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Investigating the Relationship Between Visual and Contextual Cues in Visual Word Recognition

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Abstract

A well documented finding in the word recognition literature is that accurate report of a word is facilitated when it is embedded in a meaningful and grammatical sentence. Previous researchers have accounted for the influence of context on word recognition in two ways. From a *modular* perspective, word recognition is unaffected by sentence structure or content, the effects arise from post-perceptual decisions and from spreading activation between associated words within the lexicon. In contrast, from an *interactive* perspective, word recognition receives direct facilitation from sentence content and structure either by pre-activating or constraining activation to likely word candidates.

The experiments reported in this thesis investigate the role of sentence contexts in visual word recognition in order to distinguish between modular and interactive perspectives. This was done by contrasting the effects on target word perception produced by legal, word replacement, nonword and transposed sentence contexts when the effects of semantic word association were suppressed. Performance was measured using the alternate forced choice Reicher-Wheeler Task to suppress the influences of sophisticated guesswork. Low constraint legal sentences produced superior accuracy than control contexts. High constraint legal sentences containing predictable and unpredictable target words but little word association produced superior performance for predictable targets over all other context conditions. When predictability was made more salient by increasing the amount of legal sentences in the experimental session there was no reliable effect of context. However, predictable targets were reported more accurately and unpredictable targets less accurately in legal and transposed contexts than in control conditions. Blurred target words in low and high constraint sentences produced legal sentence advantages.

These findings suggest that legal sentence contexts do influence actual word perception at low relatedness proportions but not at high relatedness proportions. The findings favour the dual route *multistage activation model* of context effects on word recognition.

CHAPTER ONE

1:1 Background

This thesis is concerned with the issue of word recognition in the act of reading. Reading is the basis of many of the arts, most of our communication systems and as such is largely responsible for knowledge proliferation. How do we begin to unravel the psychological processes that underlie reading in order to explore word recognition? The term word recognition can encompass identification of the visual stimulus, semantic understanding (what the stimulus actually means) and comprehension which includes past, present and future knowledge, goals, interpretation, intention etc. One of the most important questions in understanding the reading process is how these separate components influence each other. Despite the many aspects of reading that have been examined to date, a considerable portion of previous research falls into two very broad categories. These categories are; (1) semantic priming which concerns the linguistic components that appear to alter word recognition and (2) perceptual priming which concerns the visual characteristics that underlie word recognition.

Modular and Interactive perspectives of word recognition.

The majority of accounts concerning word recognition lie on a continuum between a 'modular' account and a fully 'interactive' account. At the extreme end of the continuum the accounts are largely untenable with most plausible models lying somewhere in-between. First, I will outline the debate and then consider each perspective in more detail.

1:2 The Modular Interactive Debate

Research into sentences and perceptual priming is complicated by the great debate of modular vs interactive processing which surrounds reading research. In this section I will provide a summary of the debate from both perspectives then turn to a more detailed description of how each perspective accounts for sentential effects. One well documented finding in the word recognition literature is that accurate report of a word is facilitated when it is embedded in a meaningful and grammatical (legal) sentence (e.g., Duffy, Henderson & Morris; 1989; Ehrlich & Rayner, 1981; Forster, 1985; Foss, 1982; Morris, 1994; Ratcliff, 1987; Sharkey & Sharkey, 1992; Simpson, Peterson, Casteel & Burgess, 1989; Stanovich & West; 1983; West & Stanovich, 1982). The following example will be used as a general example throughout this introduction; the word *people* is identified faster in the sentence ‘The auto accident drew a large crowd of *people*’ than in the sentence ‘Accident of large the drew auto crowd a *people*’ (Simpson, Peterson, Casteel & Burgess, 1989). Moreover, when the visual information provided by targets is degraded or impoverished, supporting contexts facilitate word recognition (Fischler & Bloom, 1979; McClelland & O’Regan, 1981; Stanovich & West, 1979; Stanovich, 1981; Tulving & Gold, 1963).

Controversy arises when more specific questions are asked about how influences exerted by the linguistic structure of sentences actually occur. In particular, what is the locus of the effect (i.e., pre or post lexical) and what is the source of this effect (i.e., lexical, semantic or concept priming). From a *modular* perspective, the processes actually involved in word recognition are unaffected by sentence structure or content (e.g., Fodor, 1983; 1998; Forster, 1979, 1981, 1985; Seidenberg, 1985). According to this view,

sentence effects arise from knowledge-based representations which affect post-perceptual decisions regarding the identity of words and which, therefore, affect speed of reading and comprehension in ways which do not reflect the processes underlying the actual recognition of words (Foss & Ross, 1983; Foss & Speer, 1991; Hess, Foss & Carroll, 1995; Forster, 1979; Fotster, 1994; Fodor, 1983; Sharkey & Sharkey, 1987; Sharkey & Mitchel, 1985; Sharkey & Sharkey, 1992). In contrast, from an *interactive* perspective, word recognition receives direct facilitation from sentence content and structure through expectation and constraints exerted by the sentence either pre-activating or constraining activation to likely word candidates (e.g., Duffy, Henderson & Morris, 1989; McClelland & O'Regan, 1981; Morris, 1994; Simpson, Peterson, Casteel & Burgess, 1989). In this case, sentence effects arise from direct facilitation of the very processes underlying access to lexical entries such that visual word recognition itself is facilitated.

1:3 The Modular Perspective

Fodor (1983) has argued for a modular architecture in which perceptual analysers are encapsulated from the central semantic system. Perceptual modules or input analysers feed into a central system which contains such information as semantics, prior knowledge (i.e., conceptual representations) and the individual's goals (i.e., intention, present mind sets). These input analysers can interact with each other at different computational levels but remain autonomous from the central system until they discharge their information. According to Fodor, the independence of the perceptual input analysers is a functional necessity which ensures that environmental representations are encoded quickly, unconstrained by the time consuming influences of the central system's interpretations.

Thus, speed of producing a representation is more important than producing an accurately interpreted representation by considering all the available information. Such context effects that are found can be explained either by ‘unintelligent’ processing in the form of word association or by a more ‘intelligent’ post-perceptual decision processes. For example, *people* could be identified faster in the sentence ‘The auto accident drew a large crowd of people’ in several ways. One way that *people* could be identified faster would be through the word association between crowd and people. This association would allow the target to be integrated or checked for plausibility with the context faster in legal, meaningful sentences. If it is assumed that this checking process can only take place after the target has been encoded such association would lead to faster response times without influencing the encoding of visual information. This type of modular mechanism is favoured in slightly differing forms by several authors resulting in models known as the *plausibility checking mechanism* (Norris, 1986), *compound cue theory*; (Ratcliff & McKoon, 1988; Doshier & Rosedale, 1989), *the sophisticated buffer hypothesis* (Sharkey & Sharkey, 1989), *the lexical distance model* (Sharkey & Sharkey, 1992) and *global concept priming* (Hess, Foss & Carroll, 1995). An alternative proposal is that context could promote post-perceptual guesswork to complete the sentence, a process which would be useful in speed reading and where stimuli were degraded. Under these circumstances *people* could be faster and more accurately guessed from a partially processed target (e.g., the letters *p----le*) following the word *crowd* than in control sentences where no such supporting context was presented. This proposal was first tried and tested in single word recognition by Johnston (1978) but similar proposals have been suggested in a less explicit form for sentence reading resulting in models known as *the early opening model* (Forster, 1999;

Forster & Davies, 1984; Forster & Guess, 1996) and *the modular interactive model* (Potter, Moryadas, Abrams & Noel, 1993; Potter, Stiefbold and Moryadas, 1998). Both the word association and sophisticated guesswork proposals dispute that an improvement in visual encoding has taken place due to sentential context.

Another proposal from the modular perspective is that activation spreads within the lexicon between associatively related items. In the above example this would mean that target responses are faster and more accurate in the legal sentence because activation has spread from the context word 'crowd' to the associatively related target 'people'. Fodor (1983) suggests that such associative priming reflects a network of connections between items within the lexicon, therefore, modularity is not violated. Indeed, according to Fodor, such an influence that reflects world knowledge in the input system would be functionally advantageous as its existence allows the system to mimic intelligent higher level influences without incurring the costs that interaction between semantic, conceptual and lexical levels would produce.

1:4 The Interactive Perspective

At the other end of the continuum, fully interactive models (an 'intelligent' system with top-down influences) have been proposed. A system that enables parallel processing would indeed produce more efficient representations of the environment. It seems reasonable to suggest that research should be aimed at exploring under which circumstances perceptual systems can be 'intelligent' rather than insisting that a demonstration of perceptual autonomy confirms that visual perception is 'unintelligent'. This is largely because the methods of research have been, and perhaps always will be,

largely incapable of demonstrating that the presence of contextual influence on word recognition tasks are sufficient evidence that context has affected the encoding of visual information (perceptual processing). For this reason many of the models of word recognition in context fall in-between purely modular and interactive perspectives and a detailed review becomes extremely complex and convoluted. Similarly, because of the difficulty in testing the direct effect of context on the encoding of visual information in the very early stages the matter becomes more complicated towards the interactive pole of the modular/interactive continuum. Moreover, interactive theorists at the more extreme end of the modular/interactive axis have not extended their work on single word recognition to a level sufficient enough for the production of strong detailed models of word recognition in context (ie.g., Seidenberg & McClelland, 1989). Bearing this in mind further discussion of the interactive perspective will focus on models at the further end of the axis without necessarily being full interactive models.

From an interactive perspective, contexts influence word recognition by pre-activating likely candidates in the semantic system thereby reducing threshold values of items within the semantic system itself and by reducing the amount of detailed visual evidence required from the stimulus for accurate word recognition. In the working example, the context ‘The auto accident drew a large crowd of’ would pre-activate the word entry *people*, among others, in the semantic system. On encountering the target *people*, responses would then be more efficient because the visual input would readily find a pre-activated match within the semantic system as information is fed up from the orthographic input system before the completion of full visual processing (i.e., *the logogen model*, Morton, 1969). Alternatively, where incoming information in the orthographic

system is degraded a slower and more processing intense route could facilitate word recognition. In this process, the semantic system provides feedback from the pre-activated candidate word *people* to the orthographic system which assists resolution of the poor visual input by reducing the amount of information that needs to be extracted from the visual stimulus, again facilitating word recognition. With the first proposal, monitoring the semantic system where threshold levels are reduced by pre-activation facilitates word recognition. In the second proposal, the rate of perceptual encoding necessary from the stimulus is reduced by feedback from the semantic to the orthographic level. For example, *the multistage activation model* (Besner & Smith, 1992; Smith, Besner & Miyoshi, 1994) describes a system where input from the prime word, via the orthographic input lexicon, directly activates nodes in the semantic system by means of a cascading process of features, letters, words or morphemes (pathway A). Activation can then spread within the semantic system which, in turn, feeds back into the orthographic lexicon (pathway B). Word recognition in related contexts can be achieved directly through pathway A by monitoring the semantic system. Alternatively, activation in the semantic system can feed back into the orthographic system through pathway B, reducing the necessity for stimulus data driven information in the orthographic system. In the model each system and pathway represents a separate processing system and can be selectively affected by factors that influence word recognition and production. However, word recognition may be influenced in sentence contexts by a combination of the two pathways.

The Models

There is a wide range of models that lie on the modular/interactive continuum. For simplicity I will describe the models which are discussed throughout this thesis and provide a summary table for a more comprehensive description of the literature. The models have been categorised into *weak modular*, *modified modular* and *weak interactive*. The weak modular models place contextual influence; (1) intra-lexically through word association or (2) post-lexically at an integration stage, where targets are facilitated by the ease with which they can be incorporated into the meaningful representation of the context. The modified modular models place the contextual influence at a selection stage by; (1) allowing for pre-activation of word items by the context which are searched through or (2) at a verification stage where words are validated by their possible 'fit' with the context when only a few candidates remain. The weak interactive models allow for modification of the visual input system by (1) placing contextual influence at a concept or sentence level and (2) allow for feedback between the semantic and orthographic levels to aid word recognition at the visual level.

Model	Description	Perspective
The Early Opening Model (Forster, 1999; Forster & Davies, 1984; Forster & Guess, 1996)	Visually similar words are flagged then sequentially searched for verification.	Weak Modular
Integration Accounts (O'Seaghdha, 1989, 1997; Forster, 1981; 1983)	Words are post-perceptually integrated with preceding text.	Weak Modular
The Sophisticated Buffer Hypothesis (Sharkey & Sharkey 1987)	Words are checked for relevance against memory representation of text to speed integration process.	Weak Modular
Lexical-lexical account (Stanovich & West, 1981).	Several weak sources of activation converge to produce semantic/association priming.	Weak modular
The combination account (Foss & Ross, 1983; Duffy, Henderson & Morris, 1989)	Activation is channelled by words so the sum of activation is not equal to the sum of individual items.	Weak modular
Global Concept Priming (Hess, Foss & Carroll, 1995).	Integration account where words refer to an entity (concept) in the discourse representation.	Weak modular
Compound Cue Theory (Ratcliff & McKoon, 1988; Doshier & Rosedale, 1989).	Prime and target combine to access memory, decisions are made on familiarity of combination.	Weak modular
Expectancy Model (Becker, 1980; Becker & Killon, 1977).	Context pre-activates a semantic set that is searched before visual set	Modified Modular
Lexical Distance Model (Sharkey & Sharkey, 1987; 1992).	Word information is distributed across net of features, semantic features influence those of target	Modified Modular
Plausibility Checking Mechanism (Norris, 1986)	Plausible words are selected in final stage.	Modified Modular
The Modular Interactive Model (Potter, Moryadas, Abrams & Noel, 1993; Potter, Stiefbold and Moryadas, 1998).	Context aids final selection between a few visually defined possibilities.	Modified modular
The Multistage Activation Model (Besner & Smith, 1992; Smith, Besner & Miyoshi, 1994)	Dual pathways. (A) monitor the semantic system (B) feedback from semantic to orthographic.	Weak interactive
Semantic Network/spreading Activation (Collin & Loftus, 1975)	Pure semantic relations exist at the concept rather than lexical level.	Weak interactive
The Logogen Model (Morton, 1969)	Context lowers threshold for expected words	Weak interactive

Table 1. Summary of models and where they lie on the modular/interactive continuum.

1:5 Modified modular models

Final selection models. *Plausibility checking mechanism*, (Norris, 1986); *the modular interactive model* (Potter, Moryadas Abrams & Noel, 1993; Potter, Stiefbold and Moryada, 1998).

In Norris' original formulation the target stimulus activates a visually defined set of orthographic neighbours, evidence for target identity accumulates in a dynamically reducing way from the visual stimulus itself and from additional frequency ordered weights. Once this visually defined set has been reduced to a few candidates, and while evidence is still accumulating, each candidate is checked for plausibility given the presented context. If a plausible (related) item is found within the visually defined set, threshold for this candidate is lowered. If an item is implausible (unrelated) threshold is raised. Potter et al. extended this model to include the assumption that more than one competing word candidate may remain under consideration as successive words appear. Each stage is autonomous and information is passed in only one direction, thereby separating bottom up multiple accessing of lexical candidates and recognition of one particular candidate by the semantic system. Retaining activation of several candidates in the lexical system means that context can exert influence before final selection is made. The role of context is to bias word selection. The authors explicitly argue that the semantic system makes use of pragmatic as well as intralexical spreading activation and that all processing takes place in parallel without the necessity of the semantic set being searched before the visually defined set. The role of context is to bias word selection in favour of plausible or predictable targets.

Search or verification models. *Expectancy model*, Becker (1976, 1979, 1985) and Becker and Killon (1977); *verification model*; Paap, et al. (1982, 1987).

This class of model assumes that two distinct and concurrent operations are carried out when a context and target are presented. On the basis of the context a semantic set of related items is generated in the semantic system on the assumption that a related target will follow. A visual representation of the target then forms when the target is presented while a visually defined set of orthographically similar items is generated from the visual input from the target. The visual representation is then verified through either the semantic set, which is always exhaustively searched first or the visually defined set. A related context aids recognition of targets by shortening the time needed to verify the visual representation.

1:6 Weak interactive models

Modification models. *The logogen model*, Morton (1969); *multistage activation model* (Besner & Smith, 1992; Stoltz & Neely, 1995)

Morton's (1969) Logogen Model suggests that priming results from modification to threshold values of logogen units - orthographic representations of words that serve as access codes to higher level systems such as semantic, conceptual and phonological processors - by incoming information. Contextual information decreases the threshold values of logogens representing words related to the context. This decrease in threshold values for related words allows these items to reach threshold before those of unrelated word targets so that related word targets require less visual input to reach threshold.

In the *multistage activation model* input from the prime via the orthographic input lexicon directly activates nodes in the semantic system by means of a cascading process of features, letters, words or morphemes (pathway A). Activation can then spread within the semantic system which, in turn, feeds back into the orthographic lexicon (pathway B). Word recognition in related contexts can be achieved directly through pathway A by monitoring the semantic system. Alternatively, activation in the semantic system can feedback into the orthographic system through pathway B, reducing the necessity for stimulus, data driven information in the orthographic system. In the model each system and pathway represents a separate processing system and can be selectively affected by factors that influence word recognition and production.

Research evidence for both sides of the debate

I have outlined the modular and interactive perspectives and the associated models and will now describe ways in which research has tried to tease out and explain the two opposing perspectives.

1:7 Semantic Priming: Within the lexicon or between processing systems?

In order to distinguish between the modular and interactive perspectives it is necessary to establish whether context exerts its influence after or before encoding of the visual stimulus. As can be seen from the differing explanations for the example already described, both opposing perspectives accommodate spreading activation between word entries by placing the locus of semantic influences at differing processing levels.

Modularity, as described by Fodor (1983), makes a clear distinction between semantic and

lexical level associations. Semantic associations are words that are related because they share features through a concept. Thus, for activation to spread from one to the other it would have to come from the conceptual level to activate the second word - violating modularity. On the other hand, if word association arise from connections between words that regularly go together, these words would be connected within the lexical system (intralexically) and as such do not violate the assumptions of the modular perspective (Fodor, 1983; Swinney, 1979).

However, Collin and Loftus' (1975) *semantic network/spreading activation model*, assumes the locus of purely semantic relations to be at the concept level, therefore, requiring 'intelligent' higher level processing. In this model, each lexical entry consists of a concept name that is linked to a corresponding node representing that entry in a semantic network. The concept nodes have further links that connect them to properties of that concept, which in turn link them to other semantically related properties. Priming is explained by activation spreading throughout the network from prime to the related concept of the target, pre-activating that entry and reducing the threshold necessary to activate that entry from visual input. Therefore, according to Collin and Loftus (1975; see also Lupker, 1984 and Tannenhaus & Lucas, 1987), pure semantic effects arise from higher-level concept representations whereas word association effects arise from the lexical level. For example, *doctor* is more quickly responded to after presentation of *nurse* because the words are associatively related (e.g., Becker & Killon, 1977; Fischler, 1977a, 1977b; Schvaneveldt, 1971; Meyer, Schvaneveldt & Ruddy, 1975; Neely, 1976, 1977). On the other hand, *pelican* is not readily associated with *sparrow* but can prime *sparrow* because they share semantic features through the concept node representing birds

(Fischler, 1977; Lupker, 1984). Ratcliff (1987) suggests a viable alternative where the semantic network is seen as a way of representing word meaning, which makes semantic priming a purely linguistic property rather than part of a larger conceptual system used for general cognitive processing. Under these circumstances, semantic association comes under the domain of lexical processing and does not violate modularity.

As can be seen from the above discussion, word associations (lexical or semantic) are at least one source of contextual influence from which controversy arises within the modular/interactive debate. For this reason, a significant proportion of contextual research has been carried out using the single word-priming paradigm. In light of Ratcliff's suggestion that semantic effects could be considered from an internal lexical level rather than a higher conceptual level, the locus of semantic effects is extremely hard to resolve using a single word priming paradigm. According to Forster (1979) and Ratcliff (1987) modularity cannot withstand priming that results from the activation of concepts formed by combining several word meanings during comprehension. Under these circumstances, modularity would define the reader's task as the integration of newly recognised words into the contextual representation rather than to use the context to help identify the new word (as an interactive account would suggest). For example, Tannenhaus and Lucas (1987) suggest that if the locus of semantic influence is at the semantic/conceptual level, phrases such as *large dog* should prime the word *collie* more than the phrase *dog large*. This is because *large dog* becomes a concept only when the words are properly combined. Tannenhaus use this example merely as a discussion point. While the suggestion has intuitive appeal, realistically formulating concepts that are exclusively determined by the combination of both words seems implausible. For example, there is no evidence that *large*

dog would prime *collie* significantly more than *dog* alone, nor that *dog large* would not prime *chihuahua* on the basis of *dog*. For this reason sentential research appeared to offer a more powerful approach from which to examine the influence of context on word recognition. Thus, sentential research has shifted from examining the circumstances under which contexts influence word recognition to focus on the exact circumstances under which semantic or word association priming does and does not influence word recognition. Indeed, circumstances where the effects of word priming are nullified during sentence reading by disrupting word order initially seem to provide a clear violation of the autonomy principal.

1:8 Semantic and word association effects are dependent on sentence coherence

If spreading activation remains internal to the lexicon and is not influenced by the overall meaning of a sentence then disrupting word order in sentences should not alter the facilitative effects of word association. Simpson et al. (1989) presented a similar argument that the locus of sentence effects are over and above the lexical effects of semantic association. In the working example, *people* was named significantly faster when presented in its legal context ‘the auto accident drew a large crowd of people’ than in a scrambled version ‘Accident of large the drew auto crowd a *people*’. Moreover, there was no advantage for near primes as in the above example, where *crowd* is nearly adjacent to *people*, compared to far primes (John bought four *chairs* to go with his new *table*). The authors argue that sentential influence must be over and above that of word association because priming between near items is eliminated by syntactic incoherence and not influenced by the amount of intervening items in legal sentences. Simpson and colleagues

presented three conditions all containing the same semantic association but altering the message level. For example, in the normal sentence ‘The presence of the stranger made the baby cry’, the target *cry* is semantically and associatively related to the preceding word *baby*. Both control conditions maintained the relationship between *baby* and *cry* while altering sentence meaning. For example, the anomalous sentence ‘The permit with the talent let the baby cry’ altered sentence meaning while the scrambled sentence ‘The made the of presence stranger the baby cry’ maintained lexical content but disrupted the flow of meaning. Targets were named faster in normal sentences than in all other conditions. The authors conclude that lexical, syntactic and message level information are necessary to facilitate word recognition and that word recognition in normal sentences is facilitated over and above that of semantic or word association. Simpson et al. further suggest that some of the claims made by both sides of the modular/interactive debate are too strong. The authors submit that context does not pre-activate candidates in advance but instead, acts pre-lexically to influence the final resolution of a candidate set Under these circumstances, a set of semantic featural restrictions is generated during context reading which are compared to the semantic features that define the word target Where a target has sufficient features that coincide with the featural set, word recognition is facilitated (Schwanenflugel & LaCount, 1988; Schwanenflugel & Shoben, 1985; Whitney, McKay, Kellas & Emmerson, 1985). Moreover, Stanovich and West (1981) proposed that items remain active longer in coherent texts by forming a meaning representation, a process that does not take place in scrambled texts where semantic spreading activation is more limited.

O'Seaghdha (1989) also found that word facilitation depended on syntactic coherence where word order was not altered but the intervening function words in 'scrambled' sentences were substituted (i.e., 'The author of this *book*', was changed to, 'The author the and *book*'). Responses to targets in legal sentences were faster than those in scrambled sentence. O'Seaghdha proposes that if Simpson et al's (1989) results were due to the length of the scrambled sentences negating natural reading processes, such short, and largely coherent sentences should not have influenced target word responses.

O'Seaghdha (1989, 1997) argues for a critical and insoluble, early role of syntactic assignment in sentence processing but adds "... circumstances that look strictly modular may be better understood as conditions in which the influence of top-down effects happens to be limited" (O'Seaghdha, 1997, pp 823). On one hand, several authors suggest that a demonstration of the dependence of contextual facilitation on legal coherent text violates the modularity principle while others suggest that a demonstration of the same effect confirms a level of modularity. It would seem that demonstrating the dependence of semantic association on sentence coherence cannot resolve the modular/interactive debate, thus another paradigm is needed to further the debate. As already stated, Tannenhaus and Lucas (1987) propose that where word items, insufficient to prime a target alone, combine to form a concept sufficiently strong enough to prime that word target, the modularity principle has been violated. Several authors have used this line of research to examine the debate.

1:9 Combining several weak sources of semantic association in sentences

The finding that word recognition can be facilitated by the combination of word items that are insufficient by themselves to prime targets has been described by several authors who present differing proposals for the effect (e.g., Duffy, Henderson & Morris, 1989; Foss & Ross, 1983; Morris, 1994; Sharkey & Sharkey, 1987, 1992; Stanovich & West, 1981). The transmission account describes a process whereby activation levels of lexical items are maintained in coherent sequences, and thus ‘transmitted’ over longer textual periods than in incoherent sequences (i.e., lexical-lexical account, Stanovich & West, 1981). By this account, several weak sources of activation converge on the target to produce a combined semantic/association priming effect. Duffy, Henderson and Morris (1989) compared this account with the combination account of Foss and Ross (1983). Foss and Ross (1983) state that the sum of activation on a target is not necessarily equal to the sum of individual parts of the sentence. This is because a constraint contained in the sentence or text may produce concentrated activation along a net that would not otherwise have been activated (see also Lexical Distance Model, Sharkey & Sharkey, 1987, 1992). Duffy and colleagues presented sentences containing several sources of weak association, which were then systematically replaced with neutral items to reduce the combined effect of association. For example, in the congruent condition both verb and noun are related to the target ‘The barber trimmed the *mustache*’. Both content words were then systematically replaced to form a verb-neutral condition ‘The barber saw the *mustache*’, a subject neutral condition ‘The person trimmed the *mustache*’ and verb-subject neutral condition ‘The person saw the *mustache*’. Finally, an incongruent sentence was included ‘The barber trimmed the *artefacts*’. Naming latencies improved only in congruent

sentences. This led the authors to conclude that word recognition facilitation is an emergent property of the combined words in the sentence that is not due to the summation of activation from individual words. Additionally, the authors proposed that individual word items channel the flow of semantic activation by constraining the possible relevant semantic features that will be activated from a newly encountered word item (see also *the sophisticated buffer hypothesis*, Sharkey & Sharkey 1987, where word items are checked for relevance against those already held in memory in order to speed up the final integration process). For example, encountering the word *barber* constrains the possible application of the verb *trimmed*, thereby constraining the pattern of activation within the semantic system once the verb has been encoded in the lexicon. Under these circumstances, the lack of facilitative effects found in scrambled sentences are due to the failure of this constraining influence (or checking mechanism) in incoherent sentences. Thus, according to Duffy et al. it is comprehension that is facilitated by the combined words rather than word recognition.

Morris (1994) measured eye fixation durations to sentences based on those used by Duffy et al. (1989) in order to resolve this issue by examining the influence of meaning representations on word recognition in more detail. Over two experiments, Morris presented sentences that systematically altered both the relationships between individual word items and the message that these individual items combined to form. For example, in the congruent condition the sentence ‘The barber trimmed the *mustache* this morning’ was presented while in the subject neutral condition *barber* was changed to *woman* and in the verb neutral condition *trimmed* was changed to *saw*. In order that the message level could be altered without disrupting lexical content a condition was included that preserved the

subject (barber) and verb (trimmed) ‘While she talked to him the barber trimmed the *mustache* this morning’. The message level was then altered in a final condition ‘While talking to the barber she trimmed the *mustache* this morning’. Morris found that fixation durations increased when targets were semantically inconsistent with the message (i.e., where ‘she trimmed the *mustache*’). These results contradict the modular combination account (Duffy et al. 1989; Foss & Ross, 1983), which states that a syntactically coherent sentence containing similar lexical content would exert the same constraints in the semantic system. For example, *barber* still proceeds *trimmed* and would exert the same constraints as the congruent message, providing the text was not incoherent. This led the author to conclude that the message level representation of sentences influence lexical access. Consequently, Morris (1994) placed the locus of contextual influence on word recognition back in the interactive court. The measure he used, eye fixation durations, is a measurement that does not require participants making conscious reports on word identity. For this reason, Morris infers from his data that the formation of a message level representation has a direct influence on lexical access. However, the measurement of eye fixation durations cannot distinguish between ease of integration into a message level representation, which could be post-perceptual, and direct facilitation of visual encoding due to the message level representation, as Morris suggests. For this reason not all researchers who place the locus of contextual influence on word recognition at the message level uphold this interactive perspective.

1:10 Integration accounts

O'Seaghdha (1989,1997) proposes that because disruption of coherent syntax is capable of eliminating both facilitation of word recognition in congruous sentences and inhibition in incongruous sentences, the locus of sentential influence on word recognition is at an integration stage where encountered words are fitted into an emerging meaningful representation. However, sentence presentation in both papers (and many others) consists of presenting the contexts one word at a time in a rapid serial visual presentation method (RSVP). Such a presentation method would encourage word by word recognition and integration even if this process did not always take part in natural reading where large amounts of text are visible at any one time. Moreover, it is very difficult to distinguish between integration as a pre or post-perceptual influence on the upcoming word. In other words, is the target recognised and then integrated or does the emerging meaning representation influence encoding of the target word?

Over a series of nine experiments Hess, Foss and Carroll (1995) pitted within sentence word association against an alternative discourse representation. For example, when the sentence 'the English major wrote the *poem*' was presented, naming latencies for the target *poem* were shorter than for unrelated words such as *program* and for unrelated sentences such as 'The computer scientist wrote the *poem*'. However, when an expanded text preceded the sentence, targets were only facilitated when the passage was also related to the target. For example, in the passage 'The English major met a woman who he was very fond of. He had admired her for a while but wasn't sure how to express himself. He always got nervous when trying to express himself verbally so the English major wrote the *poem*' naming latencies for *poem* were shorter than in an unrelated passage 'The English

major was taking a computer science class that she was struggling with. There was a big project that was due at the end of the semester which she had put off doing. Finally, last weekend the English major wrote the *poem*'. However, when 'the computer science major' replaced 'English major' in both passages, naming latencies were again shorter in the first passage than in the second, despite the fact that the subject of the critical sentence was now incongruent with the target. The authors conclude that a global discourse representation is the source of contextual effects since the meaning of the whole passage over-rides the previously found sentence level effects.

Hess, Foss and Carroll (1995) propose two alternative operationalizations for their discourse-based model. The first operationalization is similar to several other checking models (i.e., Sharkey & Sharkey, 1989; Norris, 1986; Ratcliff, 1989) where newly recognised words are checked very early on for reference to an existing entity in the growing discourse representation. The authors make explicit the feature that entity does not necessarily refer to a word but to something more akin to a concept (i.e., romance, creative English writing and so to poem). When such a reference is found the naming code becomes available sooner than it otherwise would have been. In other words, facilitation is not due to pre-activation of targets but to targets positively referring to an entity already in the discourse representation. The alternative operationalization proposed by the authors is also an integration process. It states that readers may be particularly sensitive to coherence relations at the highest level that the materials permit. Therefore, when passages are presented, this is the level at which coherence is sought, not the sentence level. A target word will readily cohere with the overall context even when it is not readily associated with the local context, as in the above example. When the target coheres with a

continuously shifting global discourse representation it is easily integrated and, therefore, responded to faster than words that do not cohere.

