Selective Attentional Processes in mild Parkinson's Disease and mild Alzheimer's Disease

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Abstract

On tasks of visual selective attention, both patients with mild Parkinson's disease (PD) and mild Alzheimer's disease (AD) show patterns of performance that differ from those observed in healthy controls. Typically in research, selective attention is treated as a unitary concept and altered performance explained in terms of a broad inhibitory deficit, i.e. problems ignoring extraneous stimuli. This thesis sought to clarify whether the performance of these patients reflected mechanisms that impact on different stages of attentional processing. The goal of the series of studies reported was not to compare the performance of patients with PD (n=20 throughout) and AD (n=16 to 20), rather it was to examine within each patient group (and healthy controls) similarities or differences in patterns of performance across tasks. In each study, targets and distractors were presented simultaneously and the characteristics of the distractors and/or their relationship to the target stimuli were manipulated in terms of visual characteristics, location or meaning. The performance of patients with mild PD improved when distractors were semantically related to the target. It was suggested that this was due to a priming mechanism that aided stimulus identification, and so these patients tended to rely on the meaning of items within the visual array. In contrast, the performance of patients with mild AD did not benefit from semantic similarity and was impaired by visual similarity. It was suggested that these patients tended to rely on the visual characteristics of items, and so the distraction from extraneous visual information interfered with stimulus selection. A framework was suggested that articulated how the properties of visual stimuli interact with processing mechanisms that impact on different stages of selective attention. The impairment of different visual attentional processes in patients with mild PD and mild AD could have implications for the cognitive support provided to them.

Chapter 1: Introduction

Section 1 of this chapter provides a brief overview of the importance of selective attention generally and its particular relevance to people with Parkinson's disease or Alzheimer's disease. Section 2 details the research aims and objectives whilst section 3 provides definitions of key terms and concepts. Finally, section 4 presents a summarised structure of the remainder of the thesis.

1.1 Overview

The visual environment is full of competing information and the role of selective attention is to allow selection of important and relevant stimuli whilst ignoring other irrelevant stimuli (Pashler, 1999). Of course, importance and relevance are not static variables but rather they depend on both the task at hand and the motives of the individual, making stimulus relevance context dependent. Attention is of fundamental importance since impairments in selective attention can lead to visual scenes becoming cluttered thereby interfering with the ability to carry out everyday tasks efficiently (Hasher & Zacks, 1988). This makes understanding the variables which aid or impede the ability to attend to relevant information an important topic for investigation.

Attention is also important because of its interaction with other cognitive functions such as memory and the ability to plan and execute behaviours (Perry, Watson & Hodges, 2000). Thus, failures of selective attention can result in information overload, a particular problem for those with neurological disorders for whom other areas of cognition may already be compromised. This makes the study of selective attention in patient groups with neurological disorders particularly pertinent.

One such patient group are those diagnosed with Parkinson's disease (PD) which is a chronic, progressive neurological disorder with a broadly sub-cortical neuropathology (Green, 2000) (for diagnostic criteria see 1.3.1). PD is primarily associated with impairments in motor control arising from a substantial depletion of dopamine in the striatum within the basal ganglia which particularly affects the nigrostriatal pathways that are important for the control of motor movements (Agid, 1991). Indeed, patients with PD typically showed slowed movements and particular difficulties in initiating movements (Hoehn & Yahr, 1967). There is some evidence, however, that the presentation of visual cues can aid them. For example, the presence of blocks placed on the floor can improve stride length when walking (Lewis, Byblow, & Walt, 2000; Morris, Iansek, Matyas, & Sumners, 1994). This suggests that in some circumstances additional visual cues can be helpful and therefore selective attentional processes are of particular importance to this patient group.

In addition to difficulties with motor control, patients with PD, even in the early stages of the disease's progression, often have cognitive difficulties typified by slower performance than age matched controls. These problems are particularly apparent on tasks involving higher cognitive processes that are associated with the integrity of the frontal lobes such as task switching (Gauntlett-Gilbert, Roberts, & Brown, 1999) and inhibition of pre-potent or habitual responses (Henik, Singh, Beckley, & Rafal, 1993). These impairments also fit with a reduction in dopamine which modulates information flow through the basal ganglia that influences the frontal cortex by way of the thalamus (Alexander, Delong, & Strick, 1986; Haber, 2003). These findings again suggest altered selective attentional mechanisms in patients with PD.

Alzheimer's disease (AD) is also a progressive neurodegenerative disorder characterised by an initial amnesic syndrome when patients exhibit a severe deficit in episodic memory (Braak & Braak, 1995) (for diagnostic criteria see 1.3.2). This initial episodic memory deficit fits with the early neuropathology of AD which is focused in the medial temporal lobe structures (including both the hippocampus and entorhinal cortex) that are important for consolidating new memories (for review see Squires, 1992). The pathology then spreads to neocortical areas including the parietal and frontal cortices (Braak & Braak, 1995) when impairments are observed in many other areas of cognition including executive function, language and visual spatial abilities (Salmon & Bondi, 1997).

In AD, carers frequently report that patients show high levels of distractibility and lack of concentration when completing everyday tasks relatively early in the disease's progression, difficulties which are also noted during clinical observation (Perry & Hodges, 1999). Indeed, such problems are routinely reported despite the absence of impaired performance during clinical testing of non-memory functions (Perry & Hodges, 1999). These carers' reports suggest that it might be an inability to inhibit external distraction that is a particular problem for AD patients even in the earlier stages of the disease's progression. Such impairments are normally associated with sub-cortical pathology, frontal lobe functions and the reciprocal connections between these areas (Gainotti, Camillo, & Villa, 2001).

These observational reports fit with the neuropsychological data regarding the pattern of brain degeneration observed in AD. Firstly, in addition to pathology in the cortical and neocortical areas mentioned earlier, the disease's progression is also associated with the early degeneration in sub-cortical regions most particularly the nucleus basalis of Meynert (nbM) which has an important role in the distribution of

cholinergic neurotransmitters (Everett & Robbins, 1997). Early animal lesion studies suggested that cholinergic deficits adversely affect most areas of learning and memory, however these lesions lacked specificity (Dunnett, Everitt, & Robbins, 1991). As more precise lesion methods were developed, more specific impairments in both short-term and spatial memory were observed together with attentional deficits specifically in the visual domain (Dunnett et al., 1991). This finding of attentional deficits has been replicated in research using human participants (Muir, 1997). In addition to increased lesion specificity, findings of different kinds of impairments have also been attributed to the existence of two cholinergic projection systems; one from the nbM that projects to the frontal cortex and is associated with the attentional impairments and the other from the more rostral basal system that is responsible for impairments in memory function (Muir, 1997). Secondly, AD can be considered a disconnective syndrome, whereby rather than brain atrophy within the neocortex directly resulting in impairment, damage occurs in the entorhinal region which acts as a relay station for the reciprocal connections between the neocortex and the hippocampus (Braak & Braak, 1995). Under this theory, damage extends along the cortico-cortical connections as the disease progresses (DeLacoste & White, 1993).

As illustrated above, differences in performance on tasks of visual selective attention are often reported in both patients with mild Parkinson's disease (PD) and mild Alzheimer's disease (AD) when their performance is compared to that of healthy controls. These performance differences are typically explained in terms of a broad inhibitory deficit; an explanation that often lacks specificity. This lack of specificity applies not only in terms of the mechanisms that lead to altered performance but it also assumes that selective attention is a unitary concept. Therefore the purpose of this thesis was to clarify where altered performance is observed and suggest how the

properties of the stimuli presented interact with different mechanisms that may impact on different stages of selective attention.

1.2 Research aims and objectives

The overall aim of this thesis was to provide a better understanding of visual selective attention in people with a diagnosis of either mild PD or mild AD. Whilst selective attention is often treated as a global construct, to successfully attend to relevant information, the ability is required to: select which stimuli are relevant; identify those stimuli; and to formulate an appropriate response. An outline of these stages is given in Fig 1.1. Therefore, one of the aims of this thesis was to clarify whether altered patterns of performance occur at different stages of attentional processing. Differences in selective attention are often explained as arising from a broad inhibitory deficit (see section 1.3.3 for a discussion). A further aim of this thesis was to investigate whether different mechanisms underlie altered performance patterns (see Fig 1.1 for suggested mechanisms). To achieve these aims the characteristics of target and distractor items were systematically manipulated. The effects on different stages of attentional processing were assessed and linked to suggested mechanisms underlying the altered performance. The review of research approaches in Chapter 2 will elaborate on the rationale for adopting this framework. Thus the research aims and objectives of this thesis (which were investigated at a behavioural level) were:

- **Characteristics:** To quantify the effects on performance of different types of visual distractors presented simultaneously with visual targets.

- **Mechanisms:** To infer whether different mechanisms underlie performance differences arising from the characteristics of visual distractors.
- **Stages:** To evaluate whether altered performance arising from the characteristics of the visual distractors occurs at different stages of attentional processing.

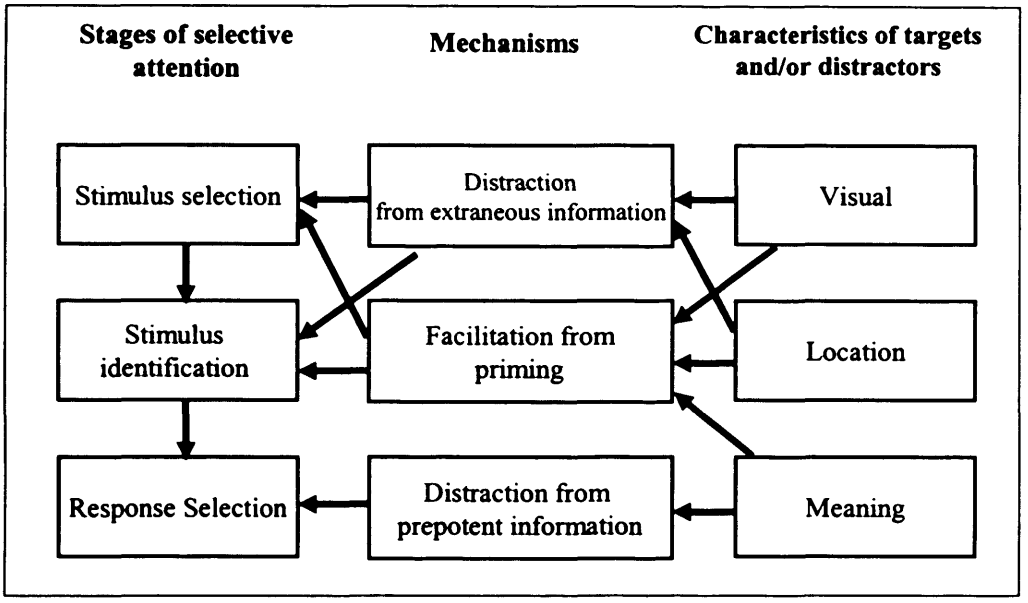


Figure 1.1: Schematic representation of stimulus characteristics and mechanisms that may impact on different stages of selective attention

Patients with PD or AD were chosen as the focus of this thesis as both are neurological disorders that are associated with disruptions in selective attentional processes (Dubois & Pillon, 1997; Perry & Hodges, 1999). The aim of this thesis was not to directly compare the performance of the two patient groups rather it was to identify the mechanisms responsible for changes in attentional processes within each

group by comparing the performance of each patient group independently with the performance of a group of healthy controls across a number of tasks (for rationale for the tasks chosen see Chapter 2, p.43).

1.3 Definition of key terms and concepts

1.3.1 Probable mild Parkinson's disease (PD)

PD is a common progressive neurological disorder affecting approximately 1 in 100 adults over the age of 60 (Cummings & Masterman, 1999). Whilst PD can occur throughout adulthood (Golbe, 1991; Schrag, Ben-Shlomo, & Quinn, 2000) it is mainly diagnosed in later life and therefore this thesis does not consider issues arising from early-onset PD. A definitive diagnosis of PD can only be made post-mortem, however probable diagnoses are made using the UK Parkinson's Disease Society Brain Bank clinical diagnostic criteria (Hughes, Daniel, Kilford, & Lees, 1992). Under these criteria a diagnosis of probable Parkinson's disease is made if patients display bradykinesia (slowness in initiating motor movements) together with at least one of the following: muscular rigidity, a 4-6 Hz resting tremor or, instability of posture not primarily due to other causes such as problems within the inner ear or visual difficulties. Also, other possible causes of the patients' difficulties such as a history of repeated strokes, head injury or dementia must be excluded before a diagnosis of probable PD can be made (Hughes et al., 1992).

As PD is a progressive disorder, the severity of the symptoms associated with it increase over time. This leads to a gradual decline in the ability to carry out everyday tasks unaided. Only people with mild symptomology were considered because this thesis was interested in changes in selective attention that occur early in

the disease's progression. Mild symptomology is defined by reference to Hoehn & Yahr's (1967) criteria. These criteria identify five stages of impairment ranging from the most minimal (stage I) to very impaired (stage V) where independent living is unlikely. All patients within the studies reported here have ratings of between stage I and stage III. Patients are classified as being within stage III if they are able to live independently but may be restricted in some activities.

Finally, all patients reported within this thesis maintained their usual dopamine replacement medication regime. Whilst differences in the pattern of results both within tasks and across tasks may be attenuated by their medication regime, differences in selective attention have been previously observed in medicated patients. This may be due to damage to the reciprocal projections between the prefrontal cortex and other cortical and sub-cortical regions (Heyder, Suchan, & Daum, 2004). There were two main reasons for choosing to test patients whilst on their medication: firstly their performance will be more analogous to their performance on everyday tasks when they will always be taking medication and secondly to ask patients to cease taking their medications albeit temporarily has ethical implications. Given that there is evidence of altered selective attention on medication it was not necessary to ask people to halt medication to effectively investigate the issues at hand.

1.3.2 Probable mild Alzheimer's disease (AD)

AD is also a common progressive neurological disorder with approximately 1 in 14 adults over the age of 65 having a form of dementia. AD is the most common type of dementia representing approximately 62% of cases (Alzheimer's Society, 2007). Like PD, AD can occur throughout adulthood although it is most common in

older people (Alzheimer's Society, 2007). This thesis does not consider issues arising from early-onset AD. Also, as the disease progresses, the level of cognitive impairment increases. As with the patients with PD, only patients with AD within the mild stages of the disease were recruited. This was because the studies within this thesis addressed changes in selective attention occurring early in the disease's progression. Defining stages of cognitive impairment in people with AD is not straightforward due to factors such as pre-morbid IQ and the heterogeneity of the disorder (Weintraub, 2000). One measure that is commonly used is the MMSE (Folstein, Folstein, & McHugh, 1975) which is a screening tool for cognitive impairment with a score of 18 or above normally taken as evidence of mild impairment. All patients within the studies reported here have MMSE scores of 18 or above.

Finally, all patients reported within this thesis had a recent diagnosis of AD and were tested either before or within a few days of commencing cholinesterase inhibitor medication. There were two main reasons for choosing to test before they commenced medication: firstly medication would be predicted to reduce problems with concentration and distractibility and secondly not all patients are suitable candidates for medication making comparisons difficult.

As with PD, a definitive diagnosis of AD can only be made post-mortem, however diagnoses of probable AD are made in accordance with the NINCDS-ADRDA criteria (McKhann et al., 1984). Under these criteria, patients must display progressive deficits in memory and at least one other area of cognition together with impaired activities of daily living and altered patterns of behaviour. Also, other disorders which could account for the pattern of cognitive deficits and behavioural changes observed must be excluded.

1.3.3 Inhibitory processes as a global concept

One of the difficulties in evaluating research which explains differences in selective attention in terms of a global impairment in inhibitory function is the failure to clearly define what is meant by the term 'inhibition' in both theoretical models and particular experimental contexts (Friedman & Miyake, 2004; Harnishfeger, 1995; MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). One global model is that of Hasher & Zacks (1988) who proposed that familiar stimuli automatically activate memory processes and that this activation is modulated by attention. In their model, attention involves both excitatory mechanisms, which activate information, and inhibitory mechanisms which suppress extraneous information thereby reducing the demands on working memory. This model has been widely tested within a number of experimental paradigms; however, it is not without its critics (for review see MacLeod et al., 2003). One of the major criticisms that may be levelled against their original model is that it lacked explanatory power. However, more recently (e.g. Lustig, Hasher, & Zacks, 2007) they have accepted that inhibitory deficits may result from multiple causes and have sought to clarify under what circumstances each of these mechanisms might be responsible for any inhibitory deficit observed.

The problem of agreeing on a definition of inhibition is also highlighted by the fact that different tasks deemed to measure inhibitory processes are often not highly correlated (e.g. Shilling, Chetwynd, & Rabbitt, 2002) suggesting that they may tap different processes which could be differentially impaired (Nigg, 2000). Whilst accepting that a lack of significant correlations need not necessarily imply separable inhibitory functions for a number of reasons such as poor reliability of measures (Rabbitt, 1997), the establishment of strategies over time (Friedman & Miyake, 2004)

and, that there are no pure measures of inhibition (Shilling et al., 2002), it still raises the question of whether incremental performance differences are indicative of a single global process or, whether different processes might be responsible for the patterns of performance observed especially in people with neurological impairment.

1.3.4 Taxonomies of inhibitory processes

Taxonomies of inhibitory functions seek to identify and quantify different types of inhibitory processes. The taxonomy approach is based on two strands of evidence: low correlations between different inhibitory tasks and evidence of disassociations between different patterns of impairments within particular disorders e.g. between Attention Deficit Disorder and Attention Deficit Hyperactive Disorder (Nigg, 2000). This evidence suggests separable inhibitory deficits.

Several authors have suggested ways in which different inhibitory processes may be differentiated. For example, Harnishfeger (1995) suggested that inhibitory processes could be differentiated on several dimensions; firstly unintentional processing which is automatic without conscious awareness versus intentional processing which requires controlled processing of the stimuli displayed. These distinctions have been adopted in evaluating inhibitory processing in AD (Amieva, Phillips, Della Sala, & Henry, 2004). Secondly, distinctions were made between behavioural inhibition, cognitive inhibition and resistance to interference. Behavioural inhibition encompasses behaviour such as inhibiting motor responses and controlling impulses. Cognitive inhibition is defined as the control of mental processes, such as suppressing irrelevant information from working memory, whilst resistance to interference pertains to preventing irrelevant information entering working memory. This taxonomy is very similar to one proposed by Nigg (2000)

although he also identified a fourth component which he termed ocular motor inhibition which seems to split behavioural inhibition between dominant motor responses and dominant cognitive responses.

Friedman & Miyake (2004) proposed an inhibitory structure which bears similarities to the earlier proposals of Harnishfeger (1995) and Nigg (2000). Taking each category in turn, prepotent response inhibition is described as 'the ability to deliberately suppress a dominant or automatic response' (Friedman & Miyake, 2004 p.104) which they measured using the antisaccade task, stop signal task and the Stroop task. Resistance to distraction is considered the ability to 'resist or resolve interference from the external environment that is irrelevant to task goals' (Friedman & Miyake, 2004 p.104) although the authors point out this can arise either through distraction from the irrelevant information or by selective enhancement of the relevant information. Finally, proactive interference is described as resistance to intrusions from previously relevant information which is no longer relevant. The important difference between resistance to distraction and resistance to proactive interference is that in resistance to proactive interference the irrelevant information was presented prior to the task at hand and not simultaneously (Friedman & Miyake, 2004). Since proactive interference is reliant on intact memory processes which are impaired in patients with AD, interference from this source is not considered in this thesis.

Friedman & Miyake (2004) noted that one problem with the taxonomy approach is the lack of systematic investigation and hence empirical evidence for the theoretical distinctions made. They tested young adults on a number of tasks deemed to tap the different inhibitory related functions they had identified using latent variable analysis. This is a statistical technique that seeks to quantify the common variance arising from multiple tasks deemed to represent a hypothesised underlying

construct (Friedman & Miyake, 2004). They found an association between prepotent response inhibition and resistance to distraction but no association between resistance to proactive interference and the other two variables. Friedman & Miyake (2004) suggested that both prepotent response inhibition and resistance to distraction require maintaining the task goal in spite of more dominant responses or distracting stimuli in the environment. They suggested that the ability to maintain goal related information might be the common mechanism between the two processes and that it is related to executive function. Therefore these attentional mechanisms were included in the framework depicted in Fig. 1.1 (p.7). Whilst Friedman & Miyake (2004) did not consider the possibility of improved performance this thesis does consider that possibility. Therefore to summarise, the following working definitions of attentional mechanisms were adopted throughout the thesis:

- **Distraction from prepotent information:** refers to impaired task performance arising from the failure to suppress a dominant or automatic response to irrelevant stimuli presented simultaneously with the to-be-attended (target) stimuli.
- **Distraction from extraneous information:** is impaired task performance arising from a failure to resist interference from the current visual environment that is irrelevant to task goals.
- **Facilitation from extraneous information:** is improved task performance arising from the presence of concurrently presented extraneous visual information.

1.3.5 Extraneous information: Presented at fixation or peripherally

Extraneous visual information can either be presented at fixation, i.e. in the same spatial location as the to-be-attended stimulus, or peripherally in a spatially separate location. Distractors presented in the same spatial location are more difficult to ignore than those presented in spatially separate locations. For example, Wühr & Waszak (2003) demonstrated that 'Stroop like' interference was significantly greater when an incongruent colour word was presented within a to-be-named colour block than when it was presented in a peripheral position. They suggested that part of the difficulty in suppressing the automaticity of word reading is that the word is integrated within the to-be-attended stimuli. This explanation fits with object-based theories of selective attention (e.g. Kahneman & Henrik, 1981) which argue that at a perceptual level items within the visual field are first separated into objects and background. Then attentional processes select particular objects for further processing at which time all features of those selected objects are processed regardless of their relevance to the task at hand. This is not to say that other factors such as the salience of the target items and the distractors are not important, rather it suggests that if the same sorts of distractors are presented peripherally as opposed to at fixation the amount of interference arising due to the presence of these distractors should be reduced because they can be categorised as background. Indeed, Hartley (1993) found that moving the incongruent colour word so that it was adjacent to a colour block attenuated the age differences in performance between young and old adults which is normally seen in the usual Stroop paradigm.

1.3.6 Extraneous information and priming

Priming occurs when the presentation of an additional stimulus (or stimuli) results in differential performance when interacting with a target stimulus even though the priming stimulus (or stimuli) is not relevant to the task at hand. Priming effects can either be positive and result in improved performance (either in terms of response times or in reduced number of errors) or alternatively priming can be negative and lead to impaired performance. Usually, in priming paradigms the priming stimulus is presented prior to the to-be-attended stimulus rather than presented simultaneously with it. Therefore such priming effects do not fall into the two types of distraction defined in 1.3.4 above. Both of these definitions refer to extraneous information currently available in the visual environment whereas priming paradigms typically involve using past information with the priming effects, rather than being instantaneous, accumulating over brief time-frames (May, Kane, & Hasher, 1995). Indeed, Friedman & Miyake (2004) reasoned that if negative priming and the effects of distractor interference (from concurrently presented distractors) resulted from the same underlying process then there should be a negative correlation between the two effects. That is, participants who show less interference from distractors should show larger negative priming effects since successfully ignoring distractors should make it correspondingly more difficult to overcome this suppression when the distractors subsequently become target items. They found no evidence that this was the case and concluded that 'the assumption that negative priming reflects the active suppression of distractors must be treated with caution' (Friedman & Miyake, 2004 p.119). Furthermore, to some degree such priming effects are reliant on short-term memory processes (May et al., 1995) which, as well as increasing the load for patients with AD, are not the focus of this thesis.

Whilst the priming effects described earlier may not be a direct measure of visual distraction, they still provide a useful basis for discussing the type of stimulus characteristics that may help or impede task performance. Distinctions can be made on several parameters, one of which is the location of the targets and whether this location is predictable or unpredictable. When the target is unpredictable across trials this necessitates a search of the entire visual field and inspection of all items (unless the target can be readily identified on the basis of a unique salient feature) whilst, when the target is predictable the participant knows in advance which area of the visual field to focus on thereby eliminating the need to search other areas. Different strategies may be required in either of these cases and may impact on overall performance. Alternatively the relationship between the target and the distractor can be manipulated so, for example, they may be semantically related versus unrelated and again the relationships between to-be-attended-to items and other items within the visual environment may impact on task performance. So, in regard to these characteristics, reference to the priming literature is pertinent to the objectives of this thesis as defined in 1.2, p.6.

1.3.7 Activation of categorical information and the relationship to distraction and facilitation

As stated above, the characteristics of the extraneous information may be an important factor in whether it disrupts or alternatively aids task performance and one variable that may be important here is the categorical relationship between the target and distractor items. One model which is relevant to this discussion of how categorical relationships are stored is the parallel distributed processing (PDP) model (e.g. McClelland & Rogers, 2003). In this model, superordinate categories (e.g.

vehicle) are represented in a semantic space with basic level categories (e.g. car) embedded within that space and subordinate categories (e.g. mini) embedded within the basic level category space. When visual stimuli are processed, the visual input from that stimulus passes through the superordinate category space before reaching the basic level category area, therefore the category becomes activated before that of the more specific basic level category, i.e. vehicle will become activated before car (Rogers & Patterson, 2007). Therefore, if the specific basic level category information cannot be accessed due to semantic difficulties, the superordinate categories which cover a wider range of features should still be available. Conversely, when visual distractors represent the superordinate category to which the target items belong, this activation might aid identification of the target providing that the patient's semantic information was intact. This motivated the use in this thesis of distractors varying in semantic similarity to the target items.

1.4 Thesis structure

Chapter 2 reviewed the visual selective attention literature and critically appraised work in the field. It also discussed the rationale for the choice of experimental paradigms used to investigate the selective attention mechanisms which may be altered in mild PD and mild AD. As the same research paradigms were used with both the patients with mild PD and the patients with mild AD, they were described in their entirety in Chapter 3 to reduce the need for repetition. Chapters 4 and 5 report the results of studies carried out with the patients with mild PD whilst Chapters 6 and 7 report the results of studies carried out with the patients with mild AD. The main aim of the first chapter for each patient group (Chapters 4 and 6) was to investigate how peripheral visual distractors altered the performance of the relevant

patient group at different stages of selective attentional processing and to infer the mechanisms that led to the altered performance. The main aim of the second chapter for each patient group (Chapters 5 and 7) was to further delineate the distractor characteristics and mechanisms underlying the altered task performance. These chapters used different variations on these original methodologies. The rationale for the variations used, together with details of these adaptations are given in the relevant chapters. Finally, Chapter 8 provides an overall discussion of the findings and brings together the themes of the thesis. It also evaluates the overall strengths and weaknesses of the experimental approach adopted together with suggestions for further research.

Chapter 2: Research Approaches in the Visual Selective Attention Literature

Sections 1 and 2 of this chapter review the relevant visual selective attention research literature that has been undertaken where the participants were patients with mild PD or mild AD. Section 3 provides a broad outline of the literature appertaining to older people generally which, whilst not the focus of this thesis, is relevant since older people acted as healthy controls in all the studies reported. Finally, section 4 describes the experimental paradigms chosen and the rationale for these choices in terms of their relevance to investigating the issues at hand.

2.1 Patients with mild PD

2.1.1 Distraction from prepotent visual information

Both medicated and un-medicated patients with PD show deficits on the classic Stroop task (Stroop, 1935) which involves naming the colour ink in which incongruent colour words are printed, e.g. the word RED printed in green ink (Brown & Marsden, 1988; Dujardin, Degreef, Rogelet, Defebvre, & Destee, 1999; Henik et al., 1993). However, Brown & Marsden (1988) also demonstrated that differences in performance (compared to healthy controls) are attenuated when a cue is provided to indicate the required response on each trial, i.e. word or colour. This suggests that patients with PD can benefit from task relevant external cues to assist them in task performance.

Henik, Singh, Beckley, & Rafal (1993) adopted a slightly different approach to evaluating the effects of prepotent information by using an adapted version of the

original Stroop colour-word task. As usual, the task was to name the colour ink in which words were written but, rather than comparing performance to baseline colour naming performance, their control trials consisted of neutral words (animals) printed in different colour inks. They then conducted independent analyses comparing performance on these trials with either the Stroop trials or with trials where the word was consistent with the ink colour e.g. the word RED printed in red ink. Finally, the trials were presented in two blocks with the proportion of incongruent to neutral words (75% neutral words or 25% neutral words) varied between blocks. In respect of the Stroop trials, the patient group made significantly more errors than the healthy controls but the groups did not differ significantly in terms of reaction times regardless of the proportion of neutral/incongruent words presented. However, the reaction time data must be interpreted cautiously because the performance of the patients with PD was slower than controls in the control condition. This could reflect either distraction from the neutral words or a more general reduction in processing speed. However, taken together with the error data this again suggests that patients with PD have particular difficulty suppressing automatic responses. As predicted, both groups showed facilitation effects indexed by faster performance when the word was congruent with the ink colour. Furthermore, in blocks of trials where the majority of words (75%) were congruent with the ink colour, there was some evidence of enhanced facilitation effects in patients with PD, although these failed to reach statistical significance ($p=.08$). There was no evidence of enhanced facilitation effects when the words were congruent with the ink colour on only 25% of the trials presented. This provides tentative evidence of enhanced facilitation effects in the patient group.

Increased interference from prepotent information presented peripherally has also been found using flanker tasks that employ arrows as target and distractor items (Praamstra, Plat, Meyer, & Horstink, 1999; Praamstra, Stegeman, Cools, & Horstink, 1998; Seiss & Praamstra, 2006; Wylie, Stout, & Bashore, 2005). In these studies, participants were required to press a key that corresponded with the direction the central target arrow was pointing; the target was either presented alone or with four distractor arrows two positioned either side of the target. The direction of these arrows was either congruent or incongruent with the target arrow. The overall findings were that the patients with PD were particularly slowed by the presence of incongruent arrows. This suggests that patients with PD have particular difficulties when presented with distracting visual stimuli that elicit a response incongruent with that required by the task at hand even when the distractor is not at fixation.

Another task frequently used to assess the ability to suppress automatic responses is the Go/No-go task. Participants are presented with repeated trials of visual stimuli and instructed to only make a response on trials where a critical stimulus appears and withhold a response on other trials (Amieva, Phillips, Della-Sala, & Henry, 2004). Bokura, Yamaguchi, & Kobayashi (2005) gave participants a version of the Go/No-go task that used different numbers as both the to-be-responded-to and the no-response stimuli. In their manipulation responses were required 70% of the time, thereby encouraging the development of an automatic tendency to respond to each stimulus. They found that the patients with PD made significantly more errors, i.e. by falsely responding to a stimulus where a response should be withheld, than did healthy controls. This suggests the patients had a reduced ability to withhold an automatic response. However, these performance differences did not extend to response times, although this could have resulted from a time-accuracy trade-off

which may have masked slower performance by the patients with PD. Similar impaired performance by patients with PD on Go/No go tasks has been found using symbols (Franz & Miller, 2002; Gauggel, Rieger, & Feghoff, 2004) and shapes (Gauggel et al., 2004) as stimuli. This also suggests that patients with PD have particular difficulties with resisting interference from visual distractors that elicit an automatic response.

The ability to inhibit semantic information has been assessed in patients with PD using the Hayling sentence completion task (Burgess & Shallice, 1997) which measures the ability to complete sentences using words which are not relevant to the sentence context. Whilst this task involves the inhibition of an internally generated prepotent response and is therefore not relevant to the effect of visual distractors, it does show how patients with PD deal with semantic distractors. People who display impairments on this task typically generate the word normally associated with the sentence or a semantically related word. Both Bouquet, Bonnaud, & Gil (2003) and Castner et al. (in press) found that patients with PD were impaired on this task such that they made more errors than healthy controls, suggesting they have particular difficulties in suppressing semantically related responses.

2.1.2 Distraction from extraneous visual information

Evidence is less clear for heightened distractibility due to irrelevant non-prepotent visual information. Lee, Wild, Hollnagel, & Grafman (1999) used letters as targets and distractors within a flanker task administered to medicated patients with mild PD and age-matched controls. They found that although the patient group were slower overall they were not significantly impaired or facilitated by incongruent or congruent flankers regardless of their spatial distance from the target letter. The same

pattern of results was obtained using flankers whose colour was either incongruent or congruent with the colour of the target item (Cagigas, Filoteo, Stricker, Rilling, & Friedrich, 2007). This suggests that only distractors that elicit a strong pre-potent response are problematic to these patients.

In contrast, Sharpe (1990) did find evidence of enhanced distractibility. Again, medicated patients with mild Parkinson's disease and age-matched controls repeated sequences of between five and nine letters immediately after presentation in one of four conditions. The participants were matched in terms of short-term memory span by using a digit forward task. In two baseline conditions each letter was presented alone either in a constant location on the screen or unpredictably switching between two possible locations. In the two distraction conditions, the target letter was also accompanied by a distractor letter; again each target letter's position within the sequence could be predictable or unpredictable. In terms of correct responses, she found that the patient group were significantly less accurate than controls when distractors were present but only when the location of the target was unpredictable. This suggests that patients with mild PD have particularly difficulties in tasks where the location of the target items is unpredictable.

2.1.3 Extraneous visual information and priming

As discussed in chapter 1, negative priming does not reflect either distraction from prepotent information or distraction from extraneous information because the distractors are not presented simultaneously with the target stimuli. However, it does afford some insight into the way that the different characteristics of extraneous information affect task performance in medicated patients with PD. However, early studies of negative priming in Parkinson's disease often produced contradictory

results. This may have been due to subtle differences in experimental manipulations (Stout, Wylie, & Filoteo, 2002) but is also likely to be due to the tendency to mix both location and identity priming within one experimental manipulation. This may have caused difficulties in interpreting the results obtained.

An example of research that has combined location and identity priming is that of Filoteo, Rilling, & Strayer (2002) who used a letter identification task where the target letter's position was unpredictable. Hence in all conditions, any priming effects could be due to location or identity. In the control condition, the target letter in both the probe and prime trials differed from the distractor letters in each trial and from each other. In the experimental ignored-repetition condition, the distractor letters in the prime display became the target letter in the probe display. They found that the control group showed negative priming whilst the patients with PD did not, although it is noteworthy that half of the patient group (8 of 15) did show evidence of negative priming. The authors did try to separate the effects of identity and spatial priming by dividing the trials on the basis of whether the location of the target letter changed between the prime and probe displays. However, this approach assumes that each trial can be treated as a discreet unit. This assumption must be made with care since the n-1 probe trial may affect performance on the n trial (prime) which in turn may affect performance on the n+1 trial. It seems that mixing the two types of trials could be equated with a task-switching paradigm, which in itself will be particularly difficult for patients with PD who have well-documented difficulties with task switching (e.g. Gauntlett-Gilbert et al., 1999).

In contrast, Wylie, & Stout (2002) used a simple choice reaction time task in which a target shape was presented with two distractor shapes on a touch screen monitor. The task was to touch the distractor shape that was the same as the target.

Several conditions were used: identity priming where the to-be-ignored distractor shape on one trial became the target on the next trial; location priming where the position of the to-be-ignored distractor shape on one trial became the position of the target shape on the following trial; combined identity and location priming where the target shape was in the same location and identical to the to-be-ignored distractor from the previous trial; and a control condition where all stimuli were different between the prime and the probe trials. Overall, whilst the patients' reaction times were slower across all trials they showed larger negative priming effects for both identity and location priming than the controls. The studies of Filoteo et al. (2002) and Wylie, & Stout (2002) thereby demonstrate the difficulties of interpretation arising from mixing both types of priming within one experimental manipulation.

