitation
You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of the study?
People who have experienced a stroke or head injury often have difficulties performing everyday tasks, such as making a cup of tea, or writing a letter. One possible problem may be that individuals do not notice when they have made an error in the performance of such tasks. The aim of this study is to evaluate how aware people are of the errors that they make. It is hoped that our findings will lead to more effective and efficient means of helping patients recover.

Why have I been chosen?

You have been invited to take part in this study because you have experienced a stroke or head injury. This study aims to recruit 22 people in whom this has affected the frontal regions of the brain, and 22 people in whom this has affected areas other than this. 22 people who have not experienced a stroke or head injury will also be invited to take part. People will be recruited for this study over the course of a year.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent

form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of care you receive.

What will happen to me if I take part?
The research will require you to attend either two or three testing sessions. This will either involve you coming to Birmingham University, or a researcher coming to visit
you. If you decide to come to the University, travel expenses will be paid. In one session, you will be asked to perform several tasks, such as making a cup of tea, writing a letter, or making a sandwich. In the other session, you will be asked to watch a video of yourself performing these tasks, and identify any places where you may have gone wrong. Finally, you will be shown a video of someone else performing some tasks, and be asked to identify whenever they have made a mistake. Consideration will be given to fatigue, and there will be provision for frequent breaks.

What are the possible disadvantages and risks of taking part?
Taking part in the study does not involve any risks to yourself or others.

What are the possible benefits of taking part?
You may or may not benefit from participation. In the future, the information gathered here may be used to inform the development of further rehabilitation programmes.

Will my taking part in this study be kept confidential?
All information which is collected about you during the course of the research will be kept strictly confidential. Any information about you which leaves the hospital/surgery will have your name and address removed so that you cannot be recognised from it.

<u>Audio/video recording:</u> you will be asked to be video taped. You have the right to refuse. If you agree to be video taped, your name will not be used in reference to the recording to maintain confidentiality.

What will happen to the results of the research study?
The results of this study will be published in a peer-reviewed journal. This is likely to take place within two years of the completion of the study. You will not be identified in any report/publication. A copy of the results can be obtained from Professor Glyn Humphreys, School of Psychology, University of Birmingham, Edgbaston, Birmingham, B15 2TT.

Who is organising the research?
This research is being conducted as part of the requirements for the Doctoral Programme in Clinical Psychology at the University of Birmingham.

Who has reviewed the study?
This study has been reviewed by the Multi-Centre Research Ethics Committee (MREC).

Contact for Further Information
Further information regarding this study can be obtained from:

Dr. Simon Gerhand, Doctoral Training Programme in Clinical Psychology, School of Psychology, University of Birmingham, Edgbaston, B15 2TT.

Professor Glyn Humphreys, Head of Department, School of Psychology, University of Birmingham, Edgbaston, Birmingham, B15 2TT.

You will be given a copy of the information sheet and a signed consent form to keep.

Thank you for agreeing to participate in this research

Appendix 7: Control participant information sheet

Control Participant Information Sheet.
Version...........................1
Date..............................21-12-2001

Title: Awareness of errors in the performance of everyday tasks

Invitation
You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of the study?
People who have experienced a stroke or head injury often have difficulties performing everyday tasks, such as making a cup of tea, or writing a letter. One possible problem may be that individuals do not notice when they have made an error in the performance of such tasks. The aim of this study is to evaluate how aware people are of the errors that they make. It is hoped that our findings will lead to more effective and efficient means of helping patients recover.

Why have I been chosen?
This study aims to recruit 22 people in whom this has affected the frontal regions of the brain, and 22 people in whom this has affected areas other than this. 22 people who have not experienced a stroke or head injury will also be invited to take part. People will be recruited for this study over the course of a year. You have been invited to participate because you are of a similar age and background to one of the patients who has agreed to take part.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of care you receive.

What will happen to me if I take part?
The research will require you to attend either two or three testing sessions. This will either involve you coming to Birmingham University, or a researcher coming to visit you. If you decide to come to the University, travel expenses will be paid. In one session, you will be asked to perform several tasks, such as making a cup of tea, writing a letter, or making a sandwich. In the other session, you will be asked to watch a video of yourself performing these tasks, and identify any places where you may have gone wrong. Finally, you will be shown a video of someone else performing some tasks, and be asked to identify whenever they have made a mistake. Consideration will be given to fatigue, and there will be provision for frequent breaks.

What are the possible disadvantages and risks of taking part?
Taking part in the study does not involve any risks to yourself or others.

What are the possible benefits of taking part?
You may or may not benefit from participation. In the future, the information gathered here may be used to inform the development of further rehabilitation programmes.

Will my taking part in this study be kept confidential?
All information which is collected about you during the course of the research will be kept strictly confidential. Any information about you which leaves the hospital/surgery will have your name and address removed so that you cannot be recognised from it.

<u>Audio/video recording:</u> you will be asked to be video taped. You have the right to refuse. If you agree to be video taped, your name will not be used in reference to the recording to maintain confidentiality.

What will happen to the results of the research study?
The results of this study will be published in a peer-reviewed journal. This is likely to take place within two years of the completion of the study. You will not be identified in any report/publication. A copy of the results can be obtained from Professor Glyn Humphreys, School of Psychology, University of Birmingham, Edgbaston, Birmingham, B15 2TT.

Who is organising the research?
This research is being conducted as part of the requirements for the Doctoral Programme in Clinical Psychology at the University of Birmingham.

Who has reviewed the study?
This study has been reviewed by the Multi-Centre Research Ethics Committee (MREC).

Contact for Further Information
Further information regarding this study can be obtained from:

Dr. Simon Gerhand, Doctoral Training Programme in Clinical Psychology, School of Psychology, University of Birmingham, Edgbaston, B15 2TT.

Professor Glyn Humphreys, Head of Department, School of Psychology, University of Birmingham, Edgbaston, Birmingham, B15 2TT.

You will be given a copy of the information sheet and a signed consent form to keep.

Thank you for agreeing to participate in this research

Appendix 8: Instructions to authors for Cognitive Neuropsychology

Monday 22, September

Arenas Menu: Select an A

Journals Listings

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- Journals by Subject

Journal Resources

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AIMS AND SCOPES OF THE JOURNAL

The basic aim of this journal is to promote the study of cognitive processes from a neurop perspective. Cognition will be understood very broadly, as including perception, attention, planning, language, thinking, memory and action, for example. Any neuropsychological w understanding of normal cognitive processes would be directly appropriate for the journal. disorders of cognition arising at any stage of the life span-both developmental disorders a associated with ageing, as well as traumatic disorders, for example-will be of interest. Als studies of cognition in normal subjects which may shed some light upon the nature of disc well as studies of rehabilitation of such disorders in which a cognitive-neuropsychological adopted. Papers need not be reports of the author's experimental research: theoretical co reviews of the literature, and commentaries on papers published in previous issues of the appropriate.

The journal will also publish in-depth critical reviews of books dealing with any aspect of c neuropsychology. There is no requirement that reviewed books be contemporary. Any boc for cognitive neuropsychology is sufficiently clear may be reviewed in the journal, no matt book was published. Anyone interested in submitting a book review to the journal should c Reviews Editor, Professor Tim Shallice, Institute of Cognitive Neuroscience, University Cc Alexandra House, 17 Queen Square, London, WC1N 3AR, UK.

Finally, it is intended that the journal will occasionally reprint important papers that have a elsewhere, but which are likely to have escaped the notice of most cognitive neuropsychol the papers were published long ago, or in languages other than English. Suggestions as t deserve reprinting for these reasons may be sent to Professor A. W. Ellis (Department of of York, Heslington, York YO1 5DD, UK).

METHODOLOGICAL CONSIDERATIONS

Papers should in general satisfy methodological standards expected of publications on no processes in such journals as the ***Journal of Experimental Psychology*** or ***Cognitive Ps*** satisfying requirements appropriate for neuropsychological publications in journals such a studies of neuropsychological patients are reported, efforts should be made to provide a c description of the general neurological and neuropsychological status of the patient).

The importance of single case studies for the resolution of theoretical issues is acknowled methodologically adequate single case studies are welcomed. In reports of such studies, t patient's deficits should be documented in quantitative terms (a simple syndrome label is of detail required here depends upon the specific hypothesis being tested. Essentially wha documentation of the presence of specified deficits and preserved capacities as these are hypotheses.

In reports of group studies, criteria for selecting and for grouping patients must be detaile related to the particular hypotheses being tested. The designation of a group of patients si aphasics", for example, would not be sufficient. A set of patients classified as Broca's aph heterogeneous, and any conclusions reached in such a study may, in fact, be true for only in this group. One way around this problem is to treat each patient as an individual, i.e., c studies. Another is to provide explicit evidence of homogeneity of the group in a group stu

SUBMISSIONS

Please note that the publisher **would actively encourage** authors to submit papers electr the peer review process. Please email your paper saved in a standard document format ty PC format), Rich Text Format, or PDF to **reviews@psypress.co.uk**

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Sophie Forster, Journals Editorial Assistant, Psychology Press, 27 Church Road, Hove, E UK. Phone: + 44 (0) 1273 225007; Fax: + 44 (0) 1273 205612; Email: **reviews@psypres**

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FORMAT

Typescripts. The style and format of the typescripts should conform to the specifications *Publication Manual of the American Psychological Association* (5th ed.). Typescripts shoul on **one side** only of A4 paper, with adequate margins, and numbered throughout. The title should contain only:

(1) the title of the paper, the name(s) and address(es) of the author(s);
(2) a short title not exceeding 40 letters and spaces, which will be used for page headlines
(3) name and full contact address of the author to whom correspondence and proofs shou
(4) your telephone, fax and email details, as this helps speed of processing considerably.

Abstract. An abstract of 100-150 words should follow the title page on a separate sheet.

Headings. Indicate headings and subheadings for different sections of the paper clearly. D headings.

Acknowledgements. These should be as brief as possible and typed on a separate sheet the text.

Permission to quote. Any direct quotation, regardless of length, must be accompanied by that includes a page number. Any quote over six manuscript lines should have formal writ quote from the copyright owner. It is the author's responsibility to determine whether perm the copyright owner and, if so, to obtain it. (See the bottom of the page for a template of a copyright permission.)

Footnotes. These should be avoided unless absolutely necessary. Essential footnotes sho superscript figures in the text and collected on a separate sheet at the end of the manuscr

Reference citations within the text. Use authors' last names, with the year of publicatior the last author's name, e.g., "Jones and Smith (1987)"; alternatively, "(Brown, 1982; Jone: White, Johnson, & Thomas, 1990)". On first citation of references with three to six authors full, thereafter use first author "et al.". If more than one article by the same author(s) in the the letters a, b, c, etc., should follow the year.

Reference list. A full list of references quoted in the text should be given at the end of the order of authors' surnames (or chronologically for a group of references by the same auth a new sheet, typed double spaced. Titles of journals and books should be given in full, e.g

Books:

Baddeley, A. D. (1999). *Essentials of human memory.* Hove, UK: Psychology Pres

Chapter in edited book:

Plomin, R., & Dale, P. S. (2000). Genetics and early language development: A UK V. M. Bishop & L. B. Leonard (Eds.),*Speech and language impairments in children. characteristics, intervention and outcome* (pp. 35-51). Hove, UK: Psychology Pres:

Journal article:

Schwartz, M. F., & Hodgson, C. (2002). A new multiword naming deficit: Evidence *Cognitive Neuropsychology, 19,* 263-288.

Tables. These should be kept to the minimum. Each table should be typed double spaced giving the heading, e.g., "Table 2", in Arabic numerals, followed by the legend, followed b) that appropriate units are given. Instructions for placing the table should be given in paren "(Table 2 about here)".