Sharkey and Sharkey (1992) have proposed a similar model with differing emphasis on interactionism within a connectionist network. In a similar vein, Sharkey and Sharkey reject the hypothesis that the locus of contextual influence is the pre-activation of likely word items or candidate sets by the context (i.e., Expectancy Model, Becker, 1980; Becker & Killon, 1977). In many instances such a set of likely words would be extremely large creating the possibility that this would actually hinder rather than facilitate word recognition. Instead, Sharkey and Sharkey propose a connectionist network in which information about an item is distributed across a set of microfeatures consisting of orthographic, syntactic, semantic and situational features. This model is essentially bottom-up in that the net of orthographic microfeatures takes precedence in determining word recognition. However, information from one source can constrain activation in another. For example, activation at the orthographic or syntactic microfeature level can constrain activation in any other net. This means that microfeatures at the situational level (this corresponds to context, message level representation or global discourse representation as described above by other authors) can influence the pattern of microfeature activation at the orthographic level. For example, were the word 'trimmed' presented in the same context as 'barber', activation in the situational net would constrain activation along a net representing hair trimming, this could then influence encoding of *mustache* at the orthographic level. The striking feature of this model is that the whole connectionist network represents the lexical level. This keeps the model technically within the modular perspective, yet the actual operationalization of the system is far removed

from Fodor's concept of encapsulated perceptual analysers, proceeding unhindered by the intention, goals and prior knowledge of the individual. This fact also forms the models most problematic aspect. Since the system has no distinction between levels it has to continually hold and update dynamically altering representations in its situational microfeatures while retaining consistent long term representations within other lexical microfeatures (i.e., orthographic, syntactic, semantic). However, it does hold both intuitive appeal and negate one of the largest problems associated with interactive models which propose pre-activation of possible candidate items, namely, that in some cases, the number of activated items could be so large as to hinder word recognition.

From this brief outline of the literature it can be seen clearly that the complexity of word recognition in contexts is such that a finding in favour of one perspective can be counter-explained by the other perspective. There is an emerging consensus that the source of semantic effects in reading is at a higher level than word or semantic association. However, there is still so much controversy as to the locus of these semantic effects that it appears fundamental to demonstrate word recognition facilitation in sentences that minimise semantic, in particular associative, variables. Thus, reducing semantic content and word association would allow a greater insight into the stage of processing where it is possible to influence word recognition - whether that is pre-lexically, intralexical, interlexical or is indeed restricted to post-lexical decisions. Forster (1981) argued that any facilitative effect found in very low constraining contexts cannot be attributed to intralexical processing, because there is very little association between items between which activation would spread. Moreover, Forster argued, because there are insufficient connections between word items to influence the course of meaning representations in the

way that *barber* and *trimmed* were thought to influence the integration process of *mustache* word recognition should not greatly influence the integration process.

Consequently, words in coherent sentences will be integrated faster than words that are incongruous with their contexts but there will not be a genuine ‘facilitation’ effect over a neutral baseline condition. To this end, Forster (1981) presented ‘unfocused’ sentences that marginalized the extent to which the target could be predicted from the sentence. Each sentence was then presented with its appropriate target or with an inappropriate but possible alternative target (e.g., ‘Every Saturday they gathered to *sing/panic*’). These sentences were compared to baselines consisting of a word list similar in length to each sentence context, which according to Forster, present a neutral baseline where no word associations can be made and no integration process can take place. Response latencies were unaffected when the target was appropriate but significantly increased when targets were inappropriate. This led the author to conclude that lexical entry was unaffected by sentence content and that such sentence effects that arise, out-with word association, can be attributed to an integration process which inhibits lexical output for inappropriate words. However, a Rapid Serial Visual Presentation (RSVP) method was used which presents words one at a time on the screen, which, by its very character, may enforce word by word integration in a way not used in natural reading. Moreover, integration may be reflected in response latencies in a way that masks an influence on lexical access. For instance, assuming that integration does indeed take place after lexical access and is time consuming, this does not exclude context from influencing lexical access and facilitating word recognition before the word is integrated. Forster clearly states that his control condition was designed to eliminate integration processes, yet latencies are the same for

both appropriate and control conditions. This could suggest that lexical access was indeed facilitated in the appropriate condition but counteracted by the time taken to integrate target and sentence context. Indeed, most of the tasks generally used in sentential research measure response latencies which cannot be said to solely reflect the rate of uptake of visual information from the target during that time. Therefore, the tasks cannot determine whether the effect they are measuring is operational during pre or post lexical access. The next section describes some of the problems associated with many of the tasks and measurements used in sentential research.

Tasks and measurements used in sentence research

So far I have outlined models and research findings yet both the findings and the models they yield depend extensively on the tasks participants engage in and the measurements these tasks produce. First I will briefly describe the tasks and measurements most widely used in sentence research and some of the problems associated with them. I will then turn to the paradigm I have used throughout this thesis and indicate how it can overcome some of the problems I have discussed.

1:11 Traditional tasks and measurements

Traditionally, sentential research has used two main target response tasks, lexical decision (the time it takes participants to decide whether targets are words or nonwords by pressing a 'yes' or 'no' key) and naming (where the time it takes participants to overtly name targets is measured). Although widely used, lexical decision is generally accepted as introducing perhaps unnatural post-lexical decision processes or criterion bias into

responses, while naming is generally accepted as a more sensitive measure of lexical access (Neely, 1991; Seidenberg, et al. 1984; Stanovich & West, 1983). However, West and Stanovich (1986) reported substantial inhibitory effects on targets which were syntactically incongruent with their sentences in a naming task. The authors attributed this to the inherently productive nature of the naming task, such that where a target is incongruous with the preceding text, a Stroop like interference inhibits production of spoken language masking the true nature of lexical access. Stroop (1938) found that if the words GREEN and GLOBE were printed in red ink participants found it harder to name the ink colour 'red' when reading GREEN than when reading GLOBE. West and Stanovich found that participants do not have the same difficulty in producing spoken output where the incongruity is semantically based. However, semantic incongruity produces large inhibitory effects in lexical decision. Therefore, syntactic and semantic anomalies differentially affect results from the two tasks. This raises two important questions; are syntactic and semantic processing psychologically distinct and discriminable processes and can either task really help us to unravel the complexities of word recognition in sentential contexts? Measuring participants' eye movements is certainly free from criterion bias and language production and less likely to be distorted by strategic decisions. When a participant encounters a word in a sentence the duration of fixation can be measured and compared to the fixation duration to the same word under differing contextual circumstances. This method provides a good and accurate description of what the participant is doing during reading and allows for a direct comparison of processing times between different manipulations. However, eye movement measurements do not provide enough detailed information for resolution of the current debates surrounding word recognition in context. For example, one fixation

could include lexical access, integration, elaboration and the processing required to plan the next eye saccade. Moreover, the pivotal issue of the modular interactive debate is whether contexts can influence the uptake of visual word information, therefore, the very processes that underlie word recognition. Shorter fixation durations may reflect guesswork rather than improved lexical access, a caveat that could also be levelled at lexical decision and naming. What is needed is a task that can provide a measure of differences in the accuracy of visual information extraction from targets between different contextual conditions.

1:12 The need to control for prediction and sophisticated guesswork

Another source of contention that clouds the issues raised by sentence research is that of perceptibility over predictability. Expectation has been defined as a participant based strategy to aid word identification (Becker, 1980; Becker & Killion, 1977) where the visual information provided by the target receives additional support from semantic or syntactic processing in the form of expectation (predictions about what word is likely to appear next). Moreover, there is growing evidence that these effects may be produced very early on in processing (Besner & Smith, 1992; Borowsky & Besner, 1993; Stoltz & Besner, 1997; Stolz & Neely, 1995). This raises potential problems for studies of sentence processing which use traditional tasks where participants' eye movements are monitored or participants are asked to either report a target word or make lexical decisions regarding a target word. Under these testing conditions, participants may use artificial strategies based on sentence context (i.e., semantic knowledge of what words are likely given the sentential content, *sentential constraint*) and knowledge about what words exist in the

language and how they are spelled (*lexical constraint*; for further discussion, see Johnston, 1978; Jordan, Patching & Milner, 1999) to infer the identity of a word when only part of that word has been perceived. For example, Morris (1994) recorded eye-fixations during reading while manipulating sentence content. In the related message conditions, (i.e., ‘The *barber* trimmed the *mustache* this morning’) the target word *mustache* was fixated for shorter periods than in the neutral sentences (i.e., ‘The *woman* trimmed the *mustache* this morning’). This led to the conclusion that the processes underlying visual word recognition are influenced by sentence content. However, an alternative explanation is that the related message sentences reduced the time spent on target processing merely through a combination of sentential and lexical constraint rather than the message directly influencing the processes which underlie actual word recognition. Participants may, therefore, have inferred the identity of the target words faster due to the increased constraint provided by related messages. In this case, the observed shorter eye fixations would reflect ‘sophisticated guesswork’ rather than an increased efficiency of perceptual processing. That is, having read the subject word *barber* the target word could be accurately guessed from very limited information (e.g., m--t--he) through a knowledge of what barbers do and spelling, whereas the neutral word *woman* provides considerably fewer constraints. Consequently, under the traditional task conditions used to date, it is impossible to determine whether participants’ responses reflect the role of sophisticated guessing due to sentential and lexical constraints or an actual change in the efficiency of processes underlying visual word recognition. Accordingly, a crucial step towards assessing whether sentential influence is due to sophisticated guesswork or the improvement of word perceptibility is to examine the

influence of sentential context under conditions that suppress the ability of sentential and lexical constraints to artificially enhance performance.

One technique which satisfies these requirements is the two alternative forced-choice procedure originally developed to investigate the relative perceptibility of words, nonwords, and single letters under brief foveal viewing conditions (generally referred to as the *Reicher-Wheeler Task*, after Reicher, 1969; Wheeler, 1970). Using this procedure, each presentation of a briefly presented target word is immediately followed by a forced-choice between two alternative words, which differ by one ('critical') letter whose serial position and probability of occurrence cannot be predicted from any other letters in the stimulus display. For example, if the word *flap* was presented, recognition of the third letter may be tested by asking the participant to choose between the alternatives *flap* and *flop*, where both critical letters, *a* and *o*, are equally consistent with the remainder of the word, where *flap* and *flop* are equally likely to be presented in the experiment and where any serial position may be tested on a particular trial. Under these conditions, participants are prevented from using information from other letter positions to determine the identity of the ('critical') letter required; accurate performance hinges on perception of the critical letter in the target which cannot be determined uniquely by any of the remaining letters in the stimulus or the forced-choice alternative. Moreover, the Reicher-Wheeler task appears to rule out influences of sophisticated guesswork not just during the selection of an overt response but at any stage of processing (for example, during the early perceptual processing of featural information where covert bias may exist; see Bjork & Estes, 1973; Rumelhart & Siple, 1974; Thompson & Massaro, 1973). Johnston (1978) argued that if guesswork were being used at any stage in the recognition of a word, it should improve

performance more for letters that are highly constrained by the remainder of the word (such as the final position of *four* where only *r* and *l* are legitimate) than for letters that are not (such as the final position of *hear* which can be completed by at least five alternatives; *r*, *l*, *d*, *p* and *t*). Johnston found no such trend using the Reicher-Wheeler task. Thus, when applied to sentential research, the Reicher-Wheeler task offers an assessment of the perceptibility of words which is not contaminated by predictions made from sentential constraints or partial word information, where sentences are equally congruous with both alternatives.

This latter point illustrates the valuable contribution that the paradigm, often used to investigate single word recognition, can offer sentential research. The Reicher-Wheeler task can be used to determine whether sentence contexts influence perception or prediction, not only because it suppresses the use of lexical constraints, but because it can also be used to suppress sentential constraints. Both members of the target word pair can be presented as valid alternatives in a legal sentence context. For example, in the sentence 'it began to *flap*', followed by the forced choice alternatives '*flap/flop*', accurate selection of the target cannot be guessed from the sentence content because both alternatives can complete the sentence with equal plausibility. Moreover, the extent to which prediction influences post-perceptual decisions can also be determined by presenting word targets where one member is predictable from the legal sentences and the alternative merely viable. For example, *wild* is predictable from the context 'born to be ----' while the alternative *mild* is merely viable. Where both alternatives are presented as targets on different occasions, models based on prediction or final selection would forecast a choice of *wild* on both trials. Consequently, any increase in target accuracy for the legal condition

over control conditions can be attributed to the extraction of more information from the target in that condition and, therefore, evidence for enhanced perceptual processing rather than participant-generated strategies based on lexical or sentential constraints.

Under the precise testing conditions provided by the Reicher-Wheeler Task, a clear distinction can be made between modular and interactive perspectives of word recognition. From a modular perspective, notwithstanding the intralexical facilitation afforded by semantically related words, word recognition is improved in sentences because decisions regarding word identity can be made faster and sufficiently accurately, using less specific visual information than would otherwise be required. In this case, distinction between equally plausible forced choice alternatives cannot be improved by the preceding sentential context, leading to the prediction that accuracy of target report will not be affected by sentential influences. On the other hand, from the interactive perspective, word recognition is improved in sentential contexts because the context can affect the processes that underlie the very processes of word recognition, through feedback from the semantic level pre-activating or constraining likely word candidates. Under these circumstances, word perceptibility should be improved and the distinction between the forced choice alternatives made more accurately when preceded by legal contexts because activation from the sentence level should facilitate perception of the actual target

Finally, this paradigm offers an extremely important indication of the extent to which integration influences word recognition in sentence reading. As described above, many authors place the locus of sentential influence on a post-perceptual integration process. While the Reicher-Wheeler task does not measure integration in any form, were integration solely responsible for the facilitation of word recognition in reading, only null

results would be obtained. Post-perceptual integration could reduce the time it takes to produce responses to targets or reduce eye fixation durations. However, since the process is post-lexical, recognition has already taken place and integration would not alter the accuracy of briefly presented targets. Therefore, by removing reaction time as a dependent variable and examining the differences in accuracy between conditions, where the time available to view the visual stimulus is limited and altered to reflect each individuals' processing speeds, differences in the uptake of visual information between context types can be revealed. Moreover, the final chapters of this thesis examine the effect of target degradation on contextual influence. If contexts were facilitating word selection at the forced choice decision stage because a more stable meaning representation could be formed between legal contexts and presented targets, degrading stimulus quality would only affect this process as far as it hindered identification of targets, making context and stimulus additive factors. Therefore, an interaction between target stimulus quality and context strongly indicates that context exerts an influence over and above that which can be explained by an integration process.

1:13 Perceptual priming and the role of basic visual cues

So far I have dealt with sentences as collections of linguistic components. One important aspect of sentence structure that has been overlooked by previous contextual research is (1) the basic visual information which sentences provide and (2) the role of this information in word recognition. To date, semantic priming (advance information about meaning characteristics of upcoming targets) has been treated largely as a distinct line of research from perceptual priming (advance information about what visual characteristics

are likely to appear in upcoming targets) yet these two processes may have profound influences on each other.

Evidence concerning the precise role of visual information in word recognition comes from a range of sources. For example, a number of studies suggest that the overall shape of a word may contribute substantially to word recognition (e.g., Healy & Cunningham, 1992; Healy & Drewnowski, 1983; Monk & Hulme, 1983; Walker, 1987). In a proofreading task, Monk and Hulme (1983) demonstrated that misspellings caused by letter substitutions that maintained word shape (in terms of ascender, descender and neutral; e.g., replacing *test* with *tesf*) were more likely to be missed than when word shape was disrupted by substitution (e.g., *tesc*). Moreover, Healy and Cunningham (1992) provided further support for the role of word shape in reading by comparing proofreading performance with uppercase and lowercase text. Target letters were chosen which apparently retained the same featural information in both typefaces (e.g., *s*, *c*, *k*, *p* and *S*, *C*, *K* and *P*). However, when deleted from lowercase words, these selections either broadly maintained (*s*, *c*) or disrupted (*k*, *p*) word shape (e.g., *disater* maintains the shape of *disaster* but *caming* disrupts the shape of *camping*). There was no difference in detecting the letter deletions when text was presented in uppercase. However, when text was presented in lowercase, letter deletions that altered word shape were reported more often than letter deletions that retained word shape. Arguments against a role for word shape in word recognition have been raised (e.g., Paap, Newsome & Noel, 1984). However, on balance, sufficient evidence exists to suggest that discounting a role for word shape in word recognition would be premature (e.g., Healy & Cunningham, 1992; Healy

& Drewnowski, 1983; Jordan, 1990, 1995; Monk & Hulme, 1983; Pollatsek & Rayner, 1982; Rayner, Well, Pollatsek & Bertera, 1982; Walker, 1987).

Further evidence that basic visual cues play an important role in word recognition is provided by Jordan (1990, 1995). Over a series of experiments, Jordan demonstrated that information relating to the boundaries of words assists access to lexical representations. Jordan (1995) briefly presented legal letter pairs (formed by deleting the interior letters of four letter words; e.g., d--k from dark), illegal letter-pairs (formed from pairs of letters which do not exist in the first and last positions of real words; e.g., d--u) and letters in isolation. Letters in legal letter-pairs (but not illegal letter-pairs) were reported more accurately than isolated letters but only when the horizontal boundaries of letter fragment masks matched the horizontal boundaries of word items. When the masks were matched with letter fragment masks for luminance, size and the amount of information they provide but contained no letter fragments, the superior performance for letters in legal letter pairs again disappeared. These findings suggest not only that exterior letter combinations have a representation but that access to these representations relies on the presence of appropriate (word) boundary information in a display. From Jordan's findings, even letter fragment masks which match the boundaries of words can provide this basic information (see Jordan, 1990, 1995, for further discussion).

Evidence for the role of boundary information in sentence processing comes from Pollatsek and Rayner (1982) and Rayner, Well, Pollatsek and Bertera (1982). Pollatsek and Rayner investigated the role of word boundaries in sentence processing by inserting gratings into the spaces between words. Under these conditions, reading time increased significantly. Moreover, these effects were observed only when spaces were filled within

50 msec of a word being fixated, suggesting that word boundary information is extracted early on in sentence processing and, therefore, may play a major role in the extraction of other information (e.g., exterior letters, see Jordan, 1990, 1995, and Walker, 1982, for discussions of this point). Further evidence for the role of basic visual information comes from Rayner, Well, Pollatsek and Bertera (1982) who adapted the moving window technique of McConkie and Rayner (1975). When the text outside this window was replaced with letter strings which matched the original text for word shape and letter confusability, speed of reading was faster in comparison to non matched letter strings. This suggests that recognition of individual words in sentences is influenced by basic visual information from word and letter shapes extracted from neighbouring items. When these basic visual cues are changed, word recognition is affected.

A finding that parallels the exterior letter advantage of Jordan (1990, 1995) was produced by Inhoff and Tousman (1990), who demonstrated the importance of exterior letters in sentence reading. Once more the moving window technique was used to demonstrate that where the initial three letters of the replacement word correspond with the original word there is as much facilitation, as measured by fixation duration, as with the original word. When the initial letters did not correspond, fixation duration was significantly increased. Moreover, a preview of end letters also reduced eye fixation durations, as long as some word length information was also displayed to indicate where in the word the letters occurred (i.e., presentation of ‘---ter’, reduced fixations over ‘ter’ where the target was ‘*butter*’; see also Rayner, 1980,1982; Balota, 1985; Inhoff, 1989).

Consequently, the evidence indicating a role for basic visual cues in word recognition raises the possibility that such cues are involved in sentential processing.

Nevertheless, contemporary research into the influence of the linguistic structure of sentences on visual word recognition has overlooked this role and, in particular, the importance of matching the visual characteristics of sentences across conditions. For example, in the highly influential study of Simpson, Peterson, Casteel and Burgess (1989), legal sentences containing two semantically related words and scrambled (transposed) versions of the same sentences were presented (e.g., ‘The auto accident drew a large crowd of *people*.’ was transposed to ‘Accident of large the drew auto crowd a *people*’). Naming latencies for target items (in this case, *people*) were increased when sentences were transposed, leading the authors to argue for a critical role for sentence structure in word recognition. However, it is clear that the sentences used in these conditions were not matched for their basic visual characteristics. In particular, although both sentences contained the same lexical content, shifts in the positions of these words resulted in substantial differences in the locations of particular word shapes, word lengths, and simple letter shapes (e.g., contrast the visual appearance of ‘The’ and ‘Accident’ at the beginning of these sentences and the words ‘of’ and ‘a’ which immediately preceded the target word). In a study of the dependence of lexical relatedness on syntactic connections, O’Seaghdha (1989) manipulated the function words intervening two related items (e.g., ‘the ceiling and the floor’ was changed to ‘the ceiling this of floor’). Lexical decision latencies were shorter in the syntactic condition, leading to the conclusion that intralexical priming was insufficient to account for the effects of linguistic content on word recognition thus suggesting a critical role of early syntactic processing. However, the basic visual characteristics of the sentences used across these conditions were not matched. For example, when comparing the visual similarity of word shape between conditions, ‘and

the’ in the syntactic condition is not matched visually with ‘this of’ in the control condition but is treated statistically as if only the linguistic content had changed.

Mismatched visual characteristics of sentences may impact on sentence processing in a number of ways. For example, Allen and colleagues (1991; 1995) proposed a two stage processing model in which both word and letter level analysis continue in parallel. Words that are highly familiar have privileged representations in the lexicon which are activated directly by the global aspect of the identified word (i.e., the pattern which is directly related to word shape and word length). There is therefore, an inherent danger in comparing between experimental and control conditions that are mismatched visually by length and shape. In particular, many short familiar words appear to be skipped over without direct fixation (Rayner, 1975) probably because they can be recognised by overall shape (i.e., Healy et al. 1992; Jordan, 1990; 1995). If some kind of holistic process is disrupted by visual mismatch, the apparent linguistic effects of sentence research may be confounded with atypical sentence processing when the basic visual cues provided by the experimental and control sentences are not suitably matched.

1:14 Are perceptual and contextual processors qualitatively separable or do they ‘talk’?

The role of basic visual content may have severe implications for the modular/interactive debate, where the key issue is whether sentential contexts influence perceptual processing or not. Several attempts have been made to examine the influence of semantic context on visual perceptual sensitivity using methodology borrowed from signal detection theory. In a literature review, Farah (1989) suggests that qualitatively different

attentional mechanisms underlie semantic and perceptual priming. Defining attention as “the activation added to a structure which facilitates processing of information through that structure” (LeBerge, 1976, pp252), Farah proposes that perceptual priming enhances sensitivity whereas semantic priming enhances bias. That is, prior knowledge (i.e., perceptual priming or parafoveal preview) about the perceptual properties of words increases sensitivity to those word properties. Semantic priming, according to Farah, does not increase clarity, speed or completeness of encoding but instead increases bias, such that responses to targets following related words are improved because they can be made on the basis of incomplete processing. Farah makes the distinction between response bias in the sense of the process model which is located at the post-encoding decision stage and bias which occurs within the semantic system. Bias at the post-encoding stage would be represented by participant based strategies where less attention was paid to visual input and participants ‘choose’ or ‘guess’ target identity. Bias (or criterion shifts) within the semantic system occurs before the target is fully encoded and results in more ‘hits’ but also in more ‘false alarms’. For example, in Morton’s (1969) *logogen model*, context creates bias within the semantic system by actively lowering thresholds for associated logogens (word representations) so that less visual input is required from targets. Similarly, bias is created within the semantic system in the expectancy model (Becker, 1980; Becker & Killon, 1977) because context activates a semantic set of possible word items such that a match can be found for predictable targets before visual encoding is complete. Farah concludes that it is this bias in the semantic system that accounts for semantic priming effects rather than an increase of sensitivity. If Farah is correct, not only is recognition of words within sentential contexts impervious to alterations in sensitivity to

visual information but altering the perceptual priming available during reading (as in mismatching sentences) may interfere with word recognition in a way that is far removed from semantic sentential effects. There is, however, insufficient evidence to assert that models which propose modifications to lexical items, introduce semantic bias. Certainly several authors (including Morton) seem to imply that such a bias would be present by explicitly stating that lowering thresholds would reduce the amount of visual information necessary for that logogen to fire. It is an assumption that lowering thresholds in this way necessarily results in more 'hits' and more 'false alarms'. It is possible that lowering the threshold for any particular logogen does indeed modify that logogen in such a way that clarity, speed and completeness of processing is improved, just as a preview of visual properties is assumed to 'alert' the system to those properties in perceptual priming. Under these circumstances, more hits would be made but not necessarily more false alarms because the target would be more readily rejected where it did not correspond to the modified logogen.

However, Rhodes, Parkin and Tremewan (1993) provided evidence from four experiments to counter-argue that semantic priming does indeed alter perceptual sensitivity. In four experiments (three lexical decision and one alternate forced choice) the authors presented pattern masked primes that were related (*street*), unrelated (*wish*) and neutral (*blank*) to a target (*road*) followed by either the target or a similar nonword that differed from the target word by one letter (e.g., *road/voad*). Related primes increased the measure of sensitivity (A') over unrelated primes, leading the authors to conclude that the autonomy principle of the modularity perspective had been violated. There are several problems with interpreting these findings. First of all, in the study by Rhodes et al. the

measure of sensitivity does not increase over neutral stimuli; so that all that can be claimed is a decrease in sensitivity to unrelated primes rather than an increase to related primes. This predominance of inhibitory effects is generally accepted as illustrating post-perceptual processing (i.e., Neely, 1977; Posner & Snyder, 1975). Secondly, related items appeared to contain semantic word association, a finding that modular architecture can accommodate (i.e., Fodor, 1983; Forster, 1985). This latter point may contribute to the failure to find increased sensitivity over neutral primes and reflect the difficulty that single word priming encounters with providing adequate neutral controls where word pairs are either related or unrelated. Moreover, the predominance of inhibition effects indicates the presence of a post-perceptual process, a recurring criticism of the lexical decision task. Therefore, it may be the lexical decision task is unable to determine between modular and interactive perspectives of word recognition. This interpretation is backed up by O'Connor and Forster (1981), who claimed that criterion bias should be inoperative in lexical decision, since correct responses must be delayed until all visual information had been checked. To increase the amount of checking participants engaged in O'Connor and Forster (1981) included an experiment which required participants to distinguish between a word, a misspelled word and a nonword (i.e., prime word *letter*, was followed by a word target, *envelope*; a misspelled word, *envleope*; or a nonword, *mirpreat*), while a further experiment mixed upper and lower cases. Semantic priming effects were observed in both these experiments. This led the authors to conclude that criterion bias models were insufficient to explain semantic facilitation.

The findings of both Rodes et al. (1993) and O'Connor and Forster (1981) may be due to an artefact of their particular choice of response possibilities. According to Norris

(1995) in alternate forced choice procedures the simple measure of percentage correct can be interpreted as an index of sensitivity and is equivalent to the nonparametric measure, the area under the receiver operator characteristic curve (McNichol, 1972). The difficulty in interpreting the findings of Rhodes et al, and O'Connor and Forster lies in the fact that one alternative is a nonword. Visual priming from nonwords will not have as much affect on activation levels within the lexicon as priming from real words. For example, in the Rhodes et al. study *-oad* will activate *road* regardless of whether *road* or *voad* were presented, but *-oad* will never fully activate *voad* because it does not have a lexical word entry. This may be in some part explain why the alternate forced choice experiment of Rhodes et al. did not reach significance over the neutral condition. Under brief presentation conditions, one forced choice alternative (the word) is more likely to be activated than the other alternative (the nonword) regardless of which target type was presented. This reasoning may explain the measures of both bias and sensitivity found in lexical decision tasks within a modular framework (Masson & Borowsky, 1998). Where both forced choice alternatives are real words that are equally plausible in the sentence context both words should undergo similar criterion shifts (or threshold modifications). For example, if the forced choice alternatives were *road* and *load*, and *load* reached threshold before the presented target *road* then a miss would have occurred. Moreover, a 'hit' can only be recorded if the presented target is chosen over an equally feasible alternative. Therefore, the Reicher-Wheeler task, as used in this thesis, becomes suitable to measure perceptual sensitivity.

Under circumstances where predictable words are reported more often than unpredictable words in legal sentences the Reicher-Wheeler task would not produce legal

sentence advantages, yet legal contexts would still be exerting an influence. In order to provide a measure sensitive to the nuances of contextual bias independent response ratio measurements were included (see Potter, Moryadas Abrams & Noel, 1993; Potter, Stiefbold and Moryadas, 1998). The ratios measures bias as the proportion of correct reports for each alternative in legal contexts to those of the same alternative in nonword contexts providing a measure of the extent to which preference for one member of a word pair may be given over the other due to the preceding context when factors such as threshold variance or individual preferences between items are removed.

1:15 The role of serial letter position curves in interpreting sentential effects

The nature of the Reicher-Wheeler task also provides a means of revealing priorities attached to different letter positions of the target word in a sentence context, and offers a particularly fine grained analysis for revealing the different patterns of processing across different sentential contexts. Serial position analysis has formed a particularly important aspect of single word recognition research for many years (e.g., Butler, Mewhort & Tramer, 1987; Campbell & Mewhort, 1980; Humphreys, Evett & Quinlan, 1990; Jordan, 1990; Jordan & Bevan, 1994; 1996; Jordan, Patching & Milner, in press; Merikle, 1974; McCusker, Gough & Bias, 1981; Merikle & Coltheart, 1972; Merikle, Coltheart & Lowe, 1971; Merikle & Glick, 1976; Mewhort & Campbell, 1978); similarly, the Reicher-Wheeler task should provide a clearer picture of the way sentences influence the encoding of orthographic information.

One previous study, which did not use the Reicher-Wheeler task, has provided information about serial letter positions in sentence reading. Ehrlich and Rayner (1981)

recorded eye fixation duration and fixation probability for targets in high and low constraining texts. When the original word was substituted for a visually similar word differing by one letter, fixation duration and probability were more likely to increase when the substitution was inspired by first or last letter positions (e.g., *right* was substituted for *night*). This finding led Ehrlich and Rayner to conclude that the linguistic content of the sentence reduced word identification threshold and that exterior letter positions took priority in word processing during sentence reading. It remains to be seen if comparable findings are produced by the Reicher-Wheeler task which overcomes sophisticated guesswork and provides an explicit measure of stimulus perception. Differences between contextual conditions may or may not reflect changes in the priorities assigned to letter positions. For example, as suggested by Ehrlich and Rayner (1981), sentential context may exaggerate first and last letter positions, or initial letters (i.e., Inhoff & Tousman, 1990), alternatively, legal sentence contexts may interact with all letter positions equally. Moreover, in the absence of an overall contextual influence using the Reicher-Wheeler task, changing priorities assigned to letter positions across contextual conditions would indicate some level of contextual influence. The inclusion of serial letter position data as presented by the Reicher-Wheeler task, therefore, gives a greater measure of sensitivity to contextual influence than is generally provided by contemporary sentential research, as well as providing a clearer picture of how orthographic information is encoded in sentences. Such attention to detail, as provided by brief presentations and the Reicher-Wheeler task has become a cornerstone in elucidating the components of single word recognition.

1:16 The search for a similar framework to the word superiority effect

Since the early findings of Cattell (1889) demonstrated contextual effects on letter identification (i.e., letters in briefly presented words are identified more accurately than letters in other alphabetic stimuli) the brief presentation method has provided invaluable insight into the components of single word recognition. In this word superiority effect, letters in real words are recognised more accurately than letters in pseudowords (nonwords that obey orthographic rules) while letters in both words and pseudowords are recognised more accurately than letters in nonsense letter strings (nonwords that violate natural letter groupings). For example, *A* is reported more accurately when it is presented in the word *LEAD* than it is when it is presented in the pseudoword *DAEL*. When the nonsense word *DLEA* is presented report accuracy of “*A*” is further reduced. Moreover, *A* is reported more accurately when it was presented in the word *LEAD* than when presented alone.

Perhaps the most influential model of word recognition, the interaction activation model (McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982) grew from the word superiority effect. In the interaction activation model, letter fragments from the presentation of alphabetic stimuli excite feature detectors which form the input into letter detectors, which in turn, feed up into the word level detectors. At each level of detectors there is also inhibition: From feature detectors to letters detectors that do not contain the fragments already detected, and from letter detectors to word detectors that do not contain the position specific letters already excited at the letter level. In this way words and their orthographic neighbours are activated and inhibited until there is only one candidate left, this is the word consciously perceived. For instance, if the word *READ* was

presented, *LEAD* and *READ* would both benefit from activation from *EAD* but *LEAD* would receive inhibition from the position specific *R* of *READ*. Activation of the letter level detectors is strengthened by feedback from the word level. The model accounts for the word superiority effect by reference to the pattern mask. The letter fragments from the pattern mask, which follows the brief presentation of the stimulus, would activate letter fragment features but inhibit any specific letter. Thus, when a letter was presented, the letter fragments in the following mask would create inhibition at the letter level, making accurate performance at the letter level problematic. However, the inhibition from random letter fragments would never agree on activation of a specific letter, eliminating any further activation or interference at the word level, making the presented word level activation much more enduring and improving performance accuracy over that of single letter presentations. Moreover, parallel processing of each level accounts for the pseudoword effect. Partial processing of word level information from a pseudoword, where none of the activated words actually reach threshold, provides sufficient feedback to the letter level to strengthen activation for letters presented in the pseudoword. Nonsense words, on the other hand, cannot provide such partial activation at the word level. Therefore, there is no feedback to the letter level and the stimulus representation is extremely susceptible to interference from pattern masks. Despite the fact there is now compelling evidence that word recognition is not always based on detailed featural information, (e.g., Allen and Emerson, 1991; Allen, Wallace & Weber, 1995), the phenomenon gave rise to interactive models of single word recognition and a clear framework from which to develop further models. No such framework exists in sentential research despite the plethora of research and models surrounding contextual influence on word recognition. In fact, some authors

suggest that word recognition is not facilitated at all by sentence contexts but inhibited and contextual effects reported are due to an increase in inhibition in incongruous sentences (e.g., Forster, 1981).