To separately investigate the effects of location and identity, Troche, Trenkwalder, Morelli-Canelo, Gibbons, & Rammsayer (2006) tested 48 medicated patients and an equivalent number of healthy controls on separate location and identity priming tasks. The identity priming task used a number version of the flanker task where participants responded to a centrally located number that was flanked on either side by two identical distractor numbers. In the location priming task the letters X and O were used and participants responded to the location of the letter X. Each task had four conditions: a) a repeat condition where the probe and prime displays were identical, b) an ignored-repetition condition where the distractors in the probe display became the target in the prime display, c) a control condition where the prime and probe displays each contained different numbers (identity priming) or, target and distractor items in different locations, and d) a target to distractor condition where the target in the probe became the distractor in the prime display. In respect of negative priming, whilst the patients with PD were slower than controls overall there was no

evidence of identity negative priming in either group. Also, both groups showed equivalent levels of location priming. These results are consistent with other studies with smaller participant numbers (e.g. Possin, Cagigas, Strayer, & Filoteo, 2006). These findings of equivalent negative priming effects in patients with PD and controls extended to the condition where targets subsequently became distractors, in which no priming effects were found in either group.

In terms of positive priming, Troche et al. (2006) found that whilst controls responded more quickly overall than the patient group, the patient group showed reliably larger positive priming when either the identity or location of the target was repeated from the probe to the prime displays. They concluded that this positive priming arose from patients with PD having difficulty attending to relevant stimuli rather than through problems ignoring irrelevant stimuli. This conclusion was supported by finding no differences in negative priming between the groups, which would have been predicted if ignoring irrelevant stimuli was responsible for the positive priming or facilitation effects observed.

Turning now to the effects of semantically related information, Mari-Beffa, Hayes, Machado, & Hindle (2005) used lexical decision tasks where, in both prime and probe trials, participants had to decide whether the target item was a word or a pseudo-word. Targets were always presented with two identical distractor words positioned immediately above and below the target item. In experiment 1 there were two conditions: semantically-related and unrelated. In the semantically-related condition, the distractor words on the prime trial were semantically related to the subsequently presented probe target whereas in the unrelated condition they were not. In experiment 2, the semantically-related trials were replaced by repetition trials in which the prime distractor word subsequently became the probe target word. In both

experiments, the distractor words on the probe trial had not been used in the prime trials and were unrelated to the target in the prime trial. Also, participants were explicitly instructed that the distractors should be ignored and that ignoring them would help in completing the task. Despite these explicit instructions, they found that in both experiments the patient group showed positive priming, with significantly faster reaction times when the prime distractors were either semantically related to the probe target or subsequently became the probe target. Furthermore, in experiment two the controls showed the opposite effect, i.e. negative priming when the distractor became the target. This suggests that extraneous visual information can benefit patients with PD by aiding them in identifying the target stimulus.

Similar effects have also been found in lexical processing tasks. For example, Spicer, Brown, & Gorell, (1994) found that patients with PD were quicker to decide if a target was a word or a non-word when it was preceded by a word as opposed to a blank screen. They suggested that patients with PD benefit from semantically related information and raised the question of whether patients with PD can more generally use extraneous information in beneficial ways to facilitate performance.

The evidence from the priming studies discussed above suggests that the characteristics of both the target stimulus (in terms of location predictability) and the distractors (in terms of meaning) may affect the performance of patients with PD. Specifically, unpredictable locations may make stimulus selection more problematic whilst semantically related categorical distractors may aid stimulus identification.

2.1.4 Summary

Patients with PD tend to show deficits on selective attentional tasks where the distractor(s) elicit an automatic response tendency which interferes with response selection (e.g. Bokura et al., 2005; Brown & Marsden, 1988). However, evidence

that patients with mild PD are distracted by extraneous visual information that does not elicit an automatic response tendency is limited to situations where the location of the target is unpredictable (Sharpe, 1990). Indeed, rather than slower performance, evidence from priming studies suggests that semantically related distractors may improve performance by aiding stimulus identification (Mari-Beffa, Hayes, Machado, & Hindle, 2005; Spicer, Brown, & Gorell, 1994).

2.2 Patients with mild AD

2.2.1 Distraction from visual prepotent information

Patients with mild AD show deficits both on the classic manual Stroop task (Bondi et al., 2002; Collette, Linden, Delrue, & Salmon, 2002; Perry et al., 2000) and on computerised versions of the same task when the trials are intermingled rather than presented in blocks (Amieva et al., 2002; Spieler, Balota, & Faust, 1996). These deficits are found both in terms of slower response times and greater number of errors. Patients with mild AD also show similar deficits on the Trail Making task. This task comprises two parts (A and B). Part A consists of numbers from 1 to 25 dispersed randomly on a sheet of paper. Part B consists of numbers from 1 to 13 and letters from A to L again dispersed randomly on a sheet of paper. In Part A participants must draw lines joining the numbers in ascending order whilst in Part B the task is to join alternate numbers and letters, i.e. from 1 to A, A to 2 , 2 to B etc. Crowell, A`Luis, Vanderploeg, Schinka, Mullen (2002) compared the performance of 15 patients with mild AD and 22 controls. They found that the patient group were significantly slower to complete Part B than the controls (after accounting for general processing speed assessed by part A of the task).

In the Trail making task, completion time is normally the variable of interest. If participants make an error it is immediately corrected and therefore erroneous performance is reflected in overall longer task completion times. However, Amieva et al. (1998), specifically compared both the types and numbers of errors made on part B of the task between patients with AD and older adults controls. They found that compared to the controls, patients with AD made significantly more errors of spatial proximity, i.e. they joined together the nearest two items on the task sheet. They also made significantly more perseveration errors, i.e. connecting consecutive letters or numbers as opposed to alternating the letter number sequence suggesting problems in inhibiting a dominant response. In evaluating the results of this study, it is important to note that no feedback about performance was given. It is therefore possible that the patients with AD may have had difficulty maintaining the task goal in memory which would lead to an increase in the number of errors made.

In addition to the Stroop task referred to above, Amieva et al. (2002) also tested 28 patients with AD and an equivalent number of age-matched controls on two other tasks that measured the ability to suppress a prepotent response. These tasks were the Stop Signal task and the Go/No-go task both of which had two parts. Part one of the Stop Signal task was a 20 trial choice reaction time task. A red circle and a blue triangle were presented simultaneously on the screen and the task was to touch the red circle as quickly as possible. In part two the task was repeated with the additional instruction that when participants heard a tone before the stimulus' appearance no response was to be made. There were no significant differences in either response times (after adjusting for base rate response times), nor error rates between the two groups. Part one of the Go/No go task was also a reaction time task. For 20 consecutive trials, participants had to touch the computer screen as quickly as

possible when a red circle appeared. Then, a further 20 trials were presented in which participants again had to respond by touching the screen when a red triangle appeared but withhold the response if the triangle was blue (which occurred on 50% of the trials). Again, no significant differences in either response times (after accounting for baseline response times), nor errors were found between the two groups. Collette, Linden, Delrue, & Salmon (2002) also used the Go/No-go paradigm to assess 26 patients with AD and an equal number of age matched controls. They used target stimuli of upright crosses and distractor stimuli which were oblique crosses. They found that whilst there was no difference in reaction times between the two groups, the patients with AD did made significantly more errors, providing some evidence of impairment on this task.

Whilst these Go/No-go studies provide limited evidence that patients with mild AD are impaired on these tasks, the experimental manipulations used are rather weak. In the Stroop and Trail making tasks the habitual response tendencies elicited by either the words or the alternating number letter sequences have accumulated and been reinforced throughout the life of the participants. Therefore manipulations of this type have more power to detect group differences in performance than manipulations where the automatic response tendency is evoked by a single session over a brief timeframe. Furthermore, given that patients with AD have difficulty learning new associations; both the number of trials presented and the 50/50 ratio of response trials versus no response trials appear rather low. This means that the patient group may not have developed an automatic response tendency which would explain the lack of group differences.

Finally, Collette, Linden & Salmon (1999) administered the Hayling task (which measures the ability to complete sentences using words which are not relevant

to the sentence context) to 20 patients with mild AD and 20 age matched controls. They found that there was no difference in the number of semantically-related responses made by patients with AD and older adults but that the patients with AD made fewer unrelated responses and more completion responses, i.e. they used the word most usually associated with the context of the sentence. This research was replicated by Belleville, Rouleau, & Van der Linden (2006) using a French version of this task with the same pattern of results. Again, these studies show that patients with mild AD have particular difficulties overcoming dominant response tendencies.

In summary, there is a wide diversity of evidence showing that patients with mild AD have difficulties with the response selection aspect of selective attention arising from a reduced ability to ignore distraction from prepotent information.

2.2.2 Distraction from extraneous visual information

Langley, Overmier, Knopman, & Prod'Homme (1998) investigated distraction arising from extraneous visual information presented at fixation using overlapping letters as targets and distractors in a blocked design. The stimuli were presented as lists on printed cards and the progression from trial-to-trial was self-paced rather than with fixed stimulus durations. They had four conditions (together with a negative priming condition which is discussed under section 2.2.3 below). The task was to name the letter presented in green whilst ignoring the red distractor letter. The conditions were: a baseline condition where the target was presented alone; a double baseline condition where the target and the distractor letters were the same; an unrelated distractor condition where the target and distractor letters had different identities; and a repeated distractor condition where the identity of the distractor was repeated throughout. Additionally, the location of the distractor letter could be either

predictable or randomly placed either to the left or the right of the target letter. Compared to age-matched controls, the patients with mild AD were slower to respond when a distractor letter was present (measured as unrelated distractor response time minus baseline response time) but this difference only reached significance when the location of the distractor was unpredictable. In terms of errors, the patients with AD made significantly more errors whenever distractors were present compared to when the target was presented alone. The response time and error data suggested that patients with mild AD are distracted by extraneous visual information that is presented at fixation.

Langley et al. (1998) also investigated the effect of different stimuli attributes on the performance of the patient group. Firstly, they compared the difference in responses times in the double baseline condition (when the target and distractor were the same letter presented in different colours) and unrelated distractor condition (when the distractor was a different letter from the target). They found that response times in these two conditions did not differ. This suggests that the distractors were processed at a perceptual level since, if they were processed at the level of meaning a facilitation effect in the double baseline condition (identical target and distractor letter) would have been predicted, which was not the case. Secondly, they considered the effect of constant versus changing extraneous information (measured as the difference in response times between unrelated distractors and repeated distractors). They found that both the patients with mild AD and the controls benefited from the repetition of distractors (regardless of location) although the benefit to the AD patients was greater when the location of the distractor was unpredictable. This suggests that patients with AD show similar levels of habituation to irrelevant repeated extraneous information as controls. However, Langley et al. (1998) did not

compare baseline response times with response times when the repeated distractor was present. Therefore it is unclear whether the patients with AD were distracted by the presence of these distractors albeit less so than when the distractors changed across trials.

Sullivan, Faust, & Balota, (1995) also investigated the effect of distractors at fixation in 21 young adults, 20 older adults and 15 patients with mild AD. However, they used overlapping line drawings (pictures), e.g. a dog, as stimuli rather than letters. They had three conditions: a drawing presented alone, a picture presented with a distractor picture and a picture presented with a semantically-related distractor picture. Participants had to name the red picture and ignore the green distractor picture. They found that all groups were significantly slower to name the picture when a distractor was present but, that the difference between non-semantically related and related distractors were not significantly different. However, in terms of errors the patients with AD made significantly more errors when distractors were present than either of the other two groups (regardless of distractor type). Sullivan et al. (1995) then replicated this study using overlapping words. Again, the target word was red and the distractor word green. The results in respect of response times were the same as with the pictures but with words the error rate of the patients with AD was not significantly different from the other two groups. This second study provides weaker support for distractibility from extraneous information presented at fixation.

In contrast, Baddeley, Baddeley, Bucks, & Wilcock (2001) investigated the effects of peripherally presented extraneous visual information. They administered a paper and pencil visual search task to 36 patients with mild AD and 36 older adult controls. In this within-participants task, participants searched for the letter Z either amongst similar letter distractors (other letters with mainly straight features) or,

amongst dissimilar letter distractors (other letters with mainly curved features). As predicted they found that the patients with AD were slower than the controls (regardless of the type of distractors) and made more omission errors, i.e. failing to cross out a Z. They also found that the performance of the patients with AD was significantly worse when the distractors were visually similar to the target. Similar patterns of results have been found using arrowheads (e.g. Tales, Muir, Jones, Bayer, & Snowden, 2004) and unfilled versus filled shapes (Foster, Behrmann, & Struss, 2004). These results suggest that during stimulus selection, at least when the location of the target is unpredictable, patients with mild AD are particularly sensitive to the visual characteristics of the target and distractor stimuli.

These findings are augmented by the work of Perry et al. (2000). They compared the performance of a group of patients with either minimal AD (classified as MMSE scores of 24 above) or mild AD (classified as MMSE scores of between 18 and 23) on a number of attentional tasks including the map search task from the Tests of Everyday Attention test battery (Robertson, Ward, Ridgeway, & Nimmo-Smith, 2000). In this task participants had to search for items such as places to eat on a map where the targets were denoted by symbols on the map. They found that the patients with mild AD were significantly slower to find the target items than both participants with minimal AD and the control group (whose performance did not significantly differ). Whilst this suggests people with mild AD are more distracted by extraneous information it is not possible to exclude the possibility that the patient group's difficulties arose at least in part from problems reconciling the verbal instructions with the symbols depicted on the map.

In summary, the evidence suggests that patients with AD are more distracted by extraneous visual information than healthy controls, especially when there are

visual similarities between the target and distractors. Nevertheless the evidence is not conclusive and is inconsistent as to which stimuli characteristics result in impaired performance. This issue was addressed by the studies reported in Chapters 6 and 7.

2.2.3 Extraneous visual information and priming

As explained in 1.3.6 (p.16), interpretation of the results of negative priming studies in patients with mild AD must be made cautiously. An absence of negative priming could arise due to memory deficits rather than due to changes in attentional processes. However, with this caveat in mind, studies of negative priming may help to suggest ways that different types of extraneous information influence task performance in patients with AD.

One study that reduced the memory load associated with the priming task was undertaken by Langley et al. (1998). As described in 2.2.2 above, they presented lists of letters as targets and distractors. This meant that participants were able to scrutinise the stimuli for as long as necessary and that previous trials could also be seen. This study intermingled identity priming, i.e. when the distractor in one trial became the target in the next trial, with location priming, i.e. when the spatial location of the distractor in one trial becomes the location of the target on the next trial. Regardless of the type of priming, neither the patients with mild AD nor the older adult controls showed significant levels of negative priming. This suggests that the performance of patients with AD does not differ from that of older people generally on priming tasks. However, the lack of location priming is surprising seeing this has been shown to be intact in patients with mild AD (Ko, Higgins, Kilduff, Milberg, & McGlinchey, 2005).

In contrast, Sullivan, Faust, & Balota (1995) compared older adults and patients with AD on a number of identity negative priming tasks using either overlapping words or pictures as stimuli. Here, the trials were displayed individually on a screen. They investigated both negative and positive priming with identity and semantically-related conditions for each. In the two negative priming conditions the distractor on one trial was either the target item in the next trial or, semantically related to the target on the following trial. In the two positive priming conditions the target was repeated in consecutive trials or, the target in the second trial was semantically related to the target presented in the preceding trial. In terms of positive priming both groups benefited from repetition of the target but neither groups' responses were significantly faster when the targets on consecutive trials were semantically-related. In respect of negative priming, in the ignored repetition condition (distractor on one trial becomes target on the next), significant negative priming effects were observed for the older adults but not for the patients with AD. Sullivan et al. (1995) interpreted the lack of identity negative priming as evidence that patients with AD have difficulties in ignoring irrelevant information. However, in this study participants were given a strategy to help them complete the task. They were told that 'the green picture is there to make the task more difficult, but as far as you are concerned it is irrelevant. So the more you can ignore the green picture, the better you will be able to name the red picture, which is what I am interested in' (Sullivan et al., 1995, p. 542). The adoption of this strategy may have led to negative priming in the older adults within this particular experimental context. Furthermore, the failure of the patients with AD to demonstrate negative priming could be attributable to either; their inability to adopt the suggested strategy or, their failure to remember the strategy during the course of the task.

Whilst the adoption of a strategy cue may have played a role in the results obtained, a partial replication (using picture stimuli only) and without the strategic hint was undertaken by Amieva et al. (2002). They found the same pattern of results i.e. negative priming in the older adults but not in the patients with mild AD, which supports the interpretation of an inhibitory deficit as purposed by Sullivan et al. (2005). Furthermore, they analysed their results over two blocks of trials and found that whilst the patients with mild AD showed no evidence of negative priming, the older adults showed negative priming in the second block only. Given that patients with mild AD have more difficulty with unfamiliar tasks than their peer group it might be that the patient group would display evidence of negative priming if the number of experimental trials were increased.

However, there is an alternative explanation for the results obtained by Sullivan et al. (1995) and Amieva et al. (2002) which can account for both the facilitation effects and the lack of negative priming in the patients with mild AD. In the repetition priming condition (repeated target) the target has to be given a verbal label on the first trial. This already accessed verbal label may have led to faster response times in the following trial. However, the distractor items do not have to be given a verbal label to complete the task. Therefore it is possible that the patient group are not categorising the distractors at a semantic level and that it is this lack of semantic categorisation which results in an absence of negative priming. Indeed, this would explain why patients with mild AD show intact location priming when no semantic categorisation is required (Ko et al., 2005).

In summary, the evidence from the priming studies described above suggests that patients with mild AD are particularly sensitive to the visual characteristics rather than the semantic characteristics of extraneous visual information.

2.2.4 Summary

In summary, there is a wide diversity of evidence showing that patients with mild AD have difficulties with the response selection aspect of selective attention, probably arising from a reduced ability to ignore distraction from prepotent information (e.g. Belleville et al., 2006; Collette et al., 2002; Crowell et al., 2002). Furthermore, the evidence suggests that patients with AD are more distracted by extraneous visual information that does not elicit a prepotent response than healthy controls, especially when there are visual similarities between the target and distractors (e.g. Baddeley et al., 2001). These findings are augmented by the results obtained in priming studies which suggest that patients with mild AD rely on the visual characteristics rather than the semantic characteristics of extraneous visual information (Ko et al., 2005).

2.3 Older adults

2.3.1 Distraction from prepotent visual information

Older adults show greater deficits on both manual and computerised versions of the Stroop task than their younger counterparts (Davidson, Zacks, & Williams, 2003; Houx, Jollies, & Vreeling, 1993; Mutter, Naylor, & Patterson, 2005; Troyer, Leach, & Strauss, 2006; West & Baylis, 1998 but see Verhaeghen & Meersman, 1998). However, when the distractor word is spatially separated from the colour block rather than presented within it, these performance decrements are no longer significant (Hartley, 1993). Furthermore, older adults have been found to have more difficulty withholding a response in the stop-signal task than younger adults (e.g. Kramer, Humphrey, Larish, Logan, & Strayer, 1994). These findings are augmented

by a study undertaken by May & Hasher (1998). They used a task where participants saw word pairs. Participants were instructed to respond *yes* if the word pairs belonged to the same semantic category and *no* if they did not. Additionally, on 33% of trials an auditory tone sounded just after the word pairs were presented. Participants were instructed to withhold a response on these trials. They found that the older adults made more errors, i.e. making a response on trials when the auditory tone was presented, than the younger adults. This evidence suggests that older adults have difficulties with response selection when the distractors elicit a prepotent response and are presented at fixation.

Finally, older adults also have longer completion times on the Trail Making Task than younger adults (e.g. May & Hasher, 1998). Recall that in this task the stimuli are randomly positioned such that all items must be searched and the position of each target item is unpredictable. This suggests that older people have particular difficulties in stimulus selection when the location of the target is unpredictable.

2.3.2 Distraction from extraneous visual information

Rabbitt (1965) used a card-sorting task to demonstrate that older adults are more distracted by extraneous information than their younger counterparts. Participants sorted the cards into two piles depending on whether they contained a randomly positioned letter A or B. These cards either contained variable numbers of distractor letters or the target letter was presented alone. He found that although the card-sorting times increased for both groups as the number of distractors increased, that rate of increase was greater for the older adults This suggests that older people are more distracted by extraneous visual information than their younger counterparts at least when the position of the target stimulus is unpredicted.

In contrast, Stolzfus, Hasher, Zacks, Ulivi, & Goldstein (1993) also used letters to investigate distraction in younger and older adults. Here, response times when a letter was presented alone was compared with the response times when a single distractor letter was presented. The target and distractor letters were presented in one of two locations. They found that whilst both groups' response times were slowed by the presence of a distractor, the magnitude of the effect was not significantly larger for the older adults. These findings were replicated by Connelly & Hasher (1993) using similar stimuli and procedure. It is possible that the older adults were not significantly worse than the younger adults as only one distractor was used and the unpredictability of the target was limited to two possible locations. Therefore the experimental manipulation may have been too weak to identify between-group differences.

The studies described above are augmented by the work of Carlson, Hasher, Connelly & Zacks (1995). They investigated the effect on reading and comprehension of distractors interspersed in text. They compared the performance of younger and older adults when the distracting items were either randomly dispersed within the text or, in fixed locations. As predicted, they found that the older adults read more slowly and made more comprehension errors than the younger adults. They also found that the older adults were significantly slower at reading the text which contained randomly dispersed distractors than in the control condition where no distractors were present. However, this effect was attenuated when the distractors were placed in fixed locations. This again suggests that older adults are susceptible to distraction when the location of the target information is unpredictable.

Furthermore, older adults but not younger ones are more slowed by distractor words (shown in italics) that are relevant to the passage being read than to irrelevant

distractor words (e.g. Dywan & Murphy, 1996; Li, Hasher, Jonas, Rahhal, & May, 1999). These findings are augmented by the work of May (1999). She tested older and younger adults using the Remote Associates Test (Mednick, 1962). Participants were given three cue words and from these were asked to identify a target word. The cue words were presented either with distractors that were related to the target word or were unrelated. She found that the older adults benefited from the presence of the related distractors to the same degree as the younger adults. This evidence suggests that the older adults are processing the words at a semantic level rather than just on the basis of visual characteristics.

2.3.3 Extraneous visual information and priming

Older adults tend to show equivalent location priming (the location of the distractor in one trial is the location of the target in the following trial) to younger adults (e.g. Connelly & Hasher, 1993; Langley et al., 1998; Stolzfus et al., 1993). This suggests that adults (across the lifespan) are particular sensitive to the location of the target during stimulus selection. In comparison the evidence on identity priming (where the distractor on one trial becomes the target on the subsequent trial) is more mixed. Some studies show a lack of identity negative priming (e.g. Hasher, Stolzfus, Zacks, & Rypia, 1991; Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; Langley et al., 1998) whilst other studies show equivalent negative priming to younger adults (For a review see Gamboz, Russo, & Fox, 2002). Often in identity priming studies the stimuli are overlapping and therefore both the target and distractor will be processed. Therefore, this suggests that adults generally process these distractors at the level of meaning rather than on the basis of perceptual characteristics.

In terms of semantically related priming, older adults tend to show larger effects in tasks that use words as target and distractor stimuli (for a review see Laver & Burke, 1993). A recent example of such research was undertaken by Kim, Hasher & Zacks (2007) who tested older and younger adults using a reading with distraction task followed by the Remote Associates Task (RAT) (Mednick, 1962). They asked participants to read a number of stories interspersed with distractor words which were semantically related to a number of the target words in the subsequent RAT. They found that the older adults (but not their younger counterparts) were significantly better at identifying the target words when they had been preceded by the semantically related distractors.

2.4 Choice of experimental paradigms

The main aims of this thesis were to quantify the effects on performance of different types of visual distractors presented simultaneously with visual targets, infer whether different mechanisms underlie altered performance arising from the characteristics of the visual distractors, and to evaluate whether such altered occurs at different stages of attentional processing. The following section describes the basic paradigms used to conduct the studies to meet these aims. The results of these studies are reported in chapters four to seven. One of the advantages of using several paradigms is it allows the results from a single group of participants to be compared across several studies which, as well as providing converging evidence, also negates the difficulties associated with comparing results across studies in heterogeneous clinical populations such as patients with AD (Perry & Hodges, 1999).

2.4.1 Flanker plus Stroop

This paradigm investigated the effects of several kinds of extraneous visual information at different stages of attentional processing (see fig.1.1, p.7). Firstly, the effects of prepotent distractors presented either in the same spatial location as the to-be-attended information or alternatively peripheral to it. This assessed the effects of performance at the response selection stage of attentional processing where participants must inhibit the automatic response elicited by the prepotent distractors.

Secondly, it considered the effects of non-prepotent peripherally placed distractors. This made it possible to assess both the stimulus selection and the stimulus identification aspects of attentional processing. In order to provide baseline information about participants' ability to process information without distraction, a condition was included without distractors. This was important since it allowed the comparison of the different types of distractors directly with the same person's performance when no distractors were present. Hence, any differences in performance patterns between groups could take account of differences in general processing speed. The targets were always presented in fixed locations to keep the task demands at a manageable level. Older people generally find tasks where the location of the to-be-attended information is unpredictable more difficult than when the location is predictable (e.g. Carlson, Hasher, Connelly, & Zacks, 1995). Therefore the effects of unpredictable target locations were considered separately in paradigm 2 (visual search) below.

Simple, familiar shapes were chosen as the target items for several reasons. Firstly, whilst shape is a superordinate category it contains a reasonable number of basic level categories which are perceptually distinct and are familiar to most people. It was necessary to choose target items which could be used across all conditions

thereby keeping the task constant throughout. This precluded using the types of stimuli that have typically been used as targets within individual flanker or Stroop studies. These include using words or numbers, which are problematic because they generally produce prepotent responses and therefore it would not be possible to have a condition with non-prepotent peripherally placed distractors. The same issue applies if using arrows as distractors as it is not possible to have a neutral arrow.

An additional advantage of choosing the superordinate category of shapes as targets was that it allowed the non-prepotent distractors to be the kinds of shapes that were not easily nameable at a basic category level and therefore should not elicit a prepotent response tendency. It also allowed the effects of categorical priming to be assessed. Words were chosen as the prepotent distractors since these stimuli were used in the original Stroop experiment (Stroop, 1935) and have reliably been shown to elicit prepotent response tendencies and therefore impair task performance. Consideration was given to the possibility of using shapes within shapes, or different coloured shapes. However, providing a reasonable contrast between stimuli, when both target and distractor were spatially integrated, was difficult to achieve, and perceptual difficulties may have confounded the results obtained especially with older participants who may have reduced visual acuity.

The task was computerised because it allowed a distinction to be made between the speed and accuracy of responding. Analysis was possible on an individual trial basis whereas, in the traditional paper and pencil task only global performance can be analysed. This traditional method of presentation is problematic because using a manual Stroop task it is difficult to assess the impact of any speed versus accuracy trade-off, i.e. quick performance could be a direct result of erroneous performance due to reading the word instead of naming the shape. Since word reading

is faster than shape naming it would appear that the participants' performance in terms of response times is fast whereas in fact it is due to their inability to complete the task. Rather than present each distractor condition in separate blocks of trials, the conditions were inter-mingled in a quasi-randomised order. The reasons for this decision were threefold: firstly, to maintain task interest and thereby encourage engagement of attention throughout the task; secondly to be more in accord with participants' usual visual environment where items within the visual field are normally changing rather than the same types of visual stimuli being repeated over blocks of time; and thirdly because blocked presentations may be more susceptible to the participants using ad- hoc strategies.

Finally, verbal responses were chosen as the mode of responding. This was because it was necessary to keep the task demands to a minimum particularly for the patients with AD. Button or key press responses require participants to remember particular response sets and hence increase the memory load which, given the problems patients with AD have with memory and learning new tasks, may have confounded the results. Also, given that the primary difficulty associated with a diagnosis of PD is with motor control (Hoehn & Yahr, 1967), using a task response that required repeated novel motor movements would be problematic. Also, the majority of participants were unfamiliar with taking part in psychological research. This, coupled with a tendency for older people to be less familiar with computers than their younger counterparts, meant the use of key presses might have increased their anxiety levels. Hence, verbal responses reduced the need to interact directly with the computer and participants were told to think of the screen as a television set.

Details of the Flanker and Stroop task are given in Chapter 3. The results from studies using this task are in Chapters 4 to 7.

2.4.2 Visual search

The Visual Search task differed from the Flanker plus Stroop described above, in that the location of the target items was unpredictable. In visual search tasks participants typically search for target items among multiple distractors (Smilek, Dixon, & Merikle, 2006). Each item in the visual array must be scrutinised during the search procedure unless the target item can be identified by a unique salient feature not shared by the distractor items (Levinoff, Li, Murtha, & Chertkow, 2004). This paradigm also assessed stimulus selection and stimulus identification. A large body of research using visual search tasks has concentrated on manipulating the physical properties of both the target and distractor items and their effect on search efficiency (for an overview see Pashler, 1999). However, few studies have investigated whether the efficiency of search is influenced by the semantic categories used and none have involved patients with PD (e.g. Brand, 1971; Jonides & Gleitman, 1972). These studies used letters and digits as targets and distractors and found that search times were slower when both the target and distractors were from the same semantic category. However, these studies failed to match visual feature similarity across categories, and subsequent studies which did so failed to replicate the effect (Krueger, 1984; White, 1977). Therefore the visual search task developed for the present research examined the effect of semantically-related versus unrelated categorical distractors, using target and distractor items matched on the base of visual similarity.

Fruit was chosen as the superordinate category for the semantically related items for several reasons. Firstly, the targets and distractors needed to be readily identifiable and perceptually distinct. They were presented as black and white images to prevent targets being identified on the basis of colour alone which could have bypassed semantic processing. The unrelated items were chosen on the basis of their

visual similarity to the semantically related distractors (See chapter 3) and also their typical mean age of acquisition, to ensure that they would be as familiar to participants as the fruit items.

A paper and pencil task was chosen despite the need to carefully consider any possible speed versus accuracy trade-off in the results obtained. The reason for choosing this method of presentation must be understood in the context of the overall testing session which each participant experienced. In addition to the three experimental paradigms described here all participants undertook additional testing that provided baseline cognitive measures (see chapter 3). Therefore it was necessary to vary the method of presentation between tasks to maintain participant interest and reduce fatigue.

2.4.3 Inattentional blindness

This paradigm was chosen to examine stimulus selection. It assessed the ability of participants to notice novel extraneous information which was not explicitly relevant to the task demands. This differs from the visual search paradigm where participants expected extraneous information that they knew to be irrelevant (Simons, 2000). In a typical inattentional paradigm, participants watch several computerised trials where they are instructed to attend to one event in the presence of distractors, for example count the number of times an object bounces off the side of the screen whilst ignoring different coloured distractors. Then in the following trial an additional distractor is introduced which is novel but shares a common visual feature, e.g. colour, with the other distractors. After that trial participants are asked if they noticed the extra distractor, using either a free recall or a recognition task (e.g. Most, Scholl, Clifford, & Simons, 2005; Simons, 2000; Simons & Chabris, 1999).

The task used in this thesis followed the basic paradigm except that the objects chosen were a green frog catching either red butterflies (targets) or brown bugs (distractors).The novel distractor items were other brown living things. Living things were chosen as the target and distractor items to make the task more realistic and engage participants' interest in the task. Also, the target and distractor items needed to be different from those used in either the Flanker plus Stroop or visual search paradigms described in 2.4.1 and 2.4.2 above. A recognition test rather than a free recall test was chosen to reduce the memory load. Finally, an additional trial was added at the end of the task where another novel animal appeared with the distractors.

This novel animal had never been seen before and whether it was noticed was again assessed using a recognition task. The reason for doing this was to evaluate whether the initial surprise recognition task acted as an implicit cue that would lead to noticing the novel distractor animal.

Chapter 3: Common Methodology for studies reported in Chapter 4 and Chapter 6

Although this thesis reports data from two groups, patients with mild PD and patients with mild AD, the goal was not to compare their relative performance on a variety of tasks. Rather the goal was to examine within each patient group the pattern of their performance across tasks, e.g. noting where facilitation or impairment occurs relative to some baseline condition. Then the theoretical focus was on the similarity or differences in these patterns of performance.

Whilst both disorders can occur throughout adulthood, with approximately 3-5% of people receiving a diagnosis of PD before the age of 40 (Golbe, 1991; Schrag et al., 2000) and one in 1400 people receiving a diagnosis of dementia between the ages of 40 and 64 (Alzheimer's Society, 2007), both disorders are typically diagnosed later in life. Therefore, to ensure that the patterns of performance observed were not a by-product of processes typically seen in normal ageing, a control group of healthy older adults (HOA) was included and their performance pattern contrasted with that of the two patient groups. However, the focus is on the pattern of performance within a group, not the absolute level of performance. As the same research paradigms were used with both the patients with mild PD and the patients with mild AD, they are described in their entirety in this chapter to reduce the need for repetition. However, the cognitive characteristics of the two patient groups are distinct and generate different hypotheses. The results and discussion arising from these hypotheses are dealt with in Chapters 4 and 6 and therefore the relevant participant characteristics are also described in those chapters.

3.1 Baseline Cognitive Measures

Task performance is influenced by age and also by IQ, with higher IQ scores being associated with better task performance across multiple cognitive domains (Stern, 2002). Therefore, it was important to control for the impact of IQ on the pattern of performance in each participant group. An assessment tool was used to estimate IQ since demographic measures alone, such as years in education, are skewed in older populations by factors such as lack of educational opportunity (O'Carroll, 1995). The Wechsler Test of Adult Reading (W-TAR^{uk}) was used, which is a well validated test of reading recognition that involves reading irregular words aloud. It was chosen as it correlates with measures of IQ and education level and is used as a measure of pre-morbid IQ in individuals with cognitive impairment (Wechsler, 2001).

A second factor which might impact on task performance is the presence of depression which is associated with cognitive impairment across multiple domains including concentration (Kasznaik & Ditraglia, 1997). Depression is common in older people and depression rates are further elevated in both people with dementia (McDougall et al., 2007) and those with PD (Stern, Marder, Tang, & Mayeux, 1993). To assess levels of depression, the BASDEC (Adshead, Day-Cody, & Pitt, 1992) was used in which participants sorted cards containing statements into two piles according to whether each statement described how they were feeling. This tool was chosen because it is quicker to administer than the Geriatric Rating Scale (Yesavage et al., 1983) but has equivalent sensitivity and specificity (Adshead et al., 1992).

Finally, a measure of general level of cognitive impairment was required for three reasons: firstly, this thesis examines the performance of patients with mild AD at the earlier stages of the disease's progression and therefore a tool to identify these

patients was needed. Secondly, a diagnosis of PD is associated with a risk of dementia between two and six times higher than that associated with healthy ageing (e.g. Aarsland et al., 2001; Aarsland, Zaccai, & Brayne, 2005). Finally, cognitive impairment is under-diagnosed within community dwelling older people. For example, The Caerphilly Prospective Study screened 180 men between 67 and 84 years of age and identified 23 cases of individuals who met the criteria for dementia but had previously been diagnosed as having a memory impairment (Fish, Bayer, Gallacher, & Ben-Shlomo, 2005). The tool used was the Mini-Mental State Examination (MMSE) (Folstein et al., 1975). It was chosen since it is widely used in clinical practice and brief to administer. Administration time was an important consideration since the overall testing session needed not to be too onerous for the participants.