Figures. Figures should only be used when essential. The same data should not be prese and in a table. Where possible, related diagrams should be grouped together to form a sir should be drawn to professional standards and it is recommended that the linear dimensic approximately twice those intended for the final printed version. Each of these should be c integrated with the text. Figures will be reproduced directly from originals supplied by the a be of good quality, clearly and completely lettered. Make sure that axes of graphs are proj appropriate units are given. Photocopies will reproduce poorly, as will pale or broken origi should be avoided, and never combined with lettering. Half-tone figures should be clear, h and white glossy prints.

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Other tests should be reported in a similar manner to the above example of an F-ratio. Fc of statistical presentation, see pages 136-147 of the *APA Publication Manual* (5th ed.). Foi presenting statistical significance, see pages 24-25.

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Appendix 9: Instructions to authors for journal Clinical Psychology Review

authorGATEWAY for Elsevier Journals

ELSEVIER **Clinical Psychology Review**

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Guide for Authors

SUBMISSION REQUIREMENTS: All manuscripts should be submitted to Alan S. Bellack, Department of Psychiatry, The University of Maryland at Baltimore, 737 W. Lombard St., Suite 551, Baltimore, MD 21201, USA. Submit three (3) high-quality copies of the entire manuscript; the original is not required. Allow ample margins and type double-space throughout. Papers should not exceed 50 pages (including references). One of the paper's authors should enclose a letter to the Editor, requesting review and possible publication; the letter must also state that the manuscript has not been previously published and has not been submitted elsewhere. One author's address (as well as any upcoming address change), telephone and FAX numbers, and E-mail address (if available) should be included; this individual will receive all correspondence from the Editor and Publisher.

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COMPUTER DISKS: Authors are encouraged to submit a 3.5" HD/DD computer disk to the editorial office; 5.25" HD/DD disks are acceptable if 3.5" disks are unavailable. Please observe the following criteria: (1) Send only hard copy when first submitting your paper. (2) When your paper has been refereed, revised if necessary, and accepted, send a disk containing the final version with the final hard copy. Make sure that the disk and the hardcopy match exactly (otherwise the diskette version will prevail). (3) Specify what software was used, including which release, e.g., WordPerfect 6.0a. (4) Specify what computer was used (IBM compatible PC, Apple Macintosh, etc.). (5) The article file should include all textual material (text, references, tables, figure captions, etc.) and separate illustration files, if available. (6) The file should follow the general instructions on style/arrangement and, in particular, the reference style of this journal as given in the Instructions to Contributors. (7) The file should be single-spaced and should use the wrap-around end-of-line feature, i.e., returns at the end of paragraphs only. Place two returns after every element such as title, headings, paragraphs, figure and table call-outs. (8) Keep a backup disk for reference and safety.

TITLE PAGE: The title page should list (1) the article; (2) the authors' names and affiliations at the time the work was conducted; (3) a concise running title; and (4) an unnumbered footnote giving an address for reprint requests and acknowledgements.

ABSTRACT: An abstract should be submitted that does not exceed 200 words in length. This should be typed on a separate page following the title page.

KEYWORDS: Authors should include up to six keywords with their article. Keywords should be selected from the APA list of index descriptors, unless otherwise agreed with the Editor.

STYLE AND REFERENCES: Manuscripts should be carefully prepared using the *Publication Manual of the American Psychological Association*, 5th ed., 1994, for style. The reference section must be double spaced, and all works cited must be listed. Avoid abbreviations of journal titles and incomplete information.

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Appendix 10: Scoring sheet for coding videos

Writing a card and enclosing a gift voucher (1)

		Errors: Per	Om	Com	Ex	Sem	Q
write card	move card to front						
	open card						
	take pen						
	alter pen to take lid off						
	write message in card						
	give pen						
place in envelope	take card						
	take voucher						
	alter voucher to inside card						
	alter card to closed						
	take envelope						
	move card to inside envelope						
	alter envelope to closed by sealing						
address envelope	take pen						
	alter envelope to addressed by writing						
	give pen						
add stamp	take stamp						
	move stamp to top right of envelope						
	alter stamp to stuck down via licking						

Writing a card and enclosing a gift voucher (2)

		Errors: Per	Om	Com	Ex	Sem	Q
write card	move card to front						
	open card						
	take pen						
	alter pen to take lid off						
	write message in card						
	give pen						
place in envelope	take card						
	take voucher						
	alter voucher to inside card						
	alter card to closed						
	take envelope						
	move card to inside envelope						
	alter envelope to closed by sealing						

address envelope	take pen alter envelope to addressed by writing alter pen to shut by putting lid on give pen
add stamp	take stamp move stamp to top right of envelope alter stamp to stuck down via licking

Error codes:	**Per** = perseveration, **Om** = omission, **Com** = commission, **Ex** = executive **Sem = semantic, Q= quality, Seq = Anticipation/ sequence error,** **OS** = object substitution

2X3 (1)   2X3 (2)

Making a cup of tea (1)

		Errors					
A-2	☐ Component A-1's	Per	Om	Com	Ex	Sem	Q
Boil the water	Take kettle Take water container Alter water container to open Move water to kettle via pouring Give water container Alter kettle to 'on' Wait Alter kettle to 'off' *(this can be at any suitable time)						
Make tea	Move cup to front Take teabag packet alter teabag packet to open take one teabag from packet move teabag to cup give teabag packet take kettle move water to cup from kettle via pouring give kettle take spoon move spoon to cup move teabag out of cup via spoon by lifting						

Add sugar	take sugar packet alter sugar packet to open take spoon move sugar to cup via spoon by lifting alter tea to 'stirred' via spoon give sugar packet give spoon
Add milk	take milk container alter milk container to open move milk to cup via container by pouring take spoon alter tea to 'stirred' via spoon give milk container give spoon

Making a cup of tea (2)

		Errors					
A-2	Component A-1's	Per	Om	Com	Ex	Sem	Q
Boiling the water	Take kettle Take water container Move water to kettle via pouring alter water container to closed Give water container Alter kettle to 'on' Wait Alter kettle to 'off' *(this can be at any suitable time)						
Make tea	Move cup to front Take teabag packet take one teabag from packet move teabag to cup alter teabag packet to closed give teabag packet take kettle move water to cup from kettle via pouring give kettle take spoon move spoon to cup move teabag out of cup via spoon by lifting						
Add sugar	take sugar packet take spoon move sugar to cup via spoon by lifting alter tea to 'stirred' via spoon alter sugar packet to closed						

give sugar packet
give spoon

Add milk

take milk container
move milk to cup via container by pouring
take spoon
alter tea to 'stirred' via spoon
alter milk container to closed
give milk container
give spoon

Error codes:	**Per** = perseveration, **Om** = omission, **Com** = commission, **Ex** = executive **Sem = semantic, Q= quality, Seq = Anticipation/ sequence error,** **OS** = object substitution

Making a cereal (1)

Errors

Per Om Com Ex Sem Q

Put cereal in bowl

move bowl to front
take cereal packet
alter cereal packet to open
move cereal to bowl via packet by pouring
give cereal packet

Add milk

take milk container
alter milk container to open
move milk to bowl via container by pouring
give milk container

Add sugar

take sugar packet
alter sugar packet to open
take spoon
move sugar to bowl via spoon by sprinkling
give spoon
give sugar packet

Error codes:	**Per** = perseveration, **Om** = omission, **Com** = commission, **Ex** = executive **Sem = semantic, Q= quality, Seq = Anticipation/ sequence error,** **OS** = object substitution

Making a cereal (2)

Errors

Per Om Com Ex Sem Q

Put cereal in bowl

move bowl to front
take cereal packet
move cereal to bowl via packet by pouring
alter cereal packet to closed
give cereal packet

Add milk	take milk container move milk to bowl via container by pouring alter milk container to closed give milk container
Add sugar	take sugar packet take spoon move sugar to bowl via spoon by sprinkling give spoon alter sugar packet to closed give sugar packet

Error codes:	**Per** = perseveration, **Om** = omission, **Com** = commission, **Ex** = executive **Sem = semantic, Q= quality, Seq = Anticipation/ sequence error,** **OS** = object substitution

Making toast and jam (1)

Errors
Per Om Com Ex Sem Q

Make toast	(alter toaster to ready via plugging in) take bread bag alter bread bag to open take two pieces of bread move bread to in toaster alter toaster to on give bread bag wait alter toaster to off move plate to front move bread to plate
Butter toast	take butter alter butter to open take knife take toast on plate move butter to toast via knife by spreading (repeat spreading) give butter give knife
Put jam on toast	take jam jar alter jam jar to open move jam to toast via knife by spreading (repeat spreading) give knife give jam jar take knife alter toast to cut in half via knife by cutting

give knife

Making toast and jam (2)

		Errors					
		Per	Om	Com	Ex	Sem	Q
Make toast	(alter toaster to ready via plugging in)						
	take bread bag						
	take two pieces of bread						
	move bread to in toaster						
	alter toaster to on						
	alter bread bag to closed						
	give bread bag						
	wait						
	alter toaster to off						
	move plate to front						
	move bread to plate						
Butter toast	take butter						
	take knife						
	take toast on plate						
	move butter to toast via knife by spreading (repeat spreading)						
	alter butter to closed						
	give butter						
	give knife						
Put jam onto toast	take jam jar						
	move jam to toast via knife by spreading (repeat spreading)						
	give knife						
	alter jam jar to closed						
	give jam jar						
	take knife						
	alter toast to cut in half via knife by cutting						
	give knife						

Error codes: **Per** = perseveration, **Om** = omission, **Com** = commission, **Ex** = executive
Sem = semantic, Q= quality, Seq = Anticipation/ sequence error,
OS = object substitution

Making a cheese sandwich (1)

		Errors					
		Per	Om	Com	Ex	Sem	Q
Butter bread	move plate to front						
	take bread bag						
	alter bread bag to open						
	move two slices of bread to plate						

	give bread bag take knife take butter alter butter to open move butter to bread via knife by spreading (repeat spreading) give knife give butter
Add cheese	take cheese packet alter cheese packet to open take cheese slice alter cheese slice to out of packet move cheese to one piece of bread give cheese packet
Make sandwich	take second piece of bread alter 2nd piece bread to upside down move 2nd piece to on top of 1st piece take knife alter sandwich to in half by cutting give knife
Wrap sandwich	take plastic bag alter plastic bag to open take half of sandwich move half sandwich to inside bag take 2nd half of sandwich move 2nd half sandwich to inside bag give bag with sandwiches in take lunchbox alter lunchbox to open move bag to inside lunchbox

Error codes:	**Per** = perseveration, **Om** = omission, **Com** = commission, **Ex** = executive **Sem = semantic, Q= quality, Seq = Anticipation/ sequence error,** **OS** = object substitution

Making a cheese sandwich (2)

		Errors					
		Per	Om	Com	Ex	Sem	Q
Butter bread	move plate to front take bread bag move two slices of bread to plate alter bread bag to closed give bread bag take knife take butter move butter to bread via knife by spreading						

	(repeat spreading)
	give knife alter butter to closed give butter
Add cheese	take cheese packet take cheese slice alter cheese slice to out of packet move cheese to one piece of bread alter cheese packet to closed give cheese packet
Make sandwich	take second piece of bread alter 2nd piece bread to upside down move 2nd piece to on top of 1st piece take knife alter sandwich to in half by cutting give knife
Wrap sandwich	take plastic bag take half of sandwich move half sandwich to inside bag take 2nd half of sandwich move 2nd half sandwich to inside bag alter bag to closed take lunchbox alter lunchbox to open move bag to inside lunchbox alter lunchbox to closed

Error codes:	**Per** = perseveration, **Om** = omission, **Com** = commission, **Ex** = executive **Sem = semantic, Q= quality, Seq = Anticipation/ sequence error,** **OS** = object substitution

Wrapping a gift (1)