In line with the concerns of this thesis, that is whether sentential contexts can influence the processes that underlie word recognition, chapter two, set out to establish whether such a framework as provided by the word superiority effect to single word recognition could be constructed in sentential contexts. Bearing in mind the concerns outlined so far, legal sentences were constructed to reduce the amount of semantic association they contain and were compared with visually matched nonword replacement, word replacement, transposed and single word presentations, using the Reicher-Wheeler task. These conditions correspond with the single word paradigm in the following way: legal contexts (e.g., ‘it began to *flap/flop*’) correspond to words; word replacement (e.g., ‘of taper he *flap/flop*’) and transposed sentences (e.g., ‘to it began *flap/flop*’) are similar to pseudowords in that they contain real words but do not form a coherent sentence contexts, transposed sentences contain the same lexical content as legal sentences and perhaps represent a higher level of pseudoword than word replacement sentences. Nonword contexts (e.g., ‘el hojem bu *flap/flop*’) correspond to nonwords, which do not obey orthographic rules, and single words (e.g., *flap/flop*) correspond to single letters. By eliminating word association as far as possible, intralexical processing in the form of spreading activation was also reduced, thereby any facilitation found for targets in legal sentences can be attributed to sentence level processing. Furthermore, the use of the Reicher-Wheeler task reduced the possibility of participants improving performance through sophisticated guesswork based on partially processed information from targets.

For example, when participants read ‘it began to *flop*’ followed by the forced choice alternatives *flop* and *flap*, accurate performance rests on recognition of the target actually presented as both alternatives are visually similar and equally plausible with the context. In order to check that the participants were reading the sentence displays and processing them into meaningful texts, an additional task was included. Participants were asked to say if the complete sentence made a legal (meaningful) phrase after their manual forced choice response by saying aloud the word “yes” if the sentence was legal and “no” if the sentence was illegal. All the experiments reported in this thesis adopted these basic principles, although experiments seven, eight and nine use highly constraining legal sentences such as ‘singing in the *rain/ruin*’.

Additionally, a response ratio analysis based on the formula and rationale of Potter et al. (1993) was conducted for each experiment. Although the Reicher-Wheeler task rules out an advantage in legal contexts, or indeed any other condition, based on bias because a preference for ‘he wanted to *flop*’ over ‘he wanted to *flap*’ would only be correct on half the trials and produce a legal sentence disadvantage, analysis of the response ratios was included to gain a greater insight into word recognition in sentence contexts. This enabled yet further assessment of the influence of context on performance by comparing response ratios for each member of target word pairs in each condition to those of the nonword condition. For example, if context in the ‘legal’ condition produced responses biased towards one member of a pair (e.g., due to participants adopting idiosyncratic associations between context and target), patterns of responding should produce response ratios above 0.5 for the preferred member and below 0.5 for the non-preferred member. In this case, an advantage conferred by legal context on performance should be treated with caution.

Alternatively, if context in the 'legal' condition produced no responses biased towards one member of a pair, patterns of responding should produce response ratios of 0.5 or higher for both members. In this case, an advantage conferred by legal contexts on performance would indicate enhanced target processing over baseline. Moreover, in the event of non-significant contextual effects the response ratio analysis provides a quantifiable measure of whether this was due to contextual bias, insufficient contextual strength (i.e., ratios above 0.5 in legal contexts) or because sentence contexts do not enhance the processes underlying word recognition.

CHAPTER TWO

The question of whether word recognition is facilitated by being in a legal sentence is a fundamental but unanswered question. This first experimental chapter set out to establish whether a framework such as the word superiority effect in single word recognition existed for words in sentences such that word recognition would be more accurate in legal sentences than in transposed and word replacement contexts and least accurate in nonword contexts and single words.

In contrast to most studies of word recognition in sentences, Forster (1981) sought to examine the modular/interactive debate using low constraining sentences to minimize word association. Forster (1981) found no reliable differences for ‘unfocused appropriate’ sentences (e.g., ‘Every Saturday they gathered to *sing*’) and inhibition effects for ‘unfocused inappropriate’ sentences (e.g., ‘Every Saturday they gathered to *panic*’) compared to a baseline of random word strings. The author concluded that when word association is limited, the assistance provided from integration of context and target is too weak to facilitate word recognition for appropriate targets but the inhibition effects remain for inappropriate targets. This study, however, measured lexical decision latencies that may mask sentential effects by creating a greater decision component than normal reading entails and rapid serial presentations which encourages a word by word integration process.

Nevertheless, Forster provided evidence that the choice of neutral baseline confounds a lot of sentential research, by demonstrating differing results with two experiments using the same congruous and incongruous stimuli taken from Stanovich and

West (1981). Forster presented congruous sentences (e.g., ‘The politician appealed to the *people*’), incongruous sentences (e.g., ‘The politician appealed to the *homecoming*’) and standard neutral sentences (e.g., ‘It was the *people*’). In a further experiment the same stimuli were presented but the neutral baseline was changed to a string of five or six content words ending in the target (random word strings). Individual comparisons with the standard neutral context showed facilitation for congruous sentences but no inhibition effect for incongruous sentences. Individual comparisons with the random word string contexts, however, showed no facilitation for congruous sentences and inhibition for incongruous sentences. Forster concluded that the apparent facilitative effects over standard neutral sentences often found in sentential research are, in fact, due to comparison with a suppressed baseline. Specifically, Forster argues, the lack of constraints in sentences such as “it was the *people*” creates a high demand on integration and/or checking processes (in contrast to that random word lists) because integration is not attempted by participants.

A similar conclusion was reached by Duffy et al. (1989). Again using rapid serial presentations Duffy et al. found target naming latencies were greater in standard neutral conditions (e.g., ‘The next word will be *mustache*’) than in subject-verb neutral conditions (e.g., ‘The woman saw the *mustache*’). The authors found that this inhibition effect disappeared when they increased the time before target presentation. Duffy et al. conclude that an automatic integration process is less efficient in standard neutral sentences due to their lack of constraints. There are several problems with this interpretation over and above those already discussed with rapid serial presentations and response production.

In both Forster (1981) and Duffy et al. (1989), standard neutral sentences were presented as often as there were experimental stimuli, such that participants read ‘The next word will be ----’ many times within the experimental session but only read ‘The woman saw the *mustache*’ or Forster’s random word lists once. This repetition may have created a Stroop like effect, as described by Stanovich and West (1982) for incongruous sentences and account for the inhibition effects found with standard neutral sentences.

This chapter re-examined the influence of ‘unfocused’ sentences. This was done to examine whether legal sentence contexts conferred an advantage on target word perception using control sentences matched for basic visual content and the Reicher-Wheeler Task to suppress sophisticated guesswork. Sentence contexts were constructed using three words and were then partnered with a word pair which differed by only one letter, and where both members of the word pair could complete the sentence with equal plausibility. For example, ‘it began to ----’ was partnered with *flap* and *flop*. Independent judges then rated each sentence and only those sentence pairs that were rated as equally plausible were selected for inclusion in the experiments. Thus, when presented in an experiment, a three word context preceded one member of its word pair and both members of the pair formed the forced choice alternatives. This represented the legal sentence condition. Three control conditions were then constructed to match the legal sentences for visual qualities. The word replacement condition used sentence contexts which replaced the words of the legal sentences with words matched for number of letters and letter and word shape by equating ascender, descender, and neutral (e.g., ‘of taper he ----’). In a similar way, nonwords were matched with the legal contexts, nonword contexts (e.g., ‘el hojem bu ----’). Transposed contexts were formed by transposing the

words of the legal sentence contexts such that they contained the same visual and lexical content as the legal sentences but disrupted legality and overall sentence shape (e.g., ‘to it began ----’). Finally, a single word condition was included where no context was presented, and targets appeared in the same position as they occupied in context conditions. In order to check that the participants were reading the sentence displays and processing them into meaningful texts, an additional task was included. Participants were asked to say if the complete sentence made a legal (meaningful) phrase after their manual forced choice response by saying aloud the word “yes” if the sentence was legal and “no” if the sentence was illegal.

Low constraining legal sentences were constructed in order to minimize word association. This approach provides circumstances where modular and interactive models make differing predictions. From a modular perspective, sentential context effects may arise in two ways. One is sophisticated guesswork, the effects of which the Reicher-Wheeler task suppresses. The other is through semantic word association, where activation spreads between related words inside the lexicon; because the locus of the effect remains internal to the mental lexicon modularity is maintained (e.g., Fodor, 1983; 1998; Forster, 1979, 1981, 1985; Seidenberg, 1985). Therefore, according to a modular account, legal sentence contexts should not facilitate word recognition in this experimental design where the effects of sophisticated guesswork and semantic word association are suppressed. Alternatively, Forster’s (1981) inhibition account suggests that very low constraining sentence contexts which do not contain word association automatically produce an inhibitory influence on word recognition, either because of integration or checking mechanisms or both. Under these circumstances, legal contexts of such low

constraint as ‘it began to ----’ should correspond to standard neutral conditions and produce inhibition effects when compared to random word list (word replacement) contexts. If, on the other hand, sentential context influences the processes that underlie actual word recognition, as proposed by interactive accounts, target accuracy should increase in legal sentence contexts despite the suppression of sophisticated guesswork and semantic association. This would occur because legal sentential contexts could constrain activation to incongruous candidates activated in the visual set thereby increasing the accuracy of both word pair members.

Experiment 1

In order to establish the existence of a framework, such as that provided by the word superiority effect in single word recognition, the sentence contexts of Experiment 1 were presented for a short time period (150 ms). Participants were advised to keep looking at the fixation spot during each presentation.

In order to examine the framework of sentence processing the conditions were constructed as follows. Legal sentence contexts (e.g., ‘it began to ----’) provided all the visual and contextual information necessary to form a meaningful, syntactically legal sentence when completed by targets but imposed very few contextual constraints on the identity of the target. Word replacement contexts (e.g., ‘of taper he ----’) are similar in construction to Forster’s (1981) random word list contexts but are matched with legal contexts for visual content. These contexts should provide a direct comparison with Forster’s results. It is not clear whether these sentence contexts or transposed contexts (e.g., ‘to it began ----’) could provide sufficient information to form a pseudo-sentence.

Assuming syntactic assignment processing is carried out adjacent to formation of message representations, performance with targets in Transposed contexts would be expected to improve over those in word replacement contexts. If target performance improves in legal contexts over transposed, it would still be unclear whether syntactic assignment precedes semantic processing, as suggested by O'Seaghda (1989, 1997), or follows it. However, presenting sentence contexts for such short durations should reveal some aspect of syntactic assignment in the 'legality' reports because the syntactic judgements between legal and illegal sentences containing the same lexical content will be made on presentations lasting only 150 ms. If syntactic assignment is an early and immutable aspect of sentence processing, transposed sentences should be accurately reported as illegal but should maintain the same level of target accuracy as word replacement contexts. Nonword contexts (e.g., 'el hojem bu ----'), on the other hand, should not activate entries in the lexicon. Therefore, performance for targets in this condition should be poorer than in legal, word replacement and transposed contexts. Nonword contexts should, however, provide sufficient visual cues in the form of alphabetic stimuli to improve target accuracy over single words. Several authors have sought to provide this kind of information in a neutral context by presenting a row of ampersands or asterisks. However, there are suggestions that this kind of prime may actively disengage normal language processing (Antos, 1979; Becker, 1985; de Groot, Thomassen & Hudson, 1982; Jonides & Mack, 1984; Kraut & Smothergill, 1978; Kraut, Smothergill & Farkas, 1981, Neely, 1991; Stoltz & Neely, 1995). In contrast, nonword contexts should provide a more authentic baseline from which to compare performance in the other conditions. Finally, the single word

condition, where no sentence context is provided, should yield lower accuracy measures if context plays an important role in visual word recognition.

General Method

All of the experiments in this thesis adopt the following paradigm and general principles. All alpha values are set at (p values 0.05 or 0.01).

Participants. Sixteen paid participants between the ages of 18 and 35 years were recruited from the student population of St. Andrews University. Each participant took part in two 30 minute sessions, all participants had normal or corrected-to-normal vision and were native speakers of English.

Stimuli. Forty-four pairs of four-letter words were selected as target stimuli (20 practice and 24 experimental stimuli pairs), with a mean frequency of written occurrence of 71.88 per million (taken from *Frequency analysis of English usage: Lexicon and grammar*. Francis & Kucera, 1982), and each pair had a mean difference of 17.77 (SD 13.66). Pair differences were calculated by averaging reported occurrence found in Francis and Kucera (1982) and Carroll, Davies and Richman (1971). Each pair differed by only one letter and all four letter-positions were equally represented (e.g., *bake/fake*; *lamp/lump*; *flop/flap*; *coat/coal*).

Forty-four base sentence contexts, each consisting of three words, were constructed to accompany each word pair in such a way that a meaningful phrase was formed when either of the word pair members was added at the end of the context. The appropriateness of each word to the accompanying context was then assessed by 12 independent judges who rated them between 0 (not appropriate) and 10 (very

appropriate). Word pairs were selected for use in the experiment when the mean appropriateness of both words was rated above 7 and did not differ by more than 1 (mean rating difference between pairs ranged from 0.07 to 1). Control contexts were constructed as described previously. For example,

(L) it began to flap/flop

(R) of taper he flap/flop

(N) el hojem bu flap/flop

(T) began to it flap/flop

Where (L) is legal context, (R) is word replacement context, (N) is nonword context and (T) is transposed context. Each sentence context had two possible endings both of which were presented as targets on different occasions such that ‘it began to flap’ became member 1 and ‘it began to flop’ became member 2.

Apparatus. The experiment was controlled by a Cambridge VSG2/3 display controller slaved to a computer. The stimuli were presented on a high-resolution display equipped with rapid-decay phosphor. Participants viewed the stimuli through a plastic molded viewfinder (approximately 18 by 71/2 cm) attached to a matte black tunnel the same size as the monitor screen (46 cm). The whole configuration resulted in a viewing distance of 68cm. The experiment was conducted in a darkened booth, and participants entered their responses via two keys interfaced with the computer.

Visual Conditions. Sentence contexts and target words were presented in lower case, Courier font. Courier font was used in order to justify the length of target word pairs and visually matched replacement words such that word length could not be used as a visual cue to target word identities nor could differing lengths interfere with visual

matching of control sentences. Sentence contexts and target words were presented on one continuous line of text (as in normal reading). Each complete sentence was shown centered around a central fixation point. A single four letter word subtended 1.5° horizontally. Words were presented in black on a white background

Design. Participants took part in two 30 min sessions, one on each of two different days. Each session consisted of 80 practice trials and one stimulus group (A or B) containing 96 experimental trials. Stimulus group A consisted of all sentence contexts completed by one, randomly assigned member of the target word pair. Stimulus group B consisted of all sentence contexts completed by the alternative member. Both members of each target word pair were presented as forced choice alternatives. Each session was divided into cycles of 20 pseudo randomly chosen stimuli counterbalanced across legal, word replacement, nonword, transposed and single word conditions and 4 critical letter position with the additional constraint that no target word could appear twice within each cycle. Each participant was presented with both stimulus groups, such that target member was a within-subject variable. Stimulus group presentation order was counterbalanced across subjects.

Response Ratio. Following Potter et al. (1993), performance accuracy for nonword contexts was taken as the baseline against which responses in all other contexts, particularly the legal condition, could be assessed. This was done by dividing the number of correct responses for member one in the legal condition plus the number of correct responses for member 1 in the nonword condition by the number of correct responses for member one in the legal condition. This was then repeated for member 2, giving a ratio for each member in the legal condition. Ratios for word replacement and transposed

conditions were calculated in the same way, note that the nonword ratio is always 0.5 indicating no contextual response bias. In this way, ratios for other conditions do not reflect idiosyncratic word biases or unintended visual differences between word pair members.

This enabled further assessment of the influence of context on performance. For example, if context in the legal condition produced responses biased towards one member of a pair (e.g., due to participants adopting idiosyncratic associations between context and target), patterns of responding should produce response ratios above 0.5 for the preferred member and below 0.5 for the non-preferred member. In this case, an advantage conferred by legal context on performance should be treated with caution. Alternatively, if context in the legal condition produced no responses biased towards one member of a pair, patterns of responding should produce response ratios of 0.5 or higher for both members. In this case, an advantage conferred by legal contexts on performance would indicate enhanced target processing over baseline.

Procedure. At the start of each trial a fixation point appeared at the center of the screen. Participants were instructed to fixate this point when initiating a display. When the participant pressed the return key on the keyboard, the fixation point was replaced with the sentence context (for 150 ms) before onset of the target word in its appropriate position at the end of the sentence. The context display remained on the screen while the target word was presented, completing the sentence display. After a predetermined time, the whole sentence (including the target) was removed. After 600 ms, during which time the screen remained blank, the forced choice alternatives were shown, one above and one below (randomly determined) the screen position previously occupied by the target.

Participants selected either the upper or lower alternative by pressing the up or down arrow key on the keyboard. After responding, participants were required to say “yes” if they thought a sentence was legal and meaningful and “no” if they thought it wasn't. These ‘legality’ responses were noted by the experimenter. Throughout the practice and experimental section, target exposure duration was reassessed after each cycle of 20 trials. Within each cycle, all targets were shown for the same exposure duration, irrespective of sentence context. Computer software assessed accuracy during each cycle and automatically adjusted target exposure duration, increasing it by 6 ms after any cycle in which accuracy fell below 13 (65%) correct, and decreasing it by 6 ms if it rose above 16 (80%) correct within that cycle. When adjustments to exposure duration were made at the end of a cycle, the same adjustments were made for each condition. This adjustment procedure ensured that overall performance fell in the midrange of the performance scale and that each condition was represented in the experiment at the same exposure duration an equal number of times. The mean exposure duration of targets in experiment 1 was 2.27 frames (46.26ms).

Results

Legality response errors, responding either “yes” to an illegal sentence or “no” to a legal sentence, were 6.87% of all experimental trials. Ninety seven percent of these errors were in the transposed condition, where participants reported contexts as legal. This indicated that participants were processing legal, word replacement, nonword and single word displays appropriately but the syntactic anomalies of transposed contexts often went unnoticed. Mean percentages of target words correctly reported for each context display

type is shown in figure 1. An analysis of variance (ANOVA) was conducted with one between-subjects factor of 2 x Stimulus Group Presentation Order (Group 1 or 2 in Session A) and three within-subjects factors [stimulus group (1 and 2), context type (legal, nonword, word replacement, transposed, and single word) and critical letter position. Main effects of context, $F(4,56)=29.09$; $p<.01$, $MS_e=185.639$ and of critical letter position, $F(3,45)=12.56$; $p<.01$, $MS_e =334.076$, were found. Newman Keuls revealed that performance in the single word condition was superior to that of all other conditions (all $p's<.0$).

Analysis by items revealed the same pattern as the subjects' analysis, main effect of context, $F(4,160)=4.126$; $p<.01$, $MS_e=183.974$ and critical letter position $F(3,44)=3.728$, $p<.01$, $MS_e=460.108$. Again Newman Keuls revealed that the effect was entirely due to the superior performance of single words over all other conditions (all $p<.0$. No other main effect or interaction was statistically reliable.

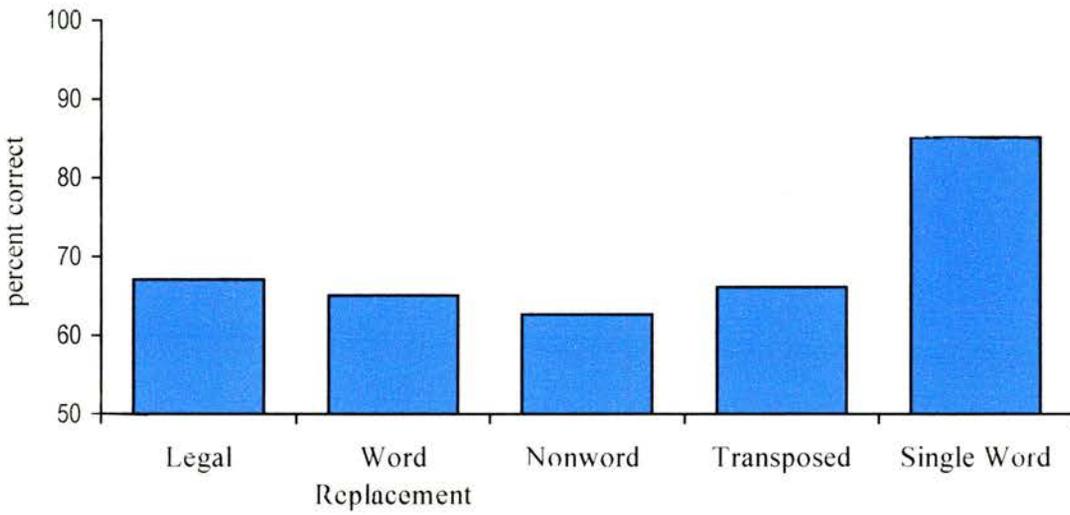


Figure 1. Mean percentage of target words correctly reported for each context display type in experiment 1.

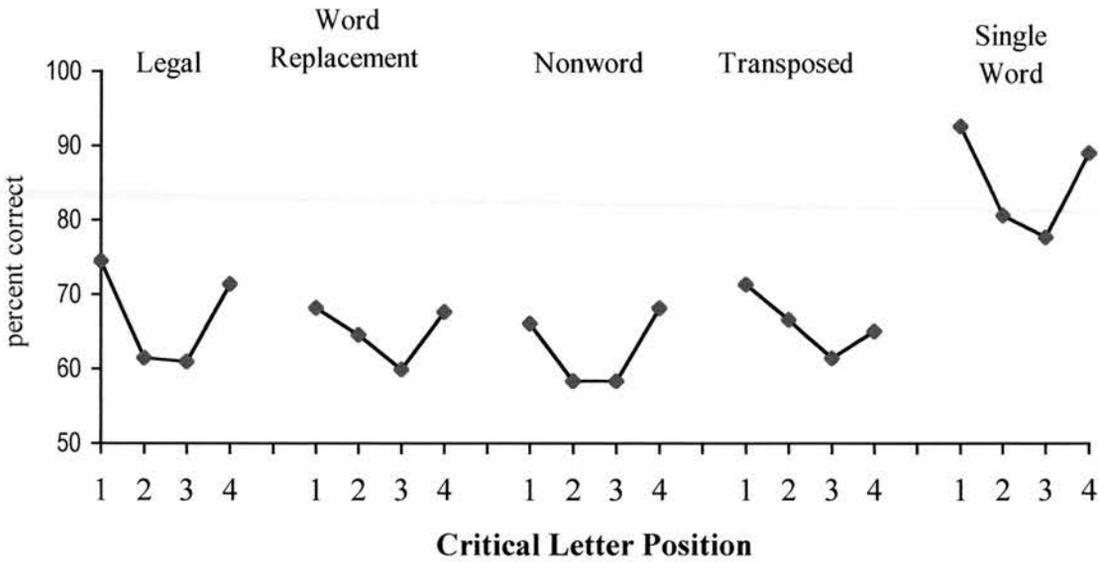


Figure 2. Mean percentage correct reports for each letter position in each context display in experiment 1.

Response ratios are shown in figure 3. T-tests for Dependent Samples were conducted on the proportional data. As would be expected with such a large single word advantage, recognition of both single word members was significantly enhanced over the Nonword control condition, (member 1, $t(15)=7.03$, $p<.001$; member 2, $t(15)=5.35$, $p<.001$). Both Legal [$t(15)=2.99$; $p<.01$] and Transposed [$t(15)=2.43$; $p<.05$] member 2 targets produced greater response ratios than those of the baseline control condition while member 1 fell below baseline [$t(15)=2.99$, $p<.01$]. Therefore, there is no response bias for legal contexts as both member ratios are above baseline and a bias in the transposed condition as the ratio for one member was above and the other below baseline. Response ratios were Legal, member 1 (0.507), member 2 (0.526); Word Replacement, member 1

(.505), member 2 (0.507); Transposed member 1 (0.470), member 2 (0.526); Single Word (0.566), member 2 (0.555).

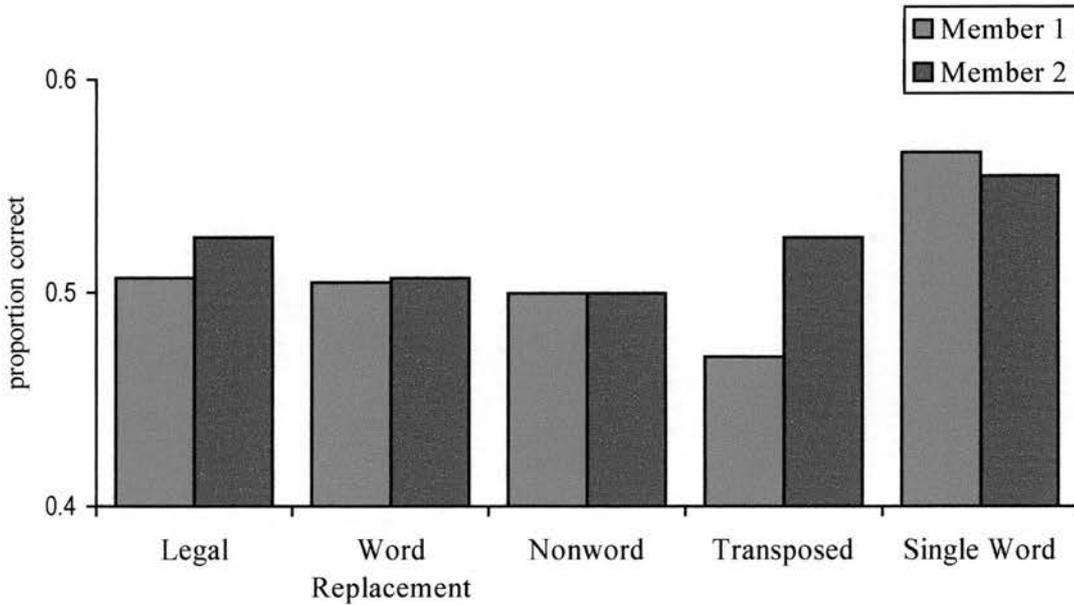


Figure 3. Response ratios for members 1 and 2 for each context display type in experiment 1.

Discussion

Under the stringent testing conditions provided by the Reicher-Wheeler task there appears to be little effect of sentence contexts on word recognition in the accuracy data when contexts are presented for very brief durations. Single words, however, were identified more accurately. From a purely modular perspective of word recognition there should be no difference between any condition. Therefore, the findings of experiment one

seem to support Duffy et al. (1989) and Forster's (1981) proposals that very low constraining sentences create an inhibition effect on word recognition. Nevertheless, under Forster's proposal, this inhibition is caused by an integration process which should not be operational in either word replacement and nonword control contexts. Under these circumstances, legal sentence contexts should produce inhibition effects when compared to control conditions. This was not found, indeed the graph displays the expected trend of results with target recognition being slightly superior in legal contexts than in all other contextual conditions, which is confirmed by the response ratios. There is, however, a strong possibility that targets were masked by their contexts due to the extremely short duration of contexts and the speed with which targets appeared. This could have had two possible effects on the results of the contextual conditions. Firstly, it could have decreased the apparent effect of all sentence context types when compared to single words. Secondly, by creating circumstances where single words were reported at such a high level could have had the effect of presenting targets at durations that were too fast to truly reflect the possible differences between contextual conditions. This possibility is borne out by the response ratios.

Where the response ratio analysis is concerned, there was some indication of contextual influence. There was a large improvement in response ratios for member two targets and a small improvement for member one targets in the legal condition over baseline. Moreover, the transposed condition ratios for member two were higher than baseline, while member one ratios fell below baseline showing a response bias in these contexts and suggests a contextual influence that may be due to some level of decision bias operating in transposed contexts. This result is all the more interesting in light of the

legality report errors. The greatest proportion of the legality errors were made by reporting transposed contexts as legal sentences indicating that on many occasions transposed sentences were processed as legal meaningful sentences. This suggests that at very brief presentation durations of the context, word order is subordinate to, and independent of, meaning. Therefore, legality per se may not be the cause of the disruption to contextual effects for transposed sentences often reported in the literature (e.g., Simpson et al., 1989). Moreover, this suggests that syntactic assignment may not be the initial and immutable process that O'Seaghda (1989, 1997) has proposed.

The possibility then arises that where syntactic irregularities are found, natural reading processes are disrupted and decision bias results. Since there is no hint of response bias in legal sentences and assuming that transposed sentences are being processed as legal sentences when they are reported as such, we can conclude that the biasing effect must arise when the syntactic irregularity is noticed. This implies two things; firstly, meaning is being extracted from transposed sentences in a way that it is not in word replacement contexts and, secondly, that syntactic assignment is made after initial meaning extraction, perhaps at an elaboration or integration stage. It would appear, therefore, that post-perceptual decisions are introduced in the process of trying to reform transposed sentences into meaningful concepts. Finally, the main effect of critical letter position suggests that whatever contextual effects are taking place, word recognition is being influenced in a uniform manner. Moreover, the result confirms the exterior letter advantage of Jordan (1990, 1995; Humphreys, Evett & Quinlan, 1990; McCusker, Gough & Bias, 1981).

From the combined results of the response ratios and the errors of legality to transposed sentences, it is becoming evident that even at the extremely brief durations of

context presentation there is some influence of context on word recognition. One hundred and fifty milliseconds was chosen because it was just above the 140 ms threshold for cognitive language operations identified by Morrison (1984) and examination of the very initial stages of sentence processing would help to elucidate the time course over which sentential components operate. Nevertheless, this duration is also at the lower limits of cognitive language processing and average fixation duration. Therefore, increasing the duration of the context presentations may prevent masking of targets by contexts and allow a clearer picture of contextual influence to be formed. Moreover, prolonging the duration of the contexts should allow participants to register the illegality of transposed sentences. If reforming transposed sentences into meaningful phrases interferes with the uptake of visual information from the target (such that post-perceptual decisions are made regarding target identity) this effect should still occur, providing context durations are sufficiently brief to prevent this process being complete. Therefore, increasing the duration of the context, while still examining the initial stages of sentence processing formed the basis of experiment two.

Experiment 2

Experiment two was a repetition of Experiment one except the duration of context presentations was increased from 150ms to 240ms. This particular duration was chosen as it would take the context duration to the higher limit of average fixation duration (average fixation 150-250ms, Rayner, 1975) within the constraints of a 6ms exposure resolution. This would allow the context to be more fully processed while still restricting visual processing.

Method

Participants. Sixteen paid participants between the ages of 18 and 35 years were recruited from the student population of St. Andrews University. Each participant took part in two 30 minute sessions, all participants had normal or corrected-to-normal vision and were native speakers of English. No participant had taken part in Experiment 1.

Visual Conditions. The context displays were presented for 240 ms before onset of the target word. All other aspects of experiment 2 were the same as experiment 1. The mean exposure duration of targets in experiment 2 was 3.04 frames (18.24 ms).

Results

Legality responses were practically error free (<1%). That is, sentence displays were accurately reported as legal or illegal, indicating that participants were processing the context displays appropriately and that increasing the duration of the display from 150 ms to 240 ms was sufficient for participants to accurately report transposed sentences as illegal. Mean percentages of target words correctly reported for each context display type are shown in figure 4. An ANOVA was conducted with one between subjects factor stimulus group order (1 or 2 first) and three within subjects factors [stimulus group (1 or 2), context (legal, word Replacement, nonword, transposed and single word) and critical letter position]. A main effect of context $F(4,56)=7.46; p<.01, MS_e=116.497$ was found. Newman Keuls revealed this was due to the inferior performance of the single words over legal, $p<.0008$, word replacement, $p<.001$; nonword, $p<.0014$, and transposed, $p<.0012$ contexts.