3.2 Chronological Procedure

All participants experienced three completely different experimental paradigms which for ease of reference will be referred to as Flanker plus Stroop, Visual Search and Inattentional Blindness. Whilst the detailed procedure of each paradigm is dealt with in the relevant sections below, the overall procedure and chronological order of task presentation is addressed here to reduce repetition.

Participants were usually seen in their own home to reduce test anxiety and to make it easier for all who wished to do so to participate. Participants were also given the option to attend the university if they preferred (for details of those who participated at each venue see Chapters 4 and 6). Furthermore, it was explicitly stated that their individual abilities were not being evaluated, since most participants were unfamiliar with research participation and therefore might be anxious about being

evaluated. Participants were also told that they could stop at any time, that the data collected would be confidential and, that they could take a break between tasks if they wished. Written informed consent was obtained from all before testing started.

Whilst the stimuli presentation order within each of the three experimental paradigms was counterbalanced (refer to relevant sections below), the experimental paradigms and the baseline cognitive measures were presented in a fixed order for all. The reasons for this were twofold: firstly it was important to inter-mingle paper and pencil tasks with the computerised ones in order to reduce participant fatigue and maintain participants' interest in the research activities. Secondly, it was necessary to keep the counterbalancing requirements at a practically manageable level. The important issue is that this presentation order was consistent between the three groups and therefore allowed comparison of the within-participants pattern of performance of each group on each experimental task, which was the question of interest throughout. The W-TAR^{uk} (Wechsler, 2001) was administered first. Afterwards, participants were asked their date of birth, their school leaving age and about their employment history. Then paradigm 1 (Flanker plus Stroop-see section 3.3) was administered in two equal blocks, with paradigm 2 (Visual Search-see section 3.4) between them to reduce participant fatigue. These tasks preceded the MMSE (Folstein et al., 1975) and paradigm 3 (Inattentional Blindness-see section 3.6). Finally, the BASDEC (Adshead et al., 1992) was administered and then participants were de-briefed.

3.3 Paradigm 1: Flanker plus Stroop

3.3.1 Materials

Ninety six computerised trials were presented in which participants saw solid blue target shapes which were always in the centre of the screen. Four different

shapes were used (square, triangle, circle, heart) all of which were easily recognisable and perceptually distinct (see Fig. 3.1). Each shape was sized to fit within an invisible 5cm. x 5cm. frame. On 25% of trials the target shape was presented alone; on 25% of trials there was an incongruent shape word within the target shape; on the other trials the target was surrounded by five orange shapes (OS) flankers either with or without an incongruent shape word in one of these shapes. Each OS flanker fitted within the same sized invisible frame as the target shape and they were arranged in fixed positions round the target within an invisible 20cms. X 17.5cms. frame. Words, when shown, were centrally positioned in the relevant shape. They were written in black ink, size 24 Times New Roman font with the first letter of each word capitalised. The choice of which OS flanker contained the word was randomised. As explained in Chapter 2, the OS flankers were chosen because they did not elicit a prepotent verbal response but were from the same semantic category as the target, namely shapes.

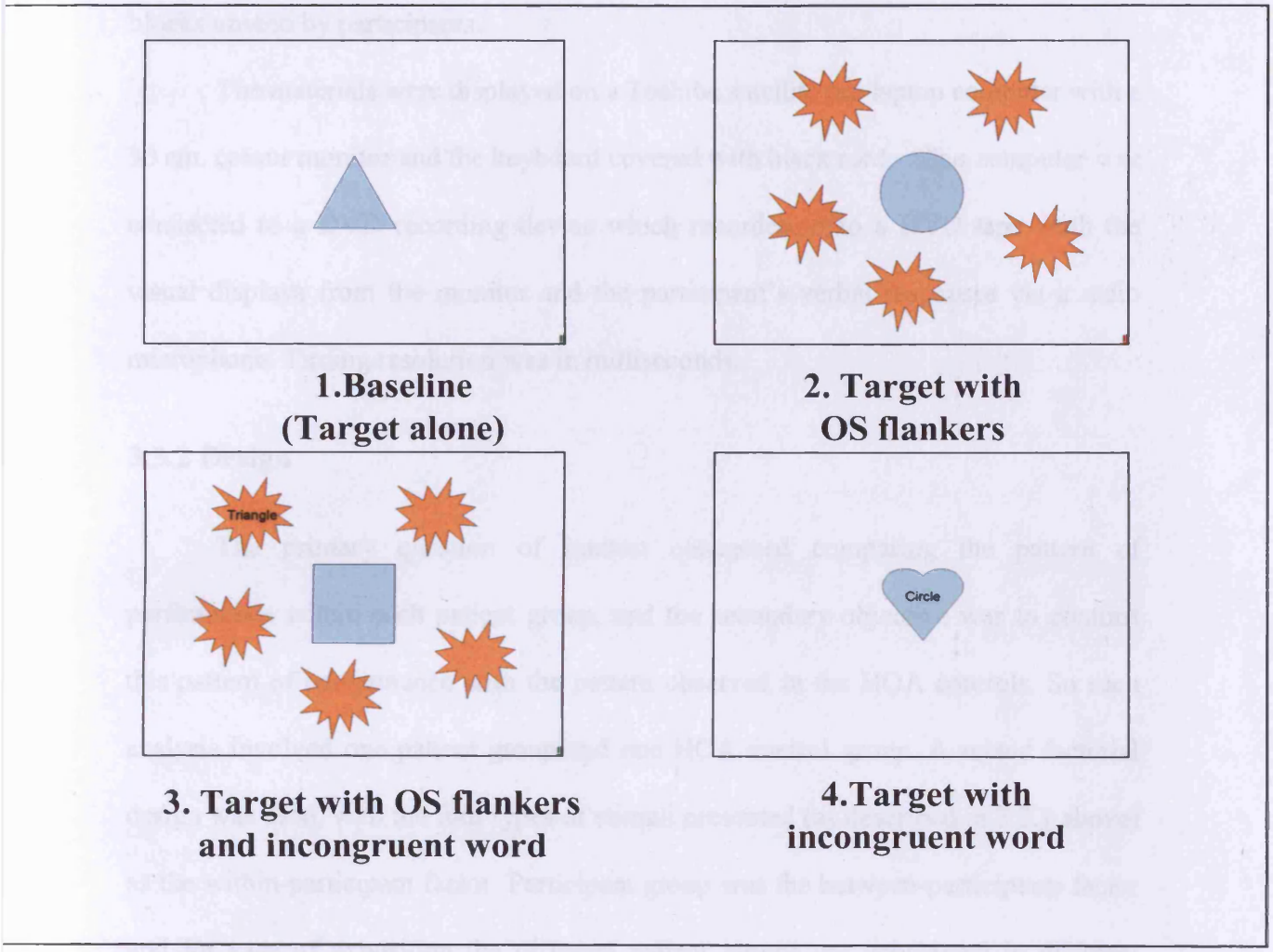


Figure 3.1: Examples of stimuli for the four experimental conditions in the Flanker plus Stroop paradigm

There were 24 trials in each of the four conditions. The order of presentation was quasi-randomised such that consecutive trials were not from the same condition, the shape or the word was not the same in consecutive trials, and the shape in one trial was not the word in the next or vice versa. The order in which the blocks were presented was counterbalanced across participants.

To facilitate subsequent analysis, after randomisation a 3mm x 5mm block was inserted in the bottom right-hand corner of each trial. These blocks were coloured using a revolving traffic-light sequence (red, amber, green) (please refer to results

section in Chapter 4). Black card covered this corner of the screen rendering the blocks unseen by participants.

The materials were displayed on a Toshiba satellite pro laptop computer with a 30 cm. colour monitor and the keyboard covered with black card. The computer was connected to a DVD recording device which recorded, onto a DVD tape, both the visual displays from the monitor and the participant's verbal responses via a radio microphone. Timing resolution was in milliseconds.

3.3.2 Design

The primary question of interest concerned comparing the pattern of performance within each patient group, and the secondary objective was to contrast this pattern of performance with the pattern observed in the HOA controls. So each analysis involved one patient group and one HOA control group. A mixed factorial design was used, with the four types of stimuli presented (as described in 3.3.1 above) as the within-participant factor. Participant group was the between-participants factor and for ease of exposition the different patient groups are considered in different chapters. The dependant variables were verbal response times and errors made.

3.3.3 Procedure

Prior to going through the instructions, the experimenter ensured that the computer monitor was a comfortable distance and angle from the participant so that they could view the screen comfortably. Participants were asked to name blue shapes that appeared one after another on the screen in front of them. For example, they were told that if they saw a blue circle they were to say 'circle'. They were also told that after they had named each shape it would be automatically replaced by another shape for them to name and that they were to always name the blue shape. They were then

given four practice trials (one for each of the target shapes), to ensure they had understood the instructions and could name each of the four shapes. Once any questions had been answered, the researcher ran the four practice trials and then proceeded to run block one (two of the practice trials presented the target shape alone whilst the other two presented the target shape surrounded by the OS flankers). The researcher instigated the transition between shapes on each trial by mouse press. This transition method has been previously adopted in studies using populations with neurological impairments (e.g. Henik et al., 1993). This avoided participants making both verbal and motor responses which may have confounded the data in both patient groups. It would require patients with AD to remember two different responses; a verbal one followed by a motor response whilst a major feature of PD is difficulties in motor control which would add extra load to the task. Then participants saw paradigm 2 (visual search) (see section 3.4 below) followed by the second block of paradigm 1 which again was preceded by the same four practice trials that preceded block 1.

3.4 Paradigm 2: Visual Search

This was an item cancellation task where the target was presented with visual distractors that varied in terms of semantic relatedness to the target item.

3.4.1 Materials

There were two task conditions which differed in visual distractors. These tasks were presented on separate A4 sheets of paper in landscape format. Each sheet contained 88 black and white pictures displayed uniformly in eight rows and 11 columns. Twenty-two targets (bananas) were randomly interspersed amongst three different distractor stimuli. On one sheet the distractors were semantically unrelated to the target; whereas on the other sheet they were semantically related to the target (all

fruit) (see fig. 3.2). Each item was sized to fit within an invisible 2cm. x 2.5cm. block and centrally aligned. Both sets of distractors (unrelated or semantically related) were empirically matched for visual similarity (see 3.5 below).

Targets (bananas) + Semantically related distractors

Targets (bananas) + Unrelated distractors

Figure 3.2: Example of stimuli in the two visual search conditions

3.4.2 Design

In this within-participants task participants deleted target items in each of two conditions, unrelated and semantically related, with the order of conditions being counterbalanced across participants. The dependant variables were errors made and the time taken (in seconds) to locate all the target items.

3.4.3 Procedure

The participants were given a pencil and told they would be given a sheet of paper containing rows of pictures. They were asked to look through the sheet and put a line through (cross out) each picture of a banana that they found. They were asked to look through the entire sheet and let the researcher know when they had finished. Once any questions had been answered, the first sheet was placed face down in front

of the participant and they were told to turn over the sheet and start when they were ready. The time recording started when the participant turned the sheet over and stopped either when the participant said they had finished or after two minutes had elapsed. The first sheet was then collected. The participant was then told they would be given a second sheet and that again they should look through it and put a line through all the bananas. The second sheet was then placed face down in front of them and the procedure repeated.

3.5. Pre-test Stimuli

The pre-test of the pictorial distractors was necessary because the research question posed concerned whether the semantic relatedness of the distractors to the target item would either facilitate or impair the performance of each patient group. It was crucial, to avoid a potential confound in the data that the stimuli did not significantly differ in visual similarity.

3.5.1 Participants

Sixteen postgraduate students of Cardiff University took part in the pre-test, none of whom were paid for their participation. They were aged between 21 and 41 with a mean age of 27 (SD 6.61) and a gender split of eleven females and five males.

3.5.2 Materials

The materials comprised a questionnaire preceded by an information and instruction sheet. Picture pairs (both semantically related and not) were displayed on the left hand side of the paper with a Likert scale opposite. The points on the scale

which were in size 12, Times New Roman font ranged from 1 (not at all similar) to 5 (very similar).

Fruits were chosen as the semantically related category due to their high familiarity. Bananas were chosen as the target (to be searched for) item. The other fruits used were apples, strawberries and a bunch of grapes. Nine further objects from other semantic categories were chosen. Each additional object shared visual commonalities (on at least one dimension) with one of the non-target fruits e.g. orientation. The pictures used were either downloaded from the International Picture Naming Project (*International Picture Naming Project*, 2005) or hand sketched and then scanned into a computer for editing. All pictures were black-and-white and sized to fit within a 2 cm. X 2.5 cm. frame. The pictures were combined to form pairs such that the banana was paired with each alternative fruit whilst all the fruits were paired with each of the non-semantically related objects. This gave a total of 51 picture pairs listed in a random order. For half the participants the order of presentation was reversed. Furthermore, for half the participants the left-right order of the individual picture pairings was reversed thus giving four presentation orders in total.

3.5.3 Design

The pilot study used a within-participant design in which participants completed a questionnaire by rating a series of picture pairs on the basis of visual similarity. The picture pairs were either semantically related (i.e. both fruit), or non-semantically related (i.e. a fruit paired with a non-fruit). This gave measures of visual similarity between both the banana and the other fruits and also between all the fruits and the non-fruits. The dependant variable was the similarity rating assigned to each picture pair.

3.5.4 Procedure

Participants were given an envelope containing a consent form for the collection of anonymous data together with the study materials. These consisted of both the information and instruction sheet and the questionnaire. The instruction sheet stated that participants would see pairs of everyday objects with a 5-point rating scale alongside. They were asked to look at each pair of pictures and rate their visual similarity by circling the relevant number on the accompanying scale (1=not at all similar and 5= very similar). They were asked to make their ratings based solely on visual similarity. The instruction sheet included two examples which were unrelated to the experimental materials, i.e. an orange paired with a tennis ball and an orange paired with an arrow. After reading the instructions, the participants completed the questionnaire and placed it back in the envelope. They then handed both the questionnaire and the consent form to the researcher and were debriefed.

3.5.5 Results

Median visual similarity scores were computed from the ratings given to each pair of pictures. The pictures rated as being the most visually similar were a slipper when paired with the grapes (median 3, range 1-5) whilst, the pictures rated as the least similar were the banana when paired with a pail (median 1, range 1-2). A Wilcoxon Signed Rank test showed that the visual similarity score for the pair of pictures rated as being most similar was significantly higher than the score for the pair of pictures rated as being the least similar, $z\ (8) = 3.34$, $p < .01$. This was important since it demonstrated that the rating scale used was sensitive enough to detect differences in the visual similarity of the pictures.

Subsequently, for each of the three semantically-related distractor pictures (apple, strawberry and grapes), a visually similar non-fruit picture was identified. They were: for the apple, a glass (median 2; range 1-5), for the strawberry, a clock (2; range 1-4) and, for the grapes, a slipper (median 3; range 1-5). Then, for each pair of pictures, separate Wilcoxon Matched Pairs Rank tests compared the similarity ratings given to each picture when it had been presented with the picture of the banana (see table 3.1). No significant differences were found (z (16) = .48, 1, .82, n.s. respectively) which is important since it demonstrated that none of these pairings significantly differ in visual similarity to the search item (the banana). Therefore the glass, the clock and the slipper were adopted as the unrelated distractors.

Table 3.1: Median similarity ratings between the target item and each pair of proposed semantically related and unrelated distractors

Semantically-related pictures		Unrelated pictures	
Banana paired with	Median rating (range)	Banana paired with	Median rating (range)
Apple	1 (2)	Glass	1 (1)
Grapes	2 (2)	Slipper	2 (1)
Strawberry	1 (2)	Clock	1 (1)

3.6 Paradigm 3: Inattentional blindness

3.6.1 Materials

This task comprised four short movies (trials) followed by a visual recognition task. The movies were created using Macromedia Flash (version 7) at a running speed of 96 frames per second and displayed using Macromedia Flash Player (version 8). Each trial was 32 seconds long and depicted a green frog, three red butterflies and three brown bugs all moving randomly against a yellow background. The creatures

were chosen as they were perceptually distinct and easily identifiable (see fig. 3.3). The motion path of the red butterflies and brown bugs never collided but the green frog occasionally landed on (ate) either a red butterfly or a brown bug and that insect disappeared. Immediately after the insect disappeared it was replaced by an identical insect entering from a randomised point on the edge of the screen. This kept the number of insects displayed constant throughout the movie. The total number of insects eaten in each movie was six with a minimum of two and a maximum of four butterflies being eaten in each. Both the proportion of bugs and butterflies eaten and the order in which the insects were eaten were randomized across trials (see Table 3.2).

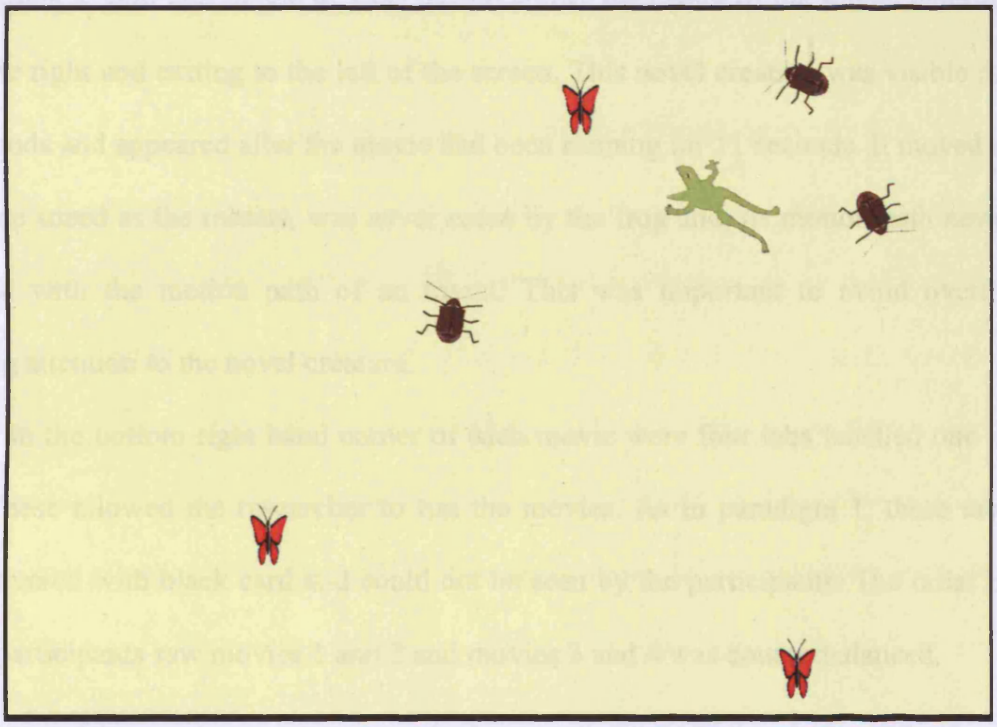


Figure 3.3: Paradigm 3: Examples of butterflies, bugs and frog

Table 3.2: Butterflies eaten and order of consumption. B=Bug, Y=Butterfly

Movie	Butterflies eaten	Order of consumption					
1	2	B	B	Y	B	B	Y
2	4	Y	Y	B	B	Y	Y
3	3	B	Y	Y	B	Y	B
4	4	B	Y	Y	Y	B	Y

In movies 3 and 4, an additional novel brown creature (for example see Fig. 3.4) (movie 3: bird and movie 4: fish) moved across the centre of the screen entering from the right and exiting to the left of the screen. This novel creature was visible for 10 seconds and appeared after the movie had been running for 11 seconds. It moved at the same speed as the insects, was never *eaten* by the frog and, its motion path never collided with the motion path of an insect. This was important to avoid overtly drawing attention to the novel creature.

In the bottom right hand corner of each movie were four tabs labelled one to four. These allowed the researcher to run the movies. As in paradigm 1, these tabs were covered with black card and could not be seen by the participants. The order in which participants saw movies 1 and 2 and movies 3 and 4 was counterbalanced.

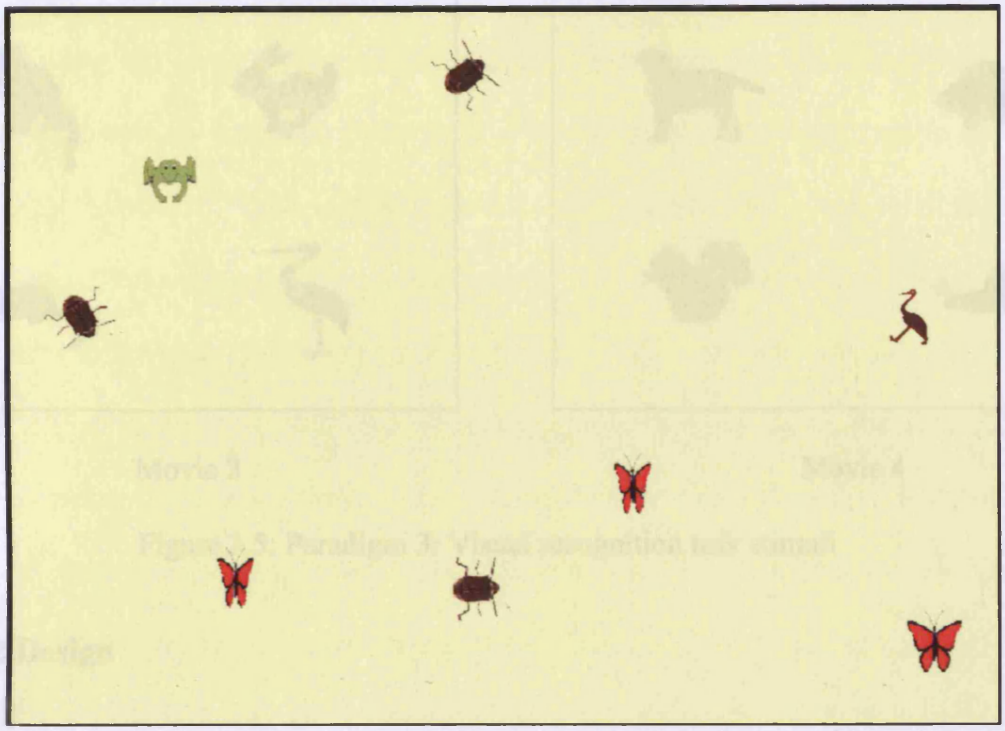
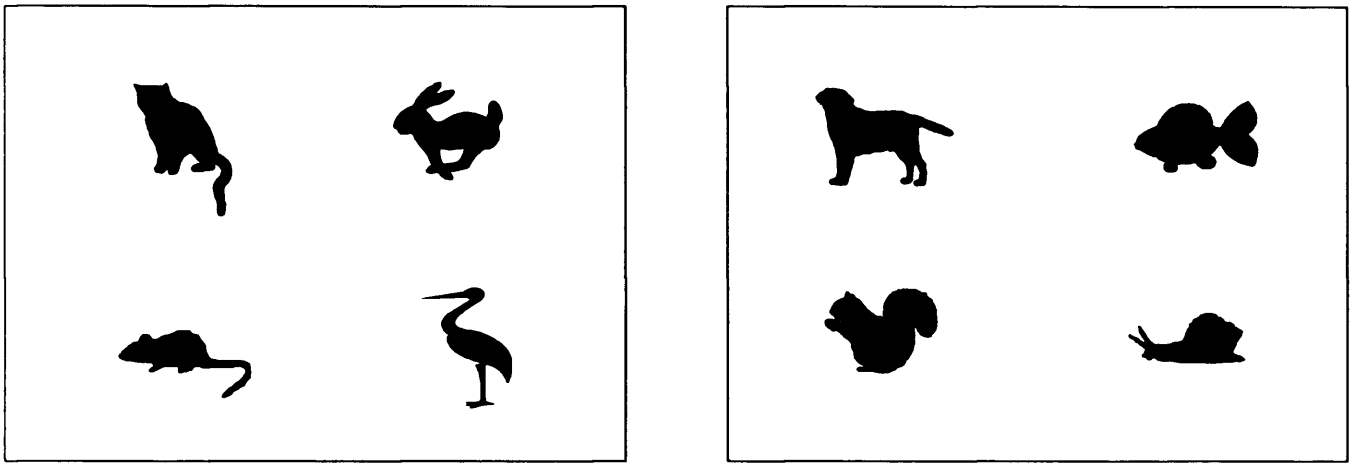


Figure 3.4: Paradigm 3: Example of novel creature

The recognition task comprised two sheets of A4 paper (one each for movies 3 and 4 respectively). Each sheet displayed four brown creatures one in each quadrant (see fig 3.4). One of these was the novel creature that had passed across the screen in the last movie shown i.e. a bird or a fish. The bird was positioned in the bottom right-hand quadrant whilst the fish was in the top right-hand quadrant. The other creatures, which were different on each sheet, had not been seen previously and were, for movie 3 (where the novel creature was a bird): a cat, a rabbit and a mouse whilst, for movie 4 (where the novel creature was a fish) they were: a dog, a squirrel and a snail. These animals were chosen as they were perceptually distinct and could reasonably be expected to be seen in a garden, which was the setting for the movies (see vignette in 3.6.3).



Movie 3 Movie 4

Figure 3.5: Paradigm 3: Visual recognition task stimuli

3.6.2 Design

The research question was whether either of the patient groups would notice the novel creature presented in movie 3 significantly more than would be predicted by chance. The purpose of movies 1 and 2 was to familiarise participants with the procedure and reduce their expectations that they would be asked any unexpected questions. Movie 4 was shown to ensure that the participants were able to purposefully divide their attention between the different visual stimuli once they had an expectation that an additional creature might be shown. The independent variable was the presence of a novel creature in movie 3 and this was tested within-participants. The dependant variable was the creature chosen in the visual recognition task. A recognition task rather than free recall task was chosen to reduce the memory load.

3.6.3 Procedure

The researcher verbally gave participants the following vignette: 'Imagine that you are sitting in a garden watching some red butterflies. You have watched these

butterflies many times before and you notice that there seem to be less of them than usual. A frog has recently moved into the garden. You know that this frog likes to eat brown bugs but you think that he might also be eating the butterflies. You decide to see if this is the case.' Participants were then told that they were going to be shown some short movies depicting events in the garden and that they were to watch the frog and count aloud each time he ate a red butterfly. They were also told that the frog might eat brown bugs but that they were only interested when he ate the butterflies. The researcher then ran the first movie. At the end of the movie the screen went blank and the researcher asked the participant how many butterflies had been eaten. Then the researcher ran the second and third movies which followed the same procedure. After the participant said how many butterflies were eaten in movie 3, they were told that during part of the last movie there was an additional animal in the garden. They were then given the recognition task and asked to point to which animal it was. If they were unsure, they were asked to guess. The fourth movie was then played and the procedure repeated as for the previous movies. Again, this movie was followed by a recognition test and participants were asked to identify the additional animal.

Chapter 4: Facilitation from extraneous visual information in patients with mild PD: Initial evidence

The main aims of the thesis were to quantify the effects on performance of different types of visual distractors presented simultaneously with visual targets, infer whether different mechanisms underlie altered performance arising from the characteristics of the visual distractors, and to evaluate whether such altered occurs at different stages of attentional processing. Specifically, this chapter reports the performance of patients with mild PD on the three studies undertaken using each of the paradigms described in Chapter 3. Since the participants and baseline cognitive measures were common to each study these are reported first to avoid repetition.

4.1 Participants

The patient group comprised 20 patients with mild Parkinson's disease (PD) with a mean age of 70.0 years (SD 6.7) and mean years in education of 13.5 (SD 3.8). The patients (15 males and 5 females) all attended the Parkinson Disease Clinic based at Rookwood Hospital, Cardiff, UK and were taking medication to control their motor symptoms. All patients were tested during their *on* period approximately one to two hours after taking their Parkinson's medication. The diagnosis of Parkinson's disease was made in accordance with the UK PDS Brain Bank criteria (Hughes et al., 1992) and the patients were classified as mild, i.e. stages 1-3 inclusive on the (Hoehn & Yahr, 1967) severity rating scale. Nineteen of the patients participated in their home and one attended the School of Psychology, Cardiff University.

The healthy older adult (HOA) controls (4 males and 16 females) were either the spouses or friends of the patient or members of the Cardiff University psychology

department's participant panel. They had a mean age of 71.4 (SD 5.3) and mean years in education of 12.2 (SD 2.2). There were no significant differences in either age or years in education between the two groups ($t<1$). Fourteen HOA controls participated in their own homes whilst six participated at the School of Psychology, Cardiff University. The HOA controls were asked to choose a participation time at the time of day when they felt at their brightest. This group also acted as HOA controls for the studies described in Chapter 6.

All participants had a Mini Mental State Examination (MMSE) (Folstein et al., 1975) score of over 25, either normal or corrected vision and English was their first language. Participants were excluded if they had a history of chronic affective disorder, schizophrenia, alcohol misuse or acquired brain injury or were currently depressed or taking CNS depressant medication (with the exception of Levadopa or dopamine agonists). The study was approved by the local NHS ethics committee and all participants gave written informed consent. No one was paid for their participation.

4.2 Results: Baseline cognition measures

The rationale for the choice of baseline cognitive measures was given in Chapter 3. Participants' scores on the W-tar, MMSE and BASDEC were calculated and are shown in Table 4.1. Raw scores rather than age adjusted scores were used in respect of the W-tar as there were no significant age differences between the two groups and therefore adjusting the scores for age would not affect the pattern of results. Unpaired t-tests showed there were no significant differences in W-tar scores suggesting similar IQ levels. Nor were there any differences in BASDEC scores showing that participants had similar depression inventory scores, all of which were below the cut-off level for depression. Whilst the controls had significantly higher

MMSE scores than the patients with mild PD, this equated to less than one additional correct answer on this task with all participants achieving a minimum score of 26.

Table 4.1: Comparison of baseline cognitive measure scores

	Patients with PD		HOA Control		p value
Measure	Mean	SD	Mean	SD	
W-tar raw score (max.=50)	**38.7**	9.3	**42.4**	6.5	n.s.
MMSE (max.=30)	**28.1**	1.3	**28.9**	1.3	0.05
BASDEC (max.= 21)	**2.4**	2.2	**2.2**	1.9	n.s

4.3 Study 1: Flanker plus Stroop

The primary purpose of study 1 was to assess the impact on stimulus identification and response selection arising from visual peripheral distractors with different characteristics (see fig 1.1, p.7). This was achieved by comparing shape naming performance when visual peripheral distractors were present to baseline performance when the shapes were presented alone (for details of distractors see Chapter 3). Specifically, the target and OS flankers assessed the effects of superordinate category priming on stimulus identification. Evidence from distractibility tasks (e.g. Sharpe, 1990) suggested that the patient group would be distracted by their presence, whilst facilitory effects observed from both congruent Stroop tasks (Henik, Singh, Beckley & Rafal, 1993) and lexical decision tasks (Spicer, Brown, & Gorell, 1994) suggest they might be aided by their presence. Here, it was predicted that the OS flankers would activate the superordinate category of shapes which would in turn prime basic level category information from the shape domain and hence improve performance.

The incongruent shape word within one of the OS flankers evaluated the effects on response selection of prepotent information presented peripherally. It was predicted that the patients would be distracted by the incongruent shape word when it

was within one of the OS flankers as their presence was predicted to activate a pre-potent response despite being outside direct fixation (Lee, Wild, Hollnagel, & Grafman, 1999), due to faster activation of the word than of the shape name. No differences in performance were predicted for the control group since previous studies has found little evidence for semantic facilitation (Mari-Beffa et al, 2005) and for distractor from prepotent peripherally presented visual distractors.

The secondary purpose of study 1 was to evaluate the effects on response selection of prepotent information presented in the same location as the target stimulus. This was assessed by placing an incongruent shape word centrally within the target shape. This was done to replicate the Stroop effect (Stroop, 1935) within the current paradigm and thereby demonstrate that the paradigm was sensitive enough to identify significant differences across conditions. It was predicted that both groups (patients with PD and HOA controls) would be impaired by the presence of the incongruent shape word within the shape but that the level of impairment would be greater for the patient group.

4.4 Data analysis strategy

4.4.1 Calculation of errors and verbal response times

A verbal response was scored as an error if a participant completely or partially verbalised an incorrect response. Errors were subdivided into two types; *pure* where participants showed no awareness of having made a mistake and, *self-corrections* where awareness of an error was shown. Awareness was classified as instances where either participants explicitly stated that a mistake had been made, typified by comments such as 'No, that was a circle' after incorrectly stating it was an alternative shape, or comments such as 'That was wrong' or, where comments such as

'You caught me out there' were made. The number of errors was calculated separately for each of the four conditions.

To calculate verbal response times, the DVD recordings were saved in .AIV movie format and participants' responses were calculated on a trial-by-trial basis. Trials where errors were made were excluded as were trials immediately following an error. These trials were excluded to reduce experimental noise resulting from participants' verbalisations or hesitations following an error trial. Because of the pseudo-random ordering of trials, this procedure reduced any bias resulting from the excluded trials being in some sense more difficult.

For each remaining trial, stimulus onset and response times were obtained and then the differences calculated to give a time per trial in milliseconds. Stimulus onset times were obtained by playing the .AIV movie frame by frame in Adobe Premiere and recording the running time at the point when the traffic-light sequenced blocks changed, e.g. from red to amber, in the bottom right hand corner of the screen. During this analysis, the remainder of the screen was covered with black card so that the researcher was blind to the particular trial condition. Response times were obtained by playing the .AIV file in Adobe Audition which played the audio and associated wave form simultaneously. The wave form was marked at the onset of each response. Again, the researcher was blind to the particular trial condition.

4.4.2 Data screening

The data screening considered individual participants' mean error rates and mean verbal responses times in each experimental condition. For each group and the two dependant variables separately (errors and verbal responses times), the mean results were checked for data inputting errors. To facilitate this, frequency charts were

produced and scrutinised to ensure that for each condition there were no values that were outside of the expected range, and that there were no missing values. Missing values were not expected as these would only be present (except if arising from data inputting errors) if participants failed to name the target shape correctly in all trials for a particular condition, which was not the case.

Finally, to account for within-condition outliers, mean verbal response times and standard deviations (split by group and presentation block) were calculated for each individual condition. Both groups' responses were inspected on a trial-by-trial basis and where any response was +/- 3 SDs from the group mean for that condition and block, the values were adjusted to equal +/- 3 SDs from that mean. This method of data trimming was advantageous since all trials were retained and still reflected the most extreme data points whilst minimising the impact of outliers on the distribution of the data. This was important since the response time data had to be normally distributed in order to use parametric statistics for the data analysis. No adjustments were required in respect of errors made as a non-parametric statistical approach was adopted (see below).

In respect of verbal response times, overall 5% of trials were adjusted for the patients with mild PD whilst 19% of trials were adjusted for the control group. This higher level of adjustment is due to the small variance across trials in the performance of the control group, with equivalent numbers of adjustments being made at both ends of the distribution curve.

The next consideration was whether the data for each group was normally distributed after accounting for outliers as detailed above. To assess this, distribution plots for each condition (split by group) were produced and inspected. There was no evidence of kurtosis but the data was positively skewed in both groups. Therefore all

data, for each group in each of the four conditions, was transformed using a log transformation. This improved the shape of the distributions although the data in the patient group was still skewed albeit not significantly so. As the main question of interest was the within-group pattern of results and since all conditions were skewed in the same direction this log-transformed data was used in all subsequent inferential analysis. The pattern of results observed within the untransformed verbal response time data and the log-transformed data was the same. Therefore, throughout this chapter the descriptive data will report the untransformed verbal response times for ease of understanding. The log transformed descriptive data can be found in the appendices as indicated in the relevant sections below.