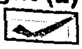
Errors

Per Om Com Ex Sem Q

cut paper to size	alter paper to decorated side down move paper to front by spreading it out take gift move gift to on top of wrapping paper move paper to around gift move paper to flat on table again move gift to the side take scissors alter paper to correct size by cutting give scissors move remaining paper to the side

wrap gift	move gift to centre of cut paper
	alter paper to around gift by folding
	take sellotape
	alter sellotape to off the roll by tearing
	move sellotape to seal edges of paper
	(repeat sealing until all folds secured)
	give sellotape
add bow	take bow
	take wrapped gift
	take sellotape
	alter sellotape to off roll by tearing
	give sellotape
	move bow to on top of gift
	alter bow to stuck to gift via s/tape

Wrapping a gift (2) Per Om Com Ex Sem Q



cut paper to size	alter paper to decorated side down
	move paper to front by spreading it out
	take gift
	move gift to on top of wrapping paper
	move paper to around gift
	move paper to flat on table again
	move gift to the side
	take scissors
	alter paper to correct size by cutting
	give scissors
	move remaining paper to the side
wrap gift	move gift to centre of cut paper
	alter paper to around gift by folding
	take sellotape
	alter sellotape to off the roll by tearing
	move sellotape to seal edges of paper
	(repeat sealing until all folds secured)
	give sellotape
add bow	take bow
	take wrapped gift
	take sellotape
	alter sellotape to off roll by tearing
	give sellotape
	move bow to on top of gift
	alter bow to stuck to gift via s/tape

Error codes:	**Per** = perseveration, **Om** = omission, **Com** = commission, **Ex** = executive **Sem = semantic, Q= quality, Seq = Anticipation/ sequence error,** **OS** = object substitution

Appendix 11: Record sheets for Neuropsychological measures used+

- National Adult reading Test (Nelson , 1982)
- BADS (Wilson et al., 1996)
- Hayling and Brixton (Burgess & Shallice, 1997)
- AMIPB (Coughlan & Hollows, 1985)
- RMBT (Wilson et al, 1989)
- TEA (Robertson et al, 1994)
- WAIS-R (Wechsler, D. 1981)
- Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983)
- Sheffield Aphasia Battery (Snyder, Parker, Body & Boddy, 1993)

National Adult Reading Test (NART)

SECOND EDITION

Answer/Record Sheet

Name:.. Date of test:...

	Errors		Errors
CHORD		SUPERFLUOUS	
ACHE		SIMILE	
DEPOT		BANAL	
AISLE		QUADRUPED	
BOUQUET		CELLIST	
PSALM		FACADE	
CAPON		ZEALOT	
DENY		DRACHM	
NAUSEA		AEON	
DEBT		PLACEBO	
COURTEOUS		ABSTEMIOUS	
RAREFY		DETENTE	
EQUIVOCAL		IDYLL	
NAIVE		PUERPERAL	
CATACOMB		AVER	
GAOLED		GAUCHE	
THYME		TOPIARY	
HEIR		LEVIATHAN	
RADIX		BEATIFY	
ASSIGNATE		PRELATE	
HIATUS		SIDEREAL	
SUBTLE		DEMESNE	
PROCREATE		SYNCOPE	
GIST		LABILE	
GOUGE		CAMPANILE	

Obtained WAIS/WAIS-R results*:

Full scale IQ ______ Verbal IQ ______ Performance IQ ______

NART error score ______

	Predicted IQ	Predicted-obtained IQ	Abnormality (%)
Full scale IQ			
Verbal IQ			
Performance IQ			

NART + Schonell error score ______

	Predicted IQ	Predicted-obtained IQ	Abnormality (%)
Full scale IQ			

*** Delete as appropriate**

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NFER NELSON

BADS

Scoring sheet

Thames Valley Test Company

Subject and test details

Name

Age

Date of test

Before you start the test battery

- Ensure that you have all the test materials, a stopwatch, a tape recorder, set of coloured pens, a pencil, eraser, spare paper, and water for the action program.

Profile score summary

Test 1: Rule shift cards	
Test 2: Action program	
Test 3: Key search	
Test 4: Temporal judgement	
Test 5: Zoo map	
Test 6: Modified six elements	
Total profile score (max = 24)	
Standardised score (Manual Table 5, p.16)	
Age corrected standardised score (Manual Table 5, p.16)	

Overall classification

- ☐ Impaired
- ☐ Borderline
- ☐ Low average
- ☐ Average
- ☐ High Average
- ☐ Superior
- ☐ Very superior

Test 1: Rule shift cards

For full text and procedure see Manual p. 8

Trial 1

- Put the playing card booklet, unopened, between you and the subject and have the rule sheet ready.
- *'This is a booklet of playing cards. I am going to turn over...'*
- Place Rule 1 in front of the subject ('Say 'yes' to red, 'no' to black').
- Remember to omit page 0 for this trial – start with the 2 of ♦.
- Time the trial.

	Correct response	Subject's response
1	Y	
2	N	
3	N	
4	N	
5	Y	
6	Y	
7	Y	
8	Y	
9	N	
10	Y	
11	Y	
12	N	
13	Y	
14	N	
15	N	
16	N	
17	Y	
18	N	
19	Y	
20	N	

Total errors

Time taken

Note that Trial 1 is not used to calculate the profile score

Trial 2

- *'I am going to turn over the set of cards again now...'*
- Place Rule 2 in front of the subject ('Say 'yes' if the card is the same colour as the last one, otherwise say 'no'').
- Remember to start on page 0 – the 4 of ♥.
- Time the trial.

	Correct response	Subject's response
1	Y	
2	N	
3	Y	
4	Y	
5	N	
6	Y	
7	Y	
8	Y	
9	N	
10	N	
11	Y	
12	N	
13	N	
14	N	
15	Y	
16	Y	
17	N	
18	N	
19	N	
20	N	

Total errors | **Profile score**

Total errors	Profile score
0	4
1–3	3
4–6	2
7–9	1
≥10	0

Time taken –

If time taken is greater than 67 seconds subtract 1 from profile score

Total profile score

Test 2: Action program

For full text and procedure see Manual p. 8

- Fill the beaker to two-thirds full of water (out of sight of the subject) and place the equipment in front of the subject.
- *'If you look at the bottom of this tube you will see a small cork...'*
- Start stopwatch
- If necessary, prompt after 2 minutes *'I'll give you some help'*, and remove the lid with the wire hook. *'Try to complete the task now'.*
- If necessary, prompt after a further 2 minutes by attaching the screw top to the container.

Tick each stage completed independently **Raw score**

- ☐ Removes lid from beaker using wire hook
- ☐ Attaches screw top to container
- ☐ Fills container with water
- ☐ Pours one containerful of water into tube containing cork
- ☐ Pours second containerful of water into tube containing cork

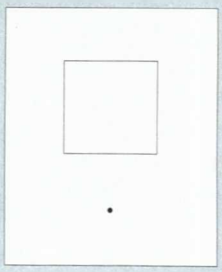
Raw score	Profile score
5	4
4	3
3	2
2	1
≤1	0

Total profile score ☐

Test 3: Key search

For full text and procedure see Manual p. 9

- Place a photocopy of the response sheet in front of the subject.
- *'I want you to imagine that this square is a large field...'*
- *'Starting from this dot I want you to draw a line with the pen to show me where you would walk to search the field...'*
- If the subject does not grasp the idea, demonstrate on another piece of paper.
- *'Although I will be timing you there is no time limit...'*
- Start the stopwatch.
- Make notes here. These could indicate, for example, the order in which the subject makes marks. This will help you to calculate the score later.
- For scoring criteria see Appendices 9.1 and 9.2 in Manual pp. 20–22.



Entering the field **Raw score**

- within 10mm of a corner (base of square) = 3
- base of square (other than within 10mm of corners) = 2
- somewhere else = 1

Finishing the search

- within 10mm of any corner = 3
- base of square (other than within 10mm of corners) = 2
- somewhere else = 1

Making a continuous line = 1

Making all parallel lines = 1

Making all vertical/horizontal lines = 1

Search patterns

- followed one of our pre-defined search patterns (see Appendix 9.1, Manual pp. 20–21) or super-imposed one pre-determined pattern over another = 5 or 3
- duplicated or combined one or more of our pre-defined search patterns = 2
- followed some other obviously systematic, but inefficient and/or unsuccessful search pattern = 1
- ad hoc – not systematic or pre-planned = 0

Has made an obvious effort to cover all the ground = 1

Using their chosen pattern, they would find the keys (95% certainty) = 1

Time taken **Total raw score** **Profile score**

Raw score	Profile score
14–16	4
11–13	3
8–10	2
5–7	1
≤4	0

If time taken is greater than 95 seconds subtract 1 from profile score –

Total profile score ☐

Test 4: Temporal judgement

For full text and procedure see Manual p. 9

- *'I'm going to ask you to estimate how long it takes to do four things...'*

Question 1
How long does it take to do a routine dental check up? **Raw score**

If between 5 & 15 mins score 1, otherwise 0

Question 2
How long does it take a window cleaner to clean the windows of an average size house?

If between 15 & 25 mins score 1, otherwise 0

Question 3
How long do most dogs live for?

If between 9 & 15 years score 1, otherwise 0

Question 4
How long does it take to blow up a party balloon?

If between 50 & 70 secs score 1, otherwise 0

Total raw score **= total profile score** ☐

Test 5: Zoo map

For full text and procedure see Manual p. 9

Version 1

- Place a photocopy of Zoo map version 1 in front of the subject.
- *'Here is a map of a zoo. Your task is to plan a route around the zoo to visit all the places indicated in the instructions...'*
- Allow the subject to read the instructions (aloud).
- Clarify the rules by reading them again.
- *'While I will use this stopwatch to see how long it takes you to do the task, the time really is not important...'*
- Start the stopwatch.
- For scoring criteria see Appendix 9.3 in Manual p. 23.

Note subject's sequence	Each correct scores 1	Correct responses		Occasions each path used more than once
		Entrance	A	
		Llamas/Cafe/Elephants	B	
		Elephants/Cafe	C	
		Cafe/Elephants/Llamas	D	
		Bears	E	
		Lions	F	
		Bird sanctuary	G	
		Picnic area	H	
			I	
			J	
			K	
			L	
			M	
Sequence score			Total	

Planning time	Total time

Errors

Total number of occasions paths used more than once (from above)	
Number of deviations from the path (i.e. cutting across the grass)	
Number of failures to make a continuous line	
Number of inappropriate places visited	
Total errors	
Version 1 raw score = sequence score minus total errors	

Version 2

- Place a photocopy of Zoo map version 2 in front of the subject.
- *'The next day you go back to the zoo for another visit...'*
- Clarify the rules and record timings as in version 1.

Note subject's sequence	Each correct scores 1	Correct response		Occasions each path used more than once
		Entrance	A	
		Llamas	B	
		Elephants	C	
		Cafe	D	
		Bears	E	
		Lions	F	
		Bird sanctuary	G	
		Picnic area	H	
			I	
			J	
			K	
			L	
			M	
Sequence score			Total	

Planning time	Total time

Errors

Total number of occasions paths used more than once (from above)	
Number of deviations from the path (i.e. cutting across the grass)	
Number of failures to make a continuous line	
Number of inappropriate places visited	
Total errors	
Version 2 raw score = sequence score minus total errors	

Add version 1 and version 2 raw scores

Raw score	Profile score
16	4
11–15	3
6–10	2
1–5	1
≤0	0

Profile score

If planning time on version 2 is greater than 15 seconds subtract 1 from profile score –

If total time on version 2 is greater than 123 seconds subtract 1 from profile score –

Total profile score

Test 6: Modified six elements

For full text and procedure see Manual p. 10

- Arrange the test materials.
- *'You get ten minutes for this next test, and in this test you will be doing three different kinds of task...'*
- Go through each task with the subject.
- *'During the next ten minutes I would like you to try to complete at least some of each of the six individual parts...'*
- *'However, there is one rule you must obey...'*
- *'Now, tell me what you must do.'*
- Set the timer for 10 minutes.
- Start the stopwatch and timer.