Analysis by items revealed a similar pattern as the subject analysis, main effect of context $F=(4,176)=9.86, p<.01, MS_e=3.636$. Newman Keuls revealed this was due to the superior performance in all sentential context conditions over single words (all p 's<.001). No other main effect or interaction was reliable.

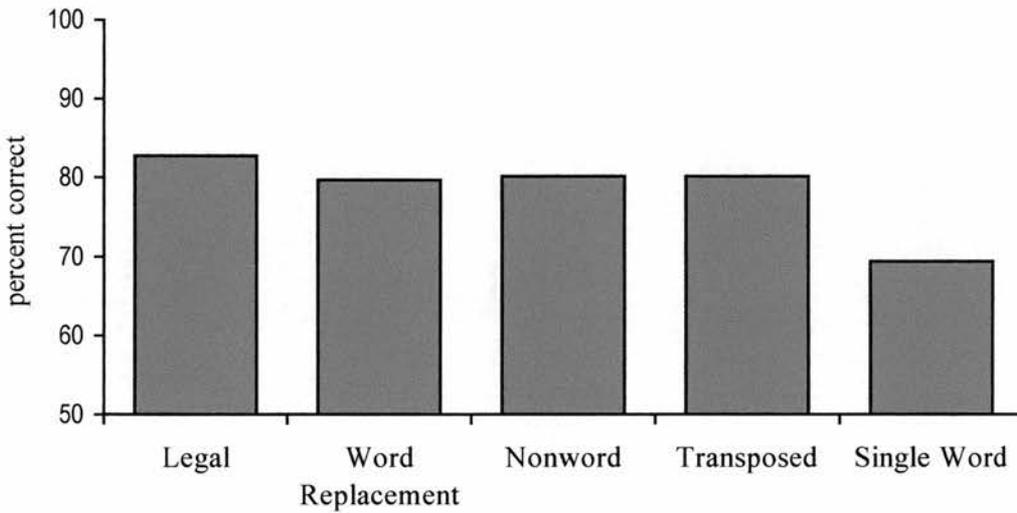


Figure 4. Mean percentages of target word correctly reported for each sentence context display type in experiment 2.

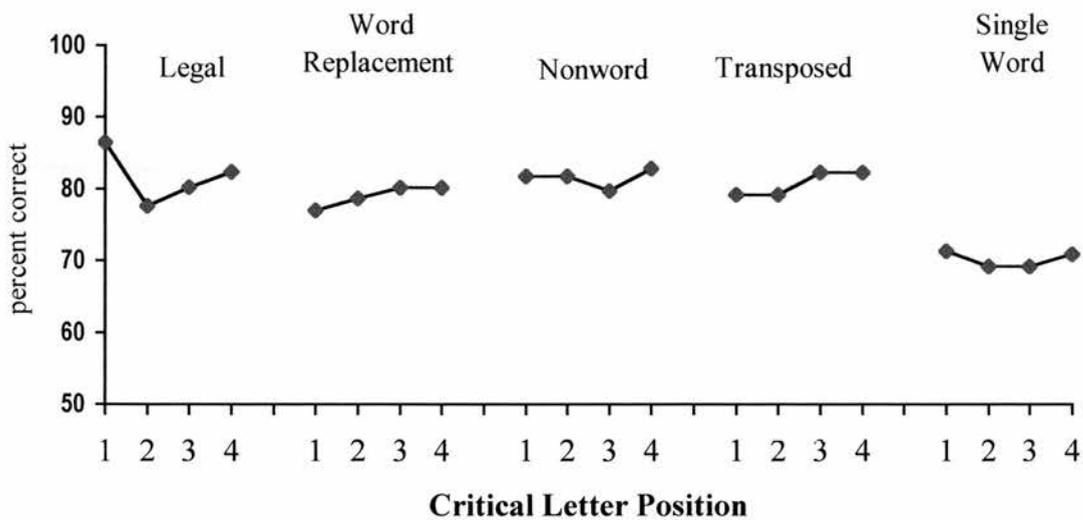


Figure 5. Mean percentages correct for each critical letter position in each sentence display type in experiment 2.

Response ratios are shown in figure 6. T-tests for Dependent Samples were conducted on the proportional data, recognition of both single word members was significantly lower than baseline, [member 1, $t(15)=-2.75$, $p<.01$; member 2, $t(15)=-3.31$, $p<.01$]. Both Legal [$t=2.38$; $p<.05$] and Transposed [$t=2.18$; $p<.05$] member 2 targets produced greater response ratios than those of the baseline control condition, while member 1 in the transposed condition showed a lower ratio than baseline [$t(15)=2.34$, $p<.05$]. Therefore, there was no response bias in the legal condition as the ratios for both members were above baseline and a response bias in the transposed condition as the ratio for member 1 fell below baseline while that of member 2 fell above baseline. Response ratios were, legal member 1 (0.506), member 2 (0.508); word replacement member 1 (0.498), member 2 (0.498); transposed member 1 (0.480), member 2 (0.510).

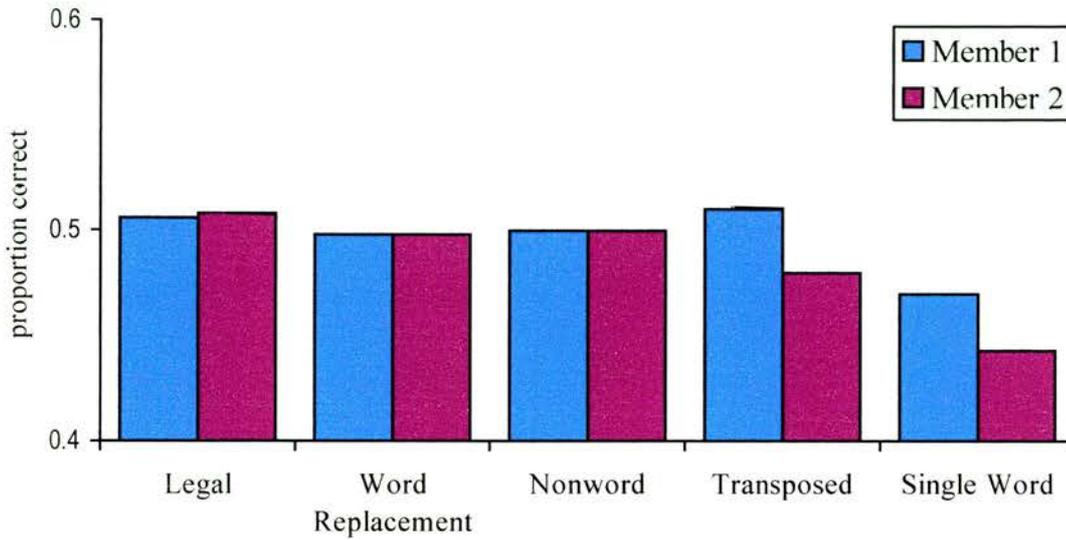


Figure 6. Response ratios of experiment 2.

Discussion

Once again there was no apparent influence of context (semantic or legality) on word recognition, beyond that provided by the basic visual information of sentence contexts when compared to single word presentations. This may have been because contexts cue the spatial location of targets in the contextual conditions. It is probable that even a nonword sentence aids word recognition by establishing language processes. There is evidence that non-alphabetic or no context presentations may actively disengage normal language processing (Antos, 1979; Becker, 1985; de Groot, Thomassen & Hudson, 1982; Jonides & Mack, 1984; Kraut & Smothergill, 1978; Kraut, Smothergill & Farkas, 1981, Neely, 1991; Stoltz & Neely, 1995). This presents the nonword condition as a likely

candidate for a more adequate baseline in sentential research than has been used to date. Moreover, lateral inhibition or interference is likely to be at least partially responsible for the poorer performance in contextual conditions in experiment one, which is another reason why the nonword condition is the best baseline.

Despite the lack of differentiation between contextual conditions in the accuracy data, once again there is a strong indication of an emerging contextual influence in the response ratios. Legal member one and two are enhanced over baseline further contradicting the inhibition hypotheses of Forster (1981) and Duffy et. al., (1989). Very low constraining sentences do not inhibit word recognition over a baseline of either word or nonword replacement contexts. On the contrary, low constraining sentences improve word recognition as measured by the proportional response ratios. Once again, transposed sentences show a slight response bias, despite the fact that the syntactic anomaly present in these contexts is reported at these longer durations. This contextual influence is strikingly different from the other control conditions, where no effects appear, and provides further support for the proposal put forward in experiment one¹, that re-ordering the words to form meaningful sentences interferes with word perception in such a way that post-perceptual decisions are made in order to complete the task. Under these circumstances, it is possible that further increasing the duration of the contexts to allow sufficient time for participants to complete such a transposition process could eliminate this bias effect. Alternatively, if post-perceptual decisions are part and parcel of illegal sentence processing, increasing the presentation durations of the sentence contexts would increase the biased effect found in transposed sentences such that the response ratio bias will remain. Moreover, most sentential research presents sentence contexts for much longer

durations than 240 ms and it is possible that increasing contextual durations, in line with previous research, will increase the contextual effect found in the response ratios such that it also appears in the accuracy data. Therefore, increasing the presentation durations of the context displays to conform with previous research formed the basis of experiment three.

Experiment 3

Pilot testing confirmed that two seconds was long enough for the short sentence contexts to be processed effectively. This was done by presenting the practice and experimental legal sentences under the presentation conditions used in experiments one and two to eight participants who were asked to repeat the sentence after each trial. No participant had any difficulty in reporting the contexts and chose the correct target on an average of 80% of the trials. However, longer presentations may increase contextual influence. Duffy et al. (1989) found that increasing the duration between context and target improved naming latencies for neutral and incongruous sentences. Moreover, Keefe and Neely (1990; see also Seidenberg, Waters, Sanders & Langer, 1984) provided evidence that effects of context take time to build to a facilitative level of activation. Therefore, contexts were presented for two and five seconds in experiment three. These particular durations also represent those most commonly used in sentence research (i.e., Duffy et al., 1989; Keefe & Neely, 1990; Morris, 1994; Seidenberg, Waters, Sanders & Langer, 1984).

Method

Participants. Sixteen paid participants between the ages of 18 and 35 years were

recruited from the student population of St. Andrews University. Each participant took part in two 40 minute sessions, all participants had normal or corrected-to-normal vision and were native speakers of English. No participant had taken part in experiments 1 or 2.

Design To avoid any disruption produced by changing the duration of the display, each participant viewed the context displays at the same duration throughout each session. Thus, as they arrived at the laboratory, participants were assigned either the 2 or 5 second display duration for the initial session. Participants were then shown the context displays for the alternative duration when they returned for the second session.

Additionally, to ensure that the critical manipulation (context duration) could be accurately assessed, participants were shown the same stimulus group (A or B) during both sessions (context duration presentation order and stimulus group were counterbalanced across subjects). All remaining aspects were the same as experiments 1 and 2. The mean exposure duration of targets in experiment 1 was 1.79 frames (10.74 ms).

Results

Legality responses were practically error free (<1%) indicating that participants were processing the context displays appropriately. Mean percentages of target words correctly reported for each context display type are shown in Figure 7. An ANOVA was conducted with two between-subjects factors, [stimulus group (group 1 or 2) and presentation duration order (2 or 5 seconds first session)] and three within-subjects factors [context type (legal, word replacement, nonword, transposed and single word), context duration (2 or 5 seconds) and critical letter position]. A main effect of context

$F(4,60)=7.82, p<.01, MS_e=3.342$, was found. Newman Keuls tests revealed that target word report was significantly greater in legal contexts than in word replacement contexts, $p<.04$, nonword contexts, $p<.003$, and single words, $p<.0001$. Moreover, targets in word replacement and transposed contexts were reported more accurately than single words, $p<.02$ and $p<.002$ respectively.

Analysis by items revealed a similar pattern of effects as the subject analysis. A main effect of context, $F(4,80) = 19.628, p <.01, MS_e=14.562$ was found. Newman Keuls revealed this was due to the superior performance for all contextual conditions over single words (all p 's $<.001$). No other main effect or interaction was significant.

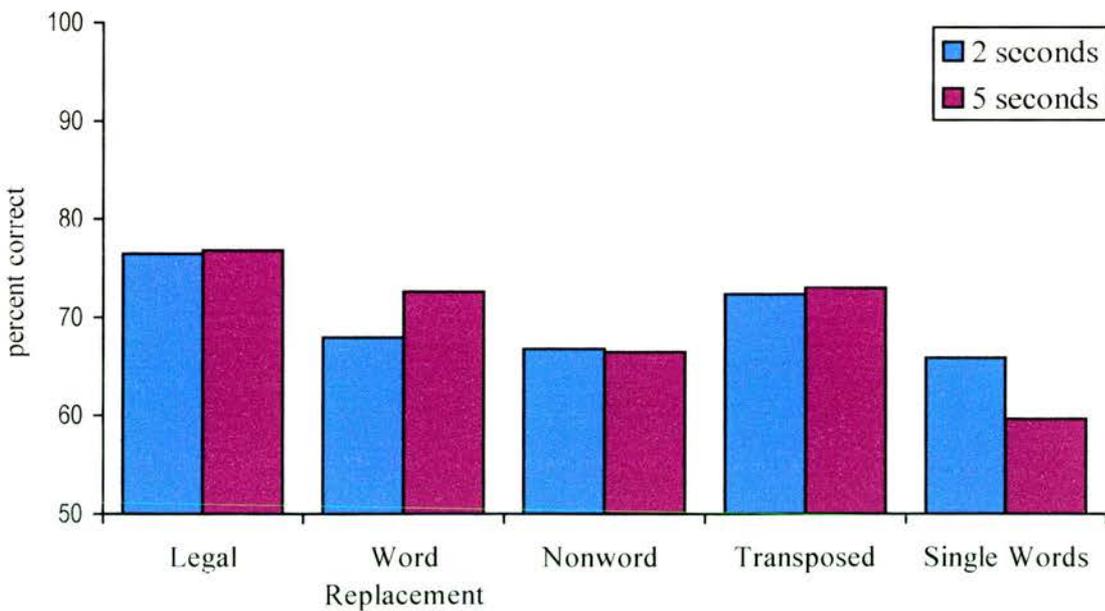


Figure 7. Mean percentage of target words correctly reported for each context display type in experiment 3.

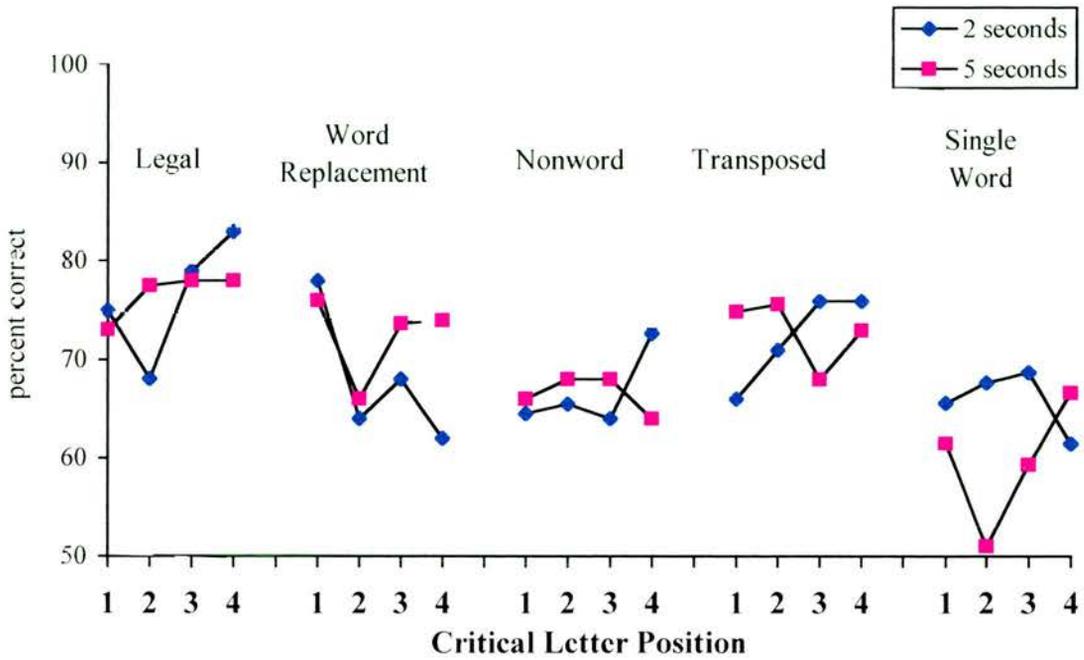


Figure 8. Mean percentages correct for each critical letter position in each sentence display type for experiment 3.

The response ratios are shown in figure 9. T-tests conducted on the results of the response ratio formula showed that both alternatives were accurately selected more often in Legal contexts than in baseline [member 1 $t(15)=3.17$, $p<.01$; member 2 $t(15)=4.24$, $p<.001$]. Perception of targets in legal contexts were significantly enhanced over baseline and in the absence of response bias in both legal and transposed conditions as all ratios were above baseline. Response ratios were; legal member 1 (0.53) member 2 (0.53), word replacement, member 1 (0.496), member 2 (0.509) and transposed, member 1 (0.515), member 2 (0.518).

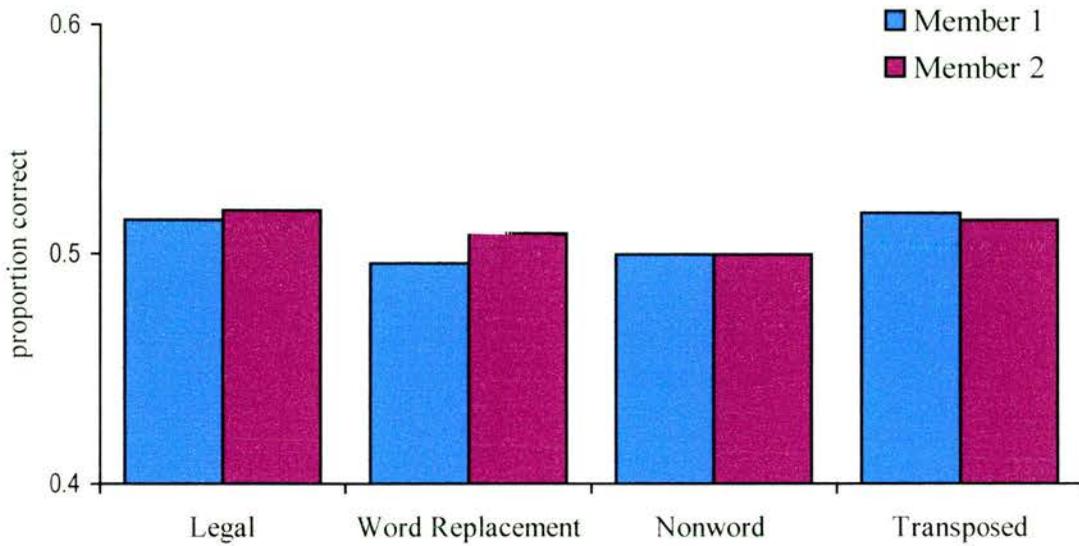


Figure 9. Response bias ratios for targets in each sentence context type for experiment 3.

Discussion

Despite the stringent testing conditions used in these experiments, accuracy of target word report was greater for simple legal contexts than word and nonword replacement controls. Moreover, transposed sentences were reliably reported as ‘illegal’ yet produced greater accuracy of target word report relative to the baseline, nonword condition. This suggests that legality per se does not account for all of the facilitation afforded by legal sentences and that illegality cannot fully account for the lack of facilitation in transposed sentences found elsewhere (i.e., O’Seaghdha, 1989, 1997; Simpson et. al. 1989).

Contrary to the findings of Duffy et al. (1989), increasing the duration of sentence

contexts from two to five seconds had no effect on the advantage conferred on target word report in the legal condition. Duffy et al. suggested that increasing the time available to process the context before onset of the target prevented residual integration processing of targets with contexts from interfering with target perception. However, it is possible that the rapid serial visual presentations (RSVP) used by Duffy et al. necessitated an integration process that the present experiment did not require. Unlike RSVP presentations where the sentence unfolds one word at a time, experiment three presented the whole context simultaneously before and during target presentation. This mode of presentation mirrors natural reading more closely and may have facilitated the use of natural sentence processing in these experiments. This distinction may also account for the finding that transposed sentences showed contexts effects in Experiment 3 but not in previous studies using RSVP (i.e., O'Seaghdha, 1989, 1997; Simpson et al., 1989). Moreover, the bias found in experiments one and two with transposed contexts disappears at these longer contextual durations. It would seem that increasing the duration of the context sufficiently to enable participants to complete the transposition process eliminates post-perceptual decisions being made to complete the task.

The absence of an interaction between context and critical letter position indicates that the advantage conferred on word recognition by the legal sentence contexts was consistent across letter positions. This suggests that legal contexts enhanced word recognition without changing its nature. Indeed, the letter position data underscore the evidence from the primary analysis and response ratio analysis that legal sentence contexts enhanced the processes underlying word recognition.

This evidence is hard to reconcile with a weak modular account of word

recognition which predicts no contextual influence under the testing conditions used in experiment three, where the effects of semantic association and sophisticated guesswork were suppressed. Rather, the findings of experiment three support a more interactive perspective which argues that feedback from the semantic level aids perception of targets by constraining the activation of unlikely word candidates. Therefore, experiment three, has found a sentence superiority effect and provides sentential research with a similar framework to that provided by the word superiority effect in single word recognition, namely, where targets are recognised more efficiently in legal sentences compared to transposed and word replacement contexts (pseudo sentences), nonword contexts and single words in descending order.

General Discussion

Experiments one, two and three redressed inadequacies in previous sentential research by comparing the influence of simple legal sentence contexts, constructed to suppress word association, on target word recognition using visually matched control sentence contexts together with the Reicher-Wheeler task (to suppress the distortion of performance by sophisticated guesswork). The experiments used low constraining legal contexts that did not define either member of a word pair, yet both members of the word pair were reported more accurately in the legal and transposed conditions of experiment three. Moreover, even at the extremely brief contextual durations of experiments one and two, analysis of response ratios showed positive contextual influence in legal contexts and a biasing trend in transposed conditions. In both experiments one and three there were very few errors in verbal reports of 'legality' and no response bias in legal contexts,

demonstrating that participants processed the stimuli appropriately and that legal stimuli formed legal, meaningful sentences when completed by either member of their target word pairs. The absence of response bias in all three experiments, outwith transposed contexts, indicates that the Reicher-Wheeler task was fulfilling its role and that participants were not using legal contexts as a means of resolving partially processed information extracted from the target. Moreover, the bias in transposed conditions confirms the task's efficiency in producing data from which it is possible to determine the level of strategic processing in sentence research and demonstrates the usefulness of using a paradigm that is sensitive to the nuances of 'intelligent' processing,

Consequently, the results of this series of experiments argue against a weak modular account of sentence processing. According to this account, legal contexts can influence word recognition only through intralexical spreading activation or sophisticated guesswork. In particular, the weak modular perspective predicts that where there is little semantic word association present in a sentence, a set of word candidates is generated on the basis of visual input from the target. The context speeds up target recognition by 'filling in' gaps in the visual input when a decision is required as to the identity of targets such as in a forced choice paradigm. However, legal contexts provided no defining clue as to the identity of the targets (e.g., 'it began to fl-p' could equally be *flop* or *flap*), yet targets in legal sentences were reported more accurately than both visually controlled (word and nonword replacement) contexts in experiment three. This suggests that sentence contexts influenced word recognition accuracy over and above decision based, post-perceptual processing either in the form of sentential or lexical constraints.

Moreover, despite the low constraints exerted by legal contexts on targets none of

the experiments presented in this chapter revealed inhibitory influences on target recognition in legal contexts. Indeed, even when contexts were presented at very brief durations, chosen to stretch the system to its limits of sentence processing (Morrison, 1984) and validated by the errors in legality reports for the transposed sentences of experiment one, response ratios indicate an improvement in word recognition in legal sentences. Therefore, results (e.g., Forster, 1981; Duffy et al., 1989) which suggest that standard neutral sentences reflect inhibition on word recognition may, in fact, be due to the frequency with which they appear in experimental sessions. This proposal is supported by the results of Duffy et al. where standard neutral sentences, presented on many occasions with different targets, slowed naming latencies to the same level as incongruous sentences whereas subject/verb neutral sentences (which were novel for each target) did not. For example, there is very little difference in terms of constraints between their standard neutral ‘They said it was the *mustache*’ and their subject neutral ‘The woman saw the *mustache*’, both of which are similar in constraints to the stimuli used in this chapter (e.g., ‘it began to *flop*’). Consequently, the present findings conform with Forster’s proposal that the use of standard neutral sentences in sentential research confounds the results and speak in favour of nonword and word replacement contexts as more adequate baselines for future research. The present findings, however, refute the auxiliary proposal of Forster and Duffy et al., that low constraining sentences create inhibition at the integration stage and suggest that it is the repetitive nature of standard neutral sentences that cause the apparent inhibition. Moreover, finding a contextual influence on word recognition with very low constraining sentences suggests that naming latencies may not be sensitive enough to examine the complex process of word recognition

in contexts. The present findings indicate that sentence contexts influenced word recognition accuracy in an interactive fashion, over and above decision based, post-perceptual processing and post-perceptual integration of targets with sentence contexts.

Stoltz and Neely (1995) have proposed an alternative hypothesis for semantic priming effects based on the *multistage activation model* of Besner and Smith (1992; Smith, Besner & Miyoshi, 1994). This model proposes two possible routes for the influence of context on word recognition. When the visual input from the target stimulus corresponds to a word node pre-activated by context, word identification is enhanced through pathway A, which links the orthographic system to the semantic system by monitoring the semantic system. Alternatively, activation in the semantic system feeds back to the orthographic system through pathway B, resulting in less data driven information being required to activate the target representation. However, as the results of the Stoltz and Neely study demonstrate, the activation through pathway B is not automatic or mandatory. In a resource limited system, this feedback will incur cost and will be operational only where there is a high likelihood that the benefits outweigh the costs; that is, when there is a high proportion of items that can utilize the information provided by the pathway.

The *multistage activation model* fits very well with the findings of the present study. Since the stimuli were low constraining, pre-activation of all possible nodes in the semantic system would be unlikely to have been complete before target onset. However, legal contexts would have constrained the number of alternatives activated by the visual input from targets through pathway A. Pathway A would be the most likely candidate for the effects found in this chapter because there is not a high proportion of legal sentences

to bring pathway B into operation. For example, when the target *vast* or *east* was presented, the visually defined set would include *cast, east, fast, last, mast, oast, past* and *vast*. However, as this information feeds into the semantic system the context, ‘the hill looks’, would reduce the number of possible candidates and improve word perception. This process is consistent with the legal advantage observed in experiment three.

The results with transposed sentences provide a valuable insight into sentence processing. The finding that transposed sentences are often processed as legal sentences at short presentation durations suggests that syntactic assignment is not an immutable early process that proceeds contextual influence as proposed by O’Seaghda (1989; 1997). Instead it appears that post-perceptual processing is employed by participants to complete the task where syntactic anomaly is detected. This proposal gained credence when the slightly longer contextual presentations of experiment two gave participants enough time to process and register the anomaly but maintained the trend towards post-perceptual processing in transposed contexts. In experiment three, where participants had ample time to process the anomaly and to extract the underlying meaning from transposed sentences, the trend towards post-perceptual processing disappeared, and word recognition was more accurate in this condition than in nonword control sentences. Taken together these results suggest that contextual influence is largely independent of word order or syntactic assignment per se. However, where syntactic anomaly is detected but readers have insufficient time to transpose sentences then this additional processing interferes with target word recognition and participants complete the task by sophisticated guesswork, at least on some occasions.

In summary, the findings suggest that word recognition is facilitated during sentence reading over and above effects produced by semantic word association and sophisticated guesswork. This evidence contradicts a weak modular account of word recognition. Moreover, the evidence from experiment three finds in favour of a *multistage activation model* of word identification such as that proposed by Besner & Smith (1992; Smith, Besner & Miyoshi, 1994; Stoltz & Neely, 1995). Additionally, this study presents evidence that illegality may not be the source of poor facilitation in transposed sentences but that disruption of more rudimentary cues may play an important role in sentence processing. More generally, the findings emphasise the need for more carefully controlled visual content and target presentation in sentential research.

CHAPTER THREE

Chapter two established that low constraining legal sentences confer an advantage on target word recognition in a manner consistent with a modified interactive perspective. In an effort to test contextual influence unconfounded by factors which may detract from sentential effects, in particular similarity between legal contexts, the low constraining sentences of chapter two were varied. This procedure makes it difficult to examine whether some types of sentence have a greater influence than other types on word recognition. There is considerable evidence that some types of word are more easily recognized than others. For example, nouns are recognized faster than verbs, concrete words are recognized faster than abstract words. Experiment four examined the possibility that concrete words may be afforded more word facilitation than more abstract words in sentence reading (concreteness effect) by presenting low constraining sentences that ended in either concrete or abstract target words. This task was chosen because concrete words have an advantage over abstract words in a variety of tasks;

1. word recognition (i.e., Begg & Paivio, 1969)
2. lexical decision (i.e., Bleasdale, 1987; Kroll & Merves, 1986)
3. naming (i.e., de Groot, 1998)
4. comprehension, (i.e., Holmes & Langford, 1976; Moeser, 1974; Schwanenflugel & Shoben, 1983)
5. recall (i.e., Gee, Nelson & Krawczyk, 1999; Marshark & Paivio, 1977).

Schwanenflugel and Shoben (1983) have shown that decisions regarding concrete words and sentences are faster than decisions about abstract words and sentences yet the concrete/abstract differences disappear when presented in the

presence of strong semantic context in the form of sentences or ongoing text. Schwanenflugel and Shoben propose that concrete words are more contextually independent than abstract words, which depend on the surrounding context for interpretation. Under this context availability model (Brensdorf & McCarrell, 1974; Kieras, 1978; Schwanenflugel & Shoben, 1983) comprehension is seen as an interaction between the readers knowledge base and the stimulus context. According to this proposal concrete words have stronger connections to associated information perhaps because they appear in less diverse contexts and are generally more familiar - they have a 'tighter fit' both with their surrounding context and with existing knowledge bases than abstract words do. Concreteness effects arise, therefore, because individuals comprehend concrete words more easily as they find it easier to retrieve the associated contextual information for concrete words than abstract words. The model predicts that concrete and abstract words should be equally easy to understand when presented in a supportive context because contexts serve to pre-activate related information in prior knowledge. This pre-activation helps to override the relative difficulty in comprehending abstract words. In other words, the concreteness effect is present where there is little supporting context to define abstract words and disappears where strong sentence contexts are presented.

Under these circumstances, the concreteness effect should be maintained in sentences, similar to those already presented in chapter two, which do little to constrain the identity of targets before they are presented. This is likely because there is insufficient contextual support to aid recognition of abstract words that rely more on the surrounding context. Thus legal sentences ending in concrete words would be expected to demonstrate a stronger recognition advantage over all other conditions and concrete words in legal sentences should be recognised more accurately than

abstract words in legal sentences. Alternatively, if the concrete/abstract differences are eliminated by contextual influence without the necessity for semantic association or strong contextual influence then there should be little difference between the findings of experiments three and four.

Experiment 4

Experiment four examined the influence of legal, low constraining sentences on the concreteness effect using visually matched word replacement, nonword and transposed control sentences and the Reicher-Wheeler task to suppress sophisticated guesswork. If Schwanenflugel and Shoben (1983) are correct and abstract words are more contextually dependent than concrete words then where sentences are very low constraining it is likely that the concreteness effect will still be present. Under these circumstances the legal sentences ending in concrete words will demonstrate a recognition advantage over abstract words in legal contexts. Additionally, if abstract words rely on strong supporting contexts to improve word recognition, these legal sentences may not produce an advantage over control sentences. If, however, sentential contexts themselves iron out the differences between concrete and abstract representations then the same pattern of results as experiment three should be found.