4.5 Results

4.5.1 Errors

Participants' responses on each shape-naming trial were scored and the number of errors calculated for each of the four conditions. Due to the low rate of errors no distinction was made between *pure* and *self-corrections* errors. In all but the target plus incongruent word condition, the number of errors made by both groups was negligible representing 0.3% of trials. Eighteen controls and 16 patients with PD made no errors in the other three conditions (target alone, OS flankers and OS flankers plus incongruent word) and no-one made more than one error in any of these conditions. When the target contained an incongruent word, 16 HOA controls and all the patients with PD made at least one error. Overall error rates were low representing 3% of trials for controls and 7% for patients with PD. The mean number of errors were 1.5 (SD 1.3) for controls and 3.0 (SD 2.0) for patients with PD. Due to the low level of errors and restricted range of the results obtained a non-parametric Mann

Whitney test was applied to the data. It showed that patients with mild PD made significantly more errors than controls, $z(38) = 2.68$, $p<0.01$.

4.5.2 Verbal response times

This study assessed the effect of extraneous visual stimuli on verbal shape naming times. When the target was presented alone was used as a baseline measure of each participant's shape naming speed without visual distractors. Thus, all within-participants comparisons were between the verbal response times when extraneous stimuli are present and the verbal response times in the baseline condition where the target shape was presented alone.

As the stimuli were presented in two blocks, the first analysis considered whether participants showed different performance patterns in the two blocks (as evidenced by verbal response times). Due to an equipment failure, data for one of the HOA controls was recorded for block 2 only. Therefore this participant's data was excluded from this particular analysis. For the 20 patients with mild PD and the remaining 19 HOA controls the mean verbal response times (in milliseconds) for each condition in blocks 1 and 2 are displayed in table 4.2 (for the log transformed data see Appendix 1).

Table 4.2: Mean verbal response times (in ms.) split by presentation block

Group	Block 1 Mean (ms.)	SD	Block 2 Mean (ms.)	SD
Patients with PD				
Target (baseline)	**1241**	201	**1186**	200
Target with OS flankers	**1195**	193	**1097**	166
Target with OS flankers plus word	**1191**	175	**1180**	258
Target plus incongruent word	**1508**	281	**1438**	371
HOA Control				
Target (baseline)	**1152**	81	**1087**	115
Target with OS flankers	**1118**	54	**1097**	92
Target with OS flankers plus word	**1133**	72	**1064**	86
Target plus incongruent word	**1386**	122	**1213**	136

To evaluate whether there was a significant difference in performance between blocks, a mixed-factorial ANOVA was used with group (patients or HOA controls) as the between-participants variable and both stimuli presented and block (1 or 2) as within-participants variables. Since the assumption of sphericity was violated (Mauchley's tests of sphericity for the stimuli X block interaction was significant ($p<.05$)), the multivariate statistics are reported for all main and interaction effects (as recommended by Keppel & Wickens, 2004).

Importantly, there were no significant interactions between either block and stimuli ($p=.34$), or block and group ($p=.45$) and no three way interaction between stimuli, block and group ($p=.09$). There was a main effect of block with both groups being significantly faster in block 2 ($p<.01$). However, this is not central to the question of the pattern of performance across conditions. Therefore in all further analyses the data was collapsed across blocks to allow the overall patterns of performance to be considered. The overall mean verbal response times for each group and condition are shown in Fig.4.1 (see Appendix 1 for log transformed data).

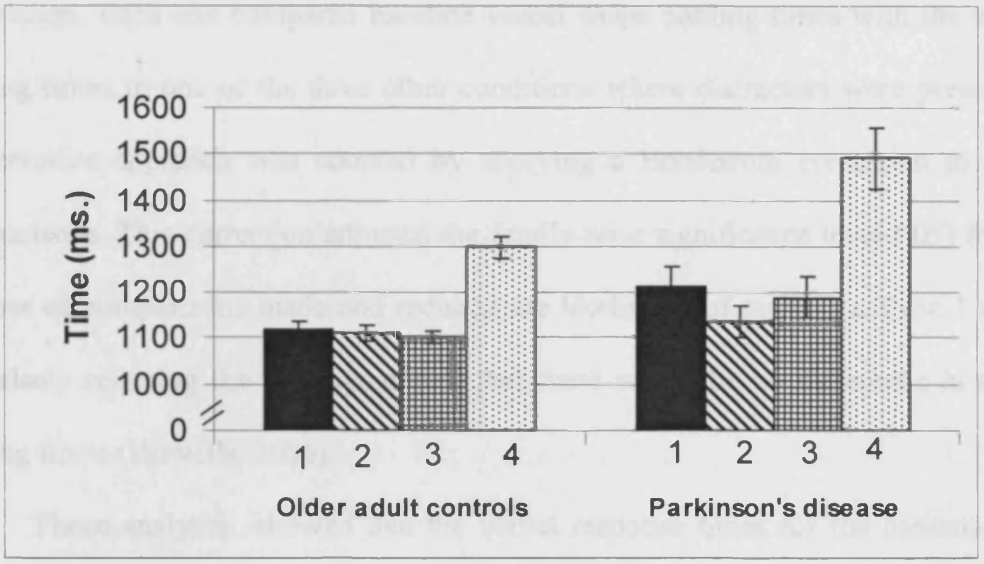


Figure 4.1: Shape naming verbal response times for study 1. Error bars=SE. Conditions: 1=Target (Baseline), 2=Target and OS flankers, 3=Target and OS flankers plus incongruent word, 4=Target plus incongruent word.

Fig. 4.1 suggests that the patients with mild PD benefited from the presence of the flankers (OS) and that both groups were slower to name the target shapes when they contain an incongruent word. To evaluate whether these differences were significant a mixed factorial ANOVA was used. Group (patient or HOA control) was the between-participants factor and the stimuli presented were the within-participants factor. Again, due to a violation of the assumption of sphericity ($p<.05$) the multivariate statistics are reported. There was a main effect of stimulus, $F(3, 36) = 73.97$, $p<.01$, $\eta_p^2 = .86$ and a main effect of group, $F= (1, 38) = 4.03$, $p<.05$. More importantly, there was an interaction between stimulus and group ($F(1, 36) = 5.75$, $p<.01$, $\eta_p^2 = .32$).

Planned pair-wise comparisons for each group independently were undertaken. Each one compared baseline verbal shape naming times with the verbal naming times in one of the three other conditions where distractors were present. A conservative approach was adopted by applying a Bonferroni correction to these comparisons. This correction adjusted the family-wise significance level (.05) for the number of comparisons made and reduced the likelihood of making a Type 1 error, i.e. falsely rejecting the null hypothesis that there would be no difference in shape naming times (Howells, 2006).

These analyses showed that the verbal response times for the patients with mild PD were significantly faster on trials when the target shape was presented with the OS flankers than when the target shapes were presented alone, i.e. they were particularly aided by the presence of the OS flankers, $F(1,19)= 21.84$, $p<.01$. However, there were no significant differences in verbal response times for the HOA controls between these two conditions ($F<1$). Furthermore, both the patients with mild PD and the HOA controls were significantly slower to name the target when an incongruent shape word was within the target shape, $F(1, 19) = 45.87, 71.36)$, $p<.01$ (for the patient group and the HOA controls respectively). There were no significant differences (for either group) between their response times when the OS flankers contained an incongruent shape word and their baseline verbal response times (for patients with PD: $p=.23$, for HOA controls: $p=.84$).

As predicted, the data displayed in Figure 4.1 suggests that the patients with PD might be slower than the controls at shape naming. Simple effect comparisons showed this to be the case, $F(1, 38) = 3.99$, $p=.053$, $\eta_p^2 =.1$. The verbal response times of the two groups did not significantly differ when either OS flankers or OS flankers plus word) were present, $p=.58$ and $p=.1$ respectively. However, when there

was an incongruent shape word within the target shape the patients with mild PD were significantly slower to name the target shape than controls, $F(1, 38) = 7.73$, $p<.01$, $\eta_p^2 = .17$. This finding may have resulted from differences in shape naming times. Therefore, the difference in verbal response times between when an incongruent shape word was within the target shape and when the target was presented alone was calculated and the differences between patients and controls compared using an unpaired t-test. This shows that when baseline shape naming times are taken into consideration, the difference between the patients with PD and the HOA controls failed to reach significance, $t(1,38)=1.75$, $p=.09$.

Seventeen out of the 20 patients with mild PD and 13 out of the 20 HOA controls were faster to name the target shape when it was surrounded by the OS flankers compared to when the target was presented alone. The next analysis considered whether the participants who had the slowest baseline verbal response times benefited most from the presence of the OS flankers. To do this, for each group (patients with mild PD and HOA controls), their log-transformed verbal response times when the target was presented alone were correlated with the difference in their log-transformed verbal response time between when the target was presented alone and when the OS flankers were present. The performance of both groups showed significant negative correlations of -.67 and -.54 for the patients with mild PD and the HOA controls respectively ($p<.01$.). This suggested that those with the slowest baseline naming speeds benefited most from the presence of the OS flankers in both groups.

Since there was a gender imbalance both within and between the two participant groups, the effects of gender were considered. The results analysed by gender are displayed in Figures 4.2 and 4.3 and suggest that there were no gender

differences in the pattern of performance for either participant group. The low number of participants in the minority gender groups meant it was not possible to undertake any meaningful inferential statistical analysis. However, scrutiny of the pattern of results for the female participants with mild PD showed that all five participants had the same pattern of results as the group as a whole. Compared to their verbal response times when they named the blue shape presented alone they were faster to name the blue shapes when the OS flankers were present and slower to name the blue shapes when these shapes contained an incongruent shape word thus suggesting that gender is not driving the pattern of interactions.

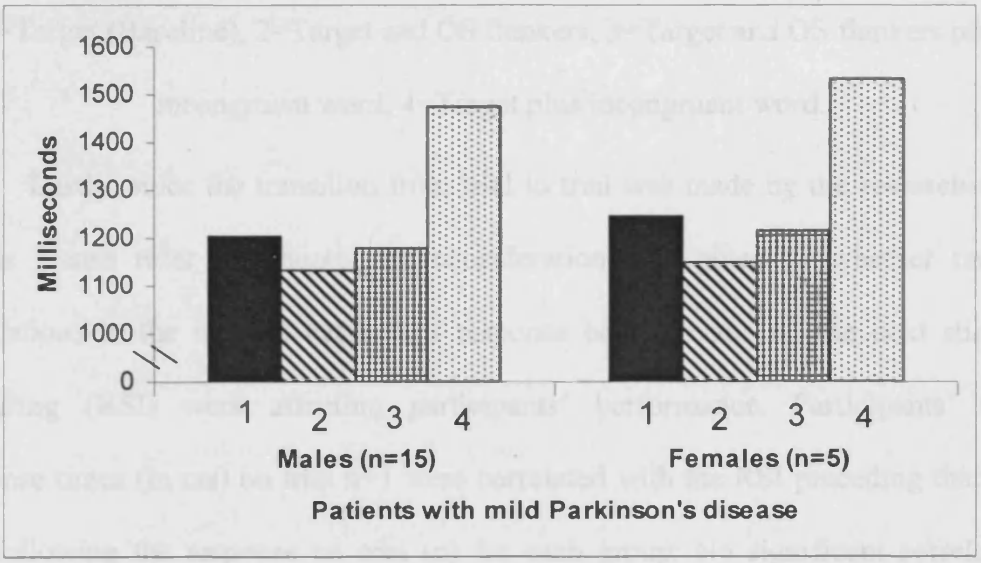


Figure 4.2: Verbal response times for patients with mild PD split by gender. Conditions: 1=Target (Baseline), 2=Target and OS flankers, 3=Target and OS flankers plus incongruent word, 4=Target plus incongruent word.

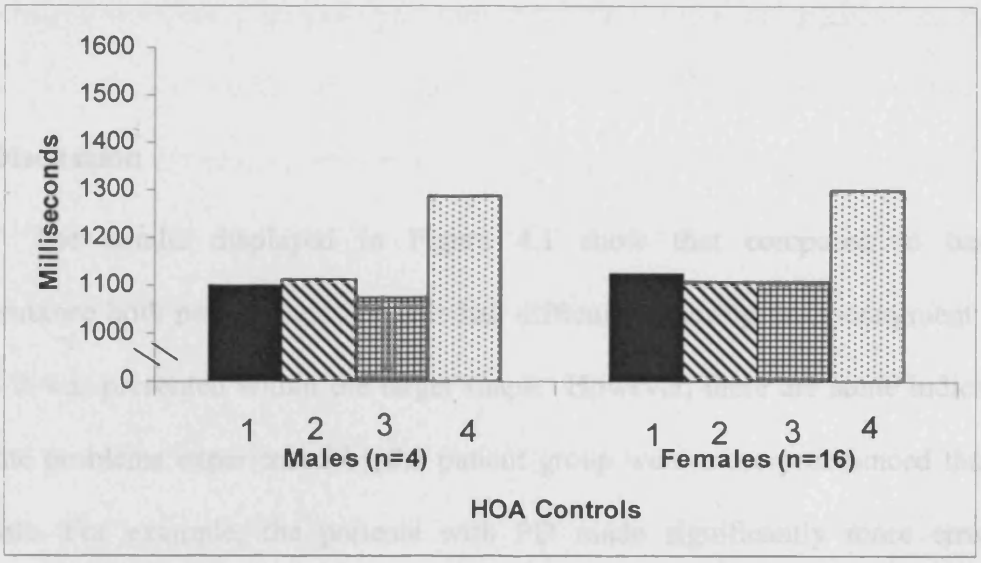


Figure 4.3: Verbal response times for HOA controls split by gender. Conditions: 1=Target (Baseline), 2=Target and OS flankers, 3=Target and OS flankers plus incongruent word, 4=Target plus incongruent word.

Lastly, since the transition from trial to trial was made by the researcher (for details please refer to Chapter 3), consideration was given to whether random fluctuations in the interval between a response being given and the next stimulus appearing (RSI) were affecting participants' performance. Participants' mean response times (in ms) on trial n+1 were correlated with the RSI preceding that trial, i.e., following the response on trial (n) for each group. No significant correlations were found (see table 4.3) suggesting that differences in RSI times were not responsible for the pattern of results observed.

Table 4.3: Study 1: Correlation coefficients between response times (trial n+1) and preceding RSI by stimulus type

	Patients with PD		HOA controls	
Condition	r	P	r	p
Target (baseline)	**.16**	.52	**-.28**	.23
Target with OS flankers	**.10**	.69	**-.12**	.63
Target with OS flankers plus word	**.12**	.61	**-.36**	.12
Target plus incongruent word	**-.02**	.95	**-.25**	.28

4.6 Discussion

The results displayed in Figure 4.1 show that compared to baseline performance both patients and controls had difficulty ignoring the incongruent word when it was presented within the target shape. However, there are some indications that the problems experienced by the patient group were more pronounced than the controls. For example, the patients with PD made significantly more errors in condition 4 than the HOA controls. Similarly, the absolute response times when the incongruent shape word was presented inside the target were significantly slower for patients than the HOA controls, although this difference failed to reach significance when baseline shape naming times were taken into consideration ($p=.09$).

The finding that patients with mild PD had more difficulty ignoring the incongruent shape word within the target shape was predicted. Participants had to suppress the automatic response of word reading in order to name the shape. Previous findings have shown that patients with PD have particular difficulties ignoring irrelevant information which elicits a strong automatic response even when the information is incongruent with the task demands (Bokura et al., 2005; Dujardin et al., 1999; Praamstra et al., 1999; Praamstra et al., 1998; Seiss & Praamstra, 2006; Wylie et al., 2005). Also, similar deficits have been found on Go/No-go tasks where participants must withhold a habitual response to stimuli presented without distractors (Bokura et al., 2005; Franz & Miller, 2002; Gauggel et al., 2004) . Findings of this type are usually taken as evidence that the difficulty arises because of problems inhibiting a habitual response. The increased difficulties in PD are due to dopamine depletion in the projective pathways to and from the basal ganglia believed to be

important in response selection (e.g. Praamstra et al., 1999; Praamstra et al., 1998). Brown, & Marsden (1988) demonstrated that whilst patients with PD were slower than controls in the original version of the Stroop task (Stroop, 1935) this difference was not found when immediately prior to each trial they received a cue (ink or word) indicating the required response and hence reducing difficulties in response selection. When the incongruent shape word is within the target then at a perceptual level both the shape and word will initially be selected as one object (Kahneman & Henrik, 1981) and without the aid of an external cue the patient group may have difficulties in differentiating between the two activated responses and selecting the one relevant to the task demands.

Stimulus identification difficulties can explain why patients with mild PD named the shapes more quickly in the presence of OS flankers. The identical OS flankers surrounding the target shape may have helped the patients to identify the target and hence facilitated their performance. The possible mechanisms that led to this facilitation are discussed later in this Chapter. This explanation fits with the work of Spicer, Brown, & Gorell, (1994) who found that the addition of word primes prior to lexical word/ non-word decision tasks resulted in patients with mild PD making quicker responses. It is also in line with the tentative evidence that patients with PD show greater facilitation effects for congruent information (Henik et al., 1993) and that patients with PD are particularly sensitive to the activation of semantically related information as in the Hayling sentence completion task (Bouquet et al., 2003; Castner et al., in press). Taken together, this evidence suggests that patients with mild PD have particular problems identifying the relevant stimulus and that additional related information which primes identification can be used to facilitate performance.

Facilitation effects have also been explained in terms of a failure of inhibitory processes (Mari-Beffa et al., 2005). They found evidence of positive priming in two lexical decision tasks both when the target word on a trial was semantically related to the distractor words on the preceding trial and when the distractor words on one trial became the target on the next. They interpreted this as evidence of an inability to ignore irrelevant visual stimuli. They reasoned that the distractors must have been processed in order for positive priming to have occurred and therefore patients with PD must have problems in inhibiting information irrelevant to the current task demands. In contrast, Troche et al (2006) found equivalent negative priming between patients with PD and controls but enhanced positive priming in the patient group. They interpreted this as being due to problems engaging with the stimulus as opposed to being distracted by extraneous information, in which case an abolition of negative priming would have been expected. Applied to the current data, this may also help to explain why the patients were aided as opposed to impaired by the addition of the OS flankers. Rather than being distracted by extraneous visual information per se, the OS flanker information was processed. This primed the shape category and was used to help in target identification. Thus rather than referring to the OS flankers as 'irrelevant' to the task demands, it is better to substitute the word 'unnecessary' since, if additional visual items can aid the patient group in task completion then for them the items are not irrelevant.

If the OS flankers were beneficial to the patient with PD it is somewhat surprising that the same facilitation effect was not observed in the control group. A negative correlation was found for both groups, such that those participants who were slower at naming shapes without distractors benefited more from the extraneous visual information provided by the OS flankers. This correlation suggests that all

participants processed the OS flankers but only those who responded most slowly used the OS flankers to facilitate performance. It is possible that ceiling effects, in the HOA controls, may have contributed to the lack of significantly faster shape naming responses when the OS flankers were present. Those HOA controls who responded very rapidly may not have been able to respond any faster even when the category shape was primed by the OS flankers.

The presence of the OS flankers may have helped the patients with PD in a number of ways. Firstly, since the OS flankers are identical and distinct from the target shapes on the basis of colour this could have made the target shapes more salient through novel- popout (Pashler, 1999), i.e. have helped with stimulus selection. However, within the novel popout literature a single target stimulus is never presented alone and it is difficult to envisage how the target could be more salient when the OS flankers are present than when the target is presented alone. A second possibility is that the patients had difficulty forming an attentional set on the basis of colour and therefore noticed the OS flankers more than the HOA controls. Again this would suggest problems with stimulus selection. However, this does not explain why the patient group's verbal response times were faster when the OS flankers were present. If they failed to maintain an attentional set it would be expected that their performance would be impaired by the presence of the OS flankers rather than aided by them. The third and favoured explanation is that the OS flankers aid stimulus identification. Here, the OS flankers prime the superordinate category of shapes which in turn aids the retrieval of other basic level shape information, thereby aiding stimulus identification and resulting in quicker response times.

Not all studies have found facilitation effects from additional visual stimuli in patients with mild PD. For example, when letters have been used as targets and

distractors in an adapted flanker task, patients were neither distracted nor facilitated by the additional letters (Lee et al., 1999). One explanation is that naming letters is easier than naming shapes and therefore the manipulation was not sensitive enough to elicit group differences. Alternatively, it could be that it is the characteristics of the additional stimuli which are important. Perhaps the letters were more visually similar to each other than the stimuli used in the current study and therefore could not be used to facilitate performance. A third explanation is that the facilitation from the category 'letter' offset the distraction arising from the automatic verbal response elicited by the letter distractors. In the current study the OS flankers did not elicit an automatic verbal response and therefore a facilitation effect was observed.

Turning to the condition where the incongruent word was within one of the OS flankers, the finding that the performance of the patients with PD was not significantly worse than baseline was unexpected. This appears to conflict with the findings of research using arrows outside fixation which has resulted in worse performance by patients with PD (Praamstra et al., 1999; Praamstra et al., 1998; Seiss & Praamstra, 2006; Wylie et al., 2005). It might be suggested that the current experimental manipulation was not powerful enough to detect a difference; but a lack of power per se seems unlikely given that both the patients with PD and the HOA controls were impaired when the incongruent word was presented within the target shape. A more plausible explanation is that the current study used only one prepotent word whereas the flanker tasks using arrows (e.g. Wylie et al. 2005) placed multiple incongruent distractor arrows either side of the target thereby increasing the strength of the effect. Also, the direction of the target arrowhead might serve to draw attention to the distractors, since one points to the other. No such problems arise when shapes are used.

Despite the explanations above, the performance of the patients with mild PD may have been adversely affected by the peripheral incongruent shape word within one of the OS flankers. This is a possibility as, the faster verbal response times when the target was presented surrounded by the OS flankers were attenuated when one of the OS flankers contained a shape word. However, this may not have resulted in significantly longer verbal response times since the facilitation effect of the OS flankers may have offset any response time decrement arising from the presence of the peripheral incongruent shape word. There are two possible explanations for this attenuation; either the patients with mild PD were distracted by the peripheral shape word or the presence of the word may have disrupted the patients' ability to use the OS flankers to improve their performance. This disruption could arise because the OS flankers were no longer identical and so could not be used to aid stimulus selection. Alternatively, the prepotent response elicited by the incongruent shape word may have interfered with the priming advantage conferred by the OS flankers. This may have prevented the OS flankers being used to aid stimulus identification. Further research helping to differentiate between these alternatives is discussed in Chapter 5.

Another consideration is whether random fluctuations in the RSI times influenced participants' performance across conditions. Previous studies (e.g. Henik et al., 1993) have used manipulations where the transition between the offset of one trial and the onset of the following trial is initiated by the researcher but have not addressed this issue. This is important because such fluctuations might result in participants, for example, having more time to recover between trials which could in turn influence performance. In the current study, it seems unlikely that the RSI times have influenced participants' verbal response times since there was no evidence of

correlations (for any stimulus condition) between the RSI times on trial n and participants' response times on trial n+1 for either participant group.

4.7 Study 2: Visual Search

In the visual search task, given that the performance of patients with PD is aided by semantically related words (Mari-Beffa et al., 2005; Spicer et al., 1994) it was predicted that a similar performance benefit would be seen when semantically related pictures were used as distractors. No performance differences between the semantically related and unrelated distractors were predicted within the control group.

4.8 Data analysis strategy

As for the Flanker plus Stroop task, for each group and the two dependant variables separately (errors and overall search times), the results were checked for data inputting errors. To facilitate this, frequency charts were produced and scrutinised to ensure that: for each condition there were no values that were outside of the expected range and that there were no missing values.

Finally, to account for within-condition outliers, overall search times for each participant in both conditions (semantically related and unrelated distractors) were calculated together with Z scores. These compared the search times of each participant with the search times of their participant group (patients with mild PD or HOA controls). Z scores of +/- 3 indicate that the search times were 3 SDs from the group mean in that condition. Both group's Z scores were inspected on a participant-by-participant basis. No Z scores of +/-3 were identified and therefore no adjustments to the search times for any participant were made. The overall level of errors was low indicating ceiling effects. Therefore only descriptive statistics for errors are reported (see 4.9.1 below).

Finally, the distribution of the data points was considered. To do this, distribution plots were produced and inspected (for each condition and group separately). There was no evidence of kurtosis but the data was positively skewed in both groups and particularly for the HOA controls. To account for this all data was subject to a log transformation and the log transformed data re-inspected. Although the data had a slight positive skew, this was no longer significant. Thus, as the main question of interest was the within-group pattern of results and all conditions were skewed in the same direction this log-transformed data was used in all subsequent inferential analysis. As with study 1, the results follow a similar pattern whether untransformed data or log-transformed data were considered. Therefore untransformed search times are reported below for ease of understanding. The log-transformed data can be found in the relevant appendices as indicated below.

4.9 Results

4.9.1 Errors

The visual search sheets were reviewed and errors noted. Controls made no errors whilst one patient with PD made two errors, with a further five patients making one error. All errors were omissions (failing to strike through a banana). Three errors were made when the distractors were semantically related and the other four when the distractors were unrelated. Errors made across conditions represented only 0.4% of the total number of targets. Having shown that the number of errors made was negligible, the time data was considered.

4.9.2 Search times

The mean search times for each type of distractor (for both participant groups) are displayed in table 4.4 (for log transformed times see Appendix 2). In terms of the

effect of visual distractors, for the HOA controls the mean search times were very similar regardless of the type of distractor (semantically-related versus unrelated) whilst for the patients with mild PD the mean search times appeared faster with semantically-related distractors. Since this study involved a within-participant manipulation, practice effects were also considered. The mean search times by order of stimuli presentation are also displayed in Table 4.4 (for log transformed times see Appendix 2). The descriptive data suggests practice effects for both groups, with faster overall search times in the second search task independent of the type of distractors. Overall, it appears that the patients with mild PD were slower to complete the task in both conditions, which was expected given the motor control problems patients with PD have.

Table 4.4: Study 2: Mean search times in seconds (by distractor type and task order)

	Distractor type		Task Order	
	Related	Unrelated	1st search	2nd search
Group	Mean (s) (SD)	Mean (s) (SD)	Mean (s) (SD)	Mean (s) (SD)
Patients with PD	**39.85**(13.72)	**43.35**(14.75)	**43.20** (13.47)	**40.00** (15.02)
HOA controls	**32.75**(9.28)	**33.05**(9.62)	**34.45** (9.37)	**31.35** (9.27)

The question posed was whether the patient group would be faster to find the targets when they were presented amongst semantically-related distractors. To eliminate order effects (over and above the counterbalancing across participants), an omnibus within-participants ANOVA analysis was undertaken for each group independently as recommended by Keppel & Wickens (2004). Using this method, separate analyses were carried out for the two variables of distractor relatedness and order effects. This reduced the overall error variance which otherwise would be inflated by the effect of practice (Keppel & Wickens, 2004). The patients with PD search times were significantly faster when the distractors were semantically-related

to the target item, $F(1, 18) = 4.96$, $p < 0.05$. No significant differences in search times between the two distractor conditions were found for the HOA control group ($F<1$). The patients with PD had significantly faster search times during the second search, $F(1, 18) = 5.51$, $p = .05$ whereas the difference in search times for the HOA controls just failed to reach significance, $F(1, 18) = 5.42$, $p= .06$.

4.10 Discussion

The mean task completion times for the patient group were significantly faster when the distractors were semantically related to the target which suggests a semantic facilitation effect. The results observed are in line with the findings of Mari-Beffa et al. (2005) and Spicer et al. (1994) who both found the patients with mild PD showed positive priming when the preceding trial's distractor became the target on the following trial, but more importantly this positive priming was maintained when the distractor on one trial was semantically related to the target on the next. This suggests that the semantically related information was beneficial to the patients and helped them in target identification even when the location of the target was unpredictable. Previously patients with PD have been shown to have more difficulties than controls (Sharpe, 1990) and to be more variable in performance when they need to selectively attend to both location and identity information in negative priming tasks (Filoteo et al., 2002; Wylie & Stout, 2002).

The explanation of semantic priming also fits with the PDP model of categorical relationships (e.g. McClelland & Rogers, 2003). Since all semantically similar distractors were fruits, this primed retrieval of items from the fruit domain and helped patients in the selection of the target bananas. In 4.6 above, three explanations for the facilitation effect observed in study 1 were offered. One explanation was also

based on semantic priming and fits with the data from study 2 whereas the other two possible explanations are more difficult to reconcile with this visual search data. Firstly, novel popout cannot explain why the patients with PD were aided by the presence of semantically related distractors since by design there were no salient visual features which would result in the target bananas popping out. Secondly, the inability to maintain an attentional set suffers from the same difficultly in that there were no salient visual features that could be used to construct the set.

The finding of semantic facilitation seems to be independent of any visual feature similarity between the target and the alternative distractors since both were pre-tested to ensure they were easily identifiable and comparably distinct. Also the results cannot be explained in terms of different feature similarity between the two sets of distractors and the target. If feature similarity was driving the results obtained, the control group would have been predicted to show differential performance between the two conditions, in line with previous studies where visual feature similarity was not matched across conditions (e.g. Brand, 1971). However, no differences in performance were observed for the control group.

It is noteworthy that large standard deviations within each group were observed. This seems to result from the different strategies participants used when completing the task. The task instructions did not state that the participants could or could not check through the sheets before finishing. Therefore some participants double-checked their sheets whilst others chose not to. However, there is no evidence that participants changed their chosen strategy between the two sheets, and this is supported by the similar within group standard deviations. It does however suggest that more explicit instructions or alternative testing procedures which minimise checking should be given to participants. These were explored in study 6.

4.11 Study 3: Inattentional Blindness

The research question here was whether the patients with mild PD have difficulties with stimulus selection, in which case they would be more distracted by and so likely to notice the extraneous visual information than the HOA controls. Specifically, if patients with mild PD were having difficulties with stimulus selection on the basis of colour, they might rely on identifying the targets and distractors on the basis of meaning. If this were the case, they would be predicted to notice the additional animal in movie 3 more than would be predicted by chance, even though the extraneous visual information had not previously been relevant in movies 1 and 2. Furthermore, asking about additional animals after movie 3 provides an implicit external cue that additional environmental stimuli might be important for this task. It was predicted that patients with mild PD would use this cue to guide their attentional processes during movie 4 in the same way they have been shown to benefit from explicit external cues (Brown & Marsden, 1988). The HOA controls were predicted to notice the extraneous animal no more than would be predicted by chance in movie 3. However, their rates of noticing should be significantly higher in movie 4 after they have been cued that other extraneous visual information presented may be important.

4.12 Results

The first analysis considered whether participants were able to complete the counting task successfully. The number of errors per trial made by each group is shown in Table 4.5.

Table 4.5: Study 3: Errors made counting butterflies eaten (max. =20 per trial)

Trial	Patients with PD No of errors	HOA Control No of errors
1	4	1
2	7	1
3	3	1
4	8	2
Total	22	4

As shown in Table 4.5, the HOA controls made few errors representing 6.25% of trials with no-one making more than one error across all four trials. However, the errors made by the patients with mild PD represented 27.5% of trials, 13 patients made one error, with a further 5 patients making two errors and 2 patients making three errors. All the errors made by the HOA controls were omission errors, i.e. failures to count an eaten red butterfly. The patients with mild PD made 16 omission errors. A further 6 errors were commission errors where either they counted a bug or, the patient counted when nothing was eaten. A non-parametric Mann-Witney test showed that overall the patients with mild PD made significantly more errors than the HOA controls, $z\ (39) = 2.93$, $p<.01$.

The number of patients who correctly identified the novel animal in the recognition tests following movies 3 and 4 are shown in Table 4.6. The results showed that when the novel animal was totally unexpected (movie 3) performance on the recognition test was no better than would be predicted by chance, for either the patients with mild PD or the HOA controls ($\chi^2 < 1$). In contrast, when a novel animal was expected (movie 4), separate Chi-squared tests for each group showed that the number of participants who successfully recognised the animal exceeded what would be predicted by chance, ($\chi^2\ (1) = 38.4$ (PD), 21.6 (HOA), $p<.01$.

Table 4.6: Study 3: Participants correctly identifying novel animals in recognition task

Trial	Patients with PD No correct	HOA Control No correct
3	6	5
4	17	14

4.13 Discussion

In terms of accuracy the patients with mild PD made more errors than the HOA controls, suggesting that they found the counting task more difficult. Despite this, neither group (patients with mild PD nor HOA controls) noticed the additional animal present in movie 3 significantly more than would be predicted by chance, suggesting equivalent performance in both groups. These findings are in line with a wide literature on inattentional blindness that shows people tend not to notice novel items which are not part of an attentional set they have formed to meet the task goal (for review see Simons, 2000). In this study the goal was to count the number of red butterflies eaten by the frog. The results demonstrate that both groups were able to form and maintain an attentional set to do this. It seems likely that this attentional set was based on colour rather than shape. Although the target butterflies differed in shape from the bugs, differentiation on the basis of shape should have resulted in participants noticing the novel animal which differed in shape from both the butterflies and bugs.

The second finding was that following movie 4, both groups noticed the novel animal significantly more than would be predicted on the basis of chance responding. This shows that both groups were able to amend their attentional sets. It also shows that both groups benefited from the implicit cue that the distractor items might be important and extends the finding that patients with PD benefit from external explicit cues (Brown & Marsden, 1988).

4.14 Chapter summary and further research

The first question posed by the thesis was whether the different characteristics of extraneous visual information presented simultaneously with visual targets differentially affected task performance at different stages of processing (see fig. 1.1 p.7). Study 1 (flanker plus Stroop) demonstrated this was the case. Both patients with mild PD and HOA controls showed impaired performance in response selection when visual distractors that elicited a prepotent response were presented in the same spatial location as the target stimulus. However for the patient group, distractors that did not elicit prepotent responses improved performance. Here, the semantic characteristics of the distractors aided stimulus identification. Study 2 extended these results by showing that these benefits persisted for the patients with mild PD even when the location of the targets was unpredictable. Finally, study 3 strengthened these findings by demonstrating that when the visual distractors did not elicit a prepotent response, the patients with mild PD were as able to avoid distraction from extraneous visual information as the HOA controls.

These findings also suggest that different processes might affect the way visual extraneous information is used to influence task performance. The results from studies 1 and 2 suggest that patients with PD use semantic information to aid them.

Other explanations such as novel popout or attentional set seem unlikely; especially as in study 3 the patients with PD showed no more difficulties in maintaining an attentional set than HOA controls. Two further studies are reported in chapter 5 that seek to replicate these findings and to clarify whether semantic information is underlying the ability of patients with mild PD to use certain types of extraneous visual information in a positive way.

Chapter 5: The mechanism underlying facilitation effects from extraneous visual information in patients with mild PD

The studies reported in Chapter 4 demonstrated that patients with mild PD can be aided by some sorts of extraneous visual information. The results from these studies supported the idea that the attentional mechanism underlying these facilitation effects was semantic priming. However, two other explanations, namely novel popout or, a failure to maintain an appropriate attentional set, could not be totally excluded. Therefore, this chapter focused on investigating which of these three explanations led to the facilitation effect. This was the purpose of study 4. In order to show that the facilitation arose from semantic priming it was necessary to demonstrate that stimuli from different semantic categories abolished the facilitation effect. One way to illustrate this was by using flankers from a different semantic category. Boats were chosen as flankers since they were easily recognisable when presented in outline as a two-dimensional figure. This was important to keep the perceptual complexity of the distractors equivalent to that of the OS flankers used in study 1. Furthermore, to demonstrate that neither novel pop-out nor failure to maintain an appropriate attentional set could account for the results obtained, it was necessary to show that types of distractors that would be predicted to support facilitation using these explanations do not. Here, these new distractor stimuli were needed that could not to be readily named or easily categorised, so that they would not interfere with any effects of semantic priming. Black squiggles were chosen for this since, in addition to being difficult to categorise, they were perceptually similar (in terms of colour and size) to the words used in Study 1. The specific rationale for how these new types of distractors modified the experimental conditions is given below in section 5.4.