Record the order of sub tasks attempted and the subject's start and stop times

Sub task	Time started	Time stopped	Time on subtask

Summary of time spent on each sub task and number of correct responses

Sub task	Total time on sub task
Dictation A	
Dictation B	
Pictures A	
Pictures B	
Arithmetic A	
Arithmetic B	

Number of sub tasks attempted (max = 6) ☐

Minus number of sub tasks where rules were broken (max = 3) ☐

Raw score ☐

Raw score	Profile score
6	**4**
4 or 5	**3**
2 or 3	**2**
≤ 1	**1**

Profile score ☐

If total time on any one sub task is greater than 271 seconds, subtract 1 from profile score – ☐

Total profile score ☐

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TVTC Thames Valley Test Company

the **Hayling** and **Brixton** tests

Scoring sheet

Subject and test details

Name

Age

Date of test

Further details

The Hayling Sentence Completion Test

Score summary

Box A (Section 1 Scaled score) + **Box B** (Section 2 Scaled score) + **Box C** (Section 2 Errors scaled score) = Total scaled scores → **Hayling overall scaled score**

Table E		
Total scaled scores	**Overall scaled score**	**Classification**
23	10	Very superior
22	9	Superior
21	8	Good
20	7	High average
17–19	6	Average
15–16	5	Moderate ave.
13–14	4	Low average
11–12	3	Poor
10	2	Abnormal
< 10	1	Impaired

Hayling Section 1: sensible completion

- *In a moment I am going to read you a series of sentences, each of which has the last word missing from it. I want you to listen carefully to each sentence, and when I have finished each one, your job is to give me a word which completes the sentence. Do you understand?*

Practice

- *Before we start, I'll give you a couple of practice sentences so that you can get the hang of it. Are you ready?*

	Response	Time
P1 The rich child attended a private		
P2 The crime rate has gone up this		

Test

- *OK, that's the end of the practice items. The next few sentences I'll read aren't really any more difficult than the two you've just done. But the important thing is that I want you to give me your answer as quickly as you can – the faster the better. Is that clear?*

	Response	Time
1 He posted a letter without a *or:* He mailed a letter without a		
2 In the first space enter your *or:* In the first blank enter your		
3 The old house will be torn		
4 It's hard to admit when one is		
5 The job was easy most of the		
6 When you go to bed turn off the		
7 The game was stopped when it started to		
8 He scraped the cold food from his		
9 The dispute was settled by a third		
10 Three people were killed in a major motorway *or:* Three people were killed in an interstate		
11 The baby cried and upset her		
12 George could not believe that his son had stolen a		
13 He crept into the room without a		
14 Billy hit his sister on the		
15 Too many men are out of		

Total time (raw score) →

Scaled score (transfer this to box A in score summary above)

Table A		
Raw score	**Scaled score**	**Comment**
0	7	High ave.
1–9	6	Average
10–18	5	Moderate ave.
19–22	4	Low ave.
23–50	3	Poor
51–60	2	Abnormal
>60	1	Impaired

Hayling Section 2: unconnected completion

- *Now we are going to move on to the second section of the test. In this section I will read you a set of sentences with the last word missing just like the ones you have already done, but this time I want you to give me a word which does not fit at the end of the sentence – I want the word you give me to be completely unconnected to the sentence in every way. Do you understand?'*

Practice

- *Before we start, I'll give you a couple of practice sentences so that you can get the hang of what is required'.*

	Response	Time
P1 London is a very busy		
P2 Her new shoes were the wrong		

- If the subject makes an error refer to instructions in Manual (page 8).

Test

- *'OK, that's the end of the practice items. Remember that the words you give me must be unconnected to the sentence, and that it is important for you to give me your answer as quickly as you can. Are you ready?'*

	Response	Time	Correct (unconnected)	Category A error (connected)	Category B error (somewhat connected)
1 The captain wanted to stay with the sinking			☐	☐	☐
2 They went as far as they			☐	☐	☐
3 Most cats see very well at			☐	☐	☐
4 Jean was glad the affair was			☐	☐	☐
5 The whole town came to hear the mayor			☐	☐	☐
6 Most sharks attack very close to			☐	☐	☐
7 None of the books made any			☐	☐	☐
8 The dough was put in the hot			☐	☐	☐
9 She called the husband at his			☐	☐	☐
10 All the guests had a very good			☐	☐	☐
11 He bought them in the sweet *or:* He bought them in the candy			☐	☐	☐
12 His leaving home amazed all his			☐	☐	☐
13 At last the time for action had			☐	☐	☐
14 The dog chased our cat up the			☐	☐	☐
15 At night they often took a short			☐	☐	☐

A score

Total Category A errors	A score
1	3
2	6
3	10
4	14
5	18
6	24
7	30
8	36
9	42
10	48
11	54
12	60
13	66
14	72
15	78

B score

Total Category B errors	B score
1	1
2	2
3	3
4	4
5	9
6	14
7	19
8	24
9	29
10	34
>10	50

Total time (raw score)

Scaled score (transfer this to box B in score summary on page 1)

Total Cat. A errors | **A score** | Total Cat. B errors | **B score** | **Converted score** (A score + B score)

Table B

Raw score	Scaled score	Comment
0	8	Good
1–2	7	High average
3–50	6	Average
51–60	5	Moderate ave.
61–100	4	Low average
101–120	3	Poor
121–130	2	Abnormal
> 130	1	Impaired

Table C

Converted score	Scaled score	Comment
0	8	Good
1–3	7	High average
4–9	6	Average
10–12	5	Moderate ave.
13–14	4	Low average
15–17	3	Poor
18–29	2	Abnormal
≥ 30	1	Impaired

Hayling 2 errors scaled score (transfer this to box C in score summary on page 1)

The Brixton Spatial Anticipation Test

- *'There are many pages here which all have the same basic design on them. There are always ten positions, and one of them is always coloured blue'* [point to filled circle on page one]. *'However the coloured one moves around according to various patterns that come and go without warning. These numbers* [point to numbers underneath the circles] *are just here to refer to the position – there is nothing complicated or mathematical about this test'.*
- *'Now, as I turn the pages over, your job is to pick up on the pattern as best you can, and point to where you think the blue one is going to be on the next page. It's not guess-work – you can work it out. For instance, imagine the blue one was here* [point to position 6], *and then when I turn the page it goes to 7, and then to 8, then to 9 – you might reasonably expect it next to go to 10'.*
- *'From time to time the pattern changes without warning, and then it is your job to pick up on the new pattern as best you can. Do you understand?'*
- Give further assistance if necessary
- *'Obviously the first time you have nothing to go on, so your first answer will have to be a guess – have a guess as to where the blue one will be next'*

Item/ page	Correct answer	Subject's response	Correct/ incorrect
1	any		
2	3		☐
3	4		☐
4	5		☐
5	6		☐
6 *	7		☐
7	4		☐
8	3		☐
9	2		☐
10	1		☐
11	10		☐
12 *	9		☐
13	10		☐
14	5		☐
15	10		☐
16	5		☐
17	10		☐
18	5		☐
19 *	10		☐
20	7		☐
21	8		☐
22	9		☐
23	10		☐
24	1		☐
25	2		☐
26 *	3		☐
27	10		☐
28	9		☐

Item/ page	Correct answer	Subject's response	Correct/ incorrect
29 *	8		☐
30	1		☐
31	2		☐
32	3		☐
33	4		☐
34 *	5		☐
35	4		☐
36	10		☐
37	4		☐
38	10		☐
39	4		☐
40	10		☐
41 *	4		☐
42	9		☐
43	9		☐
44	9		☐
45	9		☐
46	9		☐
47	9		☐
48 *	9		☐
49	9		☐
50	8		☐
51	9		☐
52	8		☐
53	9		☐
54	8		☐
55	9		☐

Total number of errors (raw score)

Scaled score

Table D

Raw score	Scaled score	Classification
0–7	**10**	Very superior
8	**9**	Superior
9–10	**8**	Good
11–13	**7**	High average
14–17	**6**	Average
18–20	**5**	Moderate ave.
21–23	**4**	Low average
24–25	**3**	Poor
26–31	**2**	Abnormal
> 31	**1**	Impaired

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AMIPB

INFORMATION PROCESSING A FORM 1

NAME ______________________ DATE ______________

AGE __________ DOB ______________________ REF. NO. ______________

Demonstration

38, 25, 79

97, 22, 18, 65

85, 27, 20, 48, 52

72, 50, 23, 74, 16

92, 18, 54, 77, 21

46, 39, 38, 16, 72

17, 54, 83, 11, 80

26, 87, 66, 39, 48

54, 56, 51, 63, 22

Demonstration

11

11

11

11

11

	Score	%ile range
Task A Total	____	________
Errors %	____	________
Speed	____	________
Adjusted	____	________

Motor Speed

11	11	11
11	11	11
11	11	11
11	11	11
11	11	11
11	11	11
11	11	11
11	11	11
11	11	11
11	11	11
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11	11	11
11	11	11
11	11	11

91, 26, 43, 82, 17
61, 59, 62, 18, 80
27, 48, 92, 36, 28
53, 29, 61, 19, 32
32, 41, 18, 24, 11

24, 82, 58, 26, 41
80, 36, 72, 43, 65
74, 19, 41, 28, 50
55, 41, 60, 11, 13
60, 99, 20, 22, 48

51, 29, 81, 16, 99
18, 32, 67, 77, 33
42, 83, 17, 56, 40
36, 98, 39, 19, 14
80, 22, 82, 75, 57

65, 26, 11, 72, 22
37, 55, 18, 53, 90
92, 49, 27, 19, 83
94, 93, 64, 11, 65
14, 18, 83, 73, 10

90, 52, 81, 23, 39
12, 49, 59, 92, 87
55, 27, 36, 84, 66
55, 86, 29, 38, 22
33, 55, 41, 61, 65

37, 51, 19, 36, 84
27, 64, 48, 63, 20
18, 16, 71, 23, 62
28, 21, 92, 74, 61
26, 54, 51, 29, 60

43, 52, 41, 80, 10
85, 22, 16, 45, 53
57, 17, 68, 98, 80
17, 23, 15, 30, 36
20, 53, 50, 72, 29

28, 62, 19, 12, 54
42, 25, 41, 33, 38
17, 12, 18, 15, 29
86, 42, 93, 28, 71
76, 72, 40, 60, 29

63, 20, 82, 18, 99
28, 40, 23, 76, 77
12, 15, 38, 65, 71
17, 57, 41, 91, 28
32, 39, 14, 56, 42

52, 91, 17, 86, 68
21, 20, 50, 94, 54
70, 13, 38, 62, 69
43, 21, 16, 50, 56
45, 48, 89, 21, 12

82, 37, 21, 97, 79
66, 29, 59, 23, 32
71, 62, 50, 82, 44
64, 97, 91, 63, 95
56, 12, 82, 43, 20

93, 78, 50, 12, 15
32, 70, 92, 65, 80
18, 29, 54, 28, 30
25, 56, 41, 39, 20
94, 34, 29, 36, 14

72, 26, 34, 61, 79
68, 17, 72, 65, 81
61, 98, 60, 27, 41
12, 83, 70, 65, 32
45, 72, 24, 59, 10

14, 45, 89, 53, 21
35, 58, 41, 65, 28
63, 30, 93, 21, 45
94, 92, 16, 82, 24
22, 59, 21, 75, 48

26, 56, 28, 93, 40
54, 90, 26, 81, 15
32, 37, 91, 15, 22
11, 42, 86, 90, 19
19, 53, 18, 92, 64

28, 21, 81, 47, 68
57, 52, 10, 69, 92
41, 60, 56, 78, 69
94, 79, 38, 20, 29
26, 94, 37, 50, 29

90, 27, 83, 41, 86
87, 15, 10, 85, 90
22, 56, 74, 36, 57
73, 80, 12, 72, 84
95, 41, 81, 70, 18

41, 30, 94, 50, 58
24, 95, 75, 81, 72
59, 26, 57, 19, 36
52, 17, 23, 60, 28
52, 68, 62, 30, 74