Method

Participants. Sixteen paid participants between the ages of 18 and 35 years were recruited from the student population of St. Andrews University. Each participant took part in two 40 minute sessions, all participants had normal or corrected-to-normal vision and were native speakers of English. All participants were naive to the experimental paradigm.

Stimuli. Stimuli were constructed in the same way as those of experiments one, two and three but legal sentences were designed such that half could be completed by a concrete words and the other half could be completed by more abstract words. In order to construct sentences that comply with the constraints already outlined in the previous chapter, namely that sentences should be four words long, contain no semantic association, be simple and completed by four letter target words, concrete targets were nouns and abstract words were descriptive. For example, each base sentence either referred to an action or to a subject noun (i.e., *kicked, threw, go into* and *use* or *boy, man, horse, and town*), which enabled targets to be concrete or descriptive. For example, the legal context ‘kicked on the ----’ was completed by the word pair *shin/chin* to form the concrete target condition and the legal context ‘the horse was ----’ was completed by the word pair *lame/tame* to form the abstract condition. Each target word pair altered by one letter in each letter position (e.g., *shin/chin, lame/tame, dart/dirt, bold/bald, cage/cave, dark/dank, coat/coal, near/neat*).

e.g.	Concrete targets	Abstract targets
(L)	kicked on the shin/chin	(L) the horse was lame/tame
(R)	herbal as flu shin/chin	(R) flu leg son lame/tame
(N)	donfot er blu shin/chin	(N) klo huj mard lame/tame
(T)	on the kicked shin/chin	(T) horse was the lame/tame

Where (L) is legal context, (R) is word replacement context, (N) is nonword context and (T) is transposed context.

Design. As there was no effect of context duration in experiment three and two seconds was considered the more natural reading time for such short sentences,

contexts were presented for 2 seconds. All other aspects of experiment four were the same as experiments one and two. The single word condition was deemed redundant at these presentation durations because of the sentence context superiority effect in experiment three when compared to single words including the baseline nonword contexts. The mean exposure duration of targets in experiment 4 was 2.54 frames (15.24 ms).

Results

Legality reports were practically error free (<1%), indicating that participants were processing the contexts appropriately. Mean percentages of target words correctly reported for each context display type is shown in figure 10. An ANOVA was conducted with one between-subjects factor [stimulus group presentation order (group 1 or 2 in session A)]; and three within subjects factors [word type (noun or verb), context type (legal, word replacement, nonword, and transposed) and critical letter position]. A main effect of word type, $F(1,15)=72.309$, $p<.001$, $MS_e=70.38$, was found. Concrete words were reported more accurately than abstract words. No other main effect or interaction was found.

Analysis by items revealed a main effect of word type $F(1,31)=44.123$, $p<.01$, $MS_e=77.27$. Concrete words were more accurately reported than abstract words.

Although no interaction was found with context and word type was found, inspection of figure 10 shows the expected trend for concrete words being reported more accurately in legal contexts than abstract words. Indeed, concrete words seem to follow the same pattern as experiment three, whereas context seems to have had no impact on recognition of abstract words. To see if this was reliable separate ANOVA's were conducted on concrete and abstract targets. Concrete targets

produced a main effect of context, $F(3,45)=2.858, p<.05, MS_e=79.81$. Newman Keuls revealed that concrete targets in legal contexts were reported more accurately than those of nonword contexts, $p<.002$. No other main effects or interactions were reliable for either ANOVA.

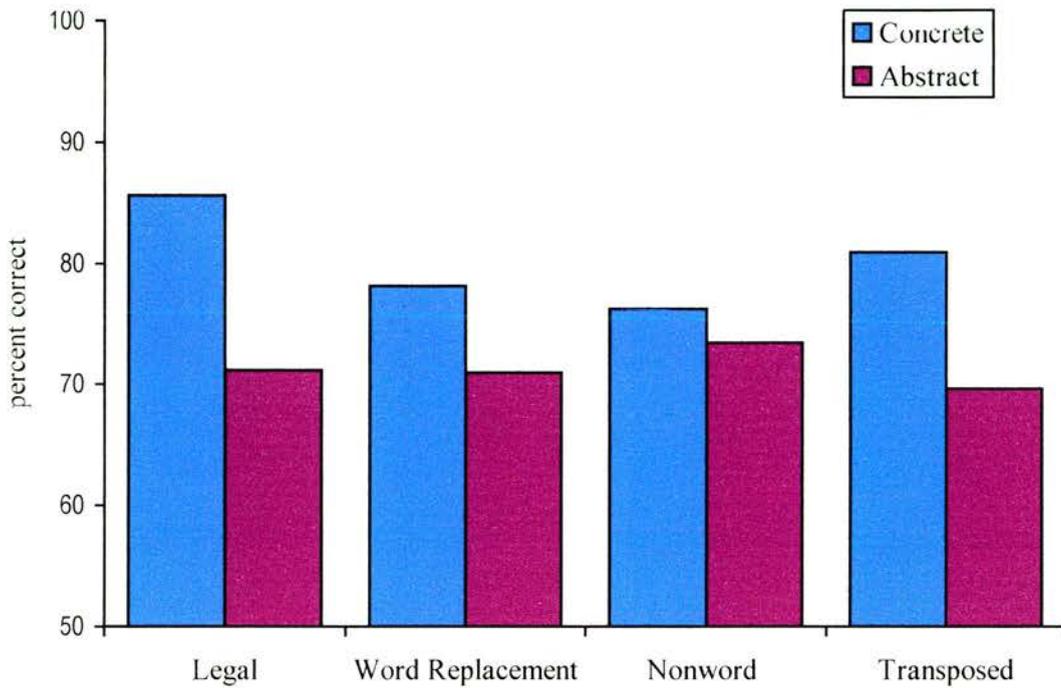


Figure 10. Mean percentage of concrete and abstract target words correctly reported for each context type in experiment 4.

Response ratios are shown in figure 11. T-tests were conducted on the proportional data, and no response bias was found and legal concrete member 1, $t(1,15)=2.76, p<.01$; and member 2, $t(1,15)=1.67, p<.05$ were enhanced above baseline. Response ratios were, legal concrete member 1 (0.536), member 2 (0.525); word replacement concrete member 1 (0.501), member 2 (0.503); transposed concrete member 1 (0.506), member 2 (0.515). Legal abstract member 1 (0.501), member 2

(0.481); word replacement abstract member 1 (0.494), member 2 (0.496); transposed abstract member 1 (0.512), member 2 (0.460).

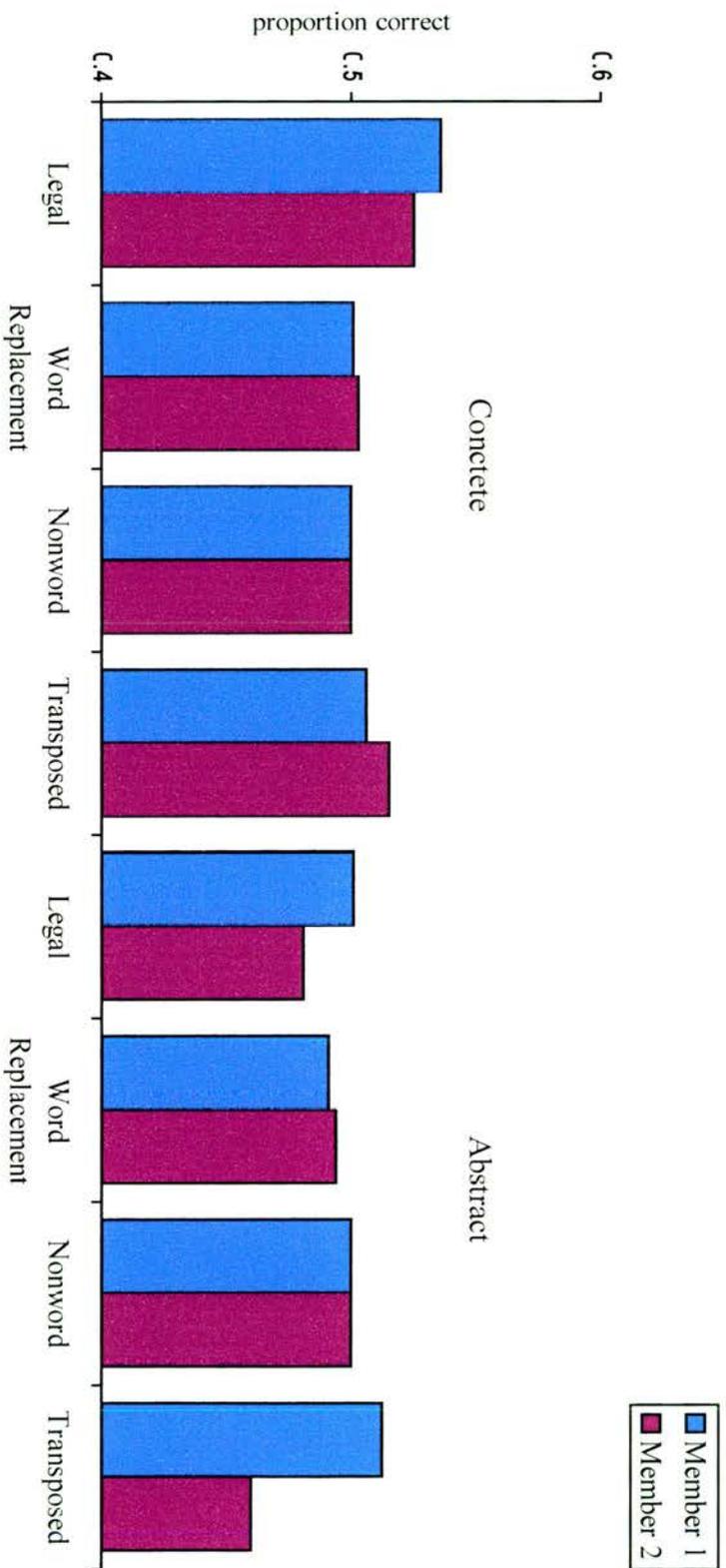


Figure 11. Response ratios for experiment 4.

Discussion

The overall accuracy findings of experiment four indicate that both concrete and abstract words are not facilitated by low constraining sentences. There was a concreteness effect but this was additive across conditions, performances in legal sentences did not differentiate between concrete and abstract targets. In fact, the sentence superiority effect found in the previous chapter completely disappeared in the accuracy analysis. However, legal concrete member 1 and 2 targets show an increased response ratio over those of baseline. Moreover, when analysed alone legal sentences with concrete targets showed the expected pattern of improved performance over nonword contexts, whereas abstract targets were reported at similar levels across conditions. This indicates that the present findings lend some support to the proposal of Schwanenflugel and Shoben (1983) that abstract words are more contextually dependent than concrete words. Where the legal sentence contexts were designed to suppress semantic associations and to limit contextual constraints, abstract words did not benefit from any additional support from context influence whereas concrete words did.

It seems unlikely, however, that there would be such a dramatic elimination of contextual influence found in experiment three in the overall accuracy results ($p > .2$) by altering sentence construction in this way. The stimuli of experiment four became more repetitive in nature than those of experiments one, two and three because of the constraints exacted by the need to control target types (i.e., the boy went *fast/last*, the horse was *lame/tame*). An additional proposition, already put forward in the general discussion of chapter two, is that presenting a repetitive type of legal stimuli affected the

configuration of the experimental procedure in such a way that the nature of participant's natural reading process was disrupted. This was examined in experiment five.

Experiment 5

Experiment five was designed to examine a proposal introduced in the preceding chapter. Repetition was proposed as the source of inhibition effects found with standard neutral sentences against which experimental sentences are often measured. These standard neutral sentences usually take the form of 'the next word will be ----' and are repeated throughout experimental sessions completed by each target word. Both Duffy et al. (1989) and Forster (1981) found this type of sentence produced inhibitory effects on target word performance and Forster found that performance for targets in appropriate sentences reached an advantage over standard neutral sentences but not over his random word list baseline. Forster (1981) concluded that sentential effects are the result of an integration process whereby targets are more easily integrated with their contexts. Where low constraining sentences are concerned the integration process can actually interfere with word recognition. Both Duffy et al., (1989) and Forster (1981) proposed that it is this automatic integration process that interferes with word recognition in standard neutral sentences. However, chapter two proposed that it is the repetition of standard neutral sentences that create a Stroop like effect, as proposed by West and Stanovich (1986) for the inhibition results of their incongruous sentences. If this proposal is correct, the similarity of the sentences in experiment four will hinder word recognition in legal contexts.

Method

Participants. Sixteen paid participants between the ages of 18 and 35 years were recruited from the student population of St. Andrews University. Each participant took part in two 40 minute sessions, all participants had normal or corrected-to-normal vision and were native speakers of English. All participants were naive to the experimental paradigm.

Stimuli. Stimuli were constructed in the same way as those of Experiments 1, 2 and 3 except that legal sentences were designed to be similar up to presentation of targets. For example, each base sentence referred to a subject noun, (i.e., *boy, man, horse*, rather than ‘it began to’, ‘run into the’, and ‘hide the black’) and targets were largely descriptive, such that each sentence followed the pattern of ‘the something was ----’. For example, the legal contexts ‘the horse was ----’ was completed by the word pair *lame/tame*. Each target word pair altered by one letter in each letter position (e.g., the horse was *lame/tame*, the man was *bold/bald*, the cellar was *dark/dank*, the town was *near/neat*).

e.g.

- (L) the horse was lame/tame
- (R) flu leg son lame/tame
- (N) klo huj mard lame/tame
- (T) horse was the lame/tame

Where (L) is legal context, (R) is word replacement context, (N) is nonword context and (T) is transposed context.

All other aspects of experiment 5 were the same as experiments 1, 2 and 4. The mean exposure duration of targets in experiment 5 was 3.01 frames (18.06 ms).

Results

Legality reports were practically error free (<1%), indicating that participants were processing the contexts appropriately. Mean percentages of target words correctly reported for each context display type is shown in Figure 10. An ANOVA was conducted with one between-subjects factor [stimulus group presentation order (group 1 or 2 in session A)]; and three within subjects factors [stimulus group (1 and 2), context type (legal, word replacement, nonword, and transposed) and critical letter position]. A main effect of critical letter position, $F(3,42)=3.23$, $p<.05$, $MSe=420.879$, was found. Newman Keuls revealed that critical letter position 4 was reported more accurately than critical letter position 1, $p<.04$. No other main effect or interaction was found.

Analysis by items revealed no main effects or interactions.

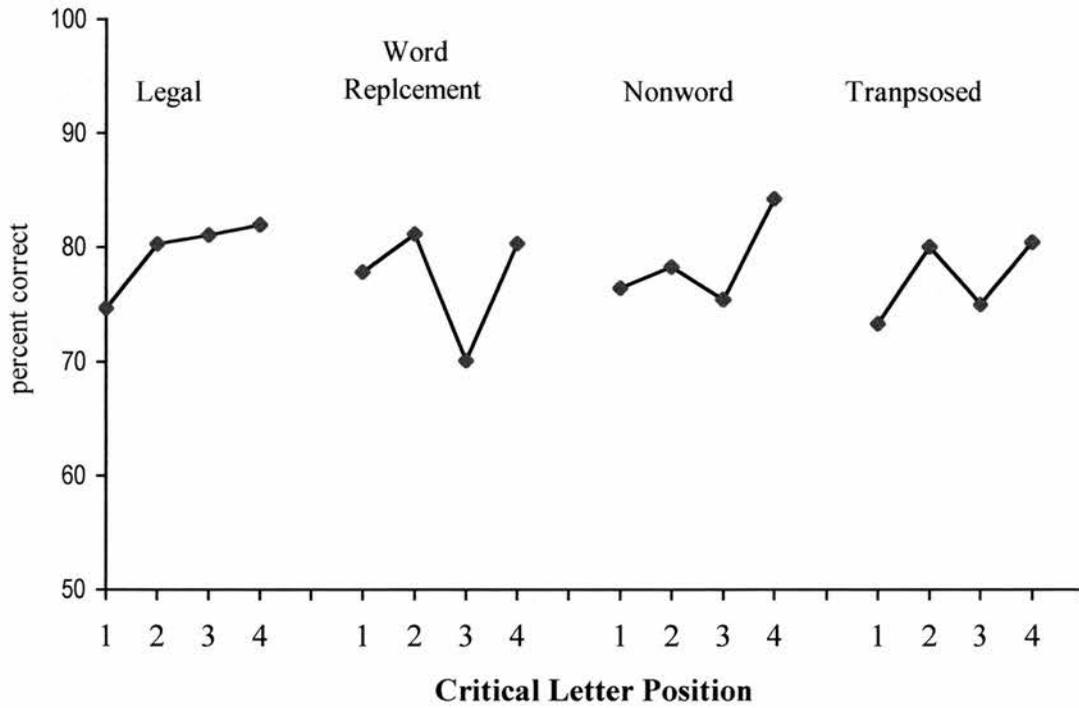


Figure 12. Mean percentage of target words correctly reported for each critical letter position in each context condition of experiment 5.

Response ratios are shown in figure 13. T-tests were conducted on the proportional data, there were no significant results and no response bias was found. Response ratios were, legal member 1 (0.505), member 2 (0.51); word replacement, member 1 (0.494), member 2, (0.496); transposed member 1 (0.509), member 2 (0.498).

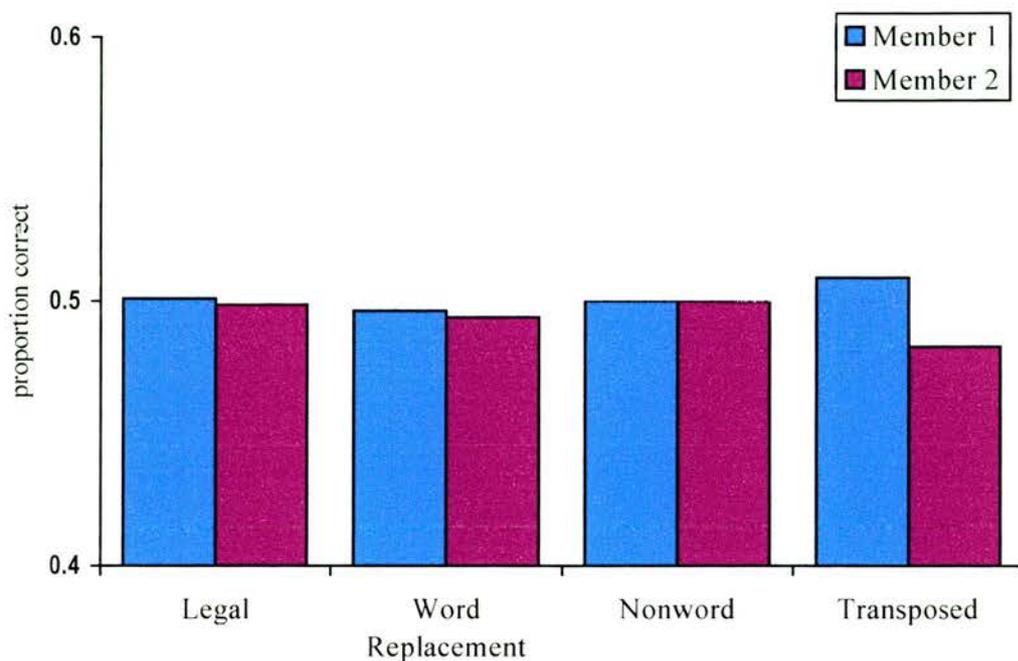


Figure 13. Response ratios for experiment 5.

Discussion

The present findings, therefore, support the proposal that similar very low constraining sentences actually degrade legal sentence processing by introducing some level of Stroop like interference on target recognition. Although there was no actual inhibition effect, legal sentences did not demonstrate greater word recognition. This may have been due to the fact that legal sentences were not identical in the way standard neutral sentences are (i.e., standard neutral, ‘the next word will be ----’; experiment five, the horse was *lame/tame*, the man was *bald/bold*, the cellar was *dark/dank*, the village was *near/neat*).

Suppressing the effects of visual cues that may be extraneous to contextual influence may make recognition of targets easier across all contextual conditions and enable a greater contextual influence to emerge. Since it is more than likely that participants use visual matching between target and response choice (at least to some extent) in order to complete the task accurately it is possible that visual matching makes word recognition easier in ways that are independent of contextual influence. Although the potential for visual matching is the same in all conditions it may have the effect of levelling off some of the contextual influence. For example, it is likely that visual matching is used in conjunction with contextual influence in legal sentence reading yet participants may match factors like word shape more in nonword conditions where there is contextual support. In this case visual matching in nonword conditions may have the effect of neutralising the contextual influence of legal sentences. This is more likely to conceal contextual effects where there is some interference in legal contexts, as in experiment four. Thus, suppressing the effects of visual matching between target and forced choice alternatives formed the basis of experiment six. Under these conditions, if contextual influence was less strong in experiment four because of the factors already stated, there will be an increase in legal sentence performance accuracy. On the other hand, if unreliable effects of experiment five were because concrete sentences do not influence word recognition then suppressing the effects of such visual cues will have no influence on the findings of experiment six.

Experiment 6

Experiment six presented all forced choice alternatives in uppercase. This left the actual target presentations in lowercase maintaining a natural reading environment but removed many of the shape cues that could have been extracted from targets in the forced choice presentation, thus suppressing the availability of visual matching to artificially aid word recognition.

Method

Participants. Sixteen paid participants between the ages of 18 and 35 years were recruited from the student population of Nottingham University. Each participant took part in two 40 minute sessions, all participants had normal or corrected-to-normal vision and were native speakers of English. All participants were naïve to the experimental task.

Stimuli. Stimuli were the same as those used in experiment 4 except the forced choice alternatives appeared in uppercase while the targets remained in lowercase. All other aspects of experiment 6 were the same as experiment 5. The mean exposure duration of targets in experiment 6 was 5.36 frames (32.16 ms).

Results

Meaningful reports were again practically error free (<1%) indicating that participants were processing the context displays appropriately. Mean percentages of target words correctly reported for each context display type are shown in figure 14. An ANOVA was conducted with one between-subjects factor [stimulus group presentation order (group 1 or 2 in session A)]; and three within subjects factors [stimulus group (1

and 2), context type (legal, word replacement, nonword, and transposed) and critical letter position]. A main effect of context was found $F(3,42)=5.644; p<.01; MSe=5.64$. Inspection of figure 14 shows that target words in legal sentences were reported more accurately than in all other conditions. Newman Keuls revealed that target words in legal sentences were reported more accurately than in all other conditions, all p 's $<.005$.

Analysis by items revealed a similar trend to the subject analysis, main effect of context $F(3,120)=5.515, p<.001, MSe=3.720$. Newman Keuls revealed this was due to the superior performance of targets in legal contexts over all other contexts, all p 's $<.005$. No other main effect or interaction was reliable.

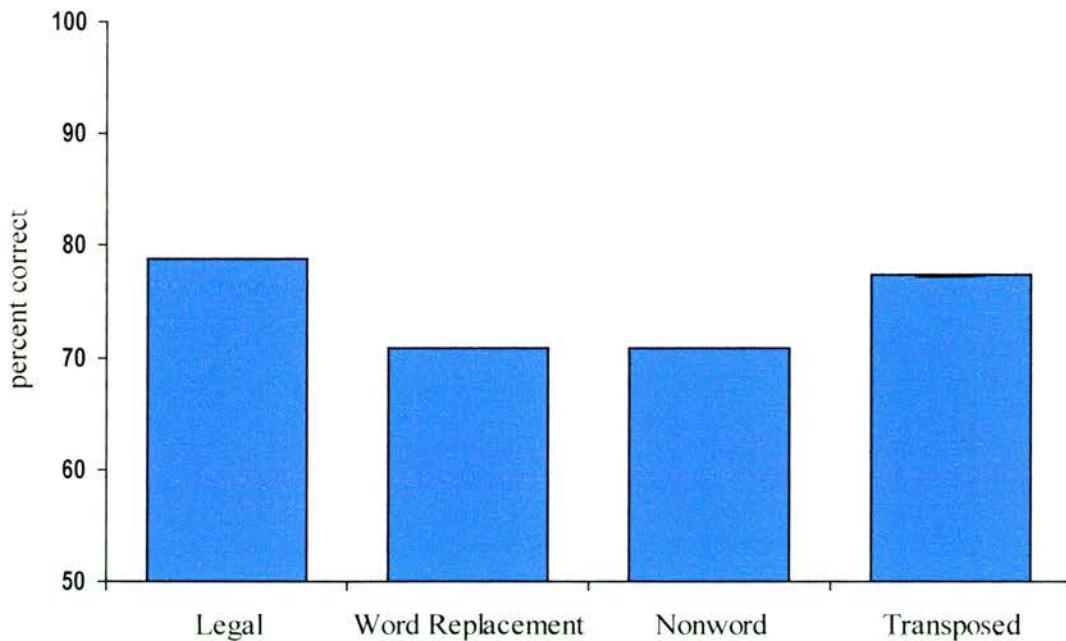


Figure 14. Mean percentage of correct target reports for each contextual type in experiment 6.

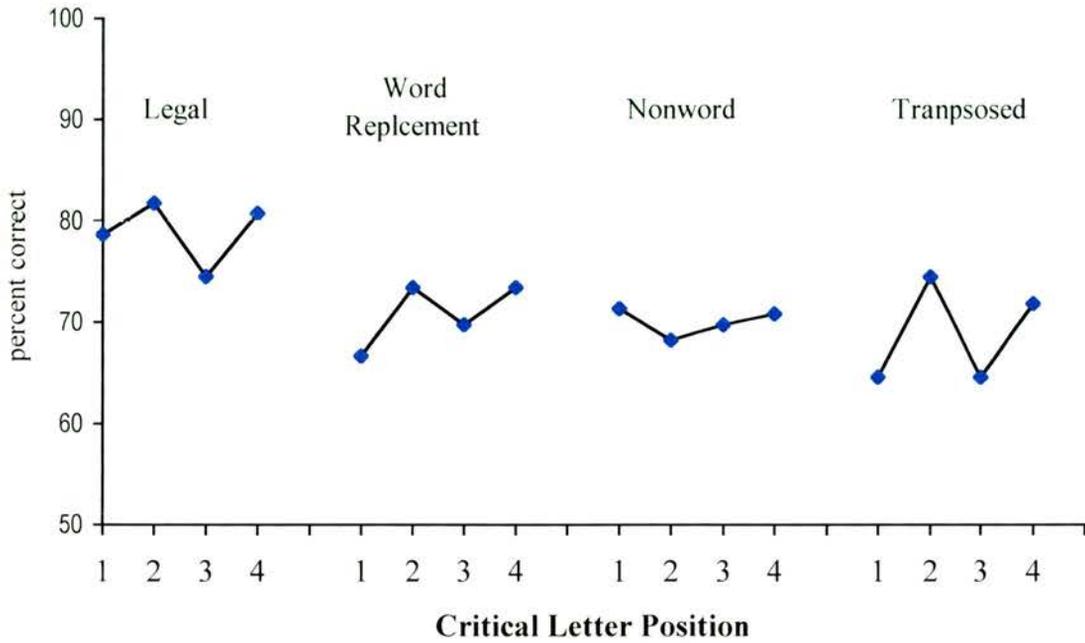


Figure 15. Mean percentage of critical letter position correctly reported in experiment 6.

Response ratios are shown in figure 16. T-tests for Dependent Samples were conducted on the proportional data, both members in the legal condition showed an increase over baseline, member 1, $t(1,15)=-1.861, p<.05$; member 2, $t(15)=4.417, p<.001$, confirming that words were recognised more accurately in this condition. Response ratios were legal member 1 (0.521), member 2 (0.540); replacement word member 1 (0.508), member 2 (0.496); transposed member 1 (0.490), member 2 (0.501).

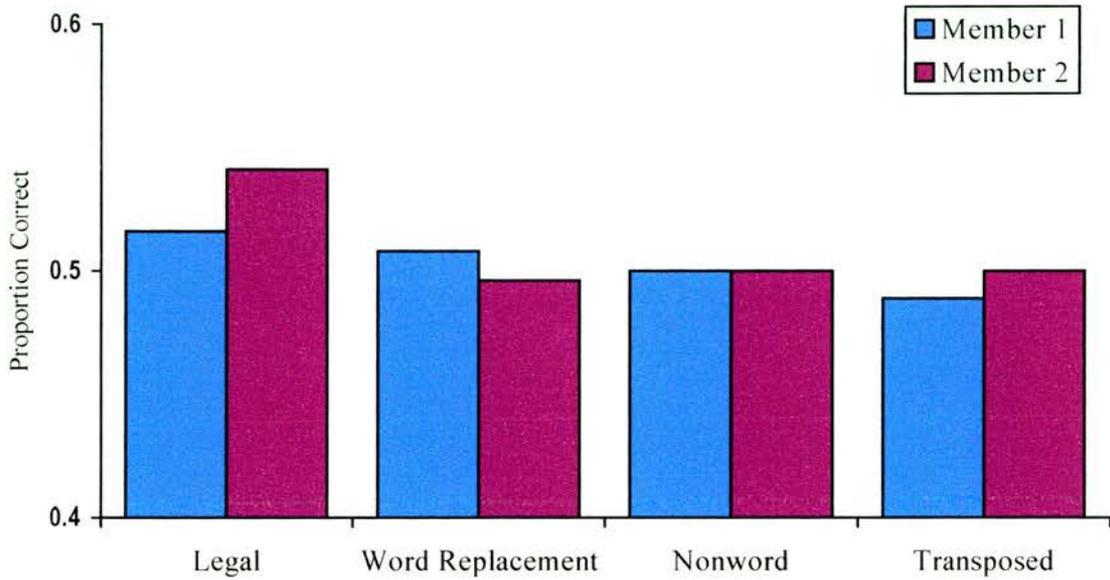


Figure 16. Proportion of responses in each context condition using nonword as baseline.

Experiment 6b

The results of experiment three were re-analysed, in the same way, using only those sentences which corresponded to the concrete stimuli of experiment 6 (i.e., ‘the room was *tidy/tiny*’). This left 6 word pairs out of 24. A main effect of context was found, $F(3,24)=3.257, p<.05, Mse=14.419$. Mean percentages correct are shown in figure 17. Newman Keuls revealed that performance for targets in legal sentences was greater than in nonword, $p<.05$, with a similar trend for word replacement, $p<.06$, while performance in transposed sentences showed a trend towards increased accuracy over the nonword baseline, $p<.07$.

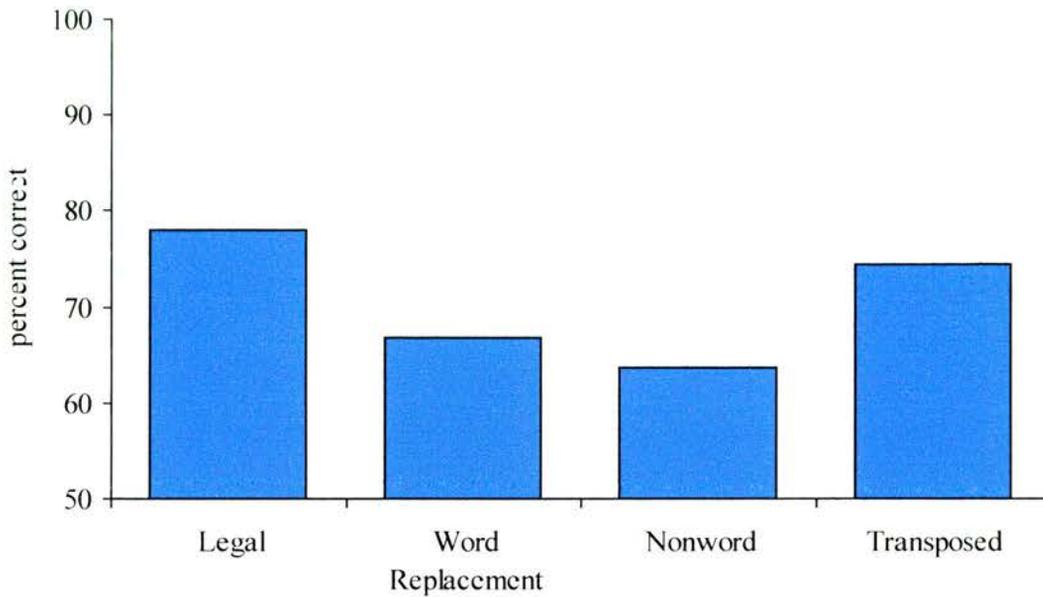


Figure 17. Mean percentage correct reports for targets in each condition in experiment 6b.