The purpose of Study 5 was to constructively replicate the results of Study 2 using a modified visual search paradigm designed to reduce the within-group standard deviations. Details are given in section 5.8. Since the participants and baseline cognitive measures are common to each study these are reported first to avoid repetition.

5.1 Participants

The 20 medicated patients with mild PD described fully in Chapter 4 were invited to take part in the two follow-up studies. Eighteen of these patients chose to participate (14 males and 4 females), seventeen of whom did so in their own homes. These patients had a mean age of 70 years (SD 6.87) and mean years in education of 13.44 (SD 3.85). All patients were tested during their *on* period approximately one to two hours after taking their Parkinson's medication.

The HOA controls (8 males and 10 females) were either the spouses or friends of the patient or alternatively members of the Cardiff University psychology department's participant panel. They did not participate in studies 1 to 3. A new control group was necessary since it was planned that the original control group would participate in a follow-up study along with the patients with mild AD. They had a mean age of 69.56 (SD 6.97) and mean years in education of 12.78 (SD 2.78). There were no significant differences in either age or years in education between the two groups ($t<1$). Sixteen of the HOA controls participated in their own homes and two participated at the School of Psychology. The HOA controls were asked to choose a participation time at the time of day when they felt at their brightest.

All participants had a Mini Mental State Examination (MMSE) (Folstein et al., 1975) score of over 25, either normal or corrected vision and English was their first language. Participants were excluded if they had a history of chronic affective

disorder, schizophrenia, alcohol misuse or acquired brain injury or were currently depressed or taking CNS depressant medication (with the exception of Levadopa or dopamine agonists). No one was paid for their participation.

5.2 Comparison of Baseline Cognitive Measure Scores

The rationale for the choice of baseline cognitive measures was described in Chapter 3. The baseline cognitive measures were only administered to the HOA control group (see 5.3 below). They were not re-administered to the patients with mild PD for three reasons: firstly, the W-TAR^{uk} is a measure of pre-morbid IQ and therefore the scores obtained would be expected to show stability across time (Wechsler, 2001), secondly the period between testing intervals was several months during which time a significant difference in either MMSE scores or BASDEC scores would not be expected and, thirdly, it was necessary to keep the testing schedule as brief as possible to encourage participants to take part in the follow-up studies. Although this meant that the HOA controls completed more tasks in one session, this is not crucial to the pattern of behavioural responses within each task which were the variables of interest throughout.

5.3 Chronological Procedure

All participants experienced the first two experimental paradigms reported in chapter 4. For ease of reference these will be referred to as Flanker plus Stroop (revision 1) and visual search (revision 1). Whilst the detailed procedure of each revised paradigm is dealt with in the relevant sections below, the overall procedure and chronological order of task presentation was similar to that in Chapter 3, except that the Flanker plus Stroop (revision 1) paradigm was administered in two equal

blocks, with visual search (revision 1) paradigm 2 presented in between these blocks to reduce participant fatigue.

For HOA controls these two experimental paradigms followed after data collection on the baseline measures. In addition, the second block of Flanker plus Stroop was followed by paradigm 3 (inattentional blindness). This was done to keep the overall procedure and the order of presentation similar to that experienced by the patients with PD at their first testing session when baseline cognitive measures were collected. Everyone was de-briefed at the end of the session.

5.4 Study 4: Flanker and Stroop (revision 1)

The primary purpose of study 4, using an adapted version of paradigm 1 (Flanker and Stroop), was a) to delineate the mechanisms that underlie the facilitation effects seen in Study 1 and b) to replicate these facilitation effects. As with study 1, all comparisons were with shape naming performance when the target was presented alone. Specifically, in respect of the patients with mild PD the expectations were i) that a facilitation effect would occur when either one or all of the OS flankers contained an object(s) that were difficult to name and categorise (squiggles). This was because these objects would not elicit a prepotent response. Therefore they would not disrupt the participants' ability to use the OS flankers to facilitate improved performance; ii) that the facilitation effect would be abolished by peripheral distractors from a different semantic category (i.e. changing the OS flankers to boat flankers). This was because identifying the target shape would no longer be primed by distractors from the same superordinate category, i.e. shapes. Additionally, a condition was included where a single incongruent shape word was peripherally presented without any other distractors. If the response times were significantly

slower when the peripheral shape word was present this would suggest that the patients were distracted by the word, whereas if no difference in performance was observed this would suggest that the presence of the incongruent shape word within one of the OS flankers disrupted the use of the subordinate categorical distractors to aid performance. No differences in performance were predicted for the control group in any of the experimental conditions, since they displayed no differences (from baseline performance) when peripheral distractors were present in Study 1.

5.5 Method

5.5.1 Materials

The number of experimental conditions was increased from 4 to 6 (see fig 5.1 for example of revised stimuli) with 20 trials per condition. In all six conditions the target blue shape was presented either alone or with distractors. In the first two conditions (target alone and target with OS flankers) the stimuli presented were replicated from Study 1. In condition 3, one of the OS flankers surrounding the target contained a black squiggle which was identical in all trials. These squiggles were positioned randomly by placing them in the position occupied by the words contained within the OS flankers in study 1. Condition 4, was as condition 3 except that all the OS flankers contained the identical black squiggles. In condition 5, the OS flankers were replaced by five identical orange boats of the same overall dimensions as the OS flankers. In condition 6, an incongruent shape word was presented peripherally to the target shape but, unlike in study 1, no OS flankers were presented in this condition.

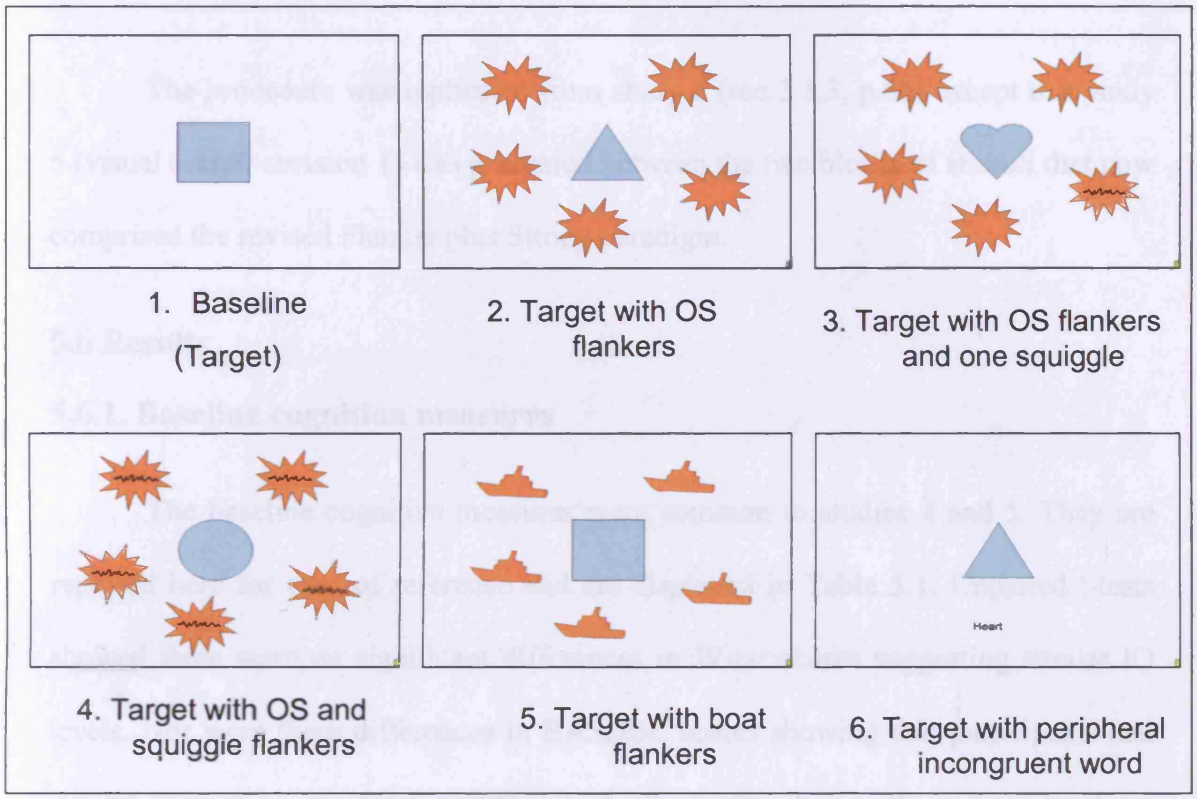


Figure 5.1: Study 4: Example Stimuli

5.5.2 Design

The primary question of interest concerned comparing the performance of the patient group when the target was presented alone with performance when distractors were present. The secondary objective was to contrast this pattern of performance with the pattern observed in the HOA controls. A mixed factorial design was used, with the six types of stimuli presented as the within-participant factor (see Fig. 5.1 above). Participant group (patients with mild PD or HOA control) was the between-participants factor. The dependant variables were verbal response times and errors made.

5.5.3 Procedure

The procedure was replicated from study 1 (see 3.3.3, p.56) except that study 5 (visual search-revision 1) was presented between the two blocks of stimuli that now comprised the revised Flanker plus Stroop paradigm.

5.6 Results

5.6.1. Baseline cognition measures

The baseline cognitive measures were common to studies 4 and 5. They are reported here for ease of reference and are displayed in Table 5.1. Unpaired t-tests showed there were no significant differences in W-tar scores suggesting similar IQ levels. Nor were there differences in BASDEC scores showing that participants had similar depression inventory scores, all of which were below the cut-off level for depression. Finally, there were no significant differences in MMSE scores with all participants achieving a minimum score of 26.

Table 5.1: Comparison of baseline cognitive measures

	Patients with PD		HOA Control	
Measure	Mean	SD	Mean	SD
W-tar raw score (max.=50)	**38.3**	9.6	**42.2**	4.2
MMSE (max.=30)	**28.1**	1.3	**28.5**	1.2
BASDEC (max.= 21)	**2.3**	2.2	**1.6**	1.6

5.6.2 Calculation of errors and verbal response times

The procedure for the calculation of errors and verbal response times was as for study 1 (see 4.4.1, p.71).

5.6.3 Data screening

The procedure adopted was replicated from study 1 (see 4.4.2, p.72). In terms of verbal response times, the overall percentage of trials adjusted to equal +/- 3 SDs to account for within-group outliers was 1.5% for the patients with mild PD and 1% for the HOA controls. No adjustments were required in respect of errors made as a non-parametric statistical approach was adopted (see below).

The next consideration was whether the data for each group was normally distributed after accounting for outliers as detailed above. To assess this, distribution plots for each condition and group separately were produced and inspected. There was no evidence of kurtosis but the data was positively skewed in both groups. Therefore all data (for both groups) was transformed using a log transformation which improved the shape of the distributions. As the main question of interest was the within-group pattern of results this log-transformed data was used in all subsequent inferential analysis. Since the pattern of results between the untransformed verbal response times and the log-transformed data are the same throughout this chapter, the descriptive data reports the untransformed verbal response times for ease of understanding. The log transformed data can be found in the relevant appendices as indicated below.

5.6.4 Descriptive and Inferential Statistics

5.6.4.1 Errors

The number of errors made was calculated for each of the six conditions and are displayed in Table 5.2. Across all participants and all conditions only two pure errors were made and therefore no distinction was made between *pure* and *self-correction* errors in the subsequent analysis. In all conditions, the number of errors

made by both groups was negligible representing 1% of trials for the patients with mild PD and 0.6% of trials for the HOA controls. This is reflected in the finding that overall, eight patients with mild PD and nine HOA controls made no errors. Paired non-parametric Mann-Witney tests (for each condition independently) showed that the number of errors made did not significantly differ between the patients with mild PD and the HOA controls in any condition.

Table 5.2: Study 4: No. of participants making errors per condition

Measure	Patients with PD	HOA Controls
Target (baseline)	4	4
Target with OS flankers	4	1
Target with OS flankers plus 1 squiggle	3	3
Target with OS flankers plus all squiggle	3	4
Target with boats	3	1
Target with peripheral incongruent shape word	5	3

5.6.4.2 Verbal response times

The focus of this study was the effect of extraneous visual stimuli on verbal shape naming times. Condition 1 where the target was presented alone was used as a baseline measure of each participant's shape naming speed without visual distractors. Thus, all within-participant comparisons were between the verbal response times when extraneous stimuli were present and the verbal response times in the baseline condition where the target shape was presented alone.

As the stimuli were presented in two blocks, the first analysis considered whether participants showed different performance patterns in the two blocks (as evidenced by verbal response times). Due to an equipment failure, data for one of the patients with mild PD and one of the HOA controls was recorded for block 2 only.

Therefore these participants' data was excluded from this bi-block analysis. For the remaining 34 participants (17 patients with mild PD and 17 HOA controls) the mean verbal responses times (in milliseconds) for each condition in blocks 1 and 2 are displayed in Table 5.3 (for the log transformed data see Appendix 3).

Table 5.3: Study 4: Mean verbal responses times (by presentation block)

	Block 1		Block 2	
Group	Mean (ms.)	SD	Mean (ms.)	SD
PD				
Target (baseline)	**1231**	166	**1182**	159
Target with OS flankers	**1143**	151	**1112**	191
Target with OS flankers plus 1 squiggle	**1140**	195	**1104**	144
Target with OS flankers plus all squiggle	**1151**	211	**1133**	194
Target with boats	**1148**	168	**1150**	205
Target with peripheral incongruent shape word	**1209**	262	**1185**	198
Control				
Target (baseline)	**1097**	107	**1049**	141
Target with OS flankers	**1088**	105	**1058**	167
Target with OS flankers plus 1 squiggle	**1100**	104	**1038**	154
Target with OS flankers plus all squiggle	**1110**	117	**1053**	123
Target with boat flankers	**1126**	140	**1008**	110
Target with peripheral incongruent shape word	**1104**	135	**1068**	138

To evaluate whether there was a significant difference in performance between blocks, a mixed-factorial ANOVA was used with group (patients or HOA controls) as the between-participants variable and both stimuli presented and block (1 or 2) as within-participants variables.

Importantly, there were no interactions between either block and stimuli ($p=.91$), or block and group ($p=.14$) and, no three way interaction between stimuli, block and group ($p=.45$). There was a main effect of block with both groups being

significantly faster in block 2 ($p<.01$). However, this is not central to the question of the pattern of performance across conditions. Therefore in all further analyses the data was collapsed across blocks to allow the overall patterns of performance to be considered. The overall mean verbal response times for each group and condition are shown in Fig.5.2 (see Appendix 3 for log transformed data).

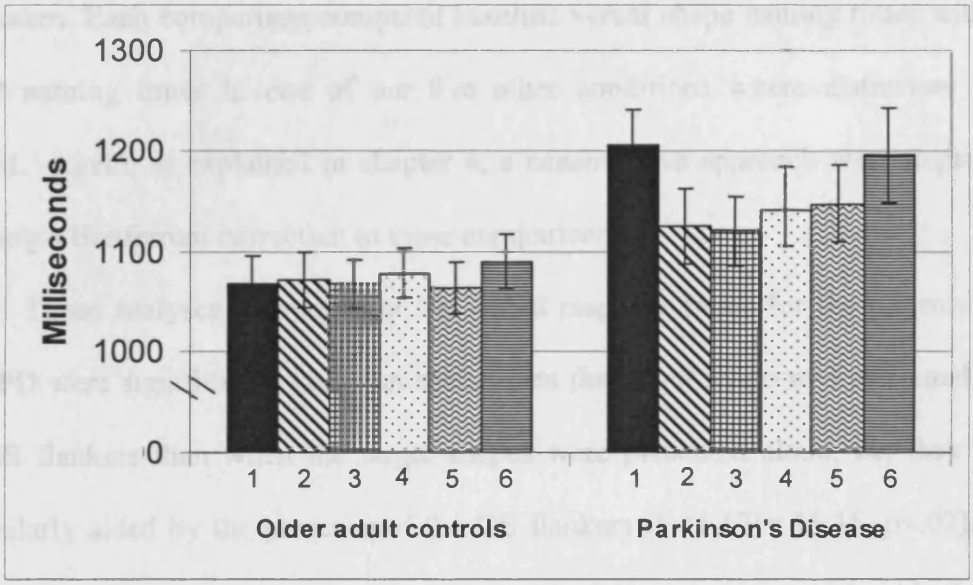


Figure 5.2: Study 4: Shape naming verbal response times. Error bars=SE. Conditions: 1=Baseline, 2=OS flankers, 3=OS flankers plus 1 squiggle, 4= OS flankers all squiggles, 5=Boat flankers, 6=Target with peripheral incongruent shape word

Fig. 5.2 suggests that the patients with mild PD benefited from the presence of the orange shape (OS) flankers when presented alone and when they contained either a single or multiple black squiggles. To evaluate whether these differences were significant a mixed factorial ANOVA was used. Group (patient or HOA control) was the between-participants factor and the stimuli presented were the within-participants factor. Again, due to a violation of the assumption of sphericity ($p<.05$) the multivariate statistics are reported. There was a main effect of stimulus, $F(5, 30) =$

3.67, $p<.01$, $\eta_p^2 = .38$ but the effect of group failed to reach significance, $F= (1, 34) = 3.48$, $p=.07$, although the difference between the two groups is of a similar magnitude to study 1 (Fig. 4.1). More importantly, there was an interaction between stimulus and group ($F (5, 30) = 3.3$, $p<.02$, $\eta_p^2 = .36$).

Planned pair-wise comparisons for each group independently were undertaken. Each comparison compared baseline verbal shape naming times with the verbal naming times in one of the five other conditions where distractors were present. Again, as explained in chapter 4, a conservative approach was adopted by applying a Bonferroni correction to these comparisons.

These analyses showed that the verbal response times for the patients with mild PD were significantly faster on trials when the target shape was presented with the OS flankers than when the target shapes were presented alone, i.e. they were particularly aided by the presence of the OS flankers ($F (1,17)= 11.15$, $p<.02$). The patient group were also faster when the target shape was presented with the OS flankers and one squiggle than when the target shape was presented alone ($F (1,17)= 21.53$, $p<.01$). When the target shape was presented with the OS flankers all containing squiggles the difference from baseline failed to reach significance ($p=.1$). Also there was no significant difference from baseline when the target was surrounded by boat flankers ($p=.39$), or when an incongruent shape word was presented in the periphery ($F<1$). The performance of the HOA controls did not significantly differ from baseline in any of the conditions (all F values < 1).

The data displayed in fig. 5.2 suggests that the patients with PD might be slower than the controls at shape naming. Indeed, simple effect comparisons of group performance in each condition showed that when the target was presented alone the patient group's verbal response times were significantly slower than those of the HOA

controls, F (1, 34) = 9.59, p<.01, η_p^2 =.22. The verbal responses times of the two groups did not significantly differ in any of the other conditions.

Lastly, since the transition from trial to trial was made by the researcher (for details please refer to Chapter 3), consideration was given to whether random fluctuations in RSIs after trial n (across stimuli) were affecting participants' performance, on the subsequent n+1 trial. Participants' mean response times (in ms) on trial n+1 were correlated with the RSI preceding that trial, i.e., following the response on trial (n) for each group. No significant correlations were found (see Table 5.4) suggesting that differences in RSI times were not responsible for the pattern of results observed.

Table 5.4: Correlation coefficients between response times (trial n+1) and preceding RSI by stimulus type (n=36)

	Patients with PD		HOA controls	
Condition	r	p	r	p
Target (baseline)	**-.03**	.90	**.02**	.95
Target with OS flankers	**.02**	.95	**.02**	.94
Target with OS flankers plus 1 squiggle	**.07**	.79	**.23**	.37
Target with OS flankers plus all squiggle	**-.07**	.78	**-.11**	.68
Target with boat flankers	**.13**	.61	**-.19**	.46
Target with peripheral incongruent shape word	**.02**	.94	**.09**	.74

5.7 Discussion

The results displayed in Figure 5.2 show that compared to baseline performance the patients with mild PD (but not the HOA controls) were quicker to name the target shapes when they were presented surrounded by orange shape (OS) flankers even when one of the OS flankers contained a squiggle. However, neither

group showed evidence of differences from baseline performance in any of the other three conditions. No differences in errors made were observed for either group in any condition and therefore all further discussion reflects differences in verbal response times only. These results replicated the facilitation effects observed in study 1 when the target was surrounded by OS flankers. Whilst this replication evidence would have been stronger using different patients from those who participated in study 1 it still suggests that the results are robust.

The main purpose of this study was to identify why the OS flankers may have facilitated shape naming in the patient group. To recap the three proposed processes were: a) novel popout, whereby the identical features of the distractor items made the target item salient; b) failure to maintain an attentional set where the target was identified on the basis of a salient visual feature (colour); or c) semantic priming, where the OS flankers primed retrieval of other shape words via activation from the superordinate to the basic level category detail. Therefore, the remaining conditions will be discussed with particular reference to these possible underlying processes.

When the OS flankers contained one squiggle, the patients with mild PD were quicker to name the target shapes than when the targets were presented alone. Since the presence of a single squiggle within one of the OS flankers meant that the distractors were no longer identical this does not support a novel popout explanation, although it does initially not rule out the failure to maintain an attentional set based on colour. However, as discussed in Chapter 4, the failure to develop an attentional set provides no insights into why patients were aided by the OS flankers. Also, a failure to maintain attentional set explanation cannot adequately account for why there is no facilitation effect when rather than a squiggle an incongruent shape word was placed within one of the OS flankers, as in study 1. If target selection was on the basis of

maintaining a colour set, e.g. attend to blue things, you would expect the pattern of results to be the same in these two conditions which was not the case. Neither can a novel popout explanation account for this data, since the distractors were the same colour. Therefore the target would be expected to be more salient and hence produce facilitation effects similar to those when the flankers were OS but this was not flankers the case. The third explanation was based on semantic priming whereby the OS flankers primed the superordinate category of shapes which in turn aided the retrieval of basic level shape words. Here, the presence of a single squiggle which cannot easily be categorised would not interfere with the identification of the superordinate shape category and hence the facilitation effect remains intact. In contrast, when an incongruent shape word was placed within the OS flankers (as in study 1) the prepotent response to the word abolished the facilitation effect.

When all the OS flankers contained a squiggle the facilitation effect was abolished and the patient group's performance was no longer faster than when they named the target shape presented alone. This finding causes problems for a novel popout explanation. Since all the distractors are identical, it would be predicted that a facilitation effect would be observed especially since the target is now unique in two respects on the basis of colour and the presence of the squiggles (all OS flankers contain an embedded squiggle whereas no such embedded object appears in the target shape). Also, if the maintenance of an attentional colour set was driving the results then the addition of black squiggles embedded within the OS flankers would not be predicted to disrupt this effect. With regard to the semantic priming explanation, at first glance the abolition of the facilitation effect appears rather problematic especially given that a single squiggle did not result in a disruption. However, the perceptual effect of the squiggles in all OS flankers may have prompted some composite

categorisation of the distractors which disrupted the priming of the shape category, thereby not permitting the OS flankers to be used in a beneficial way.

When the OS flankers were replaced with boat flankers again the facilitation effect was abolished. This finding also gives problems for either a novel popout explanation or one based on attentional set. Both these explanations would predict that the performance of the patients with mild PD should be significantly faster when the boats are present (than when the shapes were presented alone). Since the boats are all identical and the target shapes can still be selected on the basis of colour. However, a semantic priming explanation can encompass this finding. Boats come from a different semantic category than 'shapes'. Therefore they do not prime other shapes and the facilitation advantage is lost.

Finally, an incongruent shape word was placed in the periphery. This condition was included to ascertain whether in study 1 the abolition of the facilitation effect when the incongruent shape word was within an OS flankers was due to either the word disrupting the patients' ability to use the OS flankers to improve performance or whether the patients were distracted by the word and this distraction was offset by the benefits of the OS flankers. If the peripheral word within the OS flankers was distracting the patient group in study 1, the presence of a peripheral word (presented without OS flankers) would be predicted to result in significantly slower shape naming times than when the shape was presented alone. This was not the case since there were no significant differences in response times when the word was peripherally presented compared to when the target was presented alone. This suggests that rather than being distracted by the word in study 1, the word merely disrupted the priming of the superordinate category and therefore the facilitation advantage was lost.

As with study 1, the question of whether random fluctuations in RSI times influenced participants' performance in the following trial was considered. Again, this seems unlikely as there was no evidence of correlations (for any stimulus condition) between the RSI times on trial n and participants' response times on trial n+1. . This is in line with the evidence from study 1 where no significant correlations between RSI times and verbal responses times were found.

5.8 Study 5: Visual search (revision 1)

This revised visual search task sought to constructively replicate the results of study 2 using a modified paradigm that replaced the cancellation task with a counting task. Here, only a subset of the original visual search stimuli was presented at any time. This was designed to reduce the within-group standard deviations by reducing the time participants spent double checking their answers (see 4.10). Specifically, it was predicted that the patients with mild PD would benefit from the presence of semantically related distractors. No performance differences were predicted within the control group.

5.9 Method

5.9.1 Materials

The target and distractor sets were identical to study 2. The two task conditions each consisted of 8 separate sheets of A4 paper in landscape format presented within a folder. Each sheet contained 11 black and white pictures displayed uniformly in a single row. Each row was identical to the corresponding row presented in the previous visual search task (Study 2), e.g. row 1 of the study 2 (visual search) task was displayed on sheet 1 of the revised task (for details see 3.4.1, p.57). The rows were also placed in the same position on the relevant sheet as in study 2. This allowed the sheets to be cut in an overlapping manner to facilitate turning the pages.

5.9.2 Design

As in study 2, this within-participants task had two distractor conditions: unrelated and semantically related. In the unrelated condition the target item 'banana' was semantically distinct from the distractors on the page whereas in the semantically related condition the target 'banana' was semantically related to the distractors, i.e. other fruits. In both conditions, the distractors had similar levels of perceptual distinctiveness and were perceptually distinct from the target item. The order of encountering the semantically related or unrelated distractors was counterbalanced across participants. The dependant variables were errors made and the time taken (in seconds) to locate all the target items.

5.9.3 Procedure

The participants were given a folder containing either the semantically related materials or the unrelated materials. They were told that when the researcher said *start* they were to turn over the first sheet in the folder and that on the next page they would see a row of pictures. They were asked to look through the row of pictures and count the number of bananas they saw and tell the researcher, e.g. if they saw five bananas they would say *five*. They were told that after they gave an answer they would be told to turnover to the next sheet and again count the number of bananas they saw. Finally, they were told that this procedure would continue until they reached the end of the sheets within the folder. Once any questions had been answered, the researcher said *start*. The time recording started when the participant turned the first sheet over and stopped when the participant gave an answer for the final sheet in the folder (trial 8). The next folder (semantically related or unrelated materials as applicable) was given to the participant and the procedure repeated. The order of presentation of the folders was counterbalanced across participants.

5.10 Results

5.10.1 Data screening

The procedure adopted is replicated from study 1 (see 4.8, p.88). No Z scores of +/-3 were identified and therefore no adjustments to the search times for any participant were made. No adjustments were required in respect of errors made as a non-parametric statistical approach was adopted (see 5.10.2 below). The distribution of the data showed no evidence of kurtosis but was positively skewed in both groups and particularly for the HOA controls. To account for this all data was subject to a log transformation and the log transformed data re-inspected. Although the data in the

HOA controls had a slight positive skew, this was no longer significant. Thus, as the main question of interest was the within-group pattern of results and all conditions were skewed in the same direction, this log-transformed data was used in all subsequent inferential analysis. As with study 4, the results follow a similar pattern whether untransformed data or log-transformed data are considered. Therefore untransformed search times are reported below for ease of understanding. The log-transformed data can be found in the relevant appendices as indicated below.

5.10.2 Errors

Controls made no errors whilst one patient with PD made three errors, one patient made two errors, and three further patients made one error each. These errors represented 5.56% of the total number of targets. All errors were omissions (failing to count a banana). Seven of these errors were in the unrelated condition whilst only one was in the semantically related condition. A non-parametric Wilcoxon matched pairs rank test showed that the patients with PD made significantly fewer errors when the distractors were semantically related to, rather than unrelated to, the target , $Z(17) = 2.12$, $p = 0.03$, two tailed. This replicated the facilitation effect found in study 2.

5.10.3 Verbal response times

The mean search times for each type of distractor (for both participant groups) are displayed in Table 5.5 (for log transformed times see Appendix 4). In terms of the effect of visual distractors, the mean search times were very similar regardless of the type of distractor (semantically-related versus unrelated). Since this study involved a within-participant manipulation, practice effects were also considered. The mean search times by order of stimuli presentation are also displayed in Table 5.5 (for log transformed times see Appendix 4). The descriptive data suggests practice effects for

both groups, with faster overall search times in the second search task independent of the type of distractors. Overall, it appears that the patients with PD were slower to complete the task in both conditions, which was expected given the motor control problems patients with PD have.

Table 5.5: Study 5: Mean search times in seconds (by distractor type and task order)

	Distractor type		Task Order	
	Related	Unrelated	1st search	2nd search
Group	Mean (s) (SD)	Mean (s) (SD)	Mean (s) (SD)	Mean (s) (SD)
Patients with PD	**40.83** (4.14)	**42.89** (5.04)	**48.06** (5.21)	**35.67** (3.33)
HOA controls	**31.00** (2.45)	**31.00** (2.94)	**32.89** (2.70)	**29.11** (2.58)

The question posed was whether the patient group would be faster to find the targets when they were presented amongst semantically related distractors. The data analysis utilised was as described for study 2 (see 4.9.2, p.89). The search times of the patients with mild PD were significantly faster during the second search, $F(1, 18) = 34.62$, $p < 0.01$, whereas the difference in search times for the HOA controls failed to reach significance ($p = .14$). However, for both groups there were no significant differences in search times between the two distractor conditions ($F < 1$).

5.11 Discussion

The patient group made significantly more errors when counting the bananas amongst unrelated distractors which supports the idea of semantic priming. It is accepted that this evidence is quite weak for two reasons: firstly, half the patients with PD made no errors at all which raises questions about how reliable these findings are and secondly, there were ceiling effects since no HOA controls made any errors. There were no significant differences in mean task completion times in either group (patients with mild PD versus HOA controls) regardless of whether or not the

distractors were semantically related to the target. This result was unexpected as this study sought to replicate the results of study 2 where the patients with PD showed faster performance when the distractors were semantically related to the target items. The study 2 findings had augmented the earlier work of Mari-Beffa et al. (2005) and Spicer et al. (1994) who also found evidence of positive priming of semantically related information.

For the patients with mild PD, the failure to find significant faster search times when semantically related distractors were present may have been due to difficulties this group experienced when turning the pages between trials. Given the motor control difficulties associated with PD, the decision to ask the patients to turn the pages over between trials was a pragmatic one. The researcher saw the majority of patients in their own home (all but one). Based on the experience gained in studies 1 to 3, it was realised that logistically sitting close enough to the patient to turn the pages between trials would be difficult. Therefore, efforts were made to design the visual search sheets so that the pages were as easy to turn over as possible by, for example, using card which is easier to grasp than paper and by indenting each sheet so the edges were easy to grasp. Also the participants were asked if they would like the researcher to turn the sheets (only one participant asked the researcher to do so). Despite these precautions, the researcher noted that some of the patient group still had difficulty in turning over the pages particularly at the beginning of the study. This observation is in line with the finding that the mean search time for the second search was 12.39 seconds faster than the first whilst for the HOA controls the practice effect equated to only 3.78 seconds.

5.12 Chapter summary

Studies 4 and 5 sought to replicate and further extend the findings of studies 1 to 3 reported in Chapter 4. In study 4, the results extended those of study 1 and demonstrated that for patients with mild PD, different kinds of extraneous visual information presented simultaneously with visual targets differentially affected task performance. Furthermore, it also demonstrated that semantic priming at the categorical level is the process that underlies the observed facilitation effects which aid stimulus identification. Study 5 whilst failing to replicate the semantic facilitation effect in terms of the faster response times found in study 2, did show that the patients with mild PD made more errors when unrelated distractors were present. This supports the suggestion that in selective attention tasks patients with mild PD gain performance enhancement from semantically related information which aids them in stimulus identification.

Chapter 6: Distraction from extraneous visual information in patients with mild AD: Initial evidence

The main aims of the thesis were to quantify the effects on performance of different types of visual distractors presented simultaneously with visual targets, infer whether different mechanisms underlie altered performance arising from the characteristics of the visual distractors, and to evaluate whether such altered occurs at different stages of attentional processing. Specifically, this chapter reports the performance of patients with mild AD on the two studies undertaken using the Flanker plus Stroop and visual search paradigms described in Chapter 3. Although the patient group also participated in a further study using the inattentional blindness paradigm, the results of this study are not reported due to floor effects for the patients with mild AD. Since the participants and baseline cognitive measures were common to each study these are reported first to avoid repetition.

6.1 Participants

The 20 patients (12 males and 8 females) had a mean age of 82.7 years (SD 7.23) and mean years in education of 12.55 (SD 2.24). The HOA controls described fully in Chapter 4 also made up the control group for studies 6 and 7. There was no significant difference in years in education ($t < 1$) between the two groups but the patients with mild AD were significantly older, $t(38) = 5.62$, $p < .01$. All patients attended the Cardiff Memory Clinic and had received a recent diagnosis of probable AD made in accordance with the NINCDS-ADRDA criteria (McKhann et al., 1984). Their disease severity was classified as mild by reference to their Mini-Mental State

Examination (Folstein, Folstein & McHugh, 1975) score (equal to or greater than 18). All patients participated in their own homes as closely as practicable to the date they commenced taking anti-cholinesterase medication (mean no. of days of medication 3.4 (SD 2.7)). Patients were excluded if they had a history of chronic affective disorder, schizophrenia, alcohol misuse or acquired brain injury or were currently depressed or taking CNS depressant medication. The study was approved by the local NHS ethics committee and all participants gave written informed consent. No one was paid for their participation.

6.2. Results: Baseline cognition measures

The rationale for the choice of baseline cognitive measures is given in Chapter 3. Participants' scores on the W-TAR^{uk}, MMSE and BASDEC were calculated and are shown in Table 6.1. Given that the patients with mild AD were significantly older than the HOA controls, standard scores (which are age adjusted) rather than raw scores are reported for the W-TAR^{uk}. Unpaired t-tests showed there were no significant differences in W-TAR^{uk} standard scores suggesting similar IQ levels. Although the patients with AD had significantly lower BASDEC scores than the HOA controls ($p<.05$), all the participants' scores were below the cut-off level for depression. As expected the HOA controls had significantly higher MMSE scores than the patient group, $t(38) = 8.20$, $p<.01$.