27, 29, 16, 23, 38
83, 81, 75, 77, 89
91, 61, 54, 80, 59
79, 82, 47, 16, 52
80, 83, 29, 90, 10

61, 14, 15, 50, 47
44, 19, 65, 24, 13
42, 40, 55, 84, 73
37, 49, 45, 38, 27
55, 25, 86, 20, 46

61, 96, 82, 85, 74
27, 86, 50, 16, 11
43, 30, 99, 36, 22
48, 50, 60, 44, 82
68, 27, 63, 37, 45

AMIPB

MEMORY FORM 1

NAME ________________ DATE ________________

AGE __________ DOB ____________ REF. NO. ____________

LIST LEARNING

	A1	A2	A3	A4	A5	A6		B
Butter	--	--	--	--	--	--	Dance	-
Orange	--	--	--	--	--	--	Nail	-
Ink	--	--	--	--	--	--	Monkey	-
Fire	--	--	--	--	--	--	River	-
Shell	--	--	--	--	--	--	Prison	-
Salad	--	--	--	--	--	--	Grease	-
Kitchen	--	--	--	--	--	--	Friend	-
Goat	--	--	--	--	--	--	Clock	-
Thunder	--	--	--	--	--	--	Cheese	-
Bag	--	--	--	--	--	--	Square	-
Temple	--	--	--	--	--	--	Sailor	-
Needle	--	--	--	--	--	--	Pencil	-
Train	--	--	--	--	--	--	Flower	-
Skirt	--	--	--	--	--	--	Knife	-
Hedge	--	--	--	--	--	--	Tiger	-
SCORE	--	--	--	--	--	--		-

LIST LEARNING - Form 1

	Score	%ile range
Total A1-A5	______	__________
A6	______	__________
B	______	__________
Intrusions	______	__________

DESIGN LEARNING - Form 1

	Score	%ile range
Total A1-A5	______	__________
A6	______	__________
B	______	__________
Intrusions	______	__________

STORY RECALL - IMMEDIATE

Mrs Angela / Harper / was sitting in her bedroom / mending the curtains / when she heard a noise / coming from the kitchen / . She rushed to investigate / and found a boy / climbing out of the window / with her handbag / . She threw a vase at him / but it missed / and he ran* off laughing / . She chased after him / past the shops / and into the park / but he got away* / by squeezing through some railings / . On her back home / Mrs Harper phoned / the police / . She described* / the thief as quite tall / and neatly dressed / . He had a scar / on his face / but she could not rememb the colour of his hair / ..

* Score 1 if implied

Score (Max 56) ________

STORY RECALL - DELAYED

Mrs Angela / Harper / was sitting in her bedroom / mending the curtains / when she heard a noise / coming from the kitchen / . She rushed to investigate / and found a boy / climbing out of the window / with her handbag / . She threw a vase at him / but it missed / and he ran* off laughing / . She chased after him / past the shops / and into the park / but he got away* / by squeezing through some railings / . On her back home / Mrs Harper phoned / the police / . She described* / the thief as quite tall / and neatly dressed / . He had a scar / on his face / but she could not rememb the colour of his hair / .

* Score 1 if implied

Score (Max 56) ________

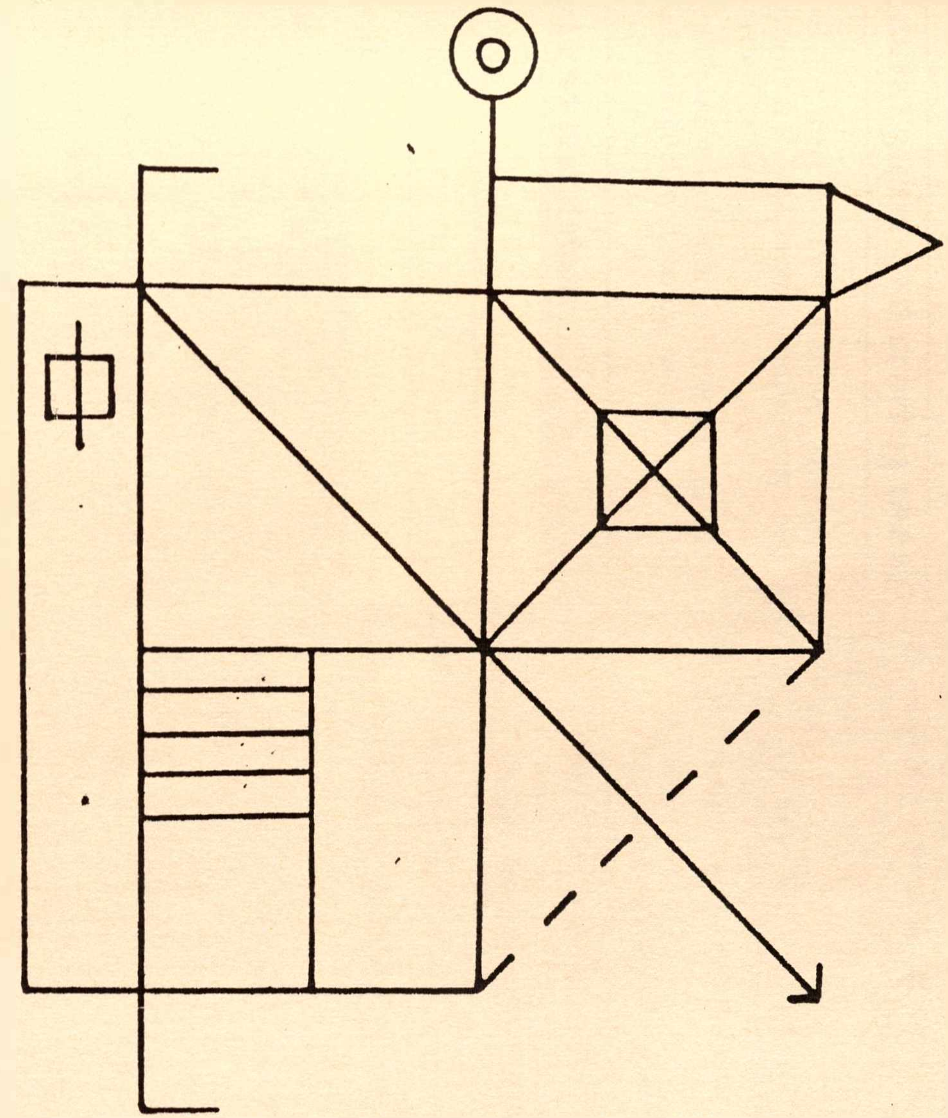
STORY RECALL - Form 1

	Score	%ile range
Immediate (I)	____	________
Delayed (D)	____	________
Retained % (D/I)	____	________

FIGURE RECALL - Form 1

	Score			%	%ile
Copy(C)	____	*	(C/80)	___	___
Immediate(I)	____	*	(I/C)	___	___
Delayed(D)	____	*	(D/C)	___	___
Retained %			(D/I)	___	___

* Max = 80



TVTC
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RBMT

The Rivermead
behavioural memory test

Procedural guide and scoring sheet

- This scoring sheet provides a summary procedure to ensure that the test is consistently carried-out in the correct order.
- Please follow the instructions in the Manual for detailed procedural and scoring guidance.

Subject and test details

Name

Date of birth

Date of test

Assessment	1	2	3	4
	☐	☐	☐	☐

Version	A (Red)	B (Blue)	C (Green)	D (Brown)
	☐	☐	☐	☐

• 1 and 2 First and Second Name

Action
Present the portrait for 'Remembering a name'.
A Catherine Taylor
B Henry Fisher
C Pauline Roberts
D Philip Goodwin

• 3 Belonging

Action
Hide a belonging for 'Remembering a hidden belonging'.
A Desk drawer
B Cupboard
C Filing cabinet
D Brief case or bag

• 4 Appointment

Action
Set the timer for 'Remembering an appointment'.
A 'When do I have to see you again?'
B 'When does this session end?'
C 'When will I know the results of the test?'
D 'What time do we finish today?'

• 5 Pictures

Action
Present the ten presentation cards for 'Picture recognition'.

• 6a Story (immediate)

Action
Read the prose passage from the separate Story Sheet. Then ask the subject to recall the prose passage.
Response
Adopt your own technique (e.g. underlining and encircling) for recording each of the 21 'ideas' correctly recalled or partially recalled against the appropriate passage on the Story Sheet.
Scoring
Scoring is based on points awarded for the number of 'ideas' correctly recalled. You should therefore count and calculate *after* the test has been completed.

☐ *Raw Score*
Each 'idea' recalled word-perfect
or using a close synonym = 1
Each 'idea' partially recalled,
or recalled with approximate
synonym = ½
(Maximum = 21)

☐ *Standardised Profile Score*

Raw Score	≤3.5	4–5.5	≥6
Standardised Profile Score	0	1	2

Screening Score
Score later

• 5 Pictures

Action
Present the 20 recognition cards for 'Picture recognition'.
Response
Tick each picture identified correctly. (Those pictures which were previously presented are indicated by superior figures on the reverse of the picture cards.)

1	2	3	4	5	6	7	8	9	10

Total ☐

Record the number of false positives ☐

Scoring

☐ *Raw Score*
Subtract the number of false positives from the
total number of pictures correctly identified
(Maximum = 10)

☐ *Standardised Profile Score*

Raw Score	≤8	9	10
Standardised Profile Score	0	1	2

○ *Screening Score*
All ten pictures identified correctly with no
false positives = 1
(Otherwise = 0)

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• 7 Faces

Action

Present the five presentation cards for 'Face recognition'.

• 8a Route (immediate)

Action

Demonstrate the route for 'Remembering a short route' (immediate). (Leave the 'Message' envelope for 'Remembering to deliver a message' at the location marked by an asterisk below.) Then ask the subject to reproduce the route. Record each of the stages reproduced correctly below. The subject's response to 'Remembering to deliver a message' should be recorded in the next section.

Response

Tick each stage of the route correctly recalled:

A Chair	door	window	table*	chair
B Door	window*	table	chair	door
C Window	table	chair*	door	window
D Table	chair	door*	window	table

Scoring

Raw Score
Total number of stages recalled correctly
(Maximum = 5)

Standardised Profile Score

Raw Score	≤3	4	5
Standardised Profile Score	0	1	2

Screening Score
All five stages of the route recalled in the correct order = 1
(Otherwise = 0)

• 9a Message (immediate)

Action

When demonstrating the route, leave the 'Message' envelope for 'Remembering to deliver a message' (immediate) at the location marked by an asterisk above.

Response

Tick as appropriate:

'Message' envelope picked-up spontaneously
picked-up after prompt
left at correct location

Scoring

Raw Score
'Message' picked-up spontaneously = 2
picked-up after prompt = 1
left at correct location = another 1
(Maximum = 3)

Standardised Profile Score
Score later

Screening Score
Score later

• 7 Faces

Action

Present the ten recognition cards for 'Face recognition'.

Response

Tick each face identified correctly. (Those faces which were previously presented are indicated by superior figures on the reverse of the face cards.)

1	2	3	4	5

Total

Record the number of false positives

Scoring

Raw Score
Subtract the number of false positives from the total number of faces correctly identified
(Maximum = 5)

Standardised Profile Score

Raw Score	≤3	4	5
Standardised Profile Score	0	1	2

Screening Score
All five faces identified correctly with no false positives = 1
(Otherwise = 0)

• 10 and 11 Orientation and Date

Action

Ask the ten questions for 'Orientation' and 'Date' in the order given below:

Response

Record the subject's responses in the spaces provided:

1 Year
2 Month
3 Day of week
4 Date
5 Place
6 City or town
7 Age
8 Year born
9 Prime Minister
10 President

Scoring

Raw Score
Score one point for each correct response.
• Total number of correct responses to Orientation questions **i.e. excluding Date**
(Maximum = 9)
• Correct Date
(Maximum = 1)

Standardised Profile Score
• Orientation questions

Raw Score	≤7	8	9
Standardised Profile Score	0	1	2

• Date

Raw Score	≥ Two days out	One day out	Correct
Standardised Profile Score	0	1	2

Screening Score

• Orientation questions

All nine Orientation questions answered correctly = 1
(Otherwise = 0)

• Date

Correct Date given = 1
(Otherwise = 0)

• 4 Appointment

Action

Engage the subject in conversation until the timer sounds for 'Remembering an appointment'. Prompt if necessary.