Experiment 6c

Since the results of experiment six are dramatically different from the results of experiment 5, yet both use exactly the same design and stimuli, their combined results were analysed together. If performance was artificially enhanced in experiment five by visual matching in control conditions then performance should deteriorate between experiments five and six for those conditions. Additionally, if visual matching concealed a contextual effect then performance should improve or remain similar in the legal condition between experiment five and six. An ANOVA was conducted with one between-subjects factor [experiment (experiment 5 or 6)]; and three within subjects factors

[stimulus group (1 and 2), context type (legal, word replacement, nonword, and transposed) and critical letter position]. A main effect of experiment, $F(1,15)=20.448$; $p<.001$; $MS_e=108.894$ and context were found $F(3,45)=5.810$; $p<.01$; $MS_e=66.370$. Overall performance was superior in experiment 6. Newman Keuls revealed that target words in legal sentences were reported more accurately than in all other conditions, all p 's $<.05$. The critical interaction between experiment and context was significant, $F(3,45)=3.079$; $p<.05$; $MS_e=96.261$. Newman Keuls revealed that performance in legal contexts remained similar across experiments but performance deteriorated for all control conditions between experiments 5 and 6; nonword and word replacement, $p<.01$; transposed $p<.005$. No other main effect or interaction was reliable.

Discussion

Word recognition improved in legal contexts over all other conditions. Moreover, the response ratios show that being in a legal sentence perceptually enhanced both members of target word pairs. The cross experiment findings of experiment six c show that that visual matching between target and forced choice alternatives artificially enhanced performance accuracy in all control conditions during experiment five in such a way that the true nature of contextual influence was concealed. Visual matching between target and forced choice alternative plays a much lesser role in task completion in legal sentences than in any of the other context conditions. This finding strengthens the proposal of chapter three that legal sentence contexts do indeed facilitate word recognition in a modified interactive process. This conclusion is drawn because weak modular models emphasise the reliance on data driven input yet suppressing the use of

data driven cues within the task increased legal contextual influence over control conditions in a paradigm where the effects of predictability and sophisticated guesswork were also suppressed.

In order to check that the unreliable effects found in experiment five were due to the repetitive nature of the stimuli, all stimuli from experiment three that corresponded to the concrete stimuli of experiment five were reanalysed separately. If the findings of experiment five were due to sentence type then the same category of sentence in experiment three should also have obtained null results. However, the findings were similar to the original analysis of experiment three - performance improved in legal sentences over baseline and word replacement contexts. Moreover, experiment six c clearly demonstrates the differential influence visual matching has on legal compared to control conditions. The present findings, therefore, provide strong evidence that the repetitive nature of the stimuli were responsible for lack of contextual influence in experiment five. Moreover, the results suggest that very low constraining legal sentences, which are repetitive throughout an experimental session, produce large contextual effects provided the task controls for extraneous factors.

Notably, contextual influence in transposed contexts mirrored that of experiment three when the concrete sentences were reanalysed in experiment six b yet there was no trace of contextual influence in experiments five or six even when the effects of visual matching was suppressed. This implies that the alteration in processing caused by the repetitive nature of low constraining sentences may prevent meaning extraction from the transposed sentences. This makes intuitive sense in a system that allocates resources based on a cost/benefit analysis. The effort of reordering transposed sentences where

there is already interference would not seem to incur sufficient benefits to outweigh the costs. The contextual influence found in transposed sentences is not as strong as that of legal sentences in any of the experiments reported so far and the results of experiment five demonstrate that contextual influence in transposed sentences is more malleable than in legal contexts.

General Discussion

Experiment four found evidence of a concreteness effect for low constraining sentences providing some support for the context availability model (Brensdorf & McCarrell, 1974; Kieras, 1978; Schwanenflugel & Shoben, 1983). Abstract words did not show any contextual influence when presented in low constraining sentences whereas concrete words did in the response ratios and when analysed separately. Thus it would seem that abstract words are more contextually dependent and require stronger supporting contexts than concrete words in order to gain facilitation from sentence contexts. However, abstract target words were used exclusively in experiments five and six, yet null results were obtained in experiment five and strong contextual effects were found in experiment six where visual matching was suppressed by presenting forced-choice alternatives in uppercase. This suggests that abstract contextual influence may have been concealed by visual matching in experiment four. Nevertheless, the extent of visual matching would have been the same for both types of target, therefore, the indications are that concrete words would still have been reported more accurately than abstract words. The present paradigm examined word recognition in sentence contexts in a novel manner. Previous research into the concreteness effect have examined the comprehension process

and speed of processing (i.e., Bleasdale, 1987; de Groot, 1998; Gee, Nelson & Krawczyk, 1999; Holmes & Langford, 1976; Kroll & Merves, 1986; Marshark & Paivio, 1977; Moeser, 1974; Schwanenflugel & Shoben, 1983) rather than word recognition accuracy at the visual level. These present findings require further detailed research but the indications are that abstract words are more contextually dependent and that these concrete abstract differences may impact on the visual level of processing during word recognition.

When the forced choice alternative display was changed from lowercase to uppercase, the unreliable effects of experiment five became an extremely robust legal sentence advantage in experiment six, providing evidence that visual matching between target and forced choice alternatives plays a stronger role in control contexts than it does in legal contexts.

This provides additional evidence against the weak modular account of word recognition. According to the weak modular perspective, where word association and sophisticated guesswork is suppressed, word recognition is based purely on visual data driven information. Therefore, the suppression of visual cues to assist task completion should be an additive factor across all conditions and not differentially affect legal and illegal conditions. On the other hand, the modified interactive perspective places more emphasis on the sentence or conceptual level for the locus of contextual influence. The present findings demonstrate that by further isolating contextual influence from data reliant factors, in this case visual cues, almost negligible contextual effects can increase to a legal sentence advantage. This finding is consistent with a modified interactive perspective. Moreover, this finding raises the possibility that stronger contextual influences may have been concealed during experiments one, two and three and more

generally that certain data driven factors may artificially enhance performance in control conditions. This implies that the sentence superiority effect is a very strong effect even with low constraining sentences contrary to the predictions of the weak modular perspective.

It appears that contextual influence of low constraining sentences is suppressed by the continuous repetition of sentence contexts within an experimental session rather than the lack of constraints the sentences exert on their word targets. In addition, the lack of inhibition in legal contexts in this forced choice task suggests that the naming task may create inhibition out with sentential influence, perhaps at an integration stage where a Stroop like effect would be far stronger due to the necessity for verbal language production.

CHAPTER FOUR

Chapters two and three demonstrated that legal sentence contexts improved target recognition when there was little opportunity to artificially enhance performance through sentential or lexical constraints in low constraining sentences. Sentential research and theoretical frameworks are also concerned with stronger contexts, particularly contexts that lead participants to anticipate particular target words (e.g., Hess et al., 1995; Morris, 1994; Paul et al., 1992; Potter et al., 1993; Sharkey & Sharkey, 1992; Simpson et al., 1989; West & Stanovich, 1982). Sentences that fall in this category usually contain semantic word associations, the effects of which can be encompassed within a weak modular framework. Moreover, highly constraining sentences are extremely susceptible to the criticisms highlighted in the introduction; namely, the confounding of sophisticated guesswork with perceptual processing. Consequently, examination of stronger contexts under the testing conditions introduced in this thesis is essential for theoretical progression.

The findings of chapters two and three are inconsistent with a weak modular account of word recognition. The findings are compatible, however, with both the modified modular models and the weak interactive models. The modified modular models (i.e., Becker, 1980; Becker & Killion, 1977; Potter et al., 1993; Potter, Stiefbold & Moryadas, 1998) predict that a set of word candidates will be generated on the basis of the visual input. When enough information accumulates to narrow the visual set to a few possible candidates, the context will aid final word selection. For example, were the context 'born to be ----' presented with either *wild* or *mild* the modified modular accounts

predict that contextual influence would ensure that the predictable target *wild* is the candidate finally selected. On the other hand, weak interactive models (i.e., Besner & Smith, 1992; Borowsky & Besner, 1993; Stoltz & Neely, 1995) propose that context operates by pre-activation of probable word candidates which provides additional support either from monitoring the semantic system or from feedback to the orthographic system. Where the context 'born to be ----' is presented with the predictable target *wild*, the account predicts that this target will correspond with a pre-activated item and be facilitated over baseline. When the unpredictable target *mild* is presented, performance accuracy will remain similar to baseline. This occurs because context influences recognition at the visual input stage not at final word selection. The visual input from *mild* does not encounter a pre-activated candidate in the semantic system and relies solely on the visual input for recognition, as does the baseline condition.

The findings with predictable and unpredictable targets are mixed. Several studies have found the biasing effect predicted by the weak modular perspective (e.g., Foster, 1979, 1981; Fischer & Bloom, 1979; Potter, Stiefbold & Moryadas, 1998; Schuberth & Eimas, 1977; Stanovich & West, 1978, 1979). Moreover, others have found the predictable target advantages without the corresponding unpredictable target disadvantage in line with the weak interactive perspective (e.g., Stanovich and West (1979, 1981). None of these studies, however, have used the present paradigm and all contain word association. Weak modular accounts encompass word association because activation is thought to spread between items within the lexicon. Under these circumstances biasing effects may be produced because activation remains internal to the lexicon. Providing conditions where sentences predict one alternative over another in the

absence of word association may produce unbiased effects by limiting intralexical activation and allowing sentential processing to show through. Forster (1981, pp474) justifies this use of word association "... the rather obvious fact that if none of the words in the context are related in any way to the target, then the target is not likely to be very predictable". While this seems reasonable, the stimuli presented in experiment seven circumvent this confounding problem by presenting phrases that predict targets because of their familiarity as word combinations (e.g., predictable 'born to be *wild*', unpredictable 'born to be *mild*').

In line with these issues, experiment seven used high constraining legal sentence contexts derived from well-known sayings, slogans and song titles, which contained no semantic word association and ended in four letter words. These target words were then paired with a visually matched alternative to produce a meaningful but unpredictable ending (e.g., 'born to be *wild*' vs. 'born to be *mild*'). In line with the findings in favour of a modified interactive account of word recognition, predictable targets in legal sentences should produce an advantage over all other conditions while unpredictable targets should remain similar to all other conditions.

Method

Participants. Sixteen paid participants, between the ages of 18 and 35 years, were recruited from the student population of St. Andrews University. Each participant took part in two 40 minute sessions. All participants had normal or corrected-to-normal vision and were native speakers of English. All participants were naïve to the experimental procedure.

Stimuli. Fifty six (24 practice and 32 experimental) familiar phrases were chosen from well known song titles, slogans, sayings and proverbs that ended in four letter words (e.g., ‘born to be wild’). The predictability of the final word in each sentence was assessed by a ‘cloze’ task in which 16 participants were asked to generate the final word of each three letter phrase (‘born to be ----’). Only those stimuli that generated the predictable target word on every occasion were chosen as experimental items. Each target word was then partnered with a visually matched alternative that differed from the target by only one letter and produced a meaningful but unpredictable ending (e.g., ‘born to be wild’ vs. ‘born to be mild’).

To ensure that semantic word association was kept to a minimum and predictability was kept to a sentence level, ten participants were then given a word association task containing only the key word from each sentence (e.g., ‘*born*’ from ‘born to be *wild/mild*’). Sentences were chosen if their key words did not generate either alternative. Thus, unlike other research where predictable targets range from 19-98% and unpredictable range from 3-10%, predictable targets in experiment 7 were 100% predictable and alternatives were 0% predictable. Each letter position was represented equally in the experiment and control conditions were constructed as in previous experiments.

e.g.,

(L) born to be wild/mild

(R) draw he do wild/mild

(N) lamo ba fa wild/mild

(T) be born to wild/mild

Where (L) is legal context, (R) is word replacement context, (N) is nonword

context and (T) is transposed context.

Design. Each 40 minute session consisted of 96 practice trials and 128 experimental trials and contexts were presented for two seconds. As the critical manipulation in this experiment was word pair member (predictable or unpredictable) it was deemed preferable that all participants were presented with both members of each word pair (i.e., both stimulus groups), keeping member as a within-subjects factor. Stimulus group presentation order was counterbalanced across participants. All other aspects of this experiment were the same as experiment 6. The mean exposure duration of targets in experiment 7 was 2.56 frames (15.36 ms).

Results

Legality responses were practically error free (<1%), demonstrating that legal sentences were processed as legal phrases. Mean percentages of target words correctly reported for each context display type are shown in figure 18. An ANOVA was conducted with one between-subjects factor stimulus group order (1 or 2 first) and four within subjects factors [stimulus group (1 or 2), context (legal, word Replacement, nonword, transposed and single word), member (predictable or unpredictable) and critical letter position]. Main effects of member, $F(1, 14)=19.9, p<.01$, context $F(3,42)=2.9, p<.05$, and Critical Letter Position, $F(3,42)=4.87, p<.01$, were found. Newman Keuls tests revealed that response accuracy in the legal condition was greater than in all other conditions, (all p 's<.05) and that performance for critical letter position 1 was superior to that of critical letter position 2 ($p<.005$), critical letter position 3 and 4 ($p<.05$).

The critical interaction for this experiment between member and context was also

significant, $F(3,42)=4.58$; $p<.01$. Newman Keuls tests revealed that response accuracy for predictable targets was greater in the legal condition than in all other conditions; word replacement ($p<.005$); nonword ($p<.001$) and transposed ($p<.005$). Response accuracy for predictable targets was also superior to that for unpredictable targets in legal and transposed conditions ($p<.0001$ and $p<.05$, respectively). Response accuracy for unpredictable targets did not differ across conditions.

Analysis by items also revealed a main effect of member, $F(3,31)=9.49$, $p<.01$, and an interaction between context and member, $F(3,93)=2.73$, $p<.05$. Newman Keuls tests revealed that response accuracy for predictable targets was greater in the legal condition than in all other conditions; word replacement ($p<.02$), nonword ($p<.0001$) and transposed ($p<.0005$). Response accuracy for predictable targets was also superior to that for unpredictable targets in legal and transposed conditions ($p<.02$ and $p<.05$, respectively). No other main effect or interaction was reliable.

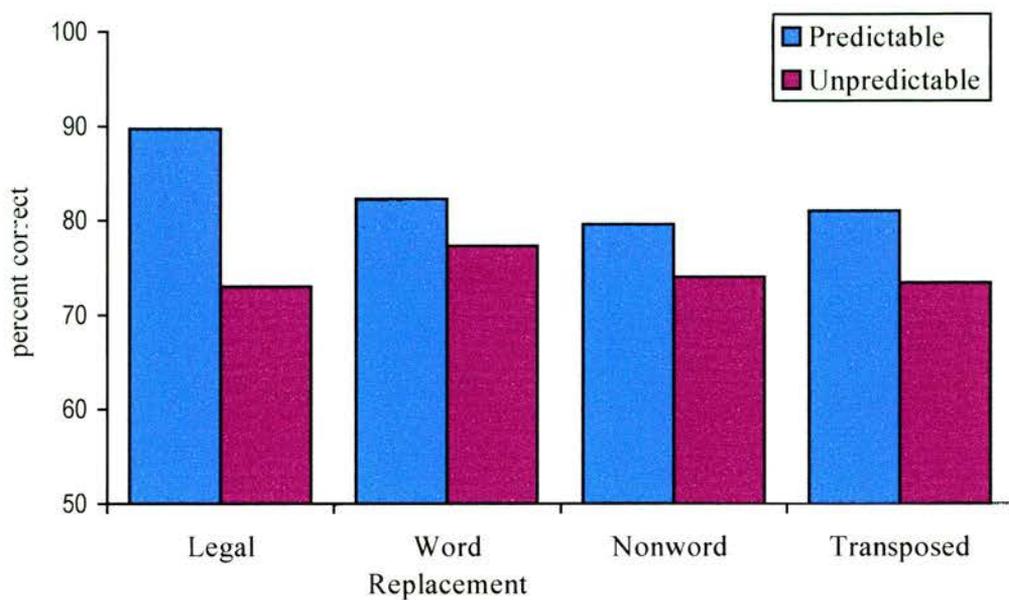


Figure 18. Mean percentage of target report correct for predictable and unpredictable targets in each contextual condition.

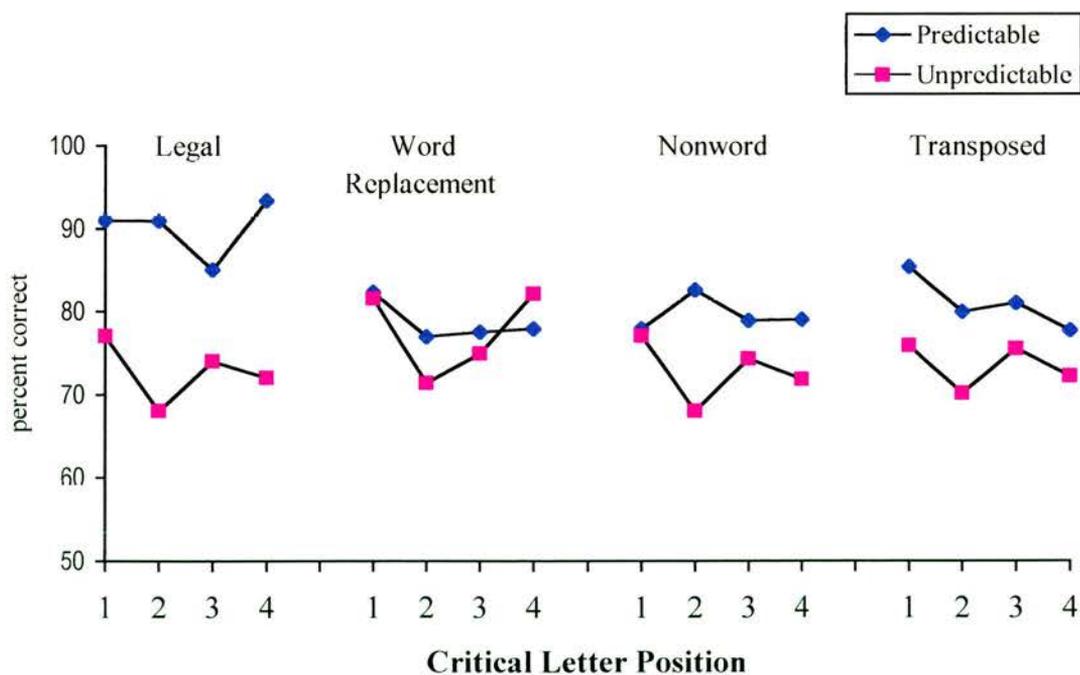


Figure 19. Mean percentages correct for each critical letter position in each contextual condition.

Response ratios are shown in figure 20. T-tests conducted on the results of the response ratio formula showed that predictable alternatives were accurately selected more often in Legal contexts than in baseline [$t(15)=4.40, p<.001$] whereas unpredictable alternatives were accurately chosen with equal frequency in Legal and baseline contexts ($p>.60$). Consequently, responses in Legal contexts were free of bias and no other response bias was found. Response ratios were as follows; legal predictable (0.531) unpredictable (0.497); word replacement predictable (0.509) unpredictable (0.510), transposed predictable (0.504) unpredictable (0.496).

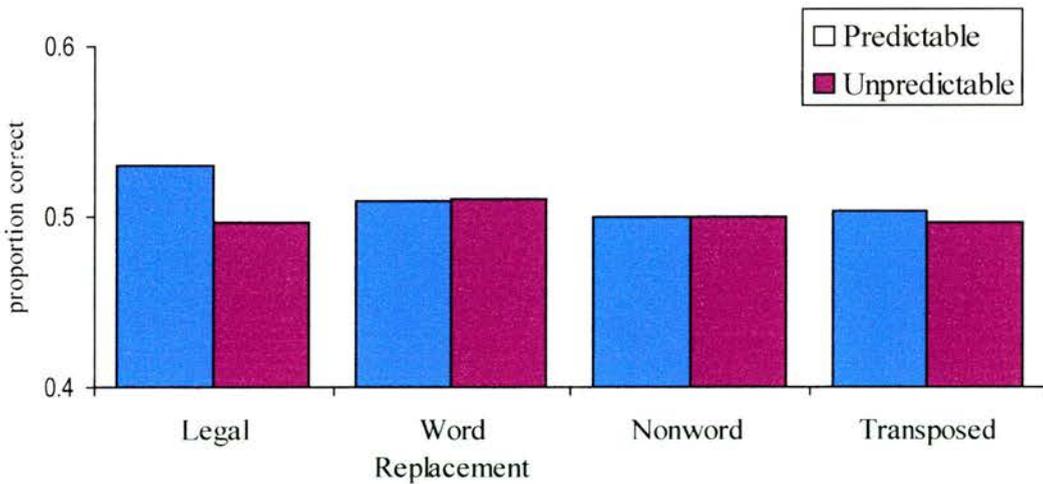


Figure 20. Response ratios for predictable and unpredictable targets in each contextual condition.

General Discussion

The findings of experiment seven show that when highly predictable targets were presented with legal contexts, performance improved overall in the legal condition despite presenting predictable targets on only half the trials. Moreover, predictable targets in legal contexts produced greater response accuracy than in all conditions while unpredictable targets showed no difference across conditions. There were very few errors to verbal reports of ‘legality’ and no response bias, demonstrating that participants processed both the predictable and unpredictable stimuli appropriately and that stimuli formed legal, meaningful sentences when completed by either predictable or unpredictable targets. Moreover, the absence of response bias indicates that the Reicher-Wheeler task was fulfilling its role and that participants were not using legal contexts as a means of resolving partially processed information extracted from the target. Furthermore, the main effect of critical letter position did not interact with context. Thus, as in chapters two and three, legal context did not alter the nature of word recognition but simply enhanced its performance. Indeed, this constancy across the different patterns of serial position performance observed in the experiments so far (which probably reflect the use of different target words and forced-choice alternatives) indicates that the enhancement provided by legal context is not a quirk of one pattern of serial position performance.

Consequently, the results of this experiment further argue against a weak modular account of sentence processing. According to this account, legal contexts can influence word recognition only through intralexical spreading activation or sophisticated guesswork. In particular, the weak modular perspective predicts that where there is no

semantic word association present in a sentence, a set of word candidates are generated on the basis of visual input from the target. The context speeds up target recognition by 'filling in' gaps in the visual input which would bias the results in favour of predictable targets. For example, reading the context 'born to be' and identifying the letters '-ild', sophisticated guesswork should have 'filled in' the visual input with *wild*. However, unpredictable alternatives (e.g., *mild*) were accurately chosen with equal frequency in the legal condition as in the control conditions. This suggests that sentence contexts influenced word recognition accuracy in a more interactive fashion, over and above decision based, post-perceptual processing either in the form of sentential or lexical constraints.

The evidence also argues against the less strong modified modular perspective (i.e., the *expectancy model*, Becker, 1980; Becker & Killon, 1977; and the *modular/interactive model*, Potter, et. al. 1993; 1998). Although these models include interactivity between semantic and visual levels of processing, the modified modular models still place the locus of contextual influence at the final word selection stage. If, however, this were the case, predictable targets in experiment seven would be given more weight by the context and become the most frequently selected and identified word. This would create a legal sentence disadvantage for unpredictable targets and a response bias. Nevertheless, accuracy for predictable targets was greater in legal contexts and accuracy for unpredictable targets was the same across all conditions, suggesting that the locus of contextual influence was at the visual input stage where feedback from the semantic level improved predictable target perception without interfering with unpredictable target perception.

Stoltz and Neely (1995) have proposed an alternative hypothesis for semantic priming effects based on the *multistage activation model* of Besner and Smith (1992) and Smith, Besner and Miyoshi (1994) which could be elaborated to include the context effects found in the present study. The *multistage activation model* proposes two possible routes for the influence of context on word recognition. When the visual input from the target stimulus corresponds to a word node pre-activated by context, word identification is enhanced through pathway A which links the orthographic system to the semantic system. Alternatively, activation in the semantic system feeds back to the orthographic system through pathway B, resulting in less data driven information being required to activate the target representation. However, as the results of the Stoltz and Neely study demonstrate, the activation through pathway B is not automatic or mandatory. In a resource limited system, this feedback will incur cost and will be operational only where there is a high likelihood that the benefits outweigh the costs; that is, when there is a high proportion of items that can utilize the information provided by the pathway.

The *multistage activation model* fits very well with the findings of the present study. In experiment seven, where pre-activation of nodes in the semantic system was possible, pathway A would have allowed the visual input from targets preceded by legal contexts to directly access the semantic system. When the visual input corresponded to a pre-activated node (as would be expected with predictable targets) word perception would have been enhanced. However, when the visual input did not correspond to a pre-activated node (as would be expected with unpredictable targets) word perception would not have been enhanced and would match recognition threshold (i.e., nonword condition).

Increasing the constraining influence of legal sentences reduced contextual influence when word order was disrupted by transposition. In contrast to the findings of previous studies (e.g., O'Seaghdha, 1989, 1997; Simpson et al., 1989), transposed sentences in chapter two showed an intermediate contextual influence on target word recognition. However, the legal sentences of chapter two were constructed to be very low constraining, with the result that individual words in each sentence provided few cues to its overall identity. For example, the individual words in 'it began to *flap*' do little to indicate the likely identity of the entire sentence. Thus, when transposed to 'to it began *flap*', participants may have initially attempted to 'legalise' this sentence giving rise to a residual 'legal' effect although further processing revealed the ultimate illegality of the display. However, individual words in high constraining sentences, like 'born to be *wild*', may provide strong cues to the identity of the entire sentence, such that the illegality produced when these sentences are transposed (e.g., 'be born to *wild*') is readily apparent and a residual legal effect less likely. Thus, when cues to the identity of an entire sentence are bound by word order, disrupting this order may make illegality more readily apparent. If this were the case, participants may be less likely to extract meaning from a highly constraining sentence that has been transposed, thereby limiting the contextual influence of transposed contexts. Therefore, experiment seven has provided evidence consistent with the proposal of Tannenhaus and Lucas (1987) and Lupker (1984) that priming results from pure semantic relatedness at a general conceptual level that cannot be explained by intralexical associations. However, disrupting word order did not completely remove all contextual influence. Unlike the control conditions, predictable targets were reported more accurately than unpredictable targets in the transposed

condition, which reinforces the proposal made in the discussion of chapter two that illegality per se may not cause the absence of facilitation in transposed sentences reported elsewhere (e.g., O'Seaghdha, 1989, 1997; Simpson, et. al. 1989).

In summary, word recognition is facilitated during sentence reading over and above the effects produced by semantic word association and sophisticated guesswork. The evidence finds in favour of a *multistage activation model* of word identification such as that proposed by Besner and Smith (1992), Smith, Besner and Miyoshi (1994) and Stoltz and Neely (1995). Additionally, this study presents evidence that illegality may not be the source of poor facilitation in transposed sentences but that disruption of more rudimentary cues may play an important role in sentence processing. Furthermore, the evidence supports the notion of conceptual priming from sentence level rather than word association (in line with the arguments of Tannenhouse and Lucas, 1987). While the present findings confirm that word recognition can be affected by sentence level processing in an interactive manner, in a resource limited system this may not always be the case. As proposed by Stoltz and Neely (1995), the cost of monitoring both pathways may be high. Thus, when the benefit derived from this level of detailed processing outweighs the apparent benefits from engaging in less detailed processing, the system may choose to reduce the processing load. Thus increasing the apparent cost of detailed processing by increasing the proportion of legal sentences formed the basis of chapter six.

CHAPTER FIVE

It has been proposed that semantic priming in single word recognition is dependent on the experimental context in which the priming occurs (e.g., de Groot, 1984; den Heyer, 1985; den Heyer, Briand & Dannenbring, 1983; Keefe & Neely, 1990; Neely 1977, Seidenberb et al., 1984; Tweedy, Lapinski & Schvaneveldt, 1977). Relatedness proportion refers to the proportion of related word-prime/word targets in an experimental session. Where relatedness proportion is high, semantic priming facilitation, as measured by lexical decision and naming, is greater than where relatedness is low. Indeed, at low relatedness proportions priming effects are often found to disappear altogether (e.g., de Groot, 1984; den Heyer, 1985; den Heyer, Briand & Dannenbring, 1983; Keefe & Neely, 1990; Neely 1977, Seidenberb et al., 1984; Tweedy, Lapinski & Schvaneveldt, 1977).

The most persuasive argument for the occurrence of relatedness proportion effects is that generating expectancies or strategies to complete the task will increase the required processing load. Where there are few items that can benefit from this costly processing it is simply not carried out and null priming effects are obtained. Under these circumstances null effects should have been obtained in experiments three, four and five where relatedness proportion was low (0.25%; relatedness proportion in sentential research is generally 0.33 – 0.5).

There is little research on the effect of relatedness on word recognition in sentential contexts. In light of the single word research findings this omission may impact on sentential research in general and, more specifically, on particular theoretical interpretations. If expectancy type strategies are responsible to some extent for contextual influence on word recognition then increasing the relatedness proportion will bring them

into operation. However, expectancy is normally measured as an increase in reaction time for unpredictable targets, where accuracy is measured the *expectancy model* (Becker, 1980; Becker & Killion, 1977) predicts no differences between conditions. This is because pre-activated items in the semantic set are matched with the visual representation in an exhaustive search. When no match is found the visually defined set is then searched in the same manner, delaying the match but not affecting accuracy because, according to search models, activation thresholds remain constant. On the other hand, an increase in performance for predictable targets with a corresponding decrease for unpredictable targets would indicate a criterion shift, brought about by the increase of predictable targets within the experimental session, where predictable alternatives are accepted as correct on the basis of less visual information.

This criterion shift proposal conforms to the two process theory, developed by Posner and Snyder (1975a, b) and applied to the lexical context effect by Neely (1976, 1977). The *criterion shift model* postulates two separate contextual effects. The first is a purely automatic process whereby activation spreads throughout a network priming word detectors that form a semantically related set. The second process is under strategic control of the reader, at least in the sense that it requires attention capacity, and primes a small set of word detectors, however, this process also inhibits the activity of non-primed detectors. According to dual process theory, therefore, any increase in magnitude between automatic priming and non-automatic priming is due to the increase of inhibition to non-primed targets rather than to an increase in facilitation. Because the second process requires the allocation of attention it would be expected to be more costly to the system and would be more likely to be brought into operation by increasing the salience

of the predictable nature of targets preceded by legal contexts. Finally, if performance for predictable targets improves in legal contexts without a corresponding decrease in performance for unpredictable targets, word recognition in contexts is unaffected by criterion shifts as presented by increasing relatedness proportion.

Experiment 8

Experiment eight increased the salience of predictable targets in legal contexts by increasing the relatedness proportion from 0.25 to 0.50 by adding filler, legal sentences in order to examine further the role of expectancy or prediction in sentence reading where sophisticated guesswork and semantic association are suppressed. Under the dual process theory, increasing the proportion of legal items in an experimental session should bring into operation participant based strategic processing whereby predictable targets are accepted on the basis of less visual information. This would have the effect of reducing the legal sentence advantage found in this thesis and creating a bias in the response ratio analysis. Under these circumstances we can conclude that increasing the salience of predictability creates a criterion shift that alters the nature of visual processing in legal contexts.

Method

Participants. Sixteen paid participants, between the ages of 18 and 35 years, were recruited from the student population of St. Andrews University. Each participant took part in two 50 minute sessions, and all participants had normal or corrected-to-normal vision and were native speakers of English. No participant had taken part in previous

experiments.

Stimuli. The same practice and experimental stimuli were presented as experiment 7 with the addition of two sets of 32 familiar legal phrases made in the same way as the previous stimuli to act as fillers. The purpose of presenting these two sets of stimuli was to equate the proportions of legal and illegal stimuli. Thus a stimulus group now represented 3 legal conditions and 3 illegal conditions but the additional stimuli were not analysed.

Design. The two new sets of stimuli were treated as two new conditions for the purposes of stimulus group and cycle formation. Therefore, each session consisted of 144 practice trials and one stimulus group (A or B) containing 192 experimental trials. Each session was divided into eight cycles of 24 pseudo randomly chosen stimuli counterbalanced across six conditions and critical letter position with the additional constraint that no target word could appear twice within each cycle. All other aspects of this experiment were the same as experiment 7. The mean exposure duration of targets in experiment 8 was 2.68 frames (16.06 ms).