Table 6.1: Comparison of baseline cognitive measure scores

	Patients with mild AD		HOA Controls	
Measure	Mean	SD	Mean	SD
W-tar standard score (max. 129)	**107.9**	13.1	**110.7**	12.4
MMSE (max. 30)	**22.8**	3.1	**28.9**	1.3
BASDEC (max. 21)	**0.8**	1.3	**2.4**	1.9

6.3 Study 6: Flanker plus Stroop

The primary purpose of study 6 was to establish whether visual peripheral distractors with different characteristics (see fig 1.1, p.7) adversely affect stimulus selection in patients with mild AD. This was achieved by comparing shape naming performance when visual peripheral distractors were present to baseline performance when the shapes were presented alone (for details of distractors see Chapter 3). As this study was interested in the effects of distractor characteristics the location of the target shape remained predictable throughout. Specifically, the target with OS flankers assessed the effects of repeated visual peripheral distractors. Whilst there is some evidence that patients with mild AD are more susceptible to the effects of visual distractors than healthy controls when the distractors are non-identical (e.g. Perry et al., 2000), it has also been shown that this susceptible is attenuated when the distractors are repeated (Langley et al., 1998). However, the current study differed as it compared performance when repeated distractors were present with performance when the target was presented alone, rather than comparing performance between identical and non-identical distractors. Here, it was predicted that the patient group

would habituate to the presence of the OS flankers and their performance would not be significantly worse than when the targets were presented alone.

The incongruent shape word within one of the OS flankers evaluated the effects of peripherally presented, non-repeated distractors on stimulus selection. It was predicted that the patients would be distracted by the incongruent shape word when it was within one of the OS flankers as the changing identity of the word meant that the visual characteristics of the distractors changed between trials. As explained in Chapter 4, it was predicted that the peripheral distractors would not affect the performance of the control group but that a performance decrement would be seen when the distractor was within the target shape.

The secondary purpose of study 6 was to evaluate the effects on response selection of prepotent information presented in the same location as the target stimulus. This was assessed by placing an incongruent shape word centrally within the target shape. The reason for including this condition was explained in 4.3 (p.70*)*. It was predicted that the patients with mild AD would be impaired by the presence of the incongruent shape word within the target shape and that their level of impairment would be greater than that shown by the HOA controls.

6.4 Data analysis strategy

6.4.1 Calculation of errors and verbal response times

The procedure adopted for the calculation of errors and verbal response times was described in Chapter 4, section 4.4.1 (p.71).

6.4.2 Data screening

The overall data screening strategy was described in 4.8 (p.88). Scrutiny of the frequency charts revealed missing verbal response time data for two of the patient group in the target plus incongruent word condition, block 1 only. This arose as they were never successfully able to name the blue target shape. This was problematic since during any inferential bi-block statistical analysis, all verbal responses from these participants would be excluded. To remedy this, a group mean substitution procedure was used (Tabachnick & Fidell, 2007). After accounting for within-group outliers (see below), the overall patient group mean in the target plus incongruent word condition was calculated as 2,160 milliseconds. This value was input as the block 1, target plus incongruent word mean verbal response times for these two patients. This adjustment did not affect the overall mean response time as, for these two participants, their actual mean response times for block 2 were also used as their overall mean response times. Outliers were identified using the procedure described in 4.4.2, p.72. For the patients with mild AD, 5% of all trials were adjusted in respect of verbal response times. No adjustments were required in respect of errors made as a non-parametric statistical approach was adopted (see below).

The next consideration was whether the data for each group was normally distributed. To assess this, distribution plots for each condition and group separately were inspected. There was no evidence of kurtosis but the data appeared positively skewed in both groups but there was only a significant positive skew (skew >2.58) in the data from the patients with mild AD. Therefore all data was transformed using an inverse transformation which improved the shape of the distributions, although the data in the patient group was still skewed albeit not significantly so. As the main question of interest was the within-group pattern of results and since all conditions

were skewed in the same direction this inverse-transformed data was used in all subsequent inferential analysis. The pattern of results between the untransformed verbal response times and the inverse-transformed data were the same. Throughout this chapter the descriptive data will report the untransformed verbal response times for ease of understanding. The inverse-transformed data can be found in the relevant appendices as indicated below.

6.5 Results

6.5.1 Errors

Pure errors and self-correction error scores were calculated (see 4.4.1 for error definitions, p.71). As reported in chapter 4, the HOA controls made no pure errors. Also, the number of self correction errors was negligible for the baseline and two flanker conditions and low for the target plus incongruent shape word condition, with errors made on only 3% of trials. In contrast the performance of the patients with AD was more variable. The number of patients making errors in each condition (split by error type) is displayed in Table 6.2.

Table 6.2: Study 6: Errors per patient with mild AD

Conditions: 1=Baseline, 2= Flanker OS, 3= Flanker OS plus incongruent word, 4=Target plus incongruent word.

	No. of patients making errors							
Errors	Condition							
	1		2		3		4	
	Pure	Self-Correct	Pure	Self-Correct	Pure	Self-Correct	Pure	Self-Correct
1-2	2	5	5	3	6	7	7	5
3-4	1	0	0	1	0	0	2	6
5-6	0	0	1	0	2	0	0	3
7-8	0	0	0	0	0	0	1	1
10+	0	0	0	0	0	0	3	0

In terms of pure errors, 15 patients with mild AD made at least one error, although the number of errors made in the baseline and two flanker conditions was negligible representing 2.29% of trials. In the target plus incongruent shape word condition the error rate increased to 17% of all trials (mean number of errors made = 4.1 (SD 6.9)). As the data was not normally distributed, a non-parametric Wilcoxon signed rank test was used. This showed that the patients with mild AD made significantly more pure errors when the target contained an incongruent shape word) than when the target was presented alone, $z(19) = 3.08$, $p<0.01$. The pattern of results for self-correction errors was similar. Sixteen patients with mild AD made at least one error, although the number of errors made in the baseline and two flanker conditions was negligible representing 1.88% of trials. In the target plus incongruent shape word condition, the error rate increased slightly to 4.2% of all trials (mean number of errors made =2.7 (SD 2.3)). Again, the number of self-correction errors made were significantly more when the target contained an incongruent shape word than when the target was presented alone, $z(19) = 3.22$, $p<0.01$.

6.5.2 Verbal response times

The focus of this study was the effect of extraneous visual stimuli on verbal shape naming times. Condition 1 where the target was presented alone was used as a baseline of each participant's shape naming speed without visual distractors. Thus, all within-participants comparisons were between the verbal response times when extraneous stimuli were present and the verbal response times in the baseline condition where the target shape was presented alone.

As the stimuli were presented in two blocks, the first analysis considered whether participants showed differential performance patterns in the two blocks (as evidenced by verbal response times). Due to an equipment failure, data from one participant in each group was recorded for block 2 only and therefore their data was excluded from this bi-block analysis. For the remaining 19 patients with mild AD and 19 HOA controls the mean verbal response times (in milliseconds) for each condition in blocks 1 and 2 are displayed in Table 6.3 (for the inverse-transformed data see Appendix 5).

Table 6.3: Study 6: Mean verbal response times (split by block)

	Block 1		Block 2	
Group	Mean (ms.)	SD	Mean (ms.)	SD
Patients with mild AD				
Target (baseline)	**1721**	673	**1418**	355
Target with OS flankers	**1762**	732	**1614**	986
Target with OS flankers plus word	**1896**	785	**1638**	706
Target plus incongruent word	**2160**	659	**2145**	875
HOA Control				
Target (baseline)	**1152**	81	**1087**	115
Target with OS flankers	**1118**	54	**1097**	92
Target with OS flankers plus word	**1133**	72	**1064**	86
Target plus incongruent word	**1386**	122	**1213**	136

To evaluate whether there was a significant difference in performance between blocks, a mixed-factorial ANOVA was used with group (patients or HOA controls) as the between-participants variable and both stimuli presented and block (1 or 2) as within-participants variables. As in chapter 4, the multivariate statistics are reported as the assumption of sphericity was violated (Mauchley's tests of sphericity for stimuli was significant ($p<.02$)). There was a main effect of block ($p<.01$) but no interactions between block and group ($p=.79$) or between block and stimuli ($p=.08$). However, there was a three way interaction between stimuli, block and group ($p<.01$).

Looking at the data displayed in Table 6.3, it appeared that whilst in block 2 the verbal response times of the HOA controls were quicker in all conditions this was not the case for the patients with mild AD. Their block 2 verbal response times appeared quicker in the baseline and two flanker conditions but not when the target contained an incongruent shape word. Separate ANOVA's for each group showed that there was no block x stimuli interaction for the HOA controls whose overall speed of responding was faster in all conditions in block 2. For the patients with mild AD, there was only an interaction between block and stimuli when baseline performance was compared to when an incongruent shape word was within the target shape, $F(1, 18) = 5.04$, $p < .04$. In the target plus incongruent shape word condition , the mean shape naming times were very similar in both blocks (2160 ms. versus 2145 ms.) whereas in the baseline condition the patients seemed to name the shape quicker in block 2 (1721 ms versus 1418 ms.). Paired t-tests confirmed this, i.e. there were no significant differences in verbal response times in condition 4 ($t < 1$), but the patients were quicker to name the shapes when presented alone in the second block of trials, $t(18) = 4.05$, $p<.01$.

This finding is not central to the question of the pattern of performance across conditions. The primary purpose of study 6 was to assess the effects of visual peripheral distractors with different characteristics on the performance of patients with mild AD. However, the only interaction effect occurred in the target plus incongruent shape word condition. Therefore in all further analysis the data was collapsed across blocks to allow the overall patterns of performance to be considered. The overall mean verbal response times for each group and condition are shown in Fig. 6.1 (see Appendix 5 for inverse-transformed data).

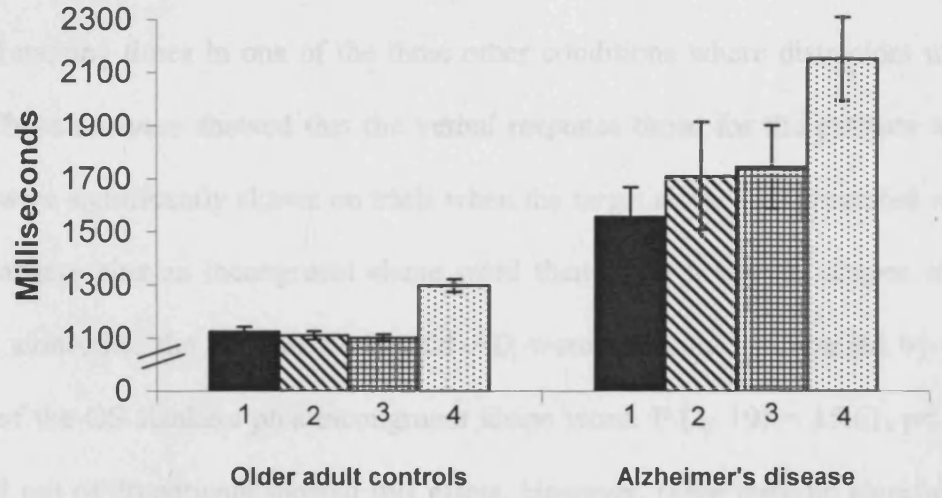


Figure 6.1: Study 6: Shape naming verbal response times (in ms.). Error bars=SE. Conditions: 1=Baseline, 2=OS flankers, 3=OS flankers plus incongruent word, 4=Target plus incongruent word.

Fig. 6.1 suggests that patients with mild AD were slower to name the target shapes when they were presented with orange shapes (OS) flankers or, OS flankers one of which contained an incongruent word. Furthermore, Figure 6.1 suggests that both groups were slower to name the target shapes when they contained an

incongruent word. To evaluate whether these differences were significant a mixed factorial ANOVA was used. Group (patient or HOA control) was the between-participants factor and the stimuli presented were the within-participants factor. Again, due to a violation of the assumption of sphericity ($p<.05$) the multivariate statistics are reported. There was a main effect of stimulus, $F(3, 36) = 39.19$, $p<.01$, $\eta_p^2 = .77$ and a main effect of group, $F= (1, 38) = 50.48$, $p<.01$. More importantly, there was an interaction between stimulus and group ($F(1, 36) = 5.44$, $p<.01$, $\eta_p^2 = .31$).

As described in Chapter 4, planned pair-wise comparisons (with a Bonferroni correction) were undertaken. Each compared baseline verbal shape naming times with the verbal naming times in one of the three other conditions where distractors were present. These analyses showed that the verbal response times for the patients with mild AD were significantly slower on trials when the target shape was presented with the OS flankers plus an incongruent shape word than when the target shapes were presented alone, i.e. the patients with mild AD were particularly impaired by the presence of the OS flankers plus incongruent shape word, $F(1, 19) = 15.61$, $p<.01$. Indeed, 17 out of 20 patients showed this effect. However, there were no significant differences in verbal response times on trials when the target shape was presented with the OS flankers compared to when the target shapes were presented alone ($p = .3$). Although Fig 6.1 suggests there might have been a difference in the means, only 10 out of 20 patients had slower than baseline response times. The performance of the HOA controls did not differ from when the target was presented alone in either of these two conditions ($F < 1$). Furthermore, both the patients with mild AD and the HOA controls were significantly slower to name the target when an incongruent shape

word was within the target shape, F (1, 19) = 61.16, 58.22, p<.01 (for the patient group and the HOA controls respectively).

As expected, the patients with AD were slower than the controls at shape naming in all conditions. However, this finding may have resulted from differences in baseline shape naming speed. Therefore, the difference in verbal response times between each of the conditions with distractors and when the target was presented alone were calculated and the group differences compared using unpaired t-tests. These showed that when baseline shape naming times are taken into consideration, the patients with AD were significantly slower than the HOA controls when the incongruent word was presented peripherally, t (38) = 3.63, p < .01, or within the target shape, t (38) = 3.17, p < .01. However, when the target was surrounded by OS flankers the difference between the patients with mild AD and the HOA controls failed to reach significance, t (1, 38) = 1.52, p=.14.

As the patients with mild AD were significantly older than the HOA controls, the effects of age were considered. Firstly, age was correlated with the verbal response time scores for the patients with mild AD. Table 6.4 shows that there were no significant correlations between verbal response times and age for any of the four experimental conditions. This suggests that age is not responsible for the observed pattern of results.

Table 6.4: Study 6: Correlations between age and verbal response times

	Patients with mild AD	
	r	p
Age and		
Target	**.05**	.83
Target with OS flankers	**.25**	.28
Target with OS flankers plus incongruent word	**.05**	.83
Target with incongruent word	**.24**	.32

Lastly, since the transition from trial to trial was made by the researcher (for details please refer to Chapter 3), consideration was given to whether random fluctuations in the interval between a response being given and the next stimulus appearing (RSI) were affecting participants' performance. Participants' mean response times (in ms) on trial n+1 were correlated with the RSI preceding that trial, i.e., following the response on trial (n) for each group. As reported in 4.5.2 (p.75), there were no significant correlations for the HOA controls. However, for the patients with AD, Table 6.5 shows that in respect of the first three experimental conditions (target alone, target with OS flankers and target with OS flankers plus incongruent shape word) there was a positive correlation between verbal response times and RSI with longer RSI being associated with longer response times. Therefore, the mean RSI times in these three conditions were calculated (896, 935 and 879 milliseconds). A within-participants ANOVA showed there were no significant differences in RSI times suggesting that differences in RSI times were not responsible for the pattern of responses obtained ($p = .3$).

Table 6.5: Study 6: Correlation coefficients between response times (trial n+1) and preceding RSI

Condition	Patients with AD r	P
Target (baseline)	**.56**	.01
Target with OS flankers	**.62**	.01
Target with OS flankers plus word	**.49**	.03
Target plus Incongruent word	**.20**	.40

6.6 Discussion

As predicted the results displayed in Figure 6.1 show that the patients with mild AD were slower overall than the HOA controls. Furthermore, compared to their baseline performance both patients and controls had difficulty ignoring the incongruent word when it was presented within the target shape. Also the problems experienced by the patient group were more pronounced since their response times when the incongruent shape word was presented inside the target were significantly slower than the HOA controls (after allowing for baseline shape naming times). Furthermore, their performance differed from HOA controls in that they made pure errors, i.e. errors where they showed no awareness that an error had been made, whilst the HOA controls never made errors (in any experimental condition). Finally, in terms of both pure and self-correction errors, the patients with mild AD made significantly more of these errors in target containing incongruent shape word) than when the target was presented alone.

The finding that the patients with mild AD had more difficulty ignoring the incongruent shape word within the target shape was predicted. Participants had to suppress the automatic response of word reading in order to name the shape. Previous findings have shown that patients with mild AD have particular difficulties ignoring

irrelevant information which elicits a strong automatic response even when the information is incongruent with the task (Amieva et al., 1998; Amieva et al., 2002; Bondi et al., 2002; Collette et al., 1999; Crowell et al., 2002; Perry et al., 2000; Spieler et al., 1996). Whilst deficits have been less evident on Go/No-go tasks where participants must withhold a habitual response to stimuli (Amieva et al., 2002; Collette et al., 2002), this lack of impairment may be due to rather weak experimental manipulations (see 2.2.1, p.29). Findings of deficits on these types of tasks are usually taken as evidence that the difficulty arises because of problems inhibiting a habitual response which interferes with response selection.

The finding that the patients with mild AD were significantly slower to name the shapes when one of the OS flankers contained an incongruent shape word than when the shape was presented alone was also predicted since it was anticipated that the distractors would interfere with stimulus selection. One possible reason for this is that patients with mild AD are more prone to distraction from extraneous visual information and were drawn to the changing visual characteristics of the distractors presented. In the OS flanker plus incongruent word condition, four different shape words were presented randomly. This meant that the appearance of each target and distractor display was visually distinct. The visual characteristics of the target and distractors, also explains why the patients with mild AD were not significantly slower to name the shapes when they were surrounded by the OS flankers. Here, the visual characteristics of the distractors were constant across trials of this type. Therefore, their presence did not impair the patients' verbal response times because they habituated to their presence over repeated presentations. Indeed, Langley et al. (1998) demonstrated that compared to their performance when target letters were presented

with changing distractors, patients with AD benefited from the repetition of constant distractors.

An alternative explanation of why the patients with mild AD were significantly slower when one of the OS flankers contained an incongruent shape word is based on the location of the words in this condition. Langley et al. (1998) showed that the performance of the patients with mild AD was only significantly slower than the control group when the location of the distractor was unpredictable (placed to the left or right of the target letter). In the current study, whilst the position of the OS flankers was predictable throughout, the incongruent shape word appeared randomly within one of the five OS flankers. Therefore the unpredictable location of the incongruent shape word may have resulted in the slower response times. However, this explanation does not seem likely since although the position of the incongruent word was random it was always within an OS flankers whose position was fixed throughout. It would be predicted that the fixed location of the distractor array would enable the patients with mild AD to habituate to their presence, which was not the case.

A third explanation of why the patients with mild AD were significantly slower when one of the OS flankers contained an incongruent shape word is that the incongruent shape words elicited a prepotent response even when they are peripherally presented. Again this would mean that the difficulties of the patient group arose in response selection rather than stimulus selection. Indeed, this explanation fits with the finding that patients with mild AD are impaired on the Trail Making task where the prepotent distractors are presented peripherally (Amieva et al., 1998; Crowell et al., 2002). Nevertheless the current study differs from the Trail Making task where all items had to be inspected to find the next target item in the

letter/number sequence. Here, the location of the target was fixed throughout thereby negating the need to scrutinise each item in the visual array. An explanation based on prepotent response tendencies seems unlikely for two reasons. Firstly, the bi-block analysis showed that in block 2 the patients with mild AD were quicker to name the shapes in all conditions except in the target plus incongruent shape word condition. In this condition the target contained an incongruent shape word which interfered with response selection. This suggests that for patients with mild AD the effects of habitual response tendencies do not significantly decrease as the amount of experience with these distractors increases. Therefore, if the slower response times in the OS flankers plus incongruent shape word condition were solely due to the prepotent properties of the peripherally presented incongruent shape words no improvement in response times between blocks would be predicted. However, this was not the case since the patient group's response times did improve in block 2. Secondly, if response selection resulted in the patients' difficulties, increased errors (compared to baseline) would be expected, as was the case when the target contained an incongruent shape word. However, this was not the case. This is not to say that response selection difficulties arising from the incongruent shape word played no part in the increased response times. Rather, the suggestion is that the changing visual properties of the distractors also cause problems for patients with mild AD by interfering with stimulus selection.

Two further potential confounds required consideration. Firstly, since the patients with mild AD were significantly older than the HOA controls, age rather than a diagnosis of mild AD might be responsible for the results obtained. This seems unlikely since there were no correlations between age and any of the experimental conditions. Secondly, random fluctuations in the RSI times may have influenced participants' performance across conditions. As explained in Chapter 4, this is

important because such fluctuations might result in participants, for example, having more time to recover between trials which could in turn influence performance. There was a correlation between RSI times and response times on the following trials when these trials were in the baseline and two flanker conditions, with longer RSI times being associated with slower participant verbal responses. However, it seems unlikely that this influenced the pattern of verbal responses across conditions as there were no significant differences in the length of the RSI times between these conditions. The correlation probably arises from participants sometimes being slow to speak their response (hence a longer RSI), and this difficulty spilling over to the next trial (hence a slower response time).

6.7 Study 7: Visual Search

In the visual search task, given that the performance of patients with mild AD is worse than age-matched controls in tests of intact semantic knowledge such as category fluency (e.g. Perry et al., 2000), it was predicted that a similar performance deficit would be seen during a task that had semantically-related distractors. This was because all the visual stimuli belonged to the superordinate category of 'fruit'. This may interfere with identifying the basic level category of the search targets (bananas). No performance differences were predicted within the control group.

6.8 Data analysis strategy

The data screening strategy is described in Chapter 4. Neither of the participants' group results contained any missing values and no adjustments to search times were required to account for within-condition outliers. The overall level of errors was low indicating ceiling effects. Therefore only descriptive statistics for

errors are reported and no adjustments were made to the raw error scores (see 6.9.1 below).

Finally, the distribution of the search times (for each participant group) was considered. There was no evidence of kurtosis but the data was positively skewed in both groups and therefore all data was subject to a log transformation and the log transformed data re-inspected. They were no longer significantly skewed and therefore this log transformed data was used for all subsequent inferential analysis. The results follow a similar pattern whether untransformed data or log-transformed data are considered. Therefore untransformed search times are reported below for ease of understanding. The log- transformed data can be found in the relevant appendices as indicated below.

6.9 Results

6.9.1 Errors

The visual search sheets were reviewed and errors noted. As stated in Chapter 4, the HOA controls made no errors whilst one patient with mild AD made three errors, with a further three patients making one error. All errors were omissions (failing to strike through a banana). Two errors were made when the distractors were semantically related and the other four when the distractors were unrelated. Across conditions errors made represented only 0.6% of the total number of targets to be found and deleted. Having shown that the number of errors made was negligible, the time data was considered.

6.9.2 Search times

The mean search times by type of distractor and also order of stimuli presentation (for both participant groups) are displayed in Table 6.6 (for log

transformed times see Appendix 6). The rationale for considering the order of presentation was given in 4.9.2 (p.89). In terms of the effect of visual distractors, for both the patients with mild AD and the HOA controls, the mean search times were very similar regardless of the type of distractor (semantically-related versus unrelated). Also, the descriptive data suggests practice effects for both groups with faster overall search times in the second search task independent of the type of distractors. Overall, it appears that the patients with AD were slower to complete the task in both conditions, which was expected given the cognitive difficulties patients with AD have with search tasks (Robertson et al., 2000).

Table 6.6: Study 7: Mean search times in seconds (by distractor type and task order)

	Distractor type		Task Order	
	Related	Unrelated	First	Second
Group	Means (SD)	Means (SD)	Means (SD)	Means (SD)
Patients with AD	**51.95** (23.14)	**54.85** (24.14)	**57.05** (23.72)	**49.75** (23.07)
HOA controls	**32.75** (9.28)	**33.05** (9.62)	**34.45** (9.37)	**31.35** (9.27)

The question posed was whether the patient group would be slower to find the targets when they were presented amongst semantically related distractors. The data analysis utilised was as described for study 2 (see 4.9.2, p.89). As explained in 4.9.2, no significant differences in search times between either of the two distractor conditions, or the first versus second search were found for the HOA control group. In respect of the patients with mild AD, there were also no significant differences in search times between the two distractor conditions ($p = .15$) but, the search times were significantly faster during the second search, $F(1,18) = 23.23$, $p < 0.01$.

6.10 Discussion

The finding that there were no significant differences in search times for the patient group regardless of the type of distractors was unexpected. It could be that the experimental manipulation was not powerful enough to identify differences between the two conditions. However, this explanation seems unlikely since significant differences using the same paradigm were reported in Chapter 4. A more likely explanation is that the target stimuli were selected on the basis of their visual properties rather than by identifying each target and distractor at a semantic level. Here, since the target and distractors were visually distinct and both sets of distractors were matched for visual similarity to each other (see Chapter 3) no significant differences between distractor conditions would be expected, which was the case. Indeed, findings of increased susceptibility to visually similar distractors have been previously identified in patients with mild AD (e.g. Baddeley et al., 2001). This interpretation also fits with the nature of the task which required cancellation of the targets rather than any verbalisation of the target and distractor stimuli which might have prompted semantic categorisation. If the patients are relying on the visual characteristics of the stimuli, it would be expected that they would be significantly slowed by visually similar target and distractors items. This was examined in Study 9.

6.11 Chapter summary and further research

The first question posed by this thesis was whether the different characteristics of extraneous visual information presented simultaneously with visual targets differentially affected task performance at different stages of processing (see fig. 1.1 p.7). Study 6 (Flanker plus Stroop) demonstrated this was the case. Both patients

with mild AD and HOA controls showed impaired performance in response selection when visual distractors that elicited a prepotent response were presented in the same spatial location as the target stimulus. However only for the patient group did some kinds of peripherally presented visual distractors also impair performance. This suggests that for patients with mild AD, the visual characteristics of the distractors are important and can impair stimulus selection. The results from Study 7 also suggest that visual characteristics may be important determinants of how this patient group deal with extraneous visual information.

These findings also suggest that different processes might affect the way visual information is used to influence task performance. The results from study 6 suggest that the performance of patients with mild AD is impaired by the visual properties of distractors, although other explanations such as the location of the distractors or the prepotent characteristics of the distractors cannot be totally excluded. Therefore, two further studies are reported in chapter 7 that sought to extend these findings and to clarify the stimuli characteristics that impair the ability of patients with mild AD to ignore distraction from certain types of extraneous visual information.

Chapter 7: The distractor characteristics underlying distraction from extraneous visual information in patients with mild AD

The studies reported in Chapter 6 demonstrated that the performance of patients with mild AD (but not the HOA controls) can be impaired by some types of peripherally presented extraneous visual information. The most likely explanation is that the patients were distracted by the extraneous information which interfered with stimulus selection. The evidence reported in Chapter 6 suggested that the changing visual characteristics of the distractors determine whether patients will be distracted by their presence, although an explanation based on their location cannot be totally excluded. Also, although unlikely, the possibility still remained that the patients' difficulties were due to the prepotent characteristics of the peripherally presented shape words which interfered with response selection. Therefore, study 8 sought to differentiate between these three possibilities.

To achieve this differentiation, firstly peripheral distractor stimuli were required that did not engender a prepotent response tendency. Secondly, stimuli were required where the visual characteristics of the distractors were either changing or held constant over trials of that type. Also, regardless of the visual distractor features the location of the distractors needed to be fixed in each condition. To see whether the changing location of items within the distractor display interfered with stimulus selection, the OS flankers which originally contained an incongruent shape word no longer contained a word and were coloured brown. Also to evaluate the effects of changing visual characteristics, the four alternating incongruent shape words used in study 6 were changed to four different orange coloured patterns (for examples see 7.5.2 below). Patterns were chosen as opposed to colours as it was not possible to find

four colours that were visually distinct from the colours already used in this paradigm. On the assumption that these patterns would not elicit a verbal label, this condition also evaluated whether impaired performance was limited to difficulties in response selection due to distraction from prepotent information. Finally, to retain the overall number of conditions, the incongruent shape word within the target was replaced with a neutral word. This condition was included to show that any distraction effect was not restricted to words which elicited a strong semantically related prepotent response. Details of the overall methodology are given in section 7.4.

The purpose of Study 9 was to investigate the effects of visually similar target and distractor items when the location of the target items was unpredictable. Details are given in section 7.9. Since the participants and baseline cognitive measures are common to each study these are reported first to avoid repetition.

7.1 Participants

A new group of patients were recruited. A new patient group was necessary since this thesis considered patients who had a recent diagnosis of AD either before or within a few days of commencing cholinesterase inhibitor medication. The rationale for this decision was explained in 1.3.2 (p.9). The studies reported in this chapter were carried out after those reported in Chapter 6. Therefore the patients who participated in Studies 7 and 8 had been taking anti-cholinesterase medication for several months before the studies reported in this chapter were undertaken.

The 16 patients (11 males and 5 females) had a mean age of 78.33 years (SD 5.82) and mean years in education of 11 (SD 1.6). They were all attending the Cardiff Memory Clinic and had received a recent diagnosis of probable AD made in

accordance with the NINCDS-ADRDA criteria (McKhann et al., 1984). Their disease severity was classified as mild by reference to their Mini-Mental State Examination (Folstein, Folstein & McHugh, 1975) score (equal to or greater than 18). All patients participated as closely as practicable to the date they commenced taking anti-cholinesterase medication (mean no. of days of medication 1.94 (SD 1.8)). All patients participated in their own homes at the time of day when they felt at their brightest.

The 15 healthy older adult (HOA) controls (5 males and 10 females) were either the spouses or friends of the patient or alternatively members of the Cardiff University psychology department's participant panel. They had a mean age of 76.9 (SD 7.21) and mean years in education of 13.33 (SD 2.53). There was no significant difference in age between the two groups ($t<1$) although the HOA controls had significantly more years in education ($p< .01$). All HOA controls participated in their own homes and had a Mini Mental State Examination (MMSE) (Folstein et al., 1975) score of over 25. The HOA controls were asked to choose a participation time at the time of day when they felt at their brightest.

Participants were excluded if they had a history of chronic affective disorder, schizophrenia, alcohol misuse or acquired brain injury or were currently depressed or taking CNS depressant medication. The study was approved by the local NHS ethics committee and all participants gave written informed consent. No one was paid for their participation.

7.2 Baseline Cognitive Measures

In addition to study 8 and study 9 described below, three other tests were administered to give baseline cognitive measures. The rationale for the choice of baseline cognitive measures is given in Chapter 3.

7.3 Chronological Procedure

All participants experienced two completely different experimental paradigms which for ease of reference will be referred to as Flanker plus Stroop (revision 2) and visual search (revision 2). Whilst the detailed procedure of each revised paradigm is dealt with in the relevant sections below, the overall procedure and chronological order of task presentation is addressed here to reduce repetition. Except where detailed, all aspects of the overall procedure and chronological order of task presentation are as described in Chapter 3. Paradigm 1 (Flanker and Stroop) was replaced with Flanker and Stroop (revision 2) and paradigm 2 (visual search) was replaced with visual search (revision 2). Paradigm 3 (inattentional blindness) was retained to keep the overall procedure and the order of presentation constant with the other studies described in this thesis. As explained in Chapter 6, the results from the study using the attentional blindness paradigm are not reported due to floor effects in the patient group.

7.4 Study 8: Flanker plus Stroop (revision 2)

Study 8 used an adapted version of paradigm 1 (Flanker and Stroop) which was described fully in Chapter 3. To avoid repetition, only variations from paradigm 1 are detailed here. As for study 4, all comparisons of shape naming times and errors made were with performance when the target shape was presented alone. Therefore the

original target only condition was retained. Two new peripheral distractor conditions were substituted for the two peripheral distractor conditions used in study 4. In the first, one of the five identical OS flankers was coloured brown. Whilst in the second, the four alternating incongruent shape words were changed to four different orange coloured patterns (for examples see fig. 7.2 below). It was predicted that the verbal response times of the patients with mild AD would be significantly slower when one of the OS flankers contained a pattern but not when one of the OS flankers was re-coloured brown. This was because the visual characteristics of the flankers (the patterns) changed across trials in OS flankers with a single pattern condition whereas, in the single brown flanker and four OS flankers condition the visual characteristics of the flankers remained consistent. No significant differences in either verbal response times or errors made were predicted in respect of the HOA controls since no evidence of impairment from any peripheral visual flankers was found in study 6. Nor were significant differences in the number of errors made by the patients with AD predicted in either flanker condition since neither condition should elicit a prepotent response which might lead to erroneous performance. Finally, the shape incongruent word within the target was replaced with a neutral word. Here, it was predicted that for the patients with mild AD response times would be longer and that they would make more errors than when the target was presented alone. Only verbal responses times were predicted to be slower for the HOA controls.

7.5 Method

7.5.1 Materials

On 25% of trials the target shape was presented alone; on 25% of trials there was a neutral word within the target shape; whilst on the other trials the target was

surrounded by five flanker shapes, four of which were orange (OS). The fifth shape was either brown or contained one of four orange patterns (see fig. 7.1 & 7.2). The choice of which flanker shape was coloured brown or patterned was randomised.