A 'When do I have to see you again?'
B 'When does this session end?'
C 'When will I know the results of the test?'
D 'What time do we finish today?'

Response

Tick as appropriate:

Subject asked appropriate question spontaneously

after prompt

Subject remembered that something had to be asked but could not remember what it was

Scoring

Raw Score

Subject asked appropriate question spontaneously = 2
after prompt = 1
Subject remembered that something had to be asked but could not remember what it was = 1
(Maximum = 2)

Standardised Profile Score

Raw Score	0	1	2
Standardised Profile Score	0	1	2

Screening Score

Appropriate question asked without prompt when timer sounded = 1
(Otherwise = 0)

• 6b Story (delayed)

Action

Ask the subject to recall the prose passage for 'Delayed prose recall'. Give opening prompt if necessary.

Response

Record each of the 'ideas' correctly recalled or partially recalled against the appropriate passage on the Story Sheet.

Scoring

Score exactly as for 'Immediate prose recall' *but deduct one point if the subject needed an opening prompt.*

Raw Score

Each 'idea' recalled word-perfect or using a close synonym = 1
Each 'idea' partially recalled, or recalled with approximate synonym = ½
(Maximum = 21)

Standardised Profile Score

Raw Score	≤1.5	2–3.5	≥4
Standardised Profile Score	0	1	2

Screening Score

If the subject recalled at least six 'ideas' on 'Story (immediate)' and at least four 'ideas' on 'Story (delayed)' = 1
(Otherwise = 0)

• 8b Route (delayed)

Action

Ask the subject to reproduce the route for 'Remembering a short route' (delayed). Record each of the stages reproduced correctly below. The subject's response to 'Remembering to deliver a message' (delayed) should be recorder in the next section.

Response

Tick each stage of the route correctly recalled:

A Chair	door	window	table*	chair
B Door	window*	table	chair	door
C Window	table	chair*	door	window
D Table	chair	door*	window	table

Scoring

Raw Score

Total number of stages recalled correctly
(Maximum = 5)

Standardised Profile Score

Raw Score	≤3	4	5
Standardised Profile Score	0	1	2

Screening Score

All five stages of the route recalled in the correct order = 1
(Otherwise = 0)

• 9b Message (delayed)

Action

Remind the subject, if necessary, about the 'Message' envelope for 'Remembering to deliver a message' (delayed). The location is marked by an asterisk above.

Response

Tick as appropriate:

'Message' envelope picked-up spontaneously

picked-up after prompt

left at correct location

Scoring

Raw Score

'Message' picked-up spontaneously = 2
picked-up after prompt = 1
left at correct location = another
(Maximum = 3)

Standardised Profile Score
The Standardised Profile Score for 'Remembering to deliver a message' is based on the sum of the Raw Scores obtained for the **immediate and delayed** recalls (therefore maximum Raw Score = 6).

Sum of Raw Scores	≤4	5	6
Standardised Profile Score	0	1	2

Screening Score
If the subject spontaneously picked-up the 'Message' envelope and left it at the correct location in the **immediate and delayed** recalls = 1
(Otherwise = 0)

• 1 and 2 First and Second Name

Action
Re-present the portrait for 'Remembering a name'.
Give first letter prompt if necessary.
A Catherine Taylor
B Henry Fisher
C Pauline Roberts
D Philip Goodwin
Response
Tick as appropriate
First Name recalled without prompt
recalled with prompt
Second Name recalled without prompt
recalled with prompt
Scoring

Raw Score
• First Name recalled without prompt = 2
recalled with prompt = 1
(Maximum = 2)
• Second Name recalled without prompt = 2
recalled with prompt = 1
(Maximum = 2)

Standardised Profile Score
The Standardised Profile Score for 'Remembering a name' is based on the sum of the Raw Scores obtained for the recall of the **First and Second Names** (therefore maximum Raw Score = 4).

Raw Score	≤2	3	4
Standardised Profile Score	0	1	2

Screening Score
• If the subject recalled the First Name without prompt = 1
(Otherwise = 0)
• If the subject recalled the Second Name without prompt = 1
(Otherwise = 0)

• 3 Belonging

Action
Inform the subject that 'We have finished this test'.
Wait for recall of 'Remembering a hidden belonging'.
Prompt if necessary.
A Desk drawer
B Cupboard
C Filing cabinet
D Brief case or bag
Response
Tick as appropriate:
Place recalled without prompt
recalled with prompt
Item recalled without prompt
recalled with prompt
Scoring

Raw Score
Place recalled without prompt = 2
recalled with prompt = 1
Item recalled without prompt = 2
recalled with prompt = 1
(Maximum = 4)

Standardised Profile Score

Raw Score	≤2	3	4
Standardised Profile Score	0	1	2

Screening Score
If the subject spontaneously recalled the item and the place where it was hidden = 1
(Otherwise = 0)

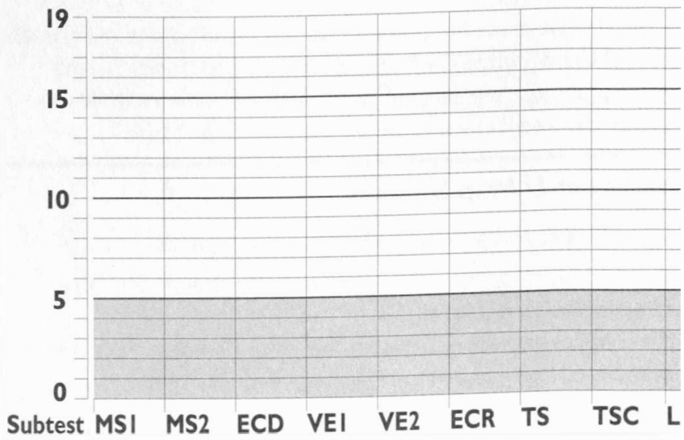
Score summary

	Standardised Profile Score (2,1 or 0)	Screening Score (1 or 0)
1 First Name		
2 Second Name		
3 Belonging		
4 Appointment		
5 Pictures		
6a Story immediate		
6b delayed		
7 Faces		
8a Route immediate		
8b delayed		
9 Message (immediate & delayed)		
10 Orientation (not including date)		
11 Date		
Total	maximum = 24	maximum = 12

TVTC Thames Valley Test Company

The Test of Everyday Attention

Scoring sheet



Subject and test details

Name

Age

Date of test

Version A B C

Score summary and scaled-scores

- **Subtest 1: Map Search** — Scaled-scores — Percentile
  - MS1: Symbols circled in one minute — see Appendix 1 Manual page 23
  - MS2: Symbols circled in two minutes — see Appendix 2 Manual page 24
- **Subtest 2: Elevator Counting**
  - Correctly-counted strings — 7 = normal; 6 = possibly abnormal; ≤5 = abnormal
- **Subtest 3: Elevator Counting with Distraction** — Scaled-score — Percentile
  - ECD: Correctly-counted strings (Rule out hearing impairments) — see Appendix 3 Manual page 25
- **Subtest 4: Visual Elevator** — Scaled-scores — Percentile
  - VE1: Raw accuracy score — see Appendix 4a Manual page 25
  - VE2: Timing score — see Appendix 4c Manual page 26
- **Subtest 5: Elevator Counting with Reversal** — Scaled-score — Percentile
  - ECR: Correctly-counted strings — see Appendix 5 Manual page 27
- **Subtest 6: Telephone Search** — Scaled-score — Percentile
  - TS: Time per target score — see Appendix 6 Manual page 27
- **Subtest 7: Telephone Search While Counting** — Scaled-score — Percentile
  - TSC: Dual task decrement — see Appendix 7 Manual page 28
- **Subtest 8: Lottery** — Scaled-score — Percentile
  - L: Number of responses with *at least* one letter correct and in the correct position — see Appendix 8 Manual page 29

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Bury St Edmunds
Suffolk IP28 6EL England

- *'We are interested in your concentration on a range of everyday tasks. I want you to imagine that you are on a long trip to Philadelphia (United States). I will ask you to do various tasks such as looking at maps and looking up telephone directories while you are on this imaginary trip. Let me explain the first task.'*

Subtest 1: Map Search

For full text and procedure see Manual page 13.

- Show subject the target symbol cue (version A, B or C in the test materials book).
- *'The symbol here shows where restaurants / garages / gas (petrol) stations can be found in the Philadelphia area. There are many symbols like this on the map.'*
- Show map and then turn over.
- *'Let's say you are with a family member or a friend...'*
- Give subject the map and red pen.
- After one minute swap red pen for blue pen.
- Stop after one further minute.

Raw score
Total symbols circled in one minute (red)

Raw score
Total symbols circled in two minutes (red + blue)

Subtest 2: Elevator Counting

For full text and procedure see Manual page 14.

- *'Imagine you are in an elevator (lift) in your hotel...'*
- Play first example (ensure you are using tape A, B or C).
- *'That's right, you would be on the third floor.'*
  (Or play tape again.)
- Play second example.
  (Rewind and repeat, counting with the subject at first, until they get the correct answer on their own.)
- *'Now I would like you to do the same thing with another series of elevator tones.'*

	1	2	3	4	5	6	7
A	3	5	6	8	11	9	14
B	4	6	7	9	12	14	10
C	5	7	6	8	10	14	12

Raw score
Score 1 for each correctly-counted string (maximum = 7)

Subtest 3: Elevator Counting with Distraction

For full text and procedure see Manual page 15.

- *'This time you will hear the same elevator tone but now there are also higher pitched tones...'*
- Play first example.
- *'That's right, you would be on the third floor.'*
  (Or play tape again.)
- Play second example.
  (Rewind and repeat, counting with the subject at first, until they get the correct answer on their own.)
- *'Now I would like you to do the same thing with another series of elevator tones.'*

	1	2	3	4	5	6	7	8	9	10
A	2	4	6	8	7	10	9	12	11	14
B	3	5	6	7	8	11	10	14	12	9
C	4	3	7	6	8	12	11	9	10	14

Raw score Score 1 for each correctly-counted string (maximum = 10)

Subtest 4: Visual Elevator

For full text and procedure see Manual page 16.

- *'Try to imagine that during your trip, you decide to stay in a large hotel...'*
- Show subject the first Visual Elevator practice item (labelled 'Practice 1' in version A, B and C in the test materials book).
- *'Look at this series of pictures...'*
- Go through Practice 1.
- Repeat Practice 1 as often as necessary until the subject gets the correct answer on their own.
- *'That's right, you would be on the second floor.'*
- *'Now try this next example.'*
- Show 'Practice 2' (next page of test materials book).
- *'That's right, you would be on the fourth floor.'*
- *'Now try and do the same with the next set of pictures...'*
- Prepare stopwatch to time each item.
- Subjects are allowed to make *one* correction on *each* item.

		1	2	3	4	5	6	7	8	9	10
Response											
✓/✗											
Time *(sec)*											
Answers	**A**	8	5	6	6	5	8	6	6	4	10
	B	8	3	2	5	8	4	9	2	10	6
	C	4	3	8	6	8	4	6	8	10	4
Switches	**A**	3	2	3	4	5	3	6	6	4	4
	B	4	2	3	3	4	3	5	3	6	4
	C	3	2	3	4	4	3	4	6	4	4

Raw accuracy score
Score 1 for each correctly-counted item (maximum = 10)

Total time taken for correct items (seconds)

÷ =

Timing score
(seconds per switch)

Total number of switches for the correct items

Subtest 5: Elevator Counting with Reversal

For full text and procedure see Manual page 18.