Results

Legality responses were practically error free (<1%), indicating that participants were processing the displays appropriately. Mean percentages of target words correctly reported for each context display type are shown in figure 21. An ANOVA was conducted with one between subjects factor stimulus group order (1 or 2 first) and four within subjects factors [stimulus group (1 or 2), context (legal, word Replacement, nonword and transposed), member (predictable and unpredictable) and critical letter

position]. A main effect of context, $F(3, 45)=3.09$; $p<.05$, $MS_e=213.36$; member, $F(1,15)=70.21$; $p<.01$, $MS_e =409.65$; and critical letter position $F(3,45)=3.28$, $p<.05$, $MS_e =202.5$; were found. Newman Keuls tests revealed that performance for both the legal and word replacement conditions were superior to that of the transposed condition (both p 's $<.05$), performance accuracy was greater for predictable targets than unpredictable targets, while critical letter position 4 was reported more accurately than critical letter position 1, $p<.05$.

Additionally there was an interaction between member and context, $F(3,45)=14.75$; $p<.01$, $MS_e=281.826$. Newman Keuls disclosed that performance for predictable targets in legal contexts was more accurate than that of word replacement contexts, $p<.01$ and nonword contexts, $p<.005$, but not that of transposed contexts. Performance accuracy for predictable targets was greater in transposed contexts over word replacement contexts and nonword contexts ($p<.05$). Where unpredictable targets were concerned performance accuracy was greater for word replacement and nonword contexts over legal contexts, $p<.05$. However, performance accuracy for unpredictable targets was greater in legal contexts than in transposed contexts, $p<.05$. Further, performance for predictable targets was greater than performance for unpredictable targets in both legal and transposed contexts (both p 's $<.0001$) but there was no difference between target types in word replacement or nonword contexts.

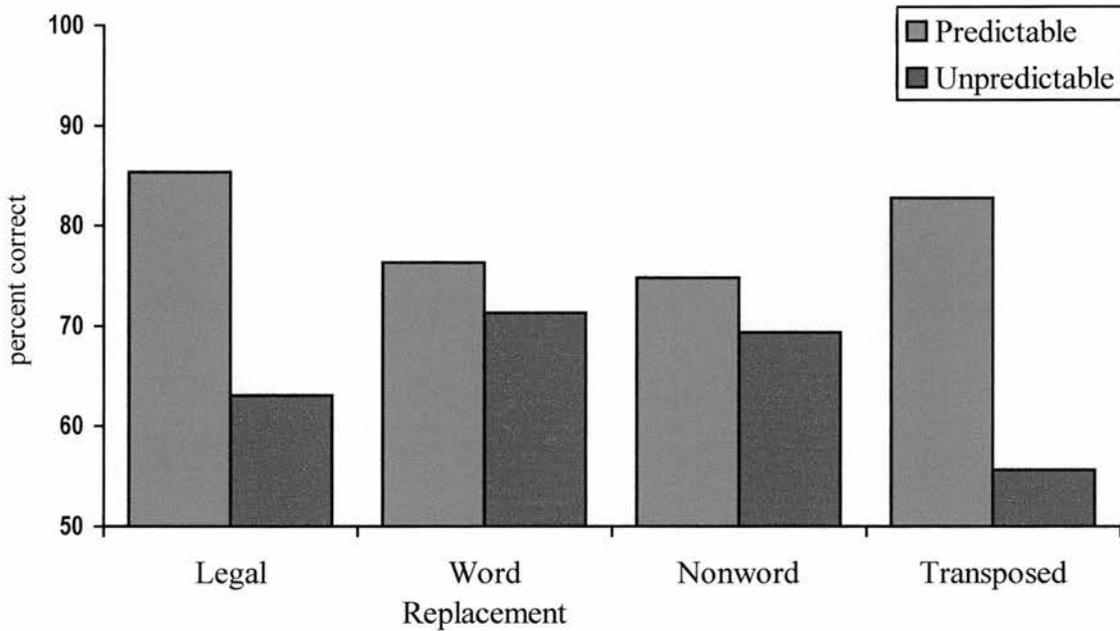


Figure 21. Mean percentage correct reports for predictable and unpredictable targets in each context condition of experiment 8.

Moreover, there was an interaction between context, member and critical letter position, $F(2.04, p < .05, MS_e = 174.3)$ (figure 22). Newman Keuls revealed that predictable targets in legal contexts representing critical letter position 1, 2 and 4 were reported more accurately than unpredictable targets representing the same letter positions (all p 's $< .01$), while in the transposed condition all predictable targets were reported more accurately than their unpredictable counterparts. Predictable targets representing critical letter position 1 in legal contexts were reported more accurately than those of word replacement and nonword contexts ($p < .05$). Unpredictable targets representing critical letter position 3 were reported more accurately in legal than transposed contexts ($p < .005$). Further, unpredictable targets in word replacement contexts that represented critical letter

positions 3 and 4 were reported more accurately than their transposed counterparts ($p < .001$, $p < .01$ respectively) and unpredictable critical letter position 4 targets in nonword contexts were reported more accurately than transposed critical letter position 4 ($p < .0001$). Thus the bias in transposed contexts seems to have been greater for the end letter positions.

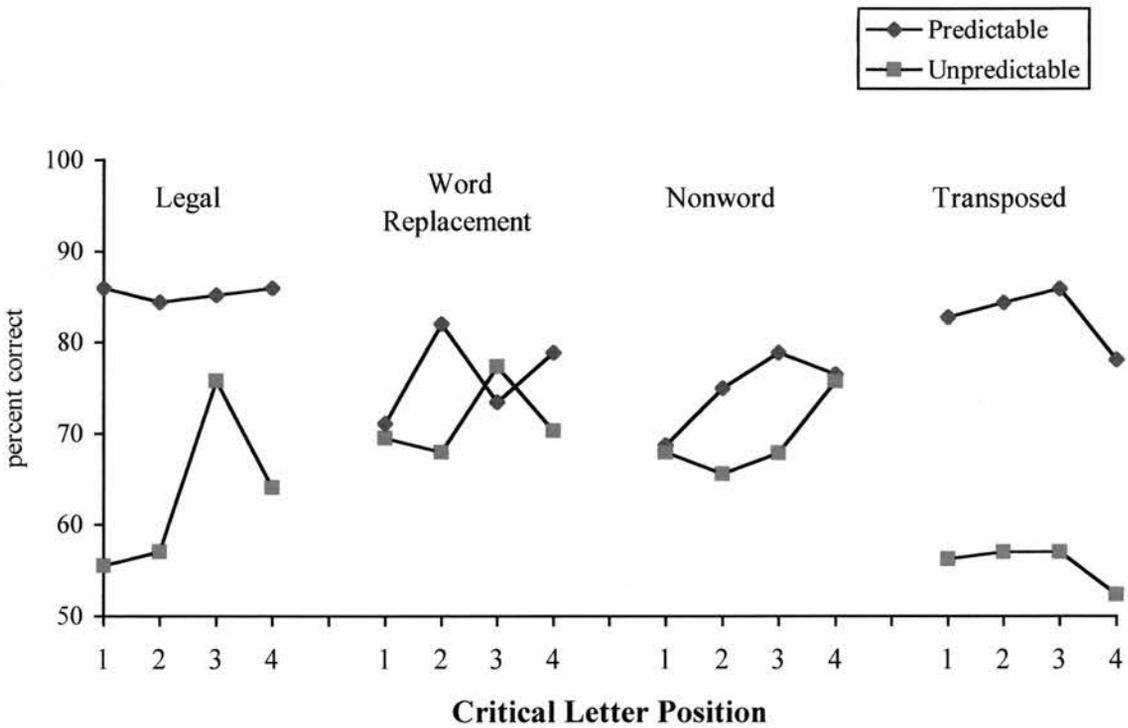


Figure 22. Mean percentage correct report for each critical letter position for predictable and unpredictable targets in each contextual condition.

Analysis by items revealed a similar pattern to the subject analysis. A main effect of member, $F(1,28)=45.103$, $p < .01$, was found. There was also an interaction between member and context, $F(3,84)=19.749$, $p < .01$. Newman Keuls revealed this was due to the greater performance for member 1 targets in both legal and transposed contexts over nonword contexts ($p < .01$; $p < .02$ respectively) and the corresponding poorer performance

for member 2 targets in both legal and transposed contexts over word replacement contexts ($p < .0006$; $p < .0001$ respectively) and nonword contexts ($p < .0002$; $p < .0001$, respectively). No other main effect or interaction was reliable.

Response ratios are shown in figure 23. Legal and transposed contexts exhibit response bias in favour of predictable targets with response ratios above 0.5 for predictable targets and a corresponding ratio below 0.5 for unpredictable targets. Additionally, the proportion of predictable target responses is greater than those of unpredictable targets in legal, $t = 3.839$, $p < .01$ and transposed, $t = 4.733$; $p < .01$, contexts. Response ratios were; legal predictable (0.532) unpredictable (0.480), word replacement predictable (0.505) unpredictable (0.506) and transposed predictable (0.527), unpredictable (0.440).

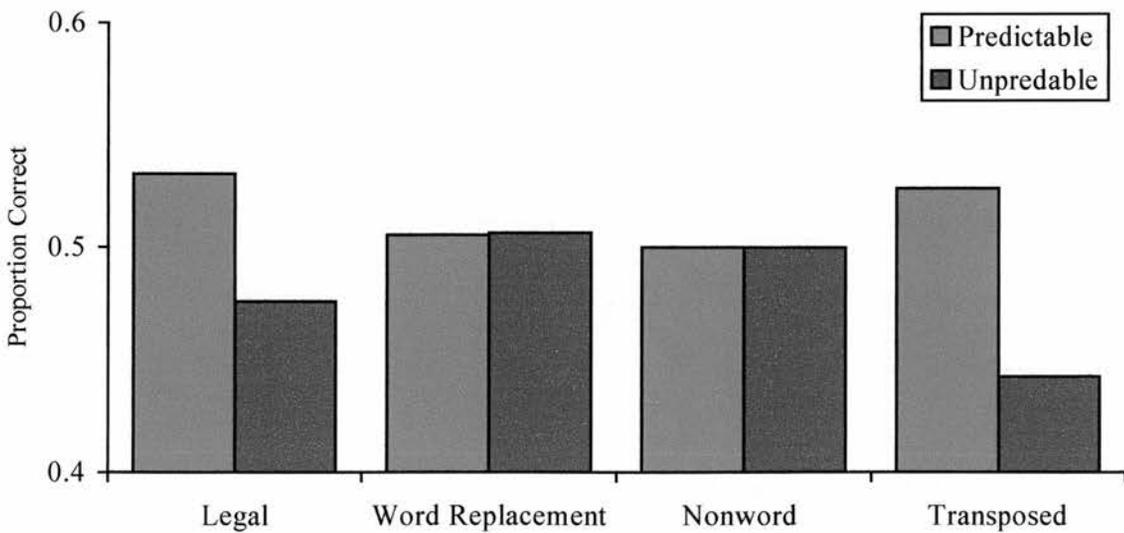


Figure 23. Response ratios for each condition in experiment 8.

Discussion

The results of experiment eight show that when the predictability of target words is made more salient by increasing the amount of legal items within the experimental session, accuracy of word recognition improves for predictable targets in both legal and transposed contexts but deteriorates for unpredictable targets over baseline. These results are quite different from those of experiment seven which used the same experimental stimuli but found no difference between unpredictable targets in any condition. Therefore, the present findings indicate a dual process model, whereby increasing the salience of legal sentences creates a criterion shift which allows targets to be accepted on the basis of less visual information. There are, however, several possible explanations for the biasing results found in the present experiment.

One possible explanation for this difference is that increasing the salience of predictable targets increased the likelihood of participants engaging in sophisticated guesswork. To determine whether an increase of sophisticated guesswork was responsible for the results of experiment eight, the response ratios of experiments seven and eight were examined. Sophisticated guesswork is a participant strategy based on sentential and lexical constraints and would increase bias in legal and transposed conditions. Response ratios for predictable targets in legal sentences remained similar between the two experiments (0.531, 0.532 respectively) while the corresponding ratios for unpredictable targets decreased from 0.497 in experiment seven to 0.480 in experiment eight. These results indicate that sophisticated guesswork did not increase in legal contexts in experiment eight but that increasing the salience of predictability had a detrimental affect on recognition of unpredictable targets. However, response ratios for predictable targets

in transposed contexts increased from 0.504 in experiment seven to 0.527 in experiment eight, while the corresponding ratios for unpredictable targets decreased from 0.46 to 0.440. Thus it would seem that increasing the salience of predictability increased sophisticated guesswork in the transposed condition but not in the legal condition.

Experiment 8b

In order to verify this proposal the results of experiments seven and eight were analysed together. If indeed sophisticated guesswork was introduced in both legal and transposed contexts by increasing the salience of legal, predictable sentences then there should be an increase in report for predictable targets in legal and transposed sentences with a corresponding decrease in report of unpredictable targets between experiments seven and eight. However, if the preceding proposal is correct and the results of experiment eight were due to the inferior performance of unpredictable legal sentences then there should be no increase in report for predictable targets between experiment eight and seven but a decrease in report of unpredictable targets. On the other hand, transposed sentences should show both an increase of report for predictable targets and a corresponding decrease for unpredictable targets between experiments seven and eight. Under these circumstances it can be concluded that post-perceptual guesswork was present in transposed sentences but cannot fully explain the results of legal sentences in experiment eight.

Results and discussion

An ANOVA was conducted on the combined results of experiments 7 and 8 with one between subjects factor experiment (7 or 8) and three within subjects factors [context (legal, word Replacement, nonword and transposed), member (predictable and unpredictable) and critical letter position]. A main effect of experiment $F(1,30)=19.01$, $p<.001$, $MS_e=473.99$, context, $F(3, 90)=5.00$; $p<.01$, $MS_e=203.56$ and member, $F(1,30)=70.73$; $p<.001$, $MS_e=470.45$ were found. Performance was greater in experiment 8 than 7. This is most likely due to the legal fillers in experiment 8 which would have been reported more accurately than the control conditions and created the effect of a reduced performance when not included in the analysis. However, this would not affect the proportion of responses between conditions or experiments. Predictable targets were reported more accurately than unpredictable targets. Newman Keuls tests revealed that performance for the legal condition was superior to that of the nonword and transposed conditions (both p 's $<.005$). There was an interaction between experiment and member $F(1,30)=7.07$, $p<.05$, $MS_e=470.45$. Newman Keuls revealed this was due to the poorer performance of unpredictable targets in experiment 8, $p<.001$. There was an interaction between member and context $F(3,90)=18.93$, $p<.001$, $MS_e=233.49$. Newman Keuls revealed this was due to the superior performance for predictable over unpredictable targets in both legal and transposed contexts (both p 's $<.001$).

Additionally, the critical interaction between experiment, context and member was significant, $F(3,90)=4.99$, $p<.005$, $MS_e=233.49$. As predicted the difference between experiments 6 and 7 in the legal contexts was due to the poorer performance of unpredictable targets in experiment 8 ($p<.001$) while the transposed contexts showed an

increase in performance to predictable targets ($p < .05$) and a corresponding decrease in performance for unpredictable targets ($p < .001$) in experiment 8.

The proposal put forward in the discussion of experiment 8 has been supported by the present analysis. The findings indicate that post-perceptual guesswork was present in transposed sentences but cannot fully explain the results of legal sentences in experiment 8 where the salience of legal sentences was increased to match that of current research.

General Discussion

In light of the present findings that a post-perceptual guesswork account is an inadequate interpretation of the decreased accuracy of unpredictable targets in legal sentences when RP is increased, an alternative explanation must be found for the results of the legal sentences. These findings are inconsistent with an expectancy based model of contextual influence, which predicts that pre-activation of possible word candidates shortens the length of time it takes to verify the visual representation. Under these conditions threshold values of predictable word items do not differ from threshold values of unpredictable word items, therefore, speed of recognition is affected but not accuracy. O'Connor and Forster (1981) have proposed an alternative explanation that can be encompassed by expectancy based models where threshold values remain the same for all word items but a 'misspelled' word is accepted as a real word. This occurs when the misspelling is sufficiently similar visually to be accepted as a real word when the pre-activated word item is encountered in the semantic set. For example, during rapid search ENVLEOPE would be accepted as the real word ENVELOPE because it is sufficiently similar to terminate the search. All targets and forced choice alternatives were real word

items in experiment eight; nevertheless, misperceiving one alternative as another (e.g. 'seeing' *mild* and encountering *wild* in the semantic set) would also be sufficiently similar to be accepted and terminate the search. This would have the effect of increasing the proportion of predictable targets reported in legal contexts to unpredictable targets reported in legal contexts. This did not occur. Moreover, this proposal cannot explain why this effect did not take place when in experiment seven, yet still produced an increased accuracy for predictable targets in legal contexts. Experiment seven suppressed the influence of semantic word association, thus, if expectancy was inoperative reliable results would not have been obtained. Moreover, the difference between the two experiments indicates a criterion shift which is outwith the theoretical framework of search based models.

A more viable alternative would appear to be provided by criterion shift models (i.e., Broadbent, 1967; *Logogen Model*, Morton, 1969). These models would explain the difference between experiments seven and eight as a shift in criterion for accepting a visual representation brought about by an increase in the salience of predictable targets in legal contexts. Under these circumstances, thresholds lower for related items as evidence is incrementally generated for a particular logogen by the attributes of the contextual and visual inputs. Thus, a word entry can be accepted from a smaller amount of evidence when it is predicted by context. Once an entry has reached threshold, activation to all other items is inhibited, thus unpredictable word items require more evidence to reach threshold. However, in their passive form, criterion shift models also have difficulty in explaining: (1) why there were either, no inhibition effects in experiment seven and (2) how facilitation was generated for predictable targets when semantic word association

was suppressed. Moreover, alterations in threshold values provided by the context would be expected to increase facilitation for predictable targets in legal contexts as well as inhibition for unpredictable targets.

Under the circumstances described by Posner and Snyder's (1975a, b) and Neely, (1976, 1977) dual route theory, the first automatic spreading activation process would account for the findings of experiment seven. During this process activation from the context spreads throughout a network priming detectors forming a semantically related set. Thus 'born to be ----' would pre-activate *wild* enhancing perception of *wild* without affecting *mild* when it was presented. Increasing the salience of predictable targets by increasing relatedness proportion would bring into operation the second processing stage. This processing route requires the allocation of attention and primes a small set of word detectors but this process also inhibits the activity of non-primed detectors. Therefore, according to dual process theory, when attention is captured any increase in magnitude between automatic priming and non-automatic priming is due to the increase of inhibition to non-primed targets rather than to an increase in facilitation. This is what was found in experiment eight in legal contexts. The combined effects of experiments seven and eight have provided, therefore, an insight into the possible causes of both bias and sensitivity changes. In short, contextual influence may operate in several ways to enhance word recognition.

Another alteration between the results of experiment seven and eight concerns the transposed sentences. In experiment seven increasing the constraining influence of legal sentences reduced the contextual influence of these sentences when word order was disrupted by transposition. On the other hand, increasing the relatedness proportion of the

entire experimental group of stimuli increased the contextual influence of legal sentences that were disrupted by word order. The results of the transposed sentences did not mirror those of legal contexts but instead seemed to indicate an increase in sophisticated guesswork. Notwithstanding the increase in response ratios for both predictable and unpredictable targets between experiments, ratios for predictable targets were similar to legal predictable targets but ratios for unpredictable targets were considerably lower than those for legal contexts. Increasing the salience of predictable targets may have encouraged participants to try and gain some indication of the possible identity of targets but this was apparently done post perceptually. On encountering transposed contexts it is likely that participants identified these contexts as illegal sentences which held some meaning. The uptake of visual information would then have been disrupted in the process of transposition and participants would have been forced to adopt strategies to complete the task increasing the biasing effect. Furthermore, this finding supports the proposal of Tannenhaus and Lucas (1987) and Lupker (1984) that priming results from conceptual or pure semantic levels rather than word association because disrupting word order distorts the concept more than the association between words and encourages sophisticated guesswork. Tannenhaus and Lucas (1987) have specified that “what differentiates potential contextual sources of facilitation in access from those of post access is the extent to which the relation between the context and word is mediated by representations stored in memory as opposed to rules computed relations” (p230).

Furthermore, the three-way interaction between context, member and critical letter position impacts mainly on transposed contexts. Performance for critical letter position one was greater for predictable targets in legal contexts when compared to word

CHAPTER SIX

A number of research studies have examined how semantic priming effects and ‘visual degradation’ of the target combine to influence target word recognition in single word priming tasks (e.g., Becker & Killon, 1977, Besner & Beneschan, 1989; Besner & Smith, 1992; Borowsky & Besner, 1993; Meyer, Schvaneveldt & Ruddy, 1975; Massaro, Jones, Lipscomb & Scholz, 1978; Stanovich & West, 1979; Stoltz & Neely, 1995). Generally, an interaction is found between context type and stimulus quality. For example, presentation of the prime *DOCTOR* improves performance to the target *NURSE* when compared to an unrelated target *HORSE*, and this superiority increases as the visual quality of the target (usually contrast) decreases. This phenomenon is known as the ‘overadditive effect’ (e.g., Becker & Killon, 1977; Besner & Smith, 1992; Borowsky & Besner, 1993; Meyer, Schvaneveldt & Ruddy, 1975; Stoltz & Neely, 1995).

In particular, examining the interaction between context and stimulus quality (degraded targets) in single word priming has been employed to elucidate the distinct stages at which contexts exert their influence. Specifically, according to Sternberg’s (1969) theoretical basis, an interaction of two factors demonstrate an influence on the same stage of processing whereas an additive effect of two factors demonstrates a separation of processing mechanisms or stages. In the single word priming literature, target visibility is assumed to represent target encoding, therefore, by interacting, context and stimulus quality are held to influence the same processing component, that of target encoding. As yet these two factors, context and stimulus quality, have not been examined in conjunction within a sentential paradigm. However, doing so could help to clarify two

contentious questions that remain largely unanswered by present sentential research, as well as confirm the proposals put forward so far in this thesis. The questions relate to the stage at which word identification is affected by contextual influences and the source of this effect. Moreover, target degradation offers a further means to examine the basic visual components that underlie word recognition and explore whether these basic components are influenced by sentential contexts. Several models of word recognition have been generated in response to the overadditive effect describing quite different operations in the reading process.

According to search based models (i.e., *expectancy & verification Models*; Becker, 1976, 1979, 1985; Becker & Killon, 1977; Paap, et. al., 1982, 1987) the overadditive effect occurs because degradation retards the formation of the visually defined set but not the semantic set. Thus, search of the semantic set takes place faster than that of the visually defined set and target recognition is based on the output of the semantic search. The interaction, therefore, is the result of ‘failed’ predictions creating a decrease in speed (or accuracy) of recognition of unrelated word items. Thus, if comparisons were possible against a neutral context, related words would be facilitated while unrelated words would be inhibited relative to baseline because no predictions would be made for the neutral contexts and recognition would proceed unheeded via matching the visual representation with the visual set.

According to post-lexical models (i.e., *plausibility checking mechanism*, Norris 1986; *the modular interactive model*, Potter, Moryadas Abrams & Noel, 1993; Potter, Stiefbold and Moryadas, 1998) the overadditive effect occurs because thresholds for plausible (related) items are reduced while thresholds for implausible (unrelated) items

are raised while evidence from the visual input is accumulating. Degradation of the visual input slows the formation of the visually defined set thereby causing greater reliance on the plausibility checking mechanism. In short, the context will bias word selection in favour of predictable targets at the expense of unpredictable targets. Thus, this type of model predicts the same pattern of results as search models but also predicts a strong response bias that should increase with degradation of the stimulus in the experimental condition.

According to modification models (i.e., *the logogen model*, Morton, 1969; *multistage activation model*, Besner & Smith, 1992; Stoltz & Neely, 1995) the overadditive effect occurs because context modifies activation levels of word items. Under the circumstances of Morton's *logogen model* the context x stimulus quality interaction is the result of decreasing threshold values for predictable words allowing these items to reach threshold before those of unpredictable word targets, therefore, related word targets require less visual input to reach threshold. Once again the interaction is explained in terms of the effect stimulus quality has on retarding recognition of unrelated word targets.

There are, however, two possible interpretations of how this system would operate in relation to predictable and unpredictable targets in legal contexts compared to neutral contexts. O'Conner and Forster (1981) have explicitly stated that Morton's *logogen model* is a criterion bias model. Under these circumstances degradation of targets would be expected to create a criterion shift, adding more weight to contextual information. Therefore, predictable targets would be accepted by the system as the presented target on the basis of more limited visual information. This interpretation would bias responses in

favour of predictable targets in the same way that increasing the proportion of predictable items did. Alternatively, Morton's *logogen model* could be seen as actually increasing sensitivity to visual information in legal contexts by decreasing threshold values. Under these circumstances, degradation will not produce a criterion shift in the same way as increasing relatedness potential did and there should be little differences between predictable and unpredictable targets as degradation increases. At the very least, the discrepancy between predictable and unpredictable targets should not alter in legal contexts.

In the *multistage activation model* (Besner & Smith, 1992; Stoltz & Neely, 1995) the overadditive effect is explained with reference to pathway B, where activation in the semantic system feeds back into the orthographic system reducing the necessity for stimulus data driven information for predictable targets. On the other hand, unrelated targets will not receive such additional support and will be affected more by stimulus degradation. Once again the influence of stimulus quality creates the interaction with context by retarding recognition of unpredictable targets. However, this model can be distinguished from search and post-lexical models which assume that incorrect predictions inhibit recognition of unpredictable items, because the multistage model only requires that the context produces activation in the semantic system in order that feedback can occur and aid the uptake of visual information.

In other words, the first two classes of model (search and post-lexical) predict inhibition of unpredictable items when compared to neutral contexts. Therefore, recognition of degraded targets would only be hindered as far as formation of the visually defined set was impeded. However, in legal contexts recognition accuracy of

unpredictable targets would be further reduced by the necessity of either searching the semantic set before the visually defined set or from the biasing effect of contexts. In both cases more decisions to choose predictable targets would be made. As far as the *multistage activation model* is concerned, targets in neutral contexts should be impeded by the same amount as unpredictable targets in legal contexts because in neither case do targets obtain additional activation from the semantic set.

As can be seen from the above outline all models of contextual influence predict that an interaction between context and stimulus quality will be obtained through the retardation of recognising unpredictable targets. Therefore, distinguishing between models through examination of stimulus quality has yielded no consensus despite the reasoning that stimulus quality must represent the input stage. This state of affairs exists mainly because of the lack of adequate controls for bias or prediction, due in part to the fact that that single word semantic priming is the accepted means for examining the overadditive effect. Neutral presentations are extremely problematic for single word prime/target presentations, as, where there is no relationship between the context and target, they are necessarily unrelated. Yet, it is in comparison with neutral contexts that the various classes of model make differing predictions for predictable and unpredictable targets. Indeed, several priming studies have reported additive effects of context and degradation where participants are discouraged from making predictions about unrelated primes by presenting the word BLANK or a row of asterisks as the unrelated prime (i.e., Borowsky & Besner, 1991; Durgunoglu, 1988; Heyer & Benson, 1988). However, there are indications that this kind of prime may actively disengage normal language processing as suggested in chapter 3 which included a condition where only targets were

presented (see also; Antos, 1979; Becker, 1985; de Groot, Thomassen & Hudson, 1982; Joindes & Mack, 1984; Kraut & Smothergill, 1978; Kraut, Smothergill & Farkas, 1981, Neely, 1991; Stoltz & Neely, 1995). Thus, sentential context will provides a more accessible means of forming related, unrelated and neutral contexts.

Examining the comparative influence of sentences on target word report, when target stimulus quality is degraded, provides a substantial tool for investigating the visual components that underlie word recognition. All the aforementioned models base word recognition on letter fragments and the usual means of reducing stimulus quality is by reducing contrast, a method which largely retains letter fragments. However, some of the evidence presented in chapter one suggests that letter fragments may not always be the word property that underlies word recognition (e.g., Allen et. al., 1991, 1995; Balota, 1985; Healy & Cunningham, 1992; Healy & Drewnowski, 1983; Inhoff, 1989; Inhoff & Tousman, 1990; Jordan, 1990, 1995; Monk & Hulme, 1983; Pollatsek & Rayner, 1982; Rayner, 1980,1982; Rayner, Well, Pollatsek & Bertera, 1982; Walker, 1987). Therefore, a means of degrading the available visual information provided by targets in such a way that letter detail was degraded without altering other factors such as word shape was required. In studying the basic visual properties that underlie the processes involved in object recognition tasks, a strategy that has been successful is to vary some critical stimulus parameter such as luminance, contrast and spatial frequency to find threshold value required for performance. Legge, Pelli, Rubin and Schleske (1985) found that the critical spatial frequency bandwidth for reading was about two cycles per character. Ginsburg (1978) demonstrated that legibility of single letters required bandwidths in the range of 1.5 to 3 cycles per character. Thus it was decided to remove mid to high spatial

frequency information from word targets. This resulted in word targets that were blurred by retained word shape.

Experiment 9

Experiment nine presented the highly constraining stimuli used in experiment seven with targets that were blurred to two different levels. In the present experiment an overadditive effect would be present if an interaction between context, stimulus quality and member was found. This is because the traditional ‘context’ factor refers to the related/unrelated distinction that can only be measured in the legal contexts where such a distinction is possible. An interaction between context and stimulus quality would indicate that performance for predictable and unpredictable targets were superior in one condition over another - not that context was differentially affected by the relationship between context and target. All models predict that an interaction should occur between context, blur level and member because unrelated items are affected more by stimulus quality degradation than related items, with the exception of modification models which predict an interaction between context and blur level with the effect of blur level being additive between contexts.

Two possible theories were proposed for the results of experiment eight, a search based model and a modification based model, neither of which were completely satisfactory as single process theories but both of which could accommodate the results if incorporated in a dual process theory. If strategies or criterion shifts are readily introduced into sentence reading then the present experiment should also produce such shifts because degrading the visual input should also create circumstances where attention

shifts in favour of legal contexts. However, if the dual process theory is correct and increasing relatedness potential introduces bias into the system on a cost/benefit basis then limiting target visual input should not alter the automatic processes responsible for the context effects found at low relatedness potentials.

Method

Participants. Sixteen paid participants between the ages of 18 and 35 years were recruited from the student population of Nottingham University. Each participant took part in two 40 minute sessions, all participants had normal or corrected-to-normal vision and were native speakers of English. All participants were naïve to these experiments.

Stimuli. The high constraining experimental stimuli of experiments 7 and 8 were used in this experiment.

e.g. **(L)** singing in the *rain/ruin*
 (N) nerjosp em bli *rain/ruin*
 (R) company as flu *rain/ruin*
 (T) the singing in *rain/ruin*

Where (L) is legal context, (N) is nonword context, (R) is word replacement context and (T) is transposed context.

Blurring. Images were filtered in the Fourier domain with a circularly symmetric Gaussian Filter (Cogimatic, PO Box 47167, San Fransisco, CA 94147-16778). The cut-off spatial frequency was 7 cycles per character width for Blur 1 (18.7 cycles per degree) and 3.5 for Blur 2. The resolution of both the original image and the filter was 256 x 256

picture elements (pixels) with a 256 gray-level range (see Legge, Pelli, Rubin & Schleske, 1984, for rationale on use of object relative filters)

e.g. Blur 1	rain	ruin
	rain	rain
Blur 2	rain	ruin
	rain	rain

Design. Each 40 minute session consisted of 96 practice trials and 128 experimental trials and contexts were presented for 2 seconds. As the critical manipulation in this experiment was level of target degradation by blur it was deemed preferable that the same word pair members were compared across blur levels within each condition. Therefore, participants were assigned to either stimulus group A or B for both sessions. Thus, stimulus group was treated as a between-subjects factor and was counterbalanced across participants. All other aspects of this experiment were the same as experiments 7 and 8. The mean exposure duration of targets in experiment was 9 3.40 frames (20.40 ms) for blur level one and 10.03 frames (60.18) for blur level two.