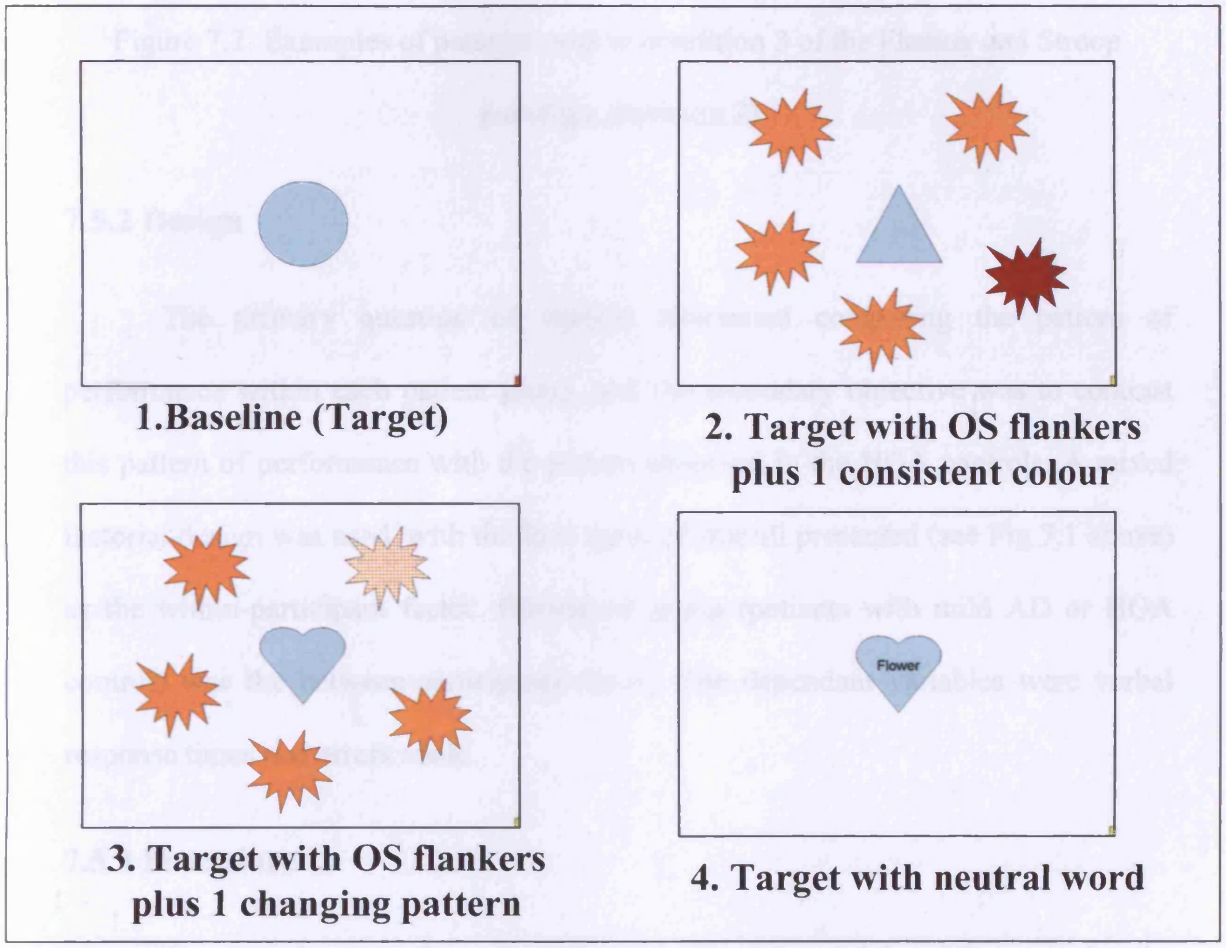


Figure 7.1: Examples of stimuli for the four experimental conditions in the Flanker and Stroop paradigm (revision 2)

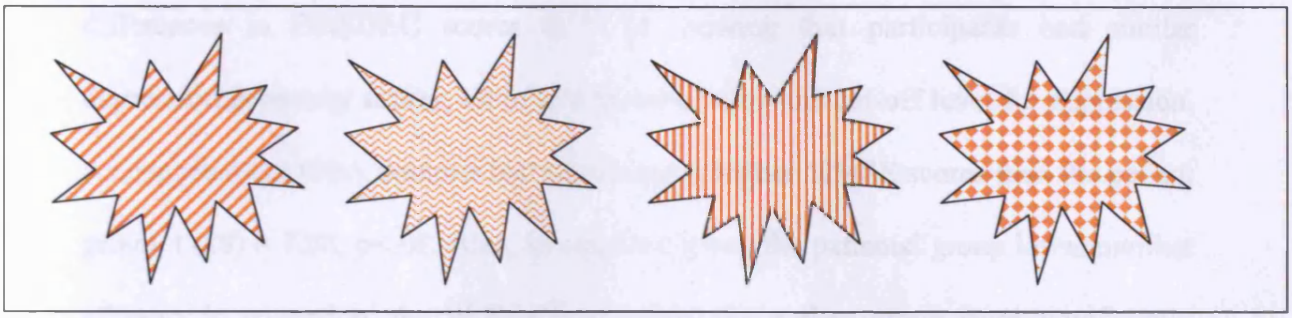


Figure 7.2: Examples of patterns used in condition 3 of the Flanker and Stroop paradigm (revision 2)

7.5.2 Design

The primary question of interest concerned comparing the pattern of performance within each patient group, and the secondary objective was to contrast this pattern of performance with the pattern observed in the HOA controls. A mixed factorial design was used, with the four types of stimuli presented (see Fig 7.1 above) as the within-participant factor. Participant group (patients with mild AD or HOA control) was the between-participants factor. The dependant variables were verbal response times and errors made.

7.5.3 Procedure

The procedure was the same as for paradigm 1 (see 3.3.3, p.56) except that the revised visual search paradigm (see study 9) below was presented between the two blocks of stimuli in place of the previous visual search.

7.6 Results

7.6.1 Baseline cognition measures

The participants' scores on the W-TAR^{uk}, MMSE and BASDEC were calculated and are shown in 7.1. Unpaired t-tests showed there were no significant

differences in BASDEC scores ($t < 1$) showing that participants had similar depression inventory scores, all of which were below the cut-off level for depression. As expected the HOA controls had significantly higher MMSE scores than the patient group, $t(28) = 7.08$, $p<.01$. Also, as expected given the patients' group lower number of years in education, the W-TAR^{uk} scores of the patient group were significantly lower than the HOA controls, $t(28) = 3.24$, $p<.01$.

Table 7.1: Comparison of baseline cognitive measure scores

	Patients with AD		HOA Controls	
Measure	Mean	SD	Mean	SD
W-tar raw score (max.=50)	**35.9**	9.0	**44.2**	4.1
MMSE (max.=30)	**22.3**	3.3	**28.5**	.7
BASDEC (max.= 21)	**1.5**	1.9	**2.0**	1.4

7.6.2 Calculation of errors, verbal response times and data screening

The procedure adopted for the calculation of errors and verbal response times is described in Chapter 4, section 4.5.1 (p.74).

7.6.3 Data screening

The overall data screening strategy was as described in Chapter 4. Scrutiny of the frequency charts revealed that in the target plus neutral word condition there was missing verbal response time data for three of the patient group. Also, a further patient had missing verbal response time data in this condition for block 1 only. This arose as they were never successfully able to name the blue target shape. No HOA controls had missing verbal response time data. This missing data was problematic since during any inferential statistical analysis, all verbal responses from these participants would be excluded. To remedy this, a group mean substitution procedure was used as described in Chapter 6.4.2 (p.125). For the patients with mild AD, after accounting for within-group outliers (see below), the target plus incongruent word condition overall

group mean together with the block 1 and 2 means were calculated. The mean values were 1,632, 1700 and 1,595 milliseconds respectively. Then, for those patients with missing verbal response time data in the target plus incongruent word condition, these mean verbal response times were input. Outliers were identified using the procedure described in 4.4.2, p.72. For the patients with mild AD, 9% of all verbal response times were adjusted whilst 10% of verbal response times were adjusted for HOA controls. No adjustments were required in respect of errors made as a non-parametric statistical approach was adopted (see below).

The next consideration was whether the data for each group was normally distributed. Distribution plots for each condition and group separately were inspected. There was no evidence of kurtosis but the data appeared positively skewed in both groups but there was only a significant positive skew (skew >2.58) in the data from the patients with mild AD. Therefore all data was transformed using a log-transformation which improved the shape of the distribution. Thus this log transformed data was used in all subsequent inferential analysis. The pattern of results between the untransformed verbal response times and the log-transformed data were the same. Throughout this chapter the descriptive data will report the untransformed verbal response times for ease of understanding. The log-transformed data can be found in the relevant appendices as indicated below.

7.6.4 Descriptive and Inferential Statistics

7.6.4.1 Errors

Pure errors and self-correction error scores were calculated (see 4.4.1 for error definitions, p.71). Due to an equipment failure, data for one of the patients with mild AD was not recorded. Therefore data from only 15 patients with mild AD are reported

for errors and verbal response times (see 7.6.4.2 below). The HOA controls made no pure errors in any condition and only two made any self-correction errors in the baseline and two flanker conditions (.04% of trials). In the target with neutral word condition, 10 HOA controls made an error (no-one made more than one error), although the number of self-correction errors made was low (3% of trials). In contrast the performance of the patients with mild AD was more variable and the number of patients making errors (in each condition) is displayed in Table 7.2.

Table 7.2: Study 8: Errors per patient with mild AD

Conditions: 1=Baseline, 2=OS flankers plus one singleton constant colour, 3=OS flankers plus one singleton changing pattern, 4=Target plus neutral word.

	No. of patients making errors							
Errors	Condition							
	1		2		3		4	
	Pure	Self-Correct	Pure	Self-Correct	Pure	Self-Correct	Pure	Self-Correct
1-2	1	6	5	6	4	6	9	4
3-4	0	0	0	0	0	0	0	2
9-10	0	0	0	0	0	0	1	0
11+	0	0	0	0	0	0	2	0

In terms of pure errors, 12 patients with mild AD made at least one error (although the errors made in the baseline and two flanker conditions were negligible representing 1.2% of trials). In the target plus neutral word condition, this error rate increased to 19% (mean number of errors =5.6 (SD 8.5)). As the data was not normally distributed a non-parametric Wilcoxon signed rank test was used to compare the number of errors made in each condition when distractors were presented with when the target was presented alone. This showed that the patients with mild AD made significantly more pure errors when the target contained a neutral word than

when the target was presented alone, z (14) = 2.99, $p<0.01$. In contrast, the pure errors in the two flanker conditions did not differ significantly from the number of errors made at baseline.

The pattern of results for self-correction errors was similar. Twelve patients with mild AD made at least one error (although the errors made in the baseline and two flanker conditions were negligible representing 1.9% of trials). In the target plus neutral word condition, this error rate increased to 11% of all trials (mean number of errors 3.4 (SD 6.6)). Again, the number of errors made were significantly more than when the target was presented alone, z (14) = 1.98, $p<0.05$.

7.6.4.2 Verbal response times

The focus of this study was the effect of extraneous visual stimuli on verbal shape naming times. When the target was presented alone was used as a baseline measure of each participant's shape naming speed without visual distractors. Thus, all within-participants comparisons are between the verbal response times when extraneous stimuli are present and the verbal response times in the baseline condition where the target shape is presented alone.

As the stimuli were presented in two blocks, the first analysis considered whether participants showed different performance patterns in the two blocks (as evidenced by verbal response times). The mean verbal responses times (in milliseconds) for each condition in blocks 1 and 2 are displayed in Table 7.3 (for the log transformed data see Appendix 7).

Table 7.3: Study 8: Mean verbal responses times (in ms.) split by presentation block

Group	Block 1 Mean (ms.)	SD	Block 2 Mean (ms.)	SD
Patients with AD				
Target (baseline)	**1393**	193	**1285**	124
Target with OS flankers plus one singleton colour	**1309**	198	**1336**	190
Target with OS flankers plus one singleton changing pattern	**1453**	268	**1376**	148
Target plus word	**1700**	271	**1595**	151
HOA Control				
Target (baseline)	**1272**	212	**1153**	164
Target with OS flankers plus one singleton constant colour	**1235**	184	**1178**	168
Target with OS flankers plus one singleton changing pattern	**1204**	194	**1166**	141
Target plus word	**1399**	181	**1301**	159

To evaluate whether there was a significant difference in performance between blocks, a mixed-factorial ANOVA was used with group (patients or HOA controls) as the between-participants variable and both stimuli presented and block (1 or 2) as within-participants variables. Importantly, there were no interactions between either: block and stimuli ($p=.15$), or block and group ($p=.5$) and, no three way interaction between stimuli, block and group ($p=.64$). There was a main effect of block with both groups being significantly faster in block 2 ($p<.01$). However, this is not central to the question of the pattern of performance across conditions. Therefore in all further analyses the data was collapsed across blocks to allow the overall patterns of performance to be considered. The overall mean verbal responses times for each group and condition are shown in Fig.7.3 (see Appendix 7 for log transformed data).

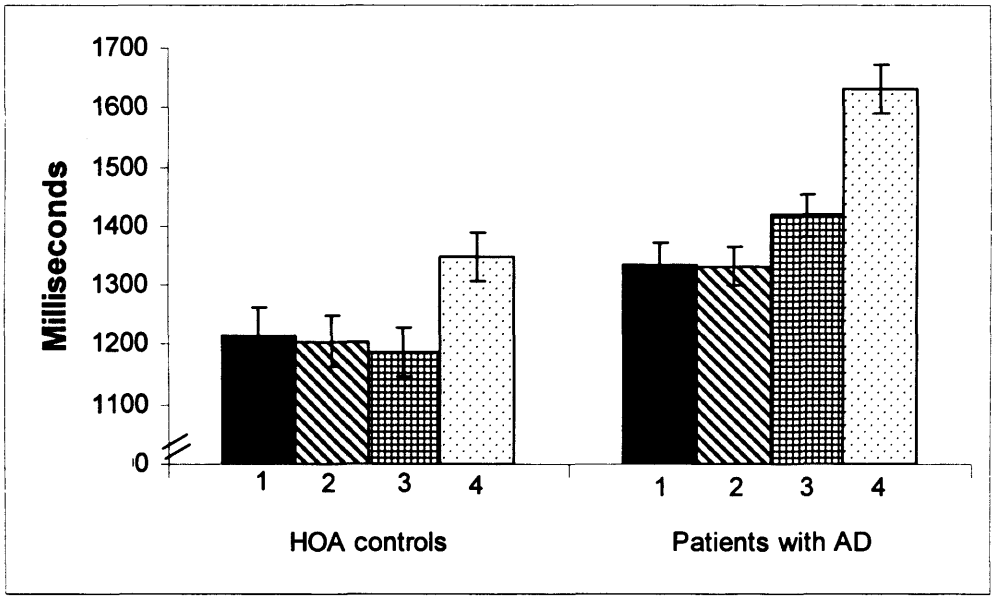


Fig 7.3: Study 8: Shape naming verbal response times. Error bars=SE.

Conditions: 1=Baseline, 2=OS flankers plus one singleton colour, 3=OS flankers plus one singleton changing pattern, 4=Target plus word.

Fig. 7.3 suggests that the patients with mild AD were slower to name the target shapes when they were presented with OS flankers one of which contained a changing pattern and that both groups were slower to name the target shapes when they contain a neutral word. To evaluate whether these differences were significant a mixed factorial ANOVA was used. Group (patient or HOA control) was the between-participants factor and the stimuli presented were the within-participants factor. There was a main effect of stimulus, $F(3, 84) = 56.93$, $p<.01$, $\eta_p^2 = .67$ and a main effect of group, $F= (1, 28) = 14.01$, $p<.01$. More importantly, there was an interaction between stimulus and group, $F(3, 84) = 6.34$, $p<.01$, $\eta_p^2 = .18$.

As described in Chapter 4, planned pair-wise comparisons (with a Bonferroni correction) were undertaken. Each compared baseline verbal shape naming times with the verbal naming times in one of the three other conditions where distractors were

present. These analyses showed that the verbal response times for the patients with mild AD were significantly slower on trials when the target shape was presented with the OS flankers plus a changing pattern than when the target shapes were presented alone, i.e. the patients with mild AD were particularly impaired by the presence of the OS flankers plus a changing pattern, $F(1, 14) = 10.17$, $p<.03$. However, there were no significant differences in verbal responses times for the HOA controls between these two conditions ($F<1$). Furthermore, both the patients with mild AD and the HOA controls were significantly slower to name the target when a neutral word was within the target shape, $F(1, 14) = 51.92, 25.72$, $p<.01$ (for the patient group and the HOA controls respectively). There were no significant differences (for either group) between their responses times when one of the OS flankers was replaced with a brown singleton shape (with a constant visual identity) and their baseline verbal response times (for patients with mild AD: $p=.98$, for HOA controls: $p=.7$).

As expected, the patients with mild AD were slower than the controls at shape naming in all conditions. However, this finding may have resulted from differences in baseline shape naming speed. Therefore, the difference in verbal response times between each of the conditions with distractors and when the target was presented alone were calculated. Then, the group differences were compared using unpaired t-tests. These showed that when baseline shape naming times are taken into consideration, the patients with mild AD were significantly slower than the HOA controls when one of the OS flankers contained a changing pattern, $t(28) = 2.94$, $p < .01$, or when there was a neutral word within the target shape, $t(28) = 2.68$, $p < .01$. However, when the target was surrounded by OS flankers with a brown coloured singleton (with a constant visual identity), the difference between the patients with mild AD and the HOA controls failed to reach significance ($t <1$).

Since there was a gender imbalance both within and between the two participant groups, the effects of gender were considered. The results analysed by gender are displayed in Figures 7.4 and 7.5 and suggest that there were no gender differences in the pattern of performance for either participant group. The low number of participants in the minority gender groups meant it was not possible to undertake any meaningful inferential statistical analysis. However, scrutiny of the pattern of results for the female participants with mild AD showed that all five participants showed the same pattern of results as the group as a whole. Compared to their verbal response times when they named the blue shape presented alone, they were slower to name the blue shapes when the OS flankers with the changing pattern was present. Also they were slower to name the blue shapes when these shapes contained a neutral word. This suggests that gender is not driving the pattern of interactions.

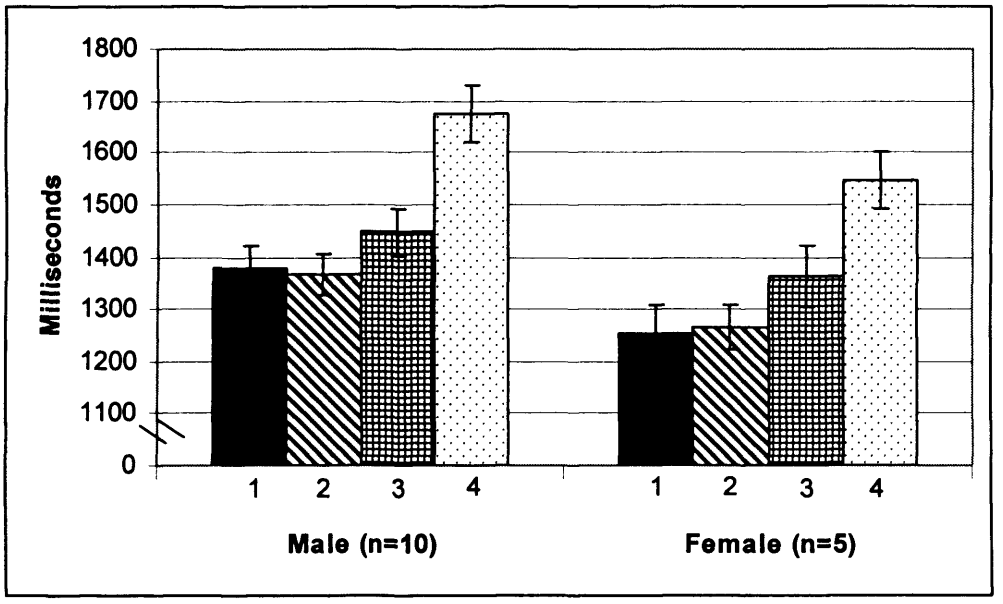


Figure 7.4: Study 8: Verbal response times for patients with mild AD split by gender. Error bars= SE. Conditions: 1=Target (Baseline), 2=OS flankers plus one singleton constant colour, 3=OS flankers plus one singleton changing pattern, 4=Target plus neutral word.

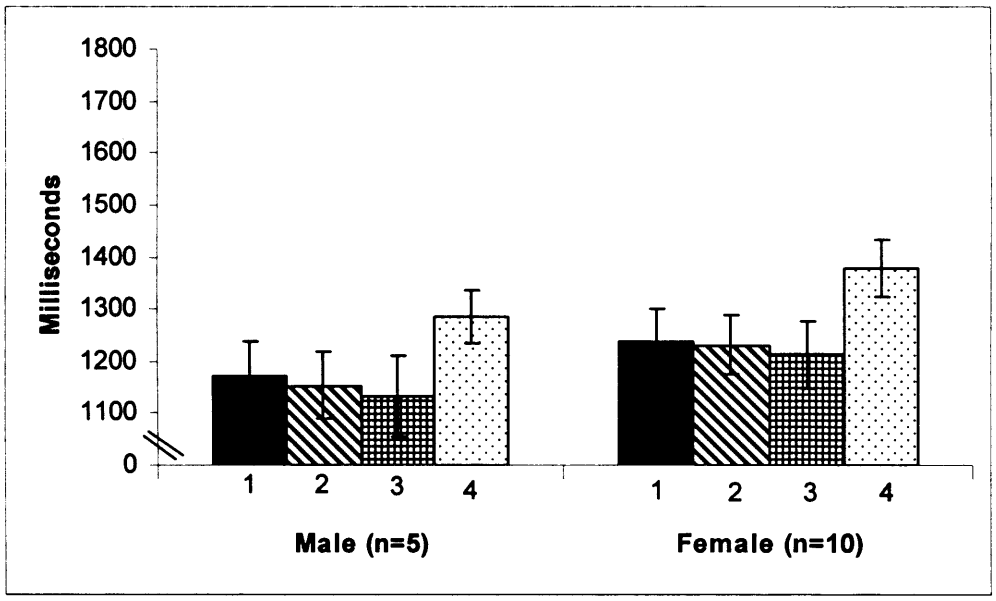


Figure 7.5: Study 8: Verbal response times for HOA controls split by gender. Error bars= SE. Conditions: 1=Target (Baseline), 2=OS flankers plus one singleton constant colour, 3=OS flankers plus one singleton changing pattern, 4=Target plus neutral word.

As the estimated pre-morbid IQ (as assessed by the W-TAR^{uk}) of the patients with mild AD was significantly lower than the HOA controls, consideration was given to whether IQ was driving the pattern of interactions observed. A median split by estimated pre-morbid IQ was undertaken for the AD group giving two new IQ sub-groups (LOWER and HIGHER). The mean ages and associated baseline cognitive measures are shown in Table 7.4. Unpaired t-tests showed that group LOWER had significantly lower estimated pre-morbid IQs than group HIGHER, $t(12) = 15.14$, $p<.01$, There were no other significant differences in baseline cognitive measures.

Table 7.4: Study 8: Post IQ median split: Baseline cognition measures and verbal response times for patients with mild AD

	Patients with mild AD			
	Lower IQ		Higher IQ	
	Mean	SD	**Mean**	SD
Baseline cognition measure	**N=7**		**N=7**	
Age	**76.3**	2.9	**80.7**	1.2
Years in education	**10.2**	0.2	**11.6**	0.8
W-tar raw score	**28.3**	6.8	**43.4**	2.9
MMSE	**21.0**	1.4	**23.0**	0.8
BASDEC	**1.7**	0.9	**1.4**	0.6
Verbal response times (ms)				
Target	**1367**	156	**1292**	139
Target with OS flankers plus one singleton constant colour	**1359**	111	**1320**	139
Target with OS flankers plus one singleton changing pattern	**1458**	143	**1377**	145
Target plus word	**1723**	176	**1566**	102

The low number of participants in each IQ group meant it was not possible to undertake any meaningful inferential statistical analysis. However, scrutiny of the results for each group showed that the pattern of results were comparable. Compared to their baseline shape naming speed, all the patients with mild AD in the lower IQ group and six out of seven patients in the higher IQ group were slower to name the target when the OS flankers with a changing pattern were present. Furthermore, all patients were slower to name the target when it contained a neutral word. This suggests that IQ is not driving the pattern of interactions.

Lastly, since the transition from trial to trial was made by the researcher (for details please refer to Chapter 3), consideration was given to whether random fluctuations in the interval between a response being given and the next stimulus

appearing (RSI) were affecting participants' performance. Participants' mean response times (in ms) on trial n+1 were correlated with the RSI preceding that trial, i.e., following the response on trial (n) for each group. No significant correlations were found (see Table 7.5) suggesting that differences in RSI times were not responsible for the pattern of results observed.

Table 7.5: Correlation coefficients between response times (trial n+1) and preceding RSI

	Patients with AD		**HOA controls**	
Condition	**r**	**p**	**r**	**p**
Target (baseline)	**.14**	.62	**.15**	.60
Target with OS flankers plus one singleton constant colour	**-.06**	.83	**.15**	.62
Target with OS flankers plus one singleton changing pattern	**.30**	.28	**.03**	.91
Target plus word	**.27**	.39	**-.15**	.72

7.7 Discussion

As expected the results displayed in Figure 7.3 showed that the patients with AD were slower overall than the HOA controls. Furthermore, compared to their baseline performance both patients and controls had difficulty ignoring the neutral word when it was presented within the target shape. Also the problems experienced by the patient group were more pronounced since their response times when the neutral word was presented inside the target were significantly slower than the HOA controls (after allowing for baseline shape naming times). Again, as in study 6, their performance also differed from that of the HOA controls in that they made pure errors, i.e. errors where they showed no awareness that an error had been made, whilst the HOA controls never made any such errors (in any of the experimental conditions).

Finally, in terms of both pure and self-correction errors, the patients with AD made significantly more of these errors in the target containing neutral word condition than when the target was presented alone. These results extended the findings of study 6 by demonstrating that the patients' enhanced difficulties with response selection are not restricted to words which elicit a strong semantically related prepotent response. Rather that they have more generalised difficulties in suppressing any prepotent response tendencies

The main purpose of this study was to identify why in study 6, the presence of a peripheral incongruent shape word impaired the shape naming performance of the patient group. To recap, the three proposed explanations were: a) that the affect is limited to words which elicit a prepotent response tendency and result in difficulties with response selection; b) that patients with mild AD are impaired when the location of the distractors are unpredictable which interferes with stimulus selection or; c) that patients with mild AD do indeed have difficulties with stimulus selection but these are due to the changing visual characteristics of the distractor items. Therefore the two flanker conditions will be discussed with particular reference to these three possibilities.

In the OS flankers with a brown singleton condition the verbal response times of the patients with mild AD were not significantly different from their response times when the target was presented alone. Recall, that whilst in this condition the overall spatial location of the distractors are constant, the spatial location of the single brown distractor was unpredictable. Therefore, if the patients with mild AD have difficulties with stimulus selection when the location of the distractors is unpredictable, the patients with mild AD would have been expected to be significantly slowed by the presence of the brown distractor. This was not the case.

In the OS flankers with a changing patterned singleton condition the verbal response times of the patients with mild AD were significantly slower than their response times when the target was presented alone. This finding suggests that the patient group's difficulties are not solely due to problems with response selection when prepotent distractors are present. The introduction of a patterned shape distractor should not engender a habitual response tendency and therefore no differences in verbal response times would be predicted (compared to when the target shapes were presented alone). However, the results do fit with an explanation based on difficulties with stimulus selection. Here, patients' difficulties arise due to the changing visual characteristics of the peripheral distractors. These changing distractors do not afford patients the opportunity to habituate to their presence over repeated presentations. However, it could also be argued that the slower response times are due to the changing spatial location of the singleton patterned distractor. In the OS flankers with a changing patterned singleton condition the location of the patterned singleton distractor was unpredictable across trials. Thus it is possible that location rather than the visual characteristics of the distractor set were responsible for the slower verbal response times. This seems unlikely since no such performance decrement was observed in the OS flankers with single brown distractor condition when the location of the OS flankers which became a brown singleton was also unpredictable.

A final consideration is whether random fluctuations in the RSI times influenced participants' performance across conditions. As explained in Chapter 4, this is important because such fluctuations might result in participants, for example, having more time to recover between trials which could in turn influence performance. In the current study it seems unlikely that the RSI times have

influenced participants' verbal response times since there was no evidence of correlations (for any stimulus condition) between the RSI times on trial n and participants' response times on trial n+1 for either participant group.

7.8 Study 9: Visual search (revision 2)

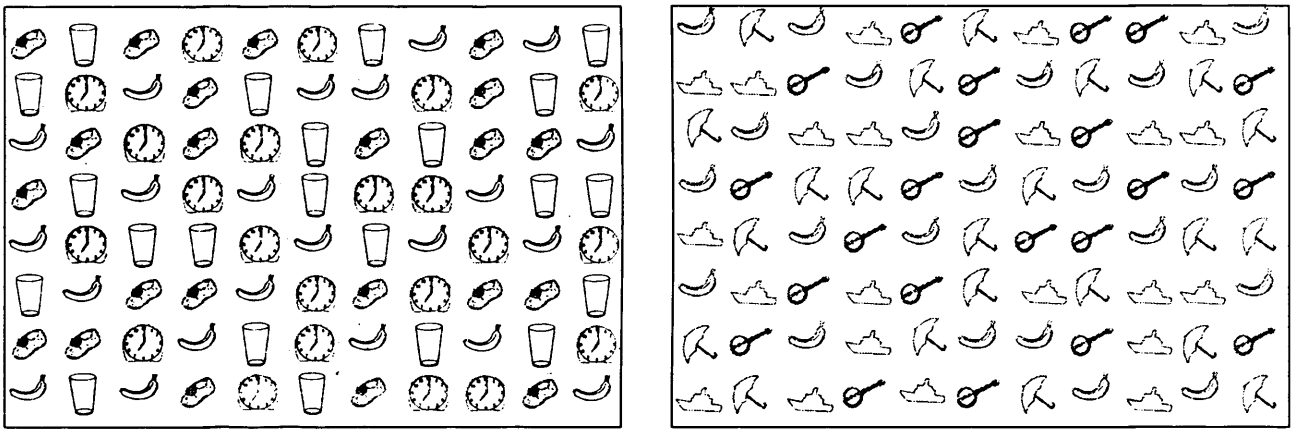
Whereas study 7 examined the effects of semantic similarity between targets and distractors, this revised visual search task sought to investigate the effect of the visual similarity of targets and distractors where the location of the targets was unpredictable. Specifically, it was predicted that both the patients with AD and the HOA controls would be impaired by distractors that were visually similar to the target items.

7.9 Method

7.9.1 Materials

As for study 7 (visual search) the target items were bananas. Again, this task had two conditions which differed in visual distractors. On one sheet the distractors were visually dissimilar to the target; whereas on the other sheet they were visually similar to the target (see fig. 7.6). The unrelated distractors used in paradigm 2 (visual search) were pre-tested to ensure they were visually distinct from the target items (for details see 3.4.1, p.57). Hence, they were used as the visually dissimilar distractors in the current study. The visually dissimilar distractors were selected by reference to the pre-test stimuli from paradigm 2 (visual search) described in 3.5 (p.59). Pictures from the pre-test were selected that were rated as being similar to the target (banana). They were: the umbrella (median 1; range 1-2), the banjo (median 2; range 1-4), and the

ship (median 2; range 1-4). These ratings were then compared with the median ratings of the three dissimilar distractors when paired with the banana. Separate Wilcoxon Matched Pairs Rank tests showed that the three similar distractors were rated as significantly more similar to the target (banana) than the dissimilar distractors, z (16) = 2.24, 2.32, 2.51, $p<.03$. This is important since it demonstrated that the distractor items differed in terms of visual similarity to the search item (the banana).



Targets + visually dissimilar distractors

Targets + visually similar distractors

Figure 7.6: Study 9: Example of stimuli in the two visual search conditions

7.9.2 Design

In this within-participants task participants deleted target items (bananas) in each of two conditions: similar and dissimilar distractors, with the order of presentation being counterbalanced across participants. The dependant variables were errors made and the time taken (in seconds) to locate all the target items.

7.9.3 Procedure

The procedure was the same as for study 7 which followed paradigm 2 (see 3.4.3, p.58).

7.10 Results

7.10.1 Data screening

The data screening strategy is described in 4.8 (p.88). Neither of the participants' group results contained any missing values and no adjustments to search times were required to account for within-condition outliers. The data from one of the HOA controls was excluded since they were unable to complete either sheet in 120 seconds or less. Therefore the data from 14 HOA controls are reported. The overall level of errors was low indicating ceiling effects. Therefore only descriptive statistics for errors are reported and no adjustments were made to the raw error scores (see 7.10.2 below).

Finally, the distribution of the search times (for each participant group) was considered. There was no evidence of kurtosis but the data was positively skewed in both groups and therefore all data was subject to a log transformation and the log transformed data re-inspected and no longer significantly skewed. Thus, this log transformed data was used in all subsequent inferential analysis.

7.10.2 Errors

The visual search sheets were reviewed and errors noted. Controls made no errors whilst two patients with mild AD made two errors, with a further four patients making one error. All errors were omissions (failing to strike through a banana), four errors were made in each of the two experimental conditions. Across conditions, the errors made by the patient group represented only 1.14% of the total number of targets to be found and deleted. Having shown that the number of errors made was negligible, the time data was considered.

7.10.3 Search times

The mean search times by type of distractor and also order of stimuli presentation (for both participant groups) are displayed in Table 7.6 (for log transformed times see Appendix 8). The rationale for considering the order of presentation was given in 4.9.2 (p.89). In terms of the effect of visual distractors, for both the patients with mild AD and the HOA controls, the mean search times seemed slower when the targets were dispersed amongst visually similar distractors than when the distractors were dissimilar. Also, the descriptive data suggests practice effects for both groups with faster overall search times in the second search task independent of the type of distractors. Overall, it appears that the patients with AD were slower to complete the task in both conditions, which was expected given the cognitive difficulties patients with AD have.

Table 7.6: Study 9: Mean search times in seconds (by distractor type and task order)

	Distractor type		Task Order	
	Similar	Dissimilar	First	Second
Group	Means (SD)	Means (SD)	Means (SD)	Means (SD)
Patients with AD	**55.81** (10.71)	**50.94** (18.09)	**58.13** (15.72)	**48.63** (12.68)
HOA controls	**39.93** (9.07)	**35.57** (7.27)	**39.21** (10.01)	**36.29** (6.37)

The question posed was whether both the patients with mild AD and the HOA controls would be slower to find the targets when they were presented amongst visually similar distractors. The data analysis strategy was the same as for study 7 and was fully described in study 2 (see 4.9.3). The search times of the patients with AD were significantly faster during the second search, $F(1, 14) = 15.27$, $p < 0.01$, whereas the difference in search times for the HOA controls failed to reach significance. However, both groups were slower in locating the targets when the

distractors were visually similar to the distractors, $F(1, 14) = 7.74$, $p < 0.03$ and $F(1, 12) = 8.09$, $p < .05$ for the patients with mild AD and the HOA controls respectively.

7.11 Discussion

The search times showed that for both the patients with mild AD and the HOA controls were slower when the distractors were visually similar to the target item. This supports the suggestion from the original visual search paradigm (Study 7) that when spatial location cannot be used as a cue to target selection, participants rely on the visual characteristics of items within the visual array. Therefore target and distractor items that are visually similar will be harder to differentiate thus resulting in longer response times.

7.12 Chapter summary

Studies 8 and 9 sought to extend the findings of studies 6 and 7 reported in Chapter 6. Study 9 (visual search- revision 2) showed that both patients with mild AD and HOA controls are sensitive to the visual characteristics of distractors when the location of the target is unpredictable. However, when the location of the target is predictable, study 8 (Flanker and Stroop- revision 2) demonstrated that patients with mild AD (but not HOA controls) are impaired by peripherally presented visual extraneous information that changes over time. Furthermore, study 8 showed that it is the variation in the visual characteristics of the distractors that impair stimulus selection.

Chapter 8: General Discussion and Conclusions

This chapter draws together the themes examined in this thesis and makes suggestions for potential applications and future research. As explained in Chapter 1, this thesis investigated whether difficulties occur at different stages of attentional processing in patients with either mild PD or mild AD. This thesis also considered (at a behavioural level) whether different types of visual distractors, when presented simultaneously with visual targets, differentially affected performance and whether different mechanisms underlie the way this extraneous visual information influences task performance.

8.1 Major findings and relationship to hypotheses

8.1.1 Patients with mild PD

The main aim of studies 1 and 4 (Flanker plus Stroop) was to assess the effect of different sorts of flankers on the performance of patients with mild PD. In all comparisons the effects of the flanker items were established by comparing performance when flankers were present to performance when the target shapes were presented alone. It was predicted that the patients with mild PD would name the blue target shapes more quickly when they were presented with OS flankers. It was hypothesised that the OS flankers would prime other shapes from the shape domain and thereby improve performance. It was also predicted that this improved performance would be attenuated when the flankers came from a different semantic category. This was found to be the case. Since these distractors were identical to each other and differed in colour from the target shapes this finding excluded an explanation based on novel pop-out or failure to maintain an attentional set.

One of the flanker conditions presented an incongruent shape word within one of the OS flankers. Here, for the patients with mild PD, no significant differences from baseline shape naming times were found. This finding was replicated by presenting the flanker incongruent shape word without the OS flankers. In contrast, when an incongruent shape word was presented within the target performance was significantly slower than baseline. This suggests that patients with mild PD have problems with extraneous visual information presented at fixation. As predicted no differences in performance (from baseline) were observed for the HOA control group in any of the flanker conditions. They were however slowed by an incongruent shape word presented at fixation. In terms of errors they had fewer difficulties than the patients with mild PD.