- Do not test subjects with severe brain damage.
- *'Now we are going to try something similar but a bit more complicated. Look again at what you did here.'*
  Point to Visual Elevator Practice 1 item.
- *'Remember how the big arrows tell you whether the elevator is going up or down? Now we are going to try an auditory (sound) version of this...'*
- Play first practice item, and count out loud: *'one – two – up – three – four – down – three – two...: so the answer is two.'*
- Rewind and play again for subject, pausing after each beep.
- Play second example. *'The answer is three.'*
- Play third example. *'The answer is three.'*
- Repeat the examples until the subject gets the correct answers on their own.

	1	2	3	4	5	6	7	8	9	10
A	3	1	3	5	8	2	6	2	6	8
B	3	5	3	3	8	2	8	4	6	8
C	1	5	1	5	8	2	8	2	6	8

Raw score Score 1 for each correctly-counted string (maximum = 10)

Subtest 6: Telephone Search

For full text and procedure see Manual page 19.

- *'In this exercise, you should imagine that you are using a telephone directory to look up various services while you are on your trip.'*
- *'Here we have the yellow pages you would see in a telephone directory, in this case it lists plumbers/restaurants/hotels.'*
- Show subject the target symbol cues (in the test materials book), the relevant yellow pages sheet, and a pen.
- *'Imagine that during your vacation (holiday)...'*
- Prepare stopwatch.
- *'Begin'*
- Start watch as subject makes first mark.
  Stop watch when subject puts cross in box.

Time taken (seconds) ÷ **Total number of correctly-circled symbols** (ignore any false positives) = **A** **Raw score** (time per target score)

Subtest 7: Telephone Search While Counting

For full text and procedure see Manual page 20.

- *'Now you will search through a different set of yellow pages for the same double symbols as in the last subtest. But this time, I will ask you to do a second and equally important task at the same time – counting a number of series of tones on the tape recorder...'*
- Show subject the restaurants/hotels/plumbers yellow pages.
- Play practice item, and count with the subject.
- *'So you will be looking for the same double symbols...'*
- *'Get ready...'*
- Prepare stopwatch.
- Subject starts when tape-voice says *'Ready...'*
- Start watch as subject makes first mark.
  Stop watch when subject puts cross in box.
- Note the number of strings of tones which the subject attempts in the box marked **C** below.

	1	2	3	4	5	6	7	8	9
Response									
✓/✗									
Answers **A**	4	8	3	6	1	12	2	5	7
B	6	1	12	2	5	7	5	9	2
C	2	5	7	5	9	2	6	11	3

	10	11	12	13	14	15	16	17	18
Response									
✓/✗									
Answers **A**	5	9	2	6	11	3	6	3	5
B	6	11	3	6	3	5	5	4	8
C	6	3	5	5	4	8	3	6	12

Time taken (seconds) ÷ **Total number of correctly-circled symbols** (ignore any false positives) = **B** Time per target score

Number of strings of tones correctly counted ÷ Number of strings of tones attempted **C** = **D** Proportion correctly counted

Re-enter **B** here ÷ Re-enter **D** here = **E** Time per target weighted for accuracy of tone-counting

Re-enter **E** here − Re-enter **A** here = **Dual task decrement**

Subtract

Subtest 8: Lottery

For full text and procedure see Manual page 21.

- *'While you are on your trip, you become interested in the state lottery...'*
- Show subject the target cues (version A, B or C in the test materials book) and give the subject a piece of paper and a pen.
- *'The radio programme goes on for quite a long time...'*
- Play the tape.
- Stop after first number ending in 55 / 88 / 33.
  Rewind and repeat until the subject responds correctly.

	1	2	3	4	5	6	7	8	9	10
A	HH	EA	LV	DR	CF	QO	TS	FN	FA	XT
B	WG	WA	LW	CT	YK	UF	CM	UA	RN	HY
C	FN	AT	XW	YG	EA	WN	RC	FO	HU	IT

Raw score Score 1 for each response with *at least* one letter correct *and* in the correct position (maximum = 10)

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RECORD FORM

NAME ______________________

ADDRESS ______________________

SEX ________ AGE ________ MARITAL STATUS ________

CCUPATION ______________________ EDUCATION ______________________

OUNTRY OF BIRTH ______________________ FIRST LANGUAGE ______________________

LACE OF TESTING ______________________ TESTED BY ______________________

THER INFORMATION ______________________

TABLE OF SCALED SCORE EQUIVALENTS*

Scaled Score	RAW SCORE											Scaled Score
	VERBAL TESTS						PERFORMANCE TESTS					
	Information	Digit Span	Vocabulary	Arithmetic	Comprehension	Similarities	Picture Completion	Picture Arrangement	Block Design	Object Assembly	Digit Symbol	
19	—	28	70	—	32	—	—	—	51	—	93	19
18	29	27	69	—	31	28	—	—	—	41	91-92	18
17	—	26	68	19	—	—	20	20	50	—	89-90	17
16	28	25	66-67	—	30	27	—	—	49	40	84-88	16
15	27	24	65	18	29	26	—	19	47-48	39	79-83	15
14	26	22-23	63-64	17	27-28	25	19	—	44-46	38	75-78	14
13	25	20-21	60-62	16	26	24	—	18	42-43	37	70-74	13
12	23-24	18-19	55-59	15	25	23	18	17	38-41	35-36	66-69	12
11	22	17	52-54	13-14	23-24	22	17	15-16	35-37	34	62-65	11
10	19-21	15-16	47-51	12	21-22	20-21	16	14	31-34	32-33	57-61	10
9	17-18	14	43-46	11	19-20	18-19	15	13	27-30	30-31	53-56	9
8	15-16	12-13	37-42	10	17-18	16-17	14	11-12	23-26	28-29	48-52	8
7	13-14	11	29-36	8-9	14-16	14-15	13	8-10	20-22	24-27	44-47	7
6	9-12	9-10	20-28	6-7	11-13	11-13	11-12	5-7	14-19	21-23	37-43	6
5	6-8	8	14-19	5	8-10	7-10	8-10	3-4	8-13	16-20	30-36	5
4	5	7	11-13	4	6-7	5-6	5-7	2	3-7	13-15	23-29	4
3	4	6	9-10	3	4-5	2-4	3-4	—	2	9-12	16-22	3
2	3	3-5	6-8	1-2	2-3	1	2	1	1	6-8	8-15	2
1	0-2	0-2	0-5	0	0-1	0	0-1	0	0	0-5	0-7	1

Clinicians who wish to draw a profile may do so by locating the subject's raw scores on the table above and drawing a line to connect them. See Chapter 4 in the Manual for a discussion of the significance of differences between scores on the tests.

	Year	Month	Day
Date Tested	___	___	___
Date of Birth	___	___	___
Age	___	___	___

SUMMARY

	Raw Score	Scaled Score
VERBAL TESTS		
Information	___	___
Digit Span	___	___
Vocabulary	___	___
Arithmetic	___	___
Comprehension	___	___
Similarities	___	___
Verbal Score		___
PERFORMANCE TESTS		
Picture Completion	___	___
Picture Arrangement	___	___
Block Design	___	___
Object Assembly	___	___
Digit Symbol	___	___
Performance Score		___

	Sum of Scaled Scores	IQ
VERBAL	___	___
PERFORMANCE	___	___
FULL SCALE	___	___

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8 9 0
k l m

1 INFORMATION Discontinue after 5 consecutive failures.	Score 1 or 0
1 Flag	
2 Ball	
3 Months	
4 Thermometer	
START → 5 Weeks	
6 PM-WW2	
7 Hamlet	
8 Italy	
9 Armstrong	
10 Johnson	
11 Sun	
12 Four PMs	
13 Brazil	
14 Pankhurst	
15 Southampton	
16 Clothes	
17 Martin L. King	
18 Sahara	
19 Genesis	
20 Relativity	
21 Koran	
22 Boiling point	
23 Yeast	
24 Blood vessels	
25 Population	
26 Curie	
27 New York	
28 Commons	
29 Faust	

Note: Be sure to include scores for items 1–4 in Total

Total	**Max=29**

2 PICTURE COMPLETION

Discontinue after 5 consecutive failures.

Item	Score 1 or 0	Item	Score 1 or 0
1 Door		11 Mirror	
2 Tennis		12 Crab	
3 Frog		13 Violin	
4 Playing card		14 Sun	
5 Car		15 Watch	
6 Pitcher		16 Leaf	
7 Glasses		17 Man	
8 Pliers		18 Horse	
9 Boat		19 Female profile	
10 Beach		20 Woodpile	
		Total	**Max = 20**

3 DIGIT SPAN

Discontinue after failure on BOTH TRIALS of any item.
Administer BOTH TRIALS of each item, even if subject passes first trial.

DIGITS FORWARD		Pass-Fail	Score 2, 1, or 0	DIGITS BACKWARD*		Pass-Fail	Score 2, 1, or 0
1	5–8–2			1	2–4		
	6–9–4				5–8		
2	6–4–3–9			2	6–2–9		
	7–2–8–6				4–1–5		
3	4–2–7–3–1			3	3–2–7–9		
	7–5–8–3–6				4–9–6–8		
4	6–1–9–4–7–3			4	1–5–2–8–6		
	3–9–2–4–8–7				6–1–8–4–3		
5	5–9–1–7–4–2–8			5	5–3–9–4–1–8		
	4–1–7–9–3–8–6				7–2–4–8–5–6		
6	5–8–1–9–2–6–4–7			6	8–1–2–9–3–6–5		
	3–8–2–9–5–1–7–4				4–7–3–9–1–2–8		
7	2–7–5–8–6–2–5–8–4			7	9–4–3–7–6–2–5–8		
	7–1–3–9–4–2–5–6–8				7–2–8–1–9–6–5–3		
	Total Forward		**Max = 14**		***Total Backward***		**Max = 14**

*Administer DIGITS BACKWARD even if subject scores 0 on DIGITS FORWARD.

Forward	+	Backward	=	Total (**Max = 28**)
	+		=	

4 PICTURE ARRANGEMENT

Discontinue after 4 consecutive failures beginning with item 2.

Arrangement		Order	Correct or *Acceptable* Order	Score (Circle)
1 House	60″	1 2	CAP	2 0 1
2 Flirt	60″		JANET *JNAET* or *AJNET*	2 0 1
3 Romeo	60″		SHADE	0 2
4 Louie	60″		ARGUES	0 2
5 Enter	90″		OPENS *OENSP*	2 0 1
6 Escape	90″		HUNT	0 2
7 Hill	90″		HELPS	0 2
8 Fish	90″		ANGLER or ARNGLE *AGNLER*	2 0 1
9 Robber	120″		LUNCH	0 2
10 Taxi	120″		SAMUEL or AMUELS *SALMUE*	2 0 1
			Total	**Max = 20**

Note: Be sure to include scores for items 1–5 in Total.

5 VOCABULARY Discontinue after 5 consecutive failures.	Score 2,1, or 0
1 Bed	
2 Ship	
3 Penny	
START → 4 Winter	
5 Breakfast	
6 Repair	
7 Fabric	
8 Assemble	
9 Enormous	
10 Conceal	
11 Sentence	
12 Consume	
13 Regulate	
14 Terminate	
15 Commence	
16 Domestic	
17 Tranquil	
18 Ponder	
19 Designate	
20 Reluctant	
21 Obstruct	
22 Sanctuary	
23 Compassion	
24 Evasive	
25 Remorse	
26 Perimeter	
27 Generate	
28 Matchless	
29 Fortitude	
30 Tangible	
31 Plagiarize	
32 Ominous	
33 Encumber	
34 Audacious	
35 Tirade	

Note: Be sure to include scores for items 1–3 in Total.

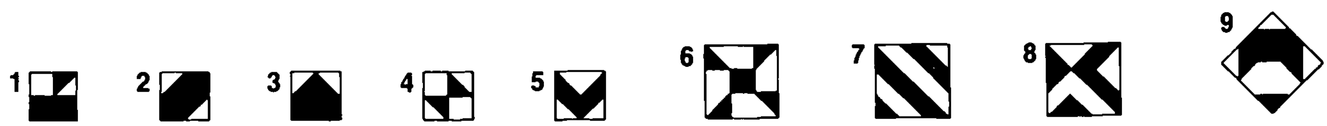
Total	**Max=70**

6 BLOCK DESIGN **Discontinue after 3 consecutive failures.**

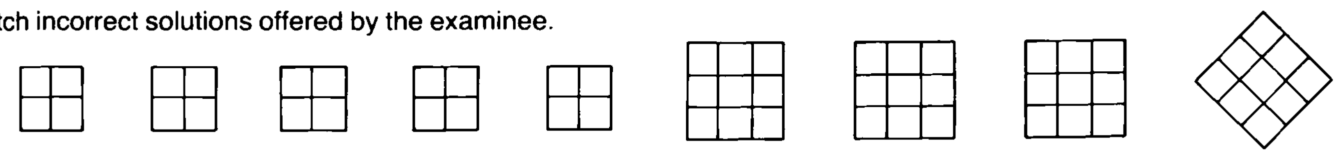
Design	Time	Pass-Fail	Score (Circle the appropriate score for each design.)						
1 60″	1				2				
	2		0	1					
2 60″	1				2				
	2		0	1					
3 60″			0			16-60 4	11-15 5	1-10 6	
4 60″			0			16-60 4	11-15 5	1-10 6	
5 60″			0			21-60 4	16-20 5	11-15 6	1-10 7
6 120″			0			36-120 4	26-35 5	21-25 6	1-20 7
7 120″			0			61-120 4	46-60 5	31-45 6	1-30 7
8 120″			0			76-120 4	56-75 5	41-55 6	1-40 7
9 120″			0			76-120 4	56-75 5	41-55 6	1-40 7

Total **Max = 51**

Correct solutions



Sketch incorrect solutions offered by the examinee.



Notes:

7 ARITHMETIC **Discontinue after 4 consecutive failures.**

Problem	Response	Score 1 or 0
1 15″		
2 15″		
3 15″		
4 15″		
5 30″		
6 30″		
7 30″		
8 30″		
9 30″		

Problem	Response	Time	Score (Circle)		
10 60″			0	11-60 1	1-10 2
11 60″			0	11-60 1	1-10 2
12 60″			0	11-60 1	1-10 2
13 60″			0	16-60 1	1-15 2
14 120″			0	16-120 1	1-15 2

Total **Max = 19**

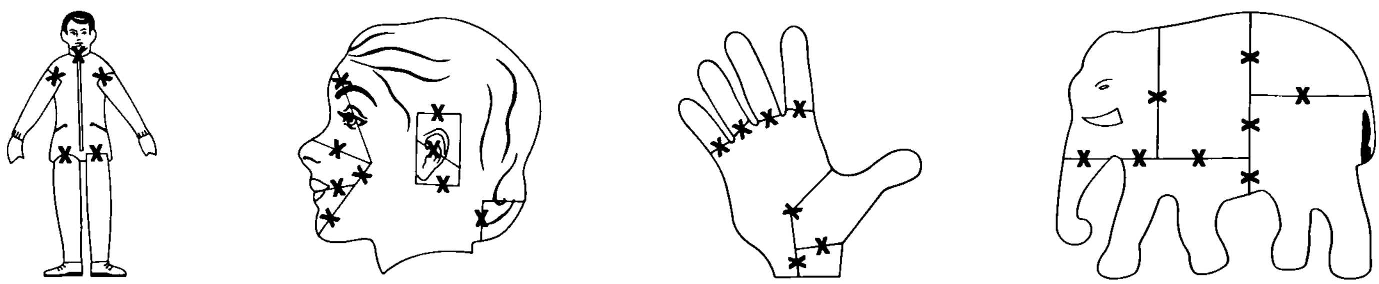
Note: Be sure to include scores for items 1-9 in Total.

8 OBJECT ASSEMBLY **Give entire test to all subjects.**

Object		Time	Score (Circle appropriate score for each object.)												
1 Manikin	120″		0	1	2	3	4	21-120 5	16-20 6	11-15 7	1-10 8				
								perfect assembly							
2 Profile	120″		0	1	2	3	4	5	6	7	8	36-120 9	26-35 10	21-25 11	1-20 12
												perfect assembly			
3 Hand	180″		0	1	2	3	4	5	6	51-180 7	36-50 8	26-35 9	1-25 10		
										perfect assembly					
4 Elephant	180″		0	1	2	3	4	5	6	7	51-180 8	31-50 9	21-30 10	1-20 11	
											perfect assembly				

Total **Max = 41**

Object Assembly: **For incomplete solutions, circle each X representing a connection for which the examinee receives credit.**



Notes:

Notes on the subject's performance of particular test items, unusual behaviour, or special conditions which may have influenced the results can be recorded below.

Test	Item No.	Notes

9 **COMPREHENSION** **Discontinue after 4 consecutive failures.**	**Score 2, 1, or 0**
1 Clothes	
2 Envelope	
*3 Foods	
*4 Child employment	
5 Deaf	
6 Borrow	
7 Cinema	
8 Marriage	
9 Tax	
10 Forest	
11 Prescription	
12 Iron	
13 Land	
14 Waters	
15 Swallow	
16 Press	
If the subject replies with only one idea, ask for a second response. Rephrase the test item appropriately, saying, **Tell me another reason why...** ***Total***	**Max=32**

Notes on the subject's performance of particular test items, unusual behaviour, or special conditions which may have influenced the results can be recorded below.

Test	**Item No.**	**Notes**

0 DIGIT SYMBOL

1	2	3	4	5	6	7	8	9
—	⊥	⊐	L	⊔	O	Λ	X	=

SCORE

SAMPLES

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4	5	6	3	1	4

1	5	4	2	7	6	3	5	7	2	8	5	4	6	3	7	2	8	1	9	5	8	4	7	3

6	2	5	1	9	2	8	3	7	4	6	5	9	4	8	3	7	2	6	1	5	4	6	3	7

9	2	8	1	7	9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

11 **SIMILARITIES** **Discontinue after 4 consecutive failures.**	**Score 2, 1, or 0**
1 Orange–banana	
2 Dog–lion	
3 Coat–suit	
4 Boat–car	
5 Eye–ear	
6 Button–zip	
7 North–west	
8 Egg–seed	
9 Table–chair	
10 Air–water	
11 Poem–statue	
12 Work–play	
13 Fly–tree	
14 Praise–punishment	
Total	**Max = 28**

ISBN 0 15 899239 3

Simon Gerhard

Hospital Anxiety and Depression Scale

NFER-NELSON
Health & Social Care

Name .... Date ....

Clinicians are aware that emotions play an important part in most illnesses. If your clinician knows about these feelings she or he will be able to help you more.

This questionnaire is designed to help your clinician to know how you feel. Ignore the numbers printed on the left of the questionnaire. Read each item and **underline** the reply which comes closest to how you have been feeling in the past week.

Don't take too long over your replies; your immediate reaction to each item will probably be more accurate than a long thought-out response.

fold along dashed line

A **I feel tense or 'wound up':**

3 Most of the time

2 A lot of the time

1 From time to time, occasionally

0 Not at all

D **I still enjoy the things I used to enjoy:**

0 Definitely as much

1 Not quite so much

2 Only a little

3 Hardly at all

A **I get a sort of frightened feeling as if something awful is about to happen:**

3 Very definitely and quite badly

2 Yes, but not too badly

1 A little, but it doesn't worry me

0 Not at all

(continued overleaf)

HOSPITAL ANXIETY AND DEPRESSION SCALE

fold along dashed line

D	A	
D		**I can laugh and see the funny side of things:**
0		As much as I always could
1		Not quite so much now
2		Definitely not so much now
3		Not at all
	A	**Worrying thoughts go through my mind:**
	3	A great deal of the time
	2	A lot of the time
	1	From time to time but not too often
	0	Only occasionally
D		**I feel cheerful:**
3		Not at all
2		Not often
1		Sometimes
0		Most of the time
	A	**I can sit at ease and feel relaxed:**
	0	Definitely
	1	Usually
	2	Not often
	3	Not at all
D		**I feel as if I am slowed down:**
3		Nearly all the time
2		Very often
1		Sometimes
0		Not at all
	A	**I get a sort of frightened feeling like 'butterflies' in the stomach:**
	0	Not at all
	1	Occasionally
	2	Quite often
	3	Very often

(continued overleaf)

HOSPITAL ANXIETY AND DEPRESSION SCALE

fold along dashed line

D	A	
D		**I have lost interest in my appearance:**
3		Definitely
2		I don't take as much care as I should
1		I may not take quite as much care
0		I take just as much care as ever
	A	**I feel restless as if I have to be on the move:**
	3	Very much indeed
	2	Quite a lot
	1	Not very much
	0	Not at all
D		**I look forward with enjoyment to things:**
0		As much as ever I did
1		Rather less than I used to
2		Definitely less than I used to
3		Hardly at all
	A	**I get sudden feelings of panic:**
	3	Very often indeed
	2	Quite often
	1	Not very often
	0	Not at all
D		**I can enjoy a good book or radio or TV programme:**
0		Often
1		Sometimes
2		Not often
3		Very seldom
D	A	

Now check that you have answered all the questions

For office use only:

D : ☐ Borderline 8–10

A : ☐ Borderline 8–10

Hospital Anxiety and Depression Scale Chart

for the monitoring of repeated scores

NFER-NELSON
Health & Social Care

Name: .... Age: .... Sex: ....

Anxiety

20
18
16
14
12
10
8
6
4
2

Depression

20
18
16
14
12
10
8
6
4
2

Treatment

Date

Code 4920 03 4

Sheffield Screening Test for Acquired Language Disorders

Diana Syder, Richard Body, Mark Parker, Margaret Boddy

NFER NELSON

Score Sheet

Client's Name .... Date of birth ....

Tester's name .... Date of test ....

....

Full instructions for administration and scoring are contained in the *Manual*.

Receptive Skills (Section 2)

1. Verbal Comprehension of Single Words *Score*

I'm going to ask you to point to some of the things in the room…

door ________ light ________ chair ________

ceiling ________ corner ________

2. Comprehension of Sequential Command

a) Point to the window and then to the door.

b) Before pointing to the ceiling, touch the chair.

3. Comprehension of a Complex Command

Tap the chair twice with a clenched fist, while looking at the ceiling.

4. Recognition of Differences in Meaning Between Words

I'm going to read you a list of words and I want you to tell me which is the odd one out:

a) chicken, duck, apple, turkey;

b) run, drink, walk, sprint;

c) small, large, massive, huge.

5. Comprehension of a Narrative

a) I'm going to read you a short paragraph and then ask you a question about it.
John went to the shop to buy a pen. When he got there he found that he had forgotten his wallet, so he came home and made himself a cup of tea.

What should he have taken with him?

b) I'm going to read you another paragraph.

Mrs Smith visited several shops. She bought a newspaper, a cauliflower, a stamp and some sausages.

What was the second shop she visited?

Receptive Skills: Total Score

Expressive Skills (Section 3)

6. Word Finding *Score*

Tell me the names of three well-known places in *the client's home town.*

Score one mark if three names are given correctly.

7. Abstract Word Finding

Tell me another word that means the same as:

a) beautiful;

b) angry;

c) ridiculous.

8. Sequencing

Describe how you would make a cup of tea.

A correct answer contains two or more appropriate stages in the right order.

9. Definitions

Describe what the following words mean:

a) home;

b) search;

c) ambitious.

10. Verbal Reasoning

I'd like you to tell me:

a) why you would use an umbrella;

b) why people go on holiday;

c) what would you do if you were locked out of the house.

Expressive Skills: Total Score

Receptive and Expressive Skills: Total Score

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