Studies 2 and 5 were visual search tasks that sought to investigate whether the improved performance of patients with mild PD when semantically related distractors were present extended to tasks where the location of the targets was unpredictable. It was predicted that the performance of the patients with mild PD would be faster when the distractors belonged to the same semantic category as the targets. Study 2 supported this prediction. Study 5, however, did not show an improvement in speed of performance although the patients with mild PD made significantly fewer errors when the distractors were semantically related to the target items. No performance differences between the semantically related and unrelated distractors were predicted within the HOA control group and this was the case.

The main aim of study 3 (Inattentional Blindness) was to assess the effects of distractor items on stimulus selection. To the author's knowledge no work has been published using this paradigm with either older people or those with mild PD. Therefore no strong predictions were made. The patients with mild PD were less

accurate at the counting task than the HOA controls. Despite this, neither group (patients with mild PD nor HOA controls) noticed the novel unexpected distractor significantly more than would be predicted by chance. However, both groups noticed the novel distractor significantly more than would be predicted on the basis of chance responding after an implicit cue that the distractor items might be important. This suggests that whilst patients with mild PD have more difficulty selecting relevant items this problem does not seem to be due to being distracted by extraneous visual information.

8.1.2 Patients with mild AD

The main aim of studies 6 and 8 was to establish whether flankers with different characteristics adversely affect stimulus selection in patients with mild AD. In all comparisons the effects of the flanker items were established by comparing performance when flankers were present to performance when the target shapes were presented alone. It was hypothesised that patients with mild AD are vulnerable to distraction from peripheral extraneous visual information when this information is not held constant. It was predicted that the patients with mild AD would be significantly slower to name the blue target shapes when they were presented with flankers which changed across trials of that type. It was also predicted that this slower performance would be attenuated when the flankers were repeated. This was found to be the case. Presenting repeated flankers did not result in significantly slower than baseline performance, whilst changing flankers (verbal and visual) resulted in slower performance. As predicted no differences in performance (from baseline) were observed for the HOA control group in any of the flanker conditions.

The secondary aim of studies 6 and 8 was to evaluate the effects on response selection of prepotent information presented in the same location as the target stimulus. It was predicted that the patients with mild AD would be impaired by the presence of words within the target shape and that their level of impairment would be greater than that shown by the HOA controls. This was found to be the case. The performance of the patients with mild AD was significantly worse than that of the HOA controls both in terms of response times and errors made regardless of whether the word was a shape word or a word from another semantic category. This shows that patients with mild AD have particular difficulty overcoming automatic response tendencies.

Studies 7 and 9 were visual search tasks that sought to investigate the effects of different kinds of distractors when the location of the targets was unpredictable. In study 7 the distractors were either semantically related or unrelated to the target items. Here, it was hypothesised that since the performance of patients with mild AD has been shown to be worse than age-matched controls in tests of intact semantic knowledge such as category fluency (e.g. Perry et al., 2000), a similar performance deficit would be seen during a task that had semantically related distractors. However, this was not the case. Regardless of the type of distractors presented, there were no significant differences in response times or errors made in either group (patients with mild AD or HOA controls). In study 9 the distractors were either visually similar or visually dissimilar to the target items. It was predicted that both the patients with AD and the HOA controls would be impaired by distractors that were visually similar to the target items. This was found to be the case. Taken with the results from studies 6 and 8 this demonstrates that when the location of the target items are unpredictable both older adults and patients with mild AD have more difficulty selecting stimuli

when they are visually similar to the distractors. However, only the response times of the patients with mild AD were slowed by distractors when the location of the targets is predictable.

8.2 Attentional processes in mild PD

The studies reported in Chapters 4 and 5 demonstrated that the performance of patients with mild PD can be improved by the presence of some types of extraneous visual information. Specifically, patients with mild PD can utilise the meaning of distractor items to aid them in stimulus identification. Furthermore, the mechanism which supports this improved performance is semantic priming (see fig. 8.1). Evidence in support of this conclusion is as follows. In both studies 1 and 4 (Flanker plus Stroop), the patients with mild PD named the blue target shapes more quickly when they were presented with other orange shapes (OS) flankers rather than when the target shapes were presented alone. Here, the OS flankers primed the superordinate shape domain and hence led to quicker identification of other basic level shape items. Furthermore, study 4 (Flanker plus Stroop- revision 1) demonstrated that when the distractors were from a different semantic category to the target, i.e. boats rather than shapes, the facilitation effect was attenuated. These findings were augmented by the results from studies 2 and 5 (visual search). These showed that even when the location of the target items was unpredictable, patients with mild PD still benefit from semantically related extraneous visual information. The patients with mild PD found the targets more quickly (study 2) and made fewer errors (study 5), when the distractors were semantically related rather than unrelated to the target, i.e. other fruit versus non-fruits.

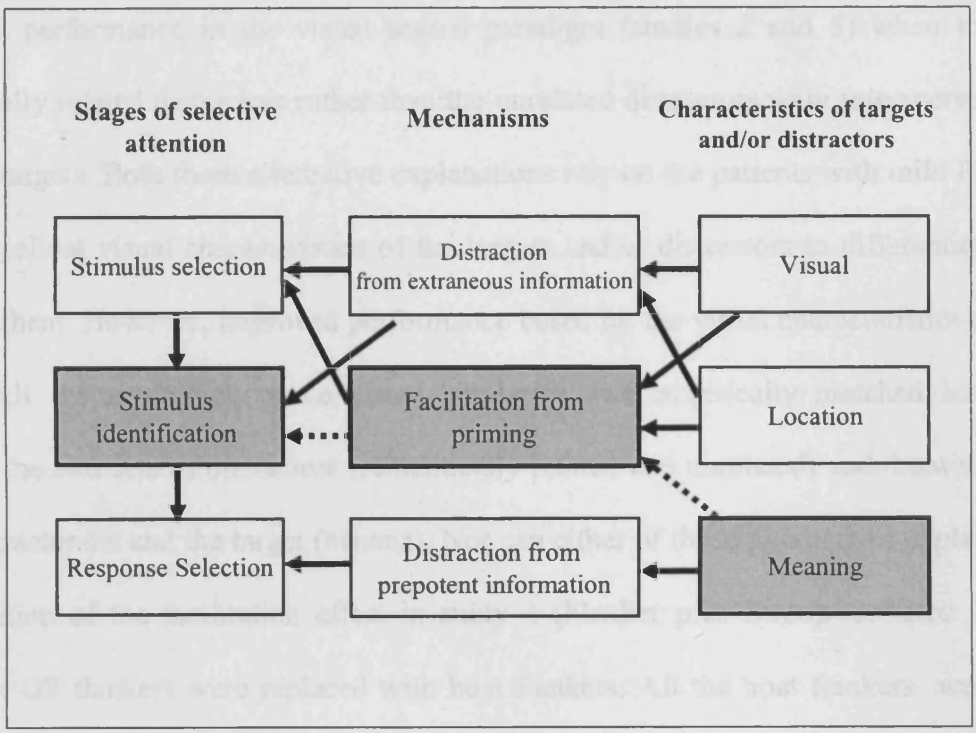


Figure 8.1: A preference for processing the meaning of distractors aids stimulus identification through priming in patients with mild PD (indicated by dashed arrows and highlighted boxes)

An explanation based on semantic priming is supported by previous findings that patients with mild PD are particularly sensitive to semantically related information in the Hayling task (Bouquet et al., 2003; Castner et al., in press). Furthermore, both Mari-Beffa et al. (2005) and Spicer et al. (1994) demonstrated that patients with PD benefited from semantically related information in priming paradigms, although in these studies the distractors were not presented concurrently with the target stimuli.

Other possible explanations for the improved performance when semantically related distractors were present, namely novel pop-out or a failure to maintain an attentional set, were considered. However, the evidence from studies 1 to 5 did not support either of these alternatives. Neither of these explanations can account for the

improved performance in the visual search paradigm (studies 2 and 5) when the semantically related distractors rather than the unrelated distractors were interspersed with the targets. Both these alternative explanations rely on the patients with mild PD utilising salient visual characteristics of the targets and/or distractors to differentiate between them. However, improved performance based on the visual characteristics of the stimuli seems unlikely since visual similarity was empirically matched both between the two sets of distractors (semantically related and unrelated) and, between each distractor set and the target (banana). Nor can either of these alternatives explain the abolition of the facilitation effect in study 4 (Flanker plus Stroop- revision 1) when the OS flankers were replaced with boat flankers. All the boat flankers were identical and the same colour and size as the OS flankers. Thus explanations based on either novel popout or a failure to maintain an attentional set, e.g. on the basis of colour, would predict faster shape naming times than when the target was presented alone, which was not the case.

Another difficulty for an explanation based on a failure to maintain an attentional set is that it does not explain why the patients with mild PD showed faster response times when the OS flankers were present in studies 1 and 4 (Flanker plus Stroop). If the patients with mild PD were having difficulties maintaining an attentional set slower response times would have been expected. Also, the results of study 3 (Inattentional Blindness) showed that whilst there was some evidence that the patients with mild PD found the task more difficult than controls, they were able to maintain an attentional set. Finally, an explanation based on novel popout is also not supported by the results of study 4 (Flanker plus Stroop- revision 1). Here, in condition 3 (OS flanker with one squiggle) the distractors were not identical and therefore no improvement in response times would have been expected. However, the

patients with mild PD did show facilitation effects in this condition. Furthermore, when an identical black squiggle was added to each OS flanker, also in study 4 (Flanker plus Stroop- revision 1), no facilitation effects were found despite all the distractor items being identical and so providing appropriate conditions for pop-out effects.

Although not specifically tested within this thesis, it seems likely that the semantic priming occurred without conscious awareness due to automatic categorisation of the distractors (e.g. Brand, 1971; McClelland & Rogers, 2003). If, for the patients with mild PD, using the semantically related extraneous visual information to improve performance were due to an automatic rather than a conscious process, then similar improvements in performance may have been predicted in the HOA controls. Indeed, older adults have shown improvements in priming studies where semantically related versus unrelated words have been used as stimuli (e.g. Kim et al., 2007; Laver & Burke, 1993). Study 1 (Flanker plus Stroop) showed that, in respect of the HOA controls, there was a correlation between shape naming speed (when the shape was presented alone) and shape naming speed when the target shape was surrounded by OS flankers. Here, slower shape naming speeds were associated with larger facilitation effects, i.e. improvements in performance, when the OS flankers were present. This suggests that the HOA controls for whom shape naming was most difficult benefited most from the semantic related extraneous visual information. Also studies 1 and 4 (Flanker plus Stroop) showed that the patients with mild PD were significantly slower than the HOA controls at naming the shapes (when no distractors were present). Taken together, these findings suggest that the semantic priming benefits gained by the patients with mild PD, rather than reflecting a qualitative difference between them and the HOA controls, more likely reflect a

compensatory mechanism that helps to minimise the impact of their slower baseline performance. This also explains why the HOA control group, showed no significant improvement in response times when semantic related distractors were present. This may be an artefact of the group's ability to name the shapes quickly which may have left little room for improvement regardless of the nature of the extraneous information.

8.3 Attentional processes in mild AD

Turning to the patients with mild AD, their baseline shape naming speed is significantly slower than that of the HOA controls (see studies 6 and 8), yet there is no evidence that they use semantic priming as a compensatory mechanism. However, this was predicted given that these patients often experience difficulties in tasks that require intact semantic knowledge (e.g. Perry et al., 2000). Furthermore, a lack of semantic priming fits with the PDP model of categorisation (e.g. McClelland & Rogers, 2003; Rogers & Patterson, 2007). As explained in 1.3.7 (p.17), in this model, superordinate, basic level and subordinate categories are represented one within another in semantic space. To successfully retrieve a basic level category name, precise activation of the features which make that particular object unique is required. Small deviations from this pattern of feature activation may result in a failure to identify the object at the basic category level. However, this would not necessarily preclude correct object identification at a superordinate category level. Category membership at the superordinate level is based on a broader range of features and therefore not so susceptible to problems due to feature specificity. Indeed, Rogers & Patterson (2007) demonstrated that patients with semantic dementia categorise colour photographs more accurately at superordinate than at more specific levels. Whilst

semantic dementia is associated with specific atrophy to the anterior temporal cortex (e.g. Garrard & Hodges, 2000) rather than the broader pathology associated with early AD (see p.4), Rogers & Patterson's (2007) results do demonstrate that a breakdown in semantic knowledge can result in a tendency to categorise at a superordinate level. Therefore, in study 6 (Flanker plus Stroop), even if the orange shape (OS) flankers had been identified at the superordinate 'shape' level, they may not have aided identification of the basic level target shape names due to difficulties in feature representation at this more precise level of categorisation.

So, patients with mild AD tend to find it difficult to use the meaning of extraneous visual information to aid them in stimulus identification. Rather, the studies reported in Chapters 6 and 7 suggest they rely on the visual characteristics of the stimuli presented to both select and subsequently identify relevant stimuli. Whilst study 9 (visual search- revision 2) showed that increased visual similarity between target and distractor items makes stimulus selection more difficult for all (at least when the location of the targets are unpredictable), only patients with mild AD seem to rely on visual characteristics when the location of the target is predictable.

Specifically, in study 6 (Flanker plus Stroop), the response times of the patients with mild AD were significantly slower when the target shape was surrounded by OS flankers one of which contained an incongruent shape word than when the shape was presented alone. This suggested that, for patients with mild AD, the ability to successfully select relevant stimuli is impaired by the presence of extraneous visual information, as displayed in Fig. 8.2. However, this interpretation lacks specificity since no significant differences were found between response times when no distractors were present and response times when the target was surrounded by identical OS flankers. This suggested that, for patients with mild AD, the ability to

select relevant stimuli is particularly vulnerable to the presence of distractors whose visual characteristics change over time. This implies that these patients are able to habituate to visual distractors whose appearance although not location remains constant over repeated presentations. This interpretation was supported by the findings of study 8 (Flanker plus Stroop- revision 2). A consistent change in the colour of one of the peripheral distractors from orange to brown, in all trials of that type, had no significant effect on response times. However, when one of the OS flankers was replaced with one of four orange patterns which varied across trials of that type, response times were significantly slower than when the shape was presented alone.

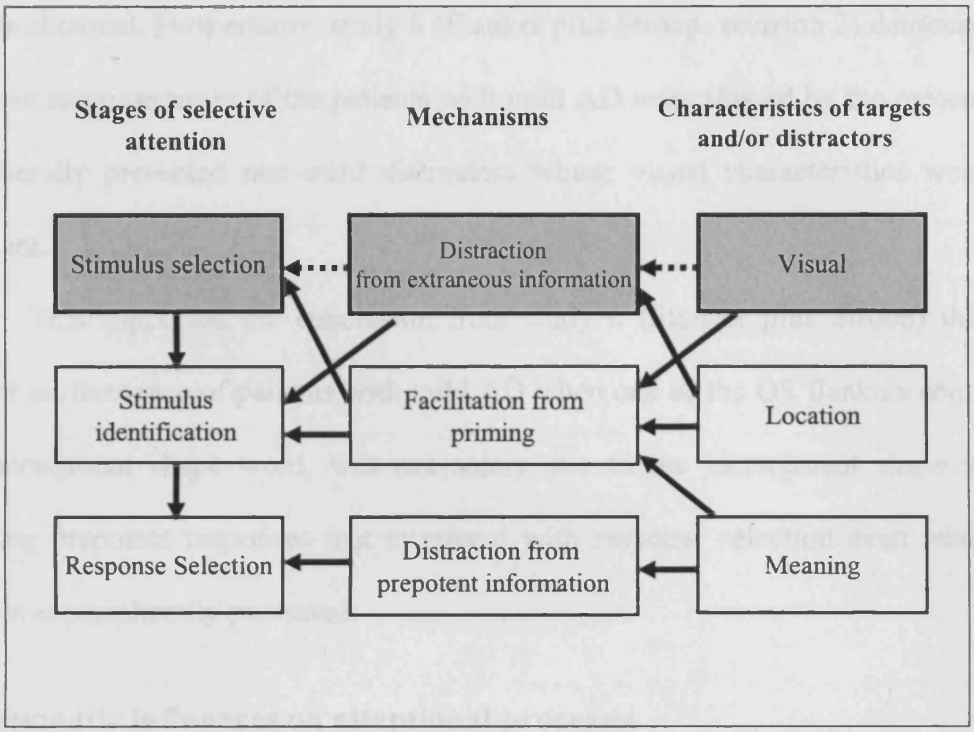


Figure 8.2: A preference for processing the visual characteristics of distractors impairs stimulus selection through distraction from extraneous information in patients with mild AD (indicated by dashed arrows and highlighted boxes)

Although unlikely, these stimulus selection problems may have been due to the variable location of individual distractor items within the visual display. However, study 8 (Flanker plus Stroop- revision 2) suggested that this was not the case. There in condition 2 (OS flankers with a brown singleton) the spatial location of the single brown distractor was unpredictable yet its presence was not detrimental to the performance of the patients with mild AD. A useful future study would replicate study 8 with the modification of making the location of both the brown singleton and the orange patterned singleton predictable within the distractor display. Then, if the pattern of results replicates the findings of study 8, this will provide further evidence

that variations in the location of the distractors were not influencing the pattern of results obtained. Furthermore, study 8 (Flanker plus Stroop- revision 2) demonstrated that, the response times of the patients with mild AD were slowed by the presence of peripherally presented non-word distractors whose visual characteristics were not constant.

This supported the conclusion from study 6 (Flanker plus Stroop) that the slower performance of patients with mild AD when one of the OS flankers contained an incongruent shape word, was not solely due to the incongruent shape words eliciting prepotent responses that interfered with response selection even when the word was peripherally presented.

8.4 Semantic influences on attentional processes

Whilst in some circumstances the meaning of peripherally presented distractors can aid stimulus identification (as discussed above), the meaning of distractors can also impair performance when they are presented at fixation. Studies 1 and 6 showed that all groups were slower to name the shapes when they contained an incongruent shape word. This was predicted as previous research has demonstrated that older people tend to more affected by visual stimuli that elicit a prepotent response (see 2.3.1, p.39). Furthermore, study 8 demonstrated that this effect continued even when the incongruent shape words were replaced with words from a different semantic category. Whilst study 8 did not include patients with mild PD (because the primary issues examined were concerned with the performance of the patients with mild AD), there is no apparent reason why centrally presented words per se should not also slow the shape naming times of this patient group. Word reading is well practiced by adulthood and therefore words tend to elicit a prepotent response

since they are automatically read even when irrelevant to the task at hand. Thus, the mechanism which links the meaning of the distractors with the negative impact on response selection is distraction from prepotent information (see fig. 8.3).

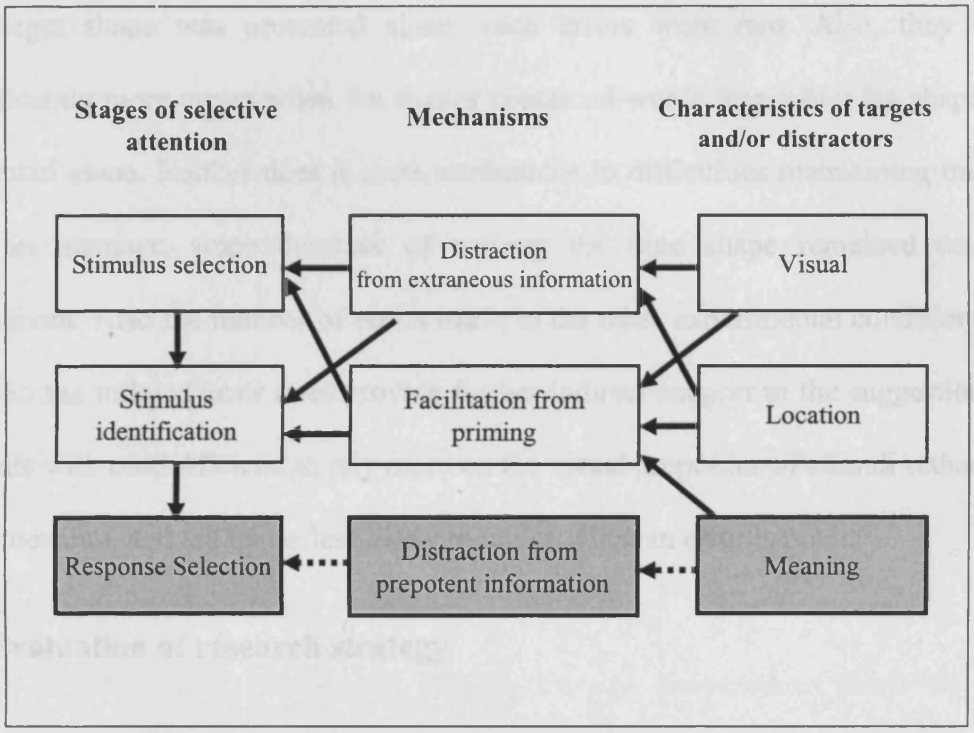


Figure 8.3: The meaning of distractors impairs response selection through distraction from prepotent information in patients with either mild PD or mild AD and HOA controls (indicated by dashed arrows and highlighted boxes)

Whilst in terms of verbal response times, both patient groups appear to be quantitatively worse than the older adult controls, the patients with mild AD also exhibit qualitatively different patterns of performance when the types of errors made are considered. When either the patients with mild PD or the HOA controls erroneously verbalised either all or part of the word rather than the shape name they showed awareness that they had made an error. Whilst the patients with mild AD also

on some occasions showed awareness that they had erroneously verbalised the word, they also made a significant number of errors where they showed no awareness that they had made an error. This cannot be solely attributed to more difficulty in shape naming per se since whilst the patients with mild AD occasionally made errors when the target shape was presented alone, such errors were rare. Also, they made significantly more errors when the shapes contained words than when the shape was presented alone. Neither does it seem attributable to difficulties maintaining the task goal in memory, since the task of naming the blue shape remained constant throughout. Also the number of errors made in the other experimental conditions was low. So the inflated error rates provide further indirect support to the suggestion that patients with mild AD tend to rely more on the visual properties of stimuli rather than their meaning, and are hence less likely to notice when an error is made.

8.5 Evaluation of research strategy

This thesis has not treated inhibitory processes as a global concept. Instead this thesis was interested in how different inhibitory mechanisms might interact with the characteristics of either target and/or distractor items and hence differentially impact upon different stages of selective attention. When work on this thesis started, there was some interest in investigating whether inhibitory mechanisms were comprised of separate components (e.g. Friedman & Miyake, 2004). This is a lively current concern both in the aging literature (e.g. Lustig et al., 2007) and among researchers concerned with neurological disorders. For example, Collette, Schmidt, Scherrer, Adam & Salmon (2007) sought to provide evidence of differential performance in patients with mild AD and age matched controls between '*interference control*' which they considered to be the automatic suppression of

distractors without conscious awareness and, *'inhibition'* which they considered to involve the controlled suppression of information identified as irrelevant to the task at hand. Two of the tasks they used, i.e., probe recency and direct forgetting, involved distractors that had been previously presented. In these tasks, no significant differences in performance between the patients with mild AD and the controls were observed, which might suggest normal interference/inhibition processes in the patient group. However, Collette et al (2007) suggested that the reason for this is more likely to be due to memory processes than intact inhibitory processes per se. They reasoned that the previously presented information would result in weaker memory traces in the patients with mild AD thus making subsequent suppression easier for them than for older adults generally. This observation supports the decision within this thesis to choose tasks that minimise the need to rely on memory processes and is one of the strengths of the research strategy adopted.

In paradigm 1 (Flanker plus Stroop), the four experimental conditions were inter-mingled rather than presented in separate blocks of trials. The rationale for this decision was explained in 2.4.1 (p.44), namely to maintain task interest, be more representative of the usual visual environment and to reduce the use of ad- hoc strategies. However, it could be argued that this inter-mingling of trials made the task particularly difficult for the patients with mild AD since the both the type of trial and the characteristics of the distractors were constantly changing. Therefore the evidence that this patient group are particular vulnerable to distraction from changing extraneous visual information would be strengthened by replicating the research using homogenous blocks of trials for each experimental condition. With repeated presentation of blocks of the same type of trial, the patients with mild AD would have more chance to habituate to the peripherally presented distractors. If the pattern of

results obtained was the same as the pattern found in studies 6 and 8, i.e. slower performance when the visual characteristics of the distractors changed between trials, this would give strong evidence that it was these changing visual characteristics that were impairing the performance of this patient group.

The research strategy adopted sought to delineate fairly fine grained distinctions in patterns of performance. However, in trying to make these more focussed distinctions, whilst minimising confounds such as impairments in memory and difficulties with fine motor movements, the experimental paradigms were more artificial than is ideal and so may not directly reflect usual behaviour in everyday situations. In mitigation, the research questions posed were theoretical in nature. Therefore, having shown that differences do arise at different stages of attentional processing, future research could seek to replicate these results using more naturalistic experimental paradigms.

8.6 Future research and potential applications

In terms of further research (in addition to the suggestions described in 8.2 and 8.4 above) it would be beneficial to change the methodology of study 5 (visual search - revision 1) to avoid the need for the participants to turn pages between trials. This could either be achieved by the researcher turning the pages or by computerising the task to automate transition between trials. The reason for not computerising the task in study 5 was to maintain task interest throughout the testing session (see 2.4.2, p.47). Therefore, the preferred method of presentation would need to be considered within the context of any other tasks to be presented within the same testing session. Also, using a different sample of patients with mild PD would increase the power of the findings. In respect of the patients with mild AD, future research may benefit from a

preliminary measure of category naming. Here, it would be predicted that those who have most difficulty with category naming, and so are less supported by the shaded pathway in Fig 8.1, would be most reliant on the visual characteristics of stimuli to complete the task at hand.

On a broader scale this research may have practical implications in terms of cognitive rehabilitation which may help patients maintain as much independence as possible. Patients with mild PD have previously been shown to benefit from visual cues designed to help them initiate motor tasks such as walking (Lewis et al., 2000). The current research suggests that they may also benefit from contextual cues when completing cognitive tasks. With regard to the patients with mild AD, the research emphasises the need for assistive technology that consists of uncluttered visual displays and for information to be displayed in a way that makes items easily distinguishable on the basis of visual characteristics. Also, labelling household items by, for example, adding a colour code to those items which have similar shapes (e.g. kettle and coffee pot, or adjacent electrical plugs) is likely to be helpful.

Another potentially fruitful area of further research is whether the finding that patients with AD, even in the early stages, tend to rely on the visual characteristics of stimuli may lead to the design of a diagnostic tool. A diagnosis of possible or probable AD requires a progressive impairment of memory plus at least one other area of cognitive function (McKhann et al., 1984). Therefore, a tool which taps into selective attentional processes could be used as part of a wider test battery. To achieve this, a task would be needed where superior performance requires processing of the meaning of distractors rather than their visual characteristics. To be clinically useful it would need to be both quick and simple to administer.

For the most part this thesis focused on the pattern of performance of patients on a group basis rather than the performance of an individual patient. Given the heterogeneous nature of both PD and AD, one challenge of developing a clinically useful diagnostic test would be to ensure that the task had high specificity to successful identify those with cognitive difficulties. One issue here will be any potential mediating effects of IQ. The results from study 8 (Flanker plus Stroop - revision 2) suggested that the pattern of performance of the patients with mild AD was not significantly effected by differences in IQ. However, larger samples of both patients and healthy controls would be required to confirm this finding, together with a sample that also includes more people with lower IQ scores. A further challenge would be to ensure that the task had high test re-test reliability. The results reported in this thesis provide some evidence that the Flanker plus Stroop paradigm had test re-test reliability since whilst the absolute response times may improve with practice (between the first and second blocks of each testing session) the pattern of results remains similar. However, this evidence would have been stronger if the results had been obtained at a later date.

8.7 Conclusions

This thesis proposed a framework which linked stimulus characteristics and attentional mechanisms to different stages of selective attentional processing (see fig 1.1, p.7). Using this framework, it was suggested that the facilitation effects observed in patients with mild PD arose due to semantic priming that helped them with stimulus identification. In contrast, this framework suggested that it was during stimulus selection that distraction from items visually similar to the target impaired the performance of patients with mild AD. This thesis has articulated how different

selective attentional pathways mediated performance at different stages of attentional processing. It also illustrated how these pathways are affected by the two neurological disorders. This interpretation offers potential resolution of conflicts in the research literature concerning the susceptibility of these patient groups to visual distraction.

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Appendix 1: Study 1: Mean log-transformed verbal responses times (in ms.)

	Overall		Block 1		Block 2	
Group	Mean (ms.)	SD	Mean (ms.)	SD	Mean (ms.)	SD
Patients with PD						
Target (baseline)	**3.08**	0.07	**3.09**	0.06	**3.07**	0.07
Target with OS flankers	**3.05**	0.05	**3.07**	0.07	**3.04**	0.06
Target with OS flankers plus word	**3.07**	0.07	**3.07**	0.06	**3.06**	0.09
Target plus incongruent word	**3.17**	0.08	**3.17**	0.08	**3.15**	0.10
HOA Control						
Target (baseline)	**3.05**	0.03	**3.06**	0.03	**3.03**	0.05
Target with OS flankers	**3.05**	0.03	**3.05**	0.02	**3.04**	0.04
Target with OS flankers plus word	**3.04**	0.02	**3.05**	0.03	**3.03**	0.03
Target plus incongruent word	**3.11**	0.04	**3.14**	0.04	**3.08**	0.05

Appendix 2: Study 2: Mean log-transformed search times (by distractor type and task order)

	Distractor type		Task Order	
	Related	Unrelated	1st search	2nd search
Group	Log means (SD)	Log means (SD)	Log means (SD)	Log means (SD)
Patients with PD	**1.58** (.15)	**1.61** (.03)	**1.61** (.14)	**1.57** (.15)
HOA controls	**1.50** (.11)	**1.50** (.02)	**1.52** (.02)	**1.48** (.02)

Appendix 3: Study 4: Mean log-transformed verbal response times (in ms.)

Group	Overall Mean (ms.)	Overall SD	Block 1 Mean (ms.)	Block 1 SD	Block 2 Mean (ms.)	Block 2 SD
Patients with PD						
Target (baseline)	**3.08**	0.05	**3.09**	0.06	**3.07**	0.06
Target with OS flankers	**3.05**	0.06	**3.06**	0.07	**3.04**	0.08
Target with OS flankers plus 1 squiggle	**3.05**	0.06	**3.05**	0.07	**3.04**	0.06
Target with OS flankers plus all squiggle	**3.05**	0.07	**3.05**	0.08	**3.05**	0.07
Target with boat flankers	**3.06**	0.06	**3.06**	0.06	**3.05**	0.08
Target with peripheral incongruent shape word	**3.07**	0.07	**3.07**	0.09	**3.07**	0.07
HOA Control						
Target (baseline)	**3.03**	0.05	**3.04**	0.04	**3.02**	0.06
Target with OS flankers	**3.02**	0.05	**3.03**	0.04	**3.02**	0.07
Target with OS flankers plus 1 squiggle	**3.03**	0.04	**3.04**	0.04	**3.01**	0.06
Target with OS flankers plus all squiggle	**3.03**	0.04	**3.04**	0.05	**3.02**	0.05
Target with boat flankers	**3.03**	0.05	**3.05**	0.06	**3.00**	0.05
Target with peripheral incongruent shape word	**3.04**	0.04	**3.04**	0.05	**3.03**	0.06

Appendix 4: Study 5: Mean log-transformed search times (by distractor type and task order)

	Distractor type		Task Order	
	Related	Unrelated	1st search	2nd search
Group	Log means (SD)	Log means (SD)	Log means (SD)	Log means (SD)
Patients with PD	**1.57** (.18)	**1.59** (.18)	**1.65** (.18)	**1.53** (.16)
HOA controls	**1.47** (.14)	**1.46** (.17)	**1.49** (.15)	**1.44** (.14)

Appendix 5: Study 6:Mean inverse-transformed verbal response times (in ms.)

Group	Overall Mean* (ms.)	Overall SD*	Block 1 Mean* (ms.)	Block 1 SD*	Block 2 Mean* (ms.)	Block 2 SD*
Patients with AD						
Target (baseline)	**6.85^{-4}**	1.55^{-4}	**6.39^{-4}**	1.70^{-4}	**7.39^{-4}**	1.53^{-4}
Target with OS flankers	**6.58^{-4}**	1.74^{-4}	**6.60^{-4}**	1.76^{-4}	**6.71^{-4}**	1.91^{-4}
Target with OS flankers plus word	**6.34^{-4}**	1.74^{-4}	**5.98^{-4}**	1.92^{-4}	**6.83^{-4}**	1.70^{-4}
Target plus incongruent word	**5.09^{-4}**	1.40^{-4}	**4.99^{-4}**	1.34^{-4}	**5.22^{-4}**	1.51^{-4}
HOA Control						
Target (baseline)	**8.94^{-4}**	$.70^{-4}$	**8.60^{-4}**	$.72^{-4}$	**9.31^{-4}**	$.99^{-4}$
Target with OS flankers	**9.04^{-4}**	$..56^{-4}$	**8.97^{-4}**	$.42^{-4}$	**9.17^{-4}**	$.76^{-4}$
Target with OS flankers plus word	**9.11^{-4}**	$.49^{-4}$	**8.86^{-4}**	$.58^{-4}$	**9.46^{-4}**	$.76^{-4}$
Target plus incongruent word	**7.75^{-4}**	$.64^{-4}$	**7.27^{-4}**	$.61^{-4}$	**8.34^{-4}**	$.91^{-4}$

* In scientific notation

Appendix 6: Study 7: Mean log-transformed search times (by distractor type and task order)

	Distractor type		Task Order	
	Related	Unrelated	1st search	2nd search
Group	Log means (SD)	Log means (SD)	Log means (SD)	Log means (SD)
Patients with AD	**1.68** (.18)	**1.70** (.19)	**1.72** (.18)	**1.66** (.18)
HOA controls	**1.50** (.11)	**1.50** (.02)	**1.52** (.02)	**1.48** (.02)

Appendix 7: Study 8: Mean log-transformed verbal response times (in ms.)

Group	Overall Mean (ms.)	Overall SD	Block 1 Mean (ms.)	Block 1 SD	Block 2 Mean (ms.)	Block 2 SD
Patients with AD						
Target (baseline)	**3.12**	0.05	**3.14**	0.07	**3.11**	0.04
Target with OS flankers plus one singleton colour	**3.12**	0.04	**3.11**	0.06	**3.12**	0.06
Target with OS flankers plus one singleton changing pattern	**3.15**	0.04	**3.16**	0.06	**3.14**	0.05
Target plus word	**3.21**	0.04	**3.23**	0.08	**3.29**	0.04
HOA Control						
Target (baseline)	**3.08**	0.06	**3.10**	0.07	**3.06**	0.06
Target with OS flankers plus one singleton constant colour	**3.08**	0.06	**3.09**	0.06	**3.07**	0.06
Target with OS flankers plus one singleton changing pattern	**3.07**	0.06	**3.08**	0.07	**3.06**	0.05
Target plus word	**3.13**	0.05	**3.14**	0.05	**3.11**	0.05

Appendix 8: Study 9: Mean log-transformed search times (by distractor type and task order)

	Distractor type		Task Order	
	Dissimilar	Similar	1st search	2nd search
Group	Log means (SD)	Log means (SD)	Log means (SD)	Log means (SD)
Patients with AD	**1.68** (.18)	**1.70** (.19)	**1.72** (.18)	**1.66** (.18)
HOA controls	**1.50** (.11)	**1.50** (.11)	**1.52** (.11)	**1.48** (.11)