Results

Legality reports were practically error free (<1%) indicating that participants were processing the sentence contexts appropriately. Mean percentages of target words correctly reported for each context display type is shown in figure 24. An ANOVA was conducted with two between-subjects factors [stimulus group (group A or B) and blur level order (1 or 2 first)]; and four within subjects factors [blur level (1 or 2), context type (legal, word replacement, nonword, and transposed), member (predictable and unpredictable) and critical letter position]. Main effects of blur level, $F(1,15)=21.896$; $p<.01$, $MS_e=442.546$; context $F(3,45)=8.140$, $p<.01$, $MS_e=534.559$, member, $F(1,15)=25.563$, $p<.01$, $MS_e=739.583$ and critical letter position $F(3,45)=7.591$, $p<.01$, $MS_e=549.859$, were found. Performance was greater for targets blurred to level 1 than level 2 and for predictable targets compared to unpredictable targets. Newman Keuls revealed that performance was greater for targets embedded in legal contexts than those in word replacement and nonword contexts (both p 's<.001). Performance for critical letter position 12 (figure 25) was greater than critical letter position 2 ($p<.001$), 3 and 4 while performance for critical letter position 3 was greater than that of 2 (all p 's<.05).

Additionally, there was an interaction between blur and context, $F(3,45)=4.266$; $p<.01$. Newman Keuls disclosed that performance was greater for targets in both legal and transposed contexts when blurred to level 2 than those in word replacement and nonword contexts (all p 's <.001). Moreover, performance for targets in both legal and transposed contexts remained equivalent between blur levels but performance deteriorated from level 1 to 2 in word replacement contexts and nonword contexts ($p<.005$). Finally, there was an interaction between context and member, $F(3,45)=7.154$,

$p < .0004$, $MS_e = 754.226$. Newman Keuls showed that performance for predictable targets in legal (both p 's $< .0005$) and transposed contexts (both p 's $< .001$) was more accurate than word replacement and nonword contexts. Performance for predictable targets was higher than for unpredictable targets in both legal contexts and transposed contexts ($p < .0004$). Performance for unpredictable targets remained similar across conditions.

The overadditive effect usually refers to a related/unrelated distinction, thus, in the absence of an interaction between blur, context and member, the interactions reported here do not correspond with that reported in the existing literature. Therefore, a one-way ANOVA was carried out on the legal contexts with two within-subject factors [stimulus quality (blur 1 & 2) and member (predictable and unpredictable)]. A main effect of member ($p < .01$) was found but there was no critical interaction between blur level, and member ($p > .920$).

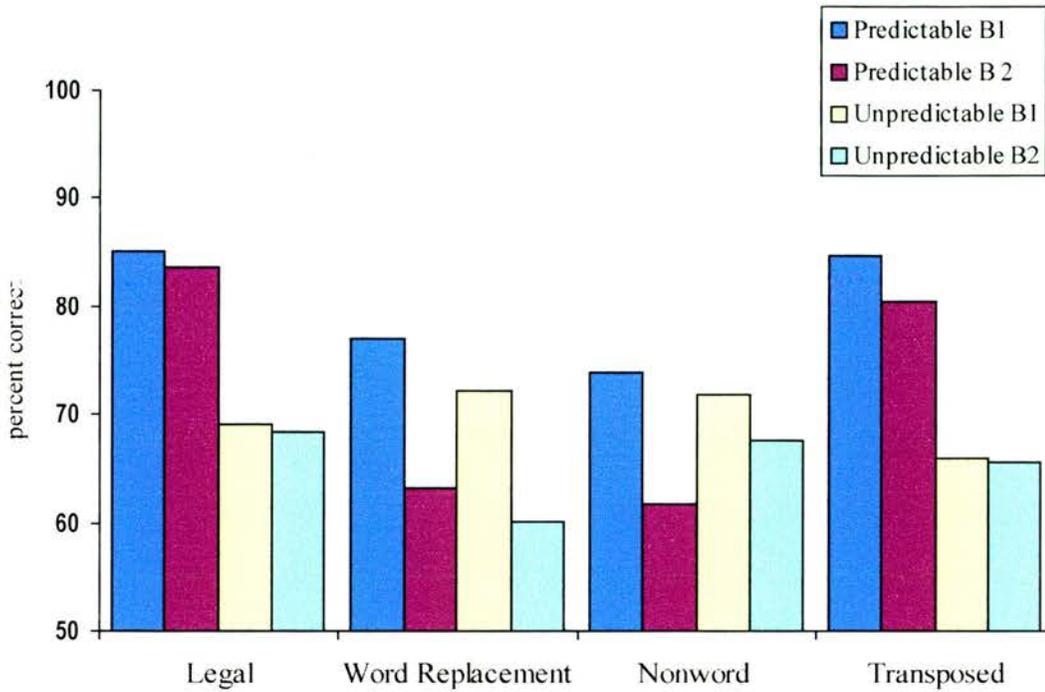


Figure 24. Mean percentage correct reports of predictable and unpredictable targets in each contextual condition.

Analysis by items revealed similar results to the subjects' analysis. Main effects of blur, $F(1,28)=11.599, p<.01$; member, $F(1,28)=5.25, p<.05$; and context, $F(3,84)=5.92, p<.001$, were found. Newman Keuls revealed that targets in legal contexts were reported with more accuracy than both word replacement ($p<.001$) and nonword contexts ($p<.005$). Additionally there was an interaction between member and context, $F(3,84)=16.74, p<.01$. Newman Keuls revealed that this interaction was due to a greater performance accuracy for member 1 targets in both legal and transposed contexts over word replacement ($p<.0001$; $p<.0005$, respectively) and nonword contexts ($p<.0001$; $p<.0005$, respectively) while performance accuracy for member 2 targets did not alter across contextual conditions.

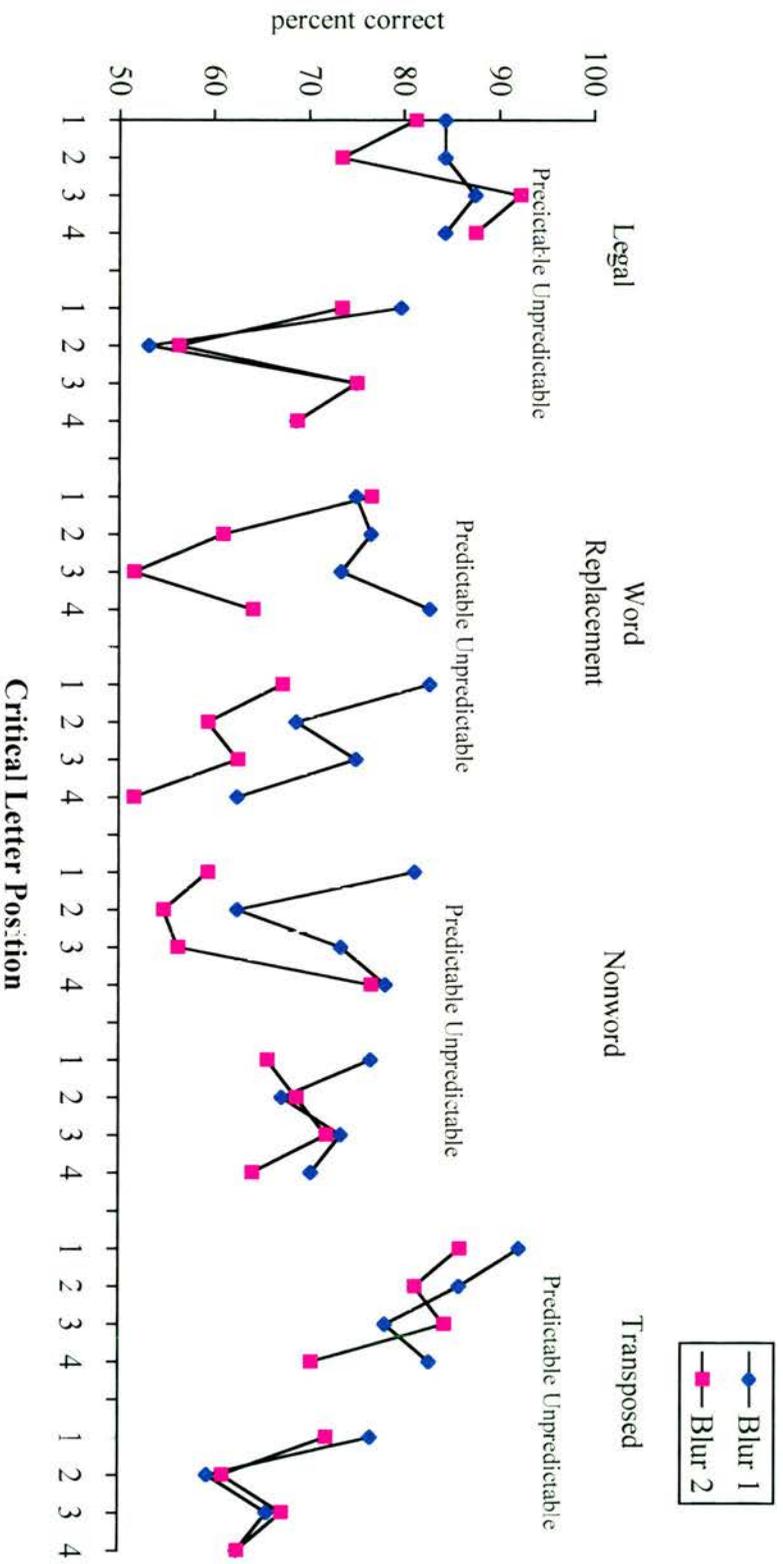


Figure 25. Mean percentages correct for each critical letter position in each contextual type in experiment 9.

Response ratios are shown in figure 26. T-tests carried out on the proportional data showed that at blur level 1, predictable targets in Legal [$t(15)=2.45, p<.01$] and Transposed [$t(15)=2.997, p<.01$] contexts were facilitated over baseline. Unpredictable targets did not fall below baseline [Legal, $t(15)=.715, p>.485$; Transposed, $t(15)=1.454, p>.166$]. At blur level 2 predictable targets in Legal [$t(15)=2.99, p<.01$] and Transposed [$t(15)=2.392, p<.01$] contexts were facilitated over baseline with no corresponding detriment to unpredictable targets [Legal, $t(15)=.046, p>.964$; Transposed, $t(15)=.607, p>.554$]. Therefore, there was no response bias at either blur level in legal contexts. Although non significant transposed sentences again showed a trend towards bias at both blur levels where unpredictable targets are reported below baseline. Response ratios for blur 1 were; legal predictable (0.539) unpredictable (0.491), word replacement predictable (0.511, unpredictable (0.504) and transposed predictable (0.538) unpredictable (0.478). Response ratios for blur 2 were legal predictable (0.578) unpredictable (0.499), word replacement (0.511) unpredictable (0.469), transposed predictable (0.571), unpredictable (0.490).

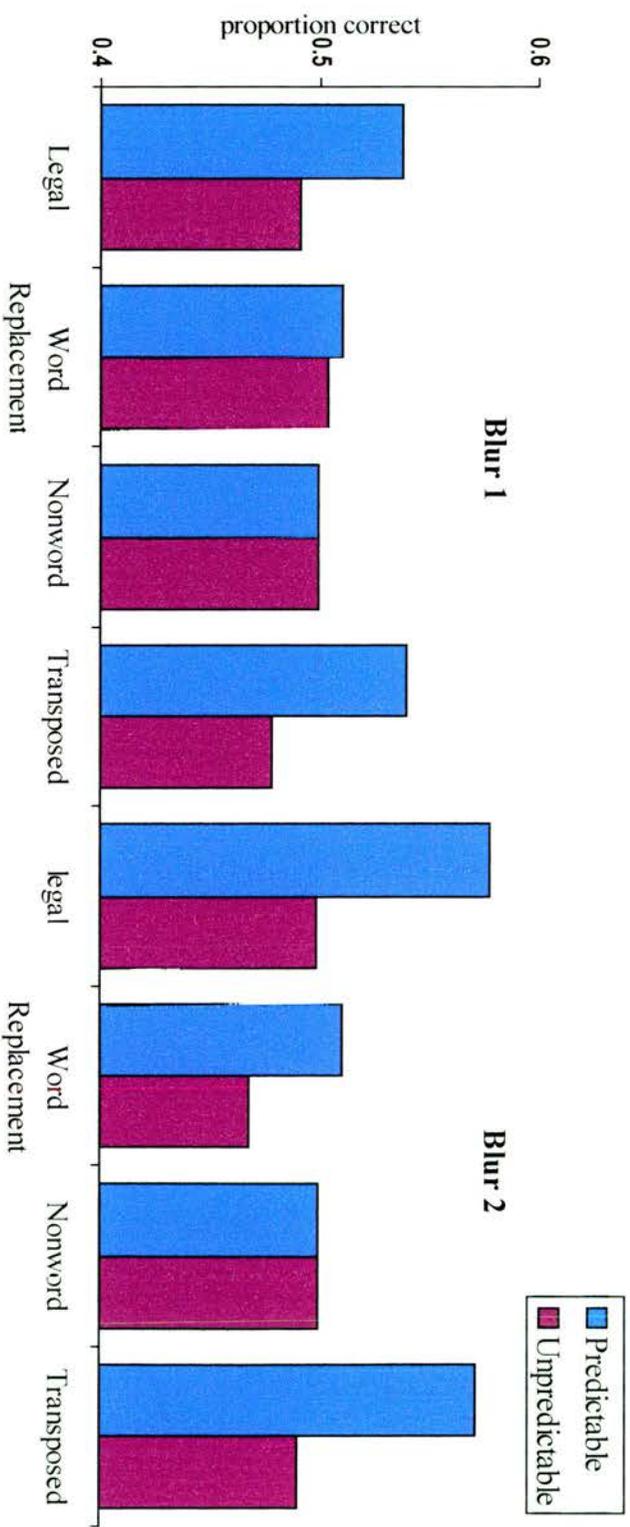


Figure 26. Response ratios for each contextual type in experiment 9.

Experiment 9b

Experiment nine produced no overadditive effect of context since there was no three-way interaction between context, member and stimulus quality. Therefore, the results of the present experiment did not conform to any previous research using degraded targets. One possible explanation for this is that targets in both conditions were blurred whereas previous research has compared non-degraded targets with degraded targets. In order to test whether this fact interfered with the results, experiment nine was re-analysed with the results of experiment six before proceeding with the discussion of experiment nine. Experiment seven was essentially the same experiment except targets were not degraded by blurring.

Results and Discussion

An ANOVA was conducted on the combined results of experiments 7 and 9 with one between subjects factor (experiment 7 or 9) and three within-subjects factors, [stimulus quality (clear and blurred), context (legal, word replacement, nonword and transposed) and member (predictable and unpredictable)]. Main effects of blur, $F(1,15)=16.569, p<.01 MS_e=176.653$; member, $F(1,15)=27.496, p<.01 MS_e=86.016$ and context, $F(3,45)=76.772, p<.01 MS_e=76.773$, were found. Additionally there were two-way interactions between stimulus quality and context, $F(3,45)=6.369, p<.01 MS_e=60.504$; stimulus quality and member, $F(3,45)=7.434, p<.01 MS_e=54.440$; and context and member, $F(3,45)=9.605, p<.01, MS_e=70.506$. However, the critical three-way interaction was still not significant and the results were remarkably similar to those of

experiment 9. Therefore, since the analysis was between different experiments the discussion will proceed on the results of experiment 9.

Discussion.

The results of the present experiment falsify the hypothesis proposed by search and post-perceptual models that the context x stimulus quality interaction is caused by the poorer performance of unpredictable (or unrelated) targets as the visual quality of the target deteriorates. In fact, the present experiment did not find an overadditive effect similar to that reported in single word priming literature (e.g., Becker & Killon, 1977, Besner & Smith, 1992; Borowsky & Besner, 1993; Meyer, Schvaneveldt & Ruddy, 1975; Stoltz & Neely, 1995). Performance for predictable and unpredictable targets was remarkably similar in both legal and transposed contexts between blur levels while performance deteriorated in both visually matched control conditions. Moreover, a look at the response ratios demonstrates that performance for predictable targets actually improved over baseline between blur levels in legal and transposed conditions while performance for unpredictable targets remained very similar.

There are several possibilities as to why the present experiment did not replicate previous results. First of all, related context/target presentations in single word priming rely on word association. In contrast, the current experiment used predictable context/target presentations which contain no direct word association and instead rely on semantic or conceptual priming for their relatedness. Further, unpredictable targets were not incongruous with their contexts in legal phrases but formed meaningful, if unpredictable, units. Moreover, targets were blurred which removed detailed visual

feature information rather than reducing contrast. If, as previously suggested, the basis of word recognition can be based on more global or rudimentary visual information than letter features then retaining this aspect of word information may have facilitated both target types in legal contexts over baseline contexts.

In this experiment the interaction between context and stimulus quality was due to the superior performance of targets in both legal and transposed contexts over both word and nonword replacement contexts as target degradation increased. Therefore, the present findings show that degraded target recognition was based on a combination of the visual input and the context because the highly constraining nature of the contexts did not create strong weighting in favour of predictable targets at the expense of unpredictable targets in legal and transposed contexts. Since the interaction occurs in the absence of any bias, the consistency of report accuracy of the legal and transposed targets between blur levels appears to be due to the context exerting its influence at the visual encoding level of the target.

Blurring targets had an unexpected impact on transposed sentences. When these sentences were presented unblurred in experiment seven, they had no influence on target performance. It was proposed that because legal sentences were highly constraining that predictability was dependent on word order so that disrupting word order alerted participants to the illegality of transposed sentences. In this case, participants may have made no further attempt to make sense of transposed sentences and the sentences became similar to word replacement sentences. In experiment nine, however, performance for predictable targets was superior to performance for unpredictable targets and response ratios were higher for predictable targets at both blur levels over baseline and superior at

blur level two than level one, despite a trend towards a biasing effect. It would seem that blurring targets in highly constraining sentences increased the likelihood that post-perceptual decisions would be made regarding the identity of targets in transposed sentences. Decreasing the available visual information created a greater reliance on contextual information which was not fully encoded before target onset.

Summary

In summary, this chapter established that word recognition can proceed with limited visual input. This questions the validity of models of word recognition that are based initially on letter fragments (i.e., Besner & Smith, 1992; Morton, 1969; Norris 1986; Potter, Moryadas Abrams & Noel, 1993; Potter, Stiefbold and Moryadas, 1998; Stoltz & Neely, 1995). High constraining contexts improve performance of predictable targets without interfering with performance for unpredictable targets, a finding that holds as the quality of the visual input decreases. This effect strongly indicates that context exerts its influence at the visual encoding stage of word recognition and poses serious problems for models which propose a biasing or final selection role for context, and therefore, supports a modification account of context. Moreover, degrading the visual input of targets did not produce a criterion or attention shift that places greater weight on contextual influence at the expense of the visual information in the same way that increasing the salience of the relationship between context and targets did in the previous chapter. Specifically, some of the findings (experiment eight) can be explained by search or final selection type models and some (experiment seven and nine) can be explained by modification models. This finding further indicates that a single mechanism cannot

account for all contextual effects because in some circumstances there is a greater reliance on contextual information at the expense of visual input and in other circumstances context influences the visual input level. There are two main contenders for a dual process model: (1) *The dual process theory* (Neely, 1976, 77); in which the first stage is an automatic semantic association stage and the second is an expectancy search stage; (2) *the multistage activation model* (Besner & Smith, 1992; Stoltz & Neely, 1995) which has two pathways, A and B. However, only the *multistage activation model* can accommodate similar findings with low constraining stimuli. The next chapter, therefore, blurs the targets of low constraining stimuli.

CHAPTER SEVEN

The findings of chapter six demonstrate that the influence of context goes beyond that proposed by post-lexical models (weak and modified modular perspectives). When high constraining sentences were presented legal contexts did not bias word identification towards predictable targets, even when the visual input from the target was blurred to level two. Moreover, experiment nine adds weight to the evidence accumulating within this thesis that context can indeed influence word recognition at the visual input level, as well as through more attention or strategic based processing (e.g. experiment eight). Thus, it would seem that only a dual process theory can accommodate these rich and diverse findings.

Nonetheless, the results of experiment nine do not completely rule out the search class of models (i.e., expectancy or verification). This is because the highly constraining nature of legal contexts might have resulted in an expectancy set of one item. Therefore, search of the semantic set may not have interfered with the formation and search of the visually defined set to an extent sufficient enough to hinder performance with unpredictable targets, in which case, making incorrect predictions may have been easily rectified. Under these circumstances search and modification based models make similar predictions – i.e., an advantage for predictable targets without a corresponding disadvantage for unpredictable targets. Although it is unlikely that search models, which do not permit modification of word representations, could account for the absence of response ratio bias at blur level two where visual input was extremely limited, search and

modification models make clear and distinct predictions where low constraining legal stimuli are concerned.

Search based models explain contextual effects by placing the locus of contextual influence at the prediction stage. Contextual effects, particularly where visual input is degraded, are the direct result of incorrect predictions being made for unpredictable targets interfering with normal word recognition. Where low constraining stimuli are concerned, it is unlikely that participants make any predictions as to target identify. In which case there will be no effect of context. If participants do make predictions then the semantic set will be so large that performance will drop in the legal condition. For example, presentation of ‘the room was ----’ would create a large number of possible word candidates which have to be searched through before search of the visually defined set could be carried out. Thus, search models predict either no reliable differences between contextual conditions or a context x stimulus quality interaction created by a legal sentence disadvantage which should increase as degradation increases.

Predictions for the *multistage activation model* are difficult to make where low constraining stimuli are concerned as the model was formed to accommodate semantic priming. However, if the assumption is made that pragmatic information (i.e., constraints) can operate between the semantic system and the orthographic input system, much the same way as semantic word association operates, then the model predicts greater performance for targets in legal contexts. For example, in the sentence ‘the room was *tidy*’ the target *tidy* would activate *tidy*, *tiny*, *tide* and *tody* as the visually defined set. However, the context constrains the possible candidates to *tidy* and *tiny* as these are the only two that form a meaningful sentence. This would reduce thresholds for these two

items in the semantic system which would allow both alternatives *tidy* and *tiny* in the sentence to be recognised more efficiently in legal contexts. Thus, by this use of pragmatic information provided by the sentence context, performance for targets in legal sentences would be more accurate. Under these circumstances, performance should increase in legal contexts over control conditions as degradation increases.

Experiment 10

In order to test the above predictions experiment ten presented the low constraining stimuli of chapter three under the same visual conditions as those of experiment nine. Search and modification models make opposing predictions where low constraining stimuli are concerned. Search based models predict either no reliable difference between contextual conditions or an interaction with context and blur level where the interaction is the result of a decrease in target performance in legal contexts as stimulus quality decreased. On the other hand, modification models predict that an interaction between context and blur level should occur where the interaction is the result of an increased performance level in legal contexts as stimulus quality decreases. Moreover, an interaction between context and blur level caused by an increase in performance for targets would demonstrate that the sentence level was at least one locus of contextual influence. This is because the system of influence must be outwith the lexicon in the absence of word or semantic association. Finally, an integration account cannot explain an increased advantage for targets in low constraining legal contexts as the visual quality decreases. This is because the formation of a visual representation in

memory would be the same between blur levels in legal contexts making stimulus quality an additive factor.

Method

Participants. Sixteen paid participants between the ages of 18 and 35 years were recruited from the student population of Nottingham University. Each participant took part in two 40 minute sessions, all participants had normal or corrected-to-normal vision and were native speakers of English. No participant had taken part in previous experiments.

Stimuli. The low constraining stimuli of experiments 1, 2, and 3 were used in this experiment. Targets were blurred in the same way as those of experiment 9. All other aspects were the same as experiment 9. The mean exposure duration of targets in experiment 10 was 3.98 frames (23.88 ms) for blur level one and 11.46 frames (68.76) for blur level two.

Results

Legality responses were practically error free (<1%) indicating that participants were processing the context displays appropriately. Mean percentages of target words correctly reported for each context display type is shown in figure 27. An ANOVA was conducted with two between-subjects factors [stimulus group (group A or B) and blur level order (1 or 2 first)]; and four within subjects factors [blur level (1 or 2), context type (legal, word replacement, nonword, and transposed), member (member 1 or member 2 of each target word pair) and critical letter position]. Main effects of blur, $F(1,12)=31.764$;

$p < .01$, $MS_e = 1435.547$, context, $F(3,36) = 4.086$; $p < .01$, $MS_e = 578.101$, and critical letter position $F(3,36) = 29.650$, $p < .01$, $MS_e = 491.295$, were found. Newman Keuls revealed that targets embedded in legal contexts were reported more accurately than those in word replacement and nonword contexts (both p 's $< .02$). Performance for critical letter position 1 was more accurate than that of 2, 3 and 4 (all p 's $< .0001$) and performance for critical letter position 4 was more accurate than 2 ($p < .03$). There was no interaction between blur and context, $F(3,36) = 2.532$; $p < .07$, $MS_e = 415.099$.

Due to the trend and the amount of variables that are not normally included in overadditive research, blur and context were reanalysed without the letter position data. When this was done an interaction between blur and context was revealed, $F(3,34) = 3.146$, $p < .05$, $MS_e = 52.541$. Newman Keuls disclosed that the interaction was due to the more accurate report of targets embedded in legal contexts when blurred to level 2 over all other contexts (all p 's $< .001$). Performance for targets in word replacement, nonword and transposed conditions when blurred to level 1 was greater than level 2 (all p 's $< .001$) whereas report accuracy for targets embedded in legal contexts increased as stimulus quality decreased, $p < .05$.

Analysis by items revealed a similar pattern as the subjects analysis, main effect of blur, $F(1,23) = 49.904$, $p < .01$ and no interaction between blur and context $F(3,69) = 2.568$, $p < .06$.

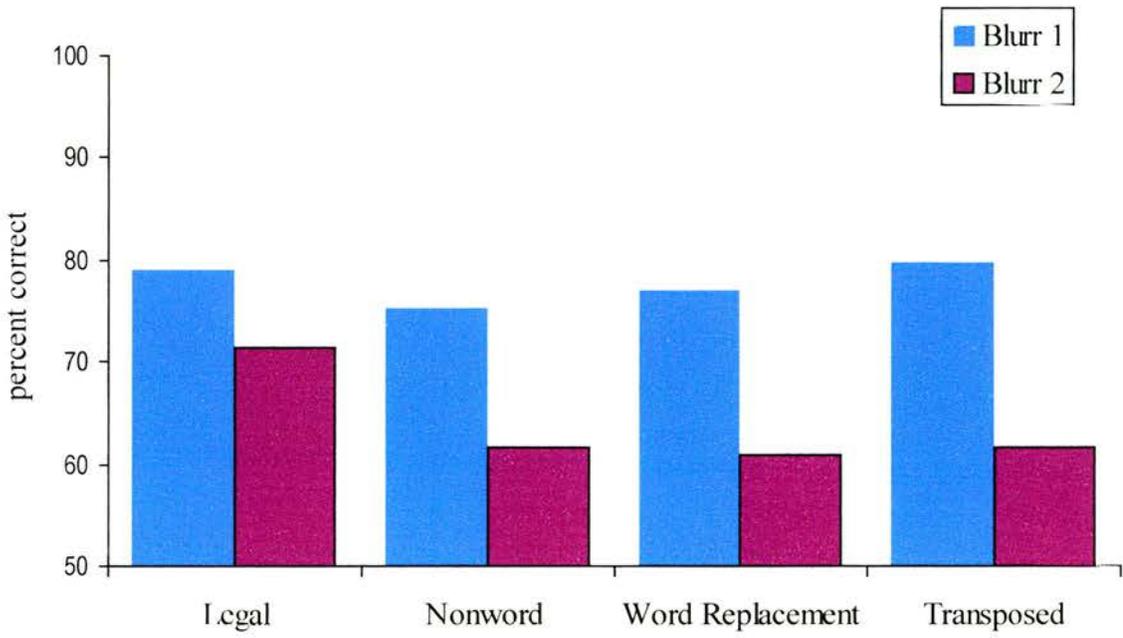


Figure 27. Mean percentage of target words correctly reported for each context display type in experiment 10.

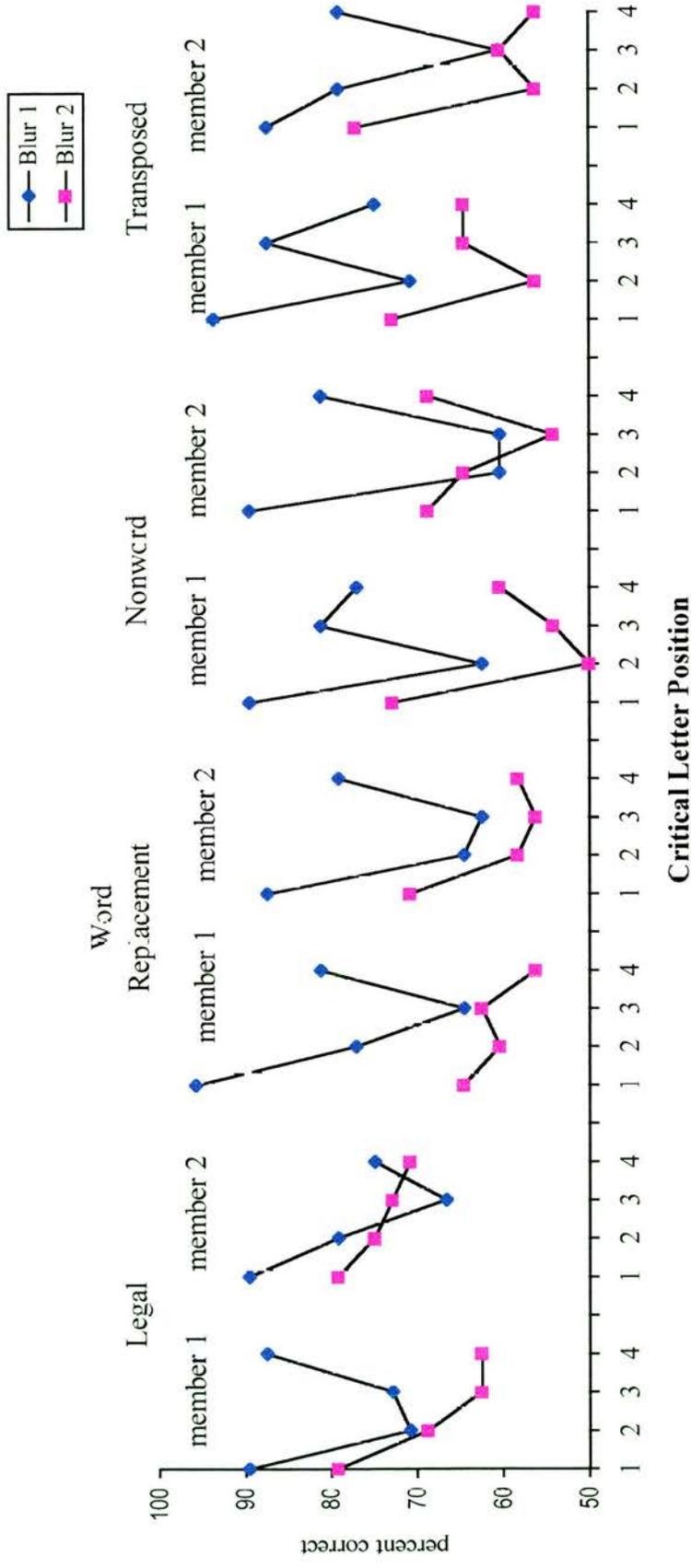


Figure 28. Mean percentage correct for each critical letter position for each contextual display in experiment 10.

Figure 29 shows the response ratios. T-tests showed no effect for any target type compared to baseline at blur level 1. However, at blur level 2 both members in the legal contexts showed greater response ratios than baseline, member 2, $t(15)=2.55$; $p<.01$; member 1, $t(15)=2.02$; $p<.05$. Thus, response ratios for both members of the target word pairs increased between blur levels in the legal condition showing no response bias. Response ratios for blur 1 were legal member 1 (0.509) member 2 (0.514), word replacement member 1 (0.509) member 2 (0.484), transposed member 1 (0.513) member 2 (0.499). Response ratios for blur 2 were; legal member 1 (0.537) member 2 (0.534), word replacement member 1 (0.507) member 2 (0.484), transposed member 1 (0.522) member 2 (0.492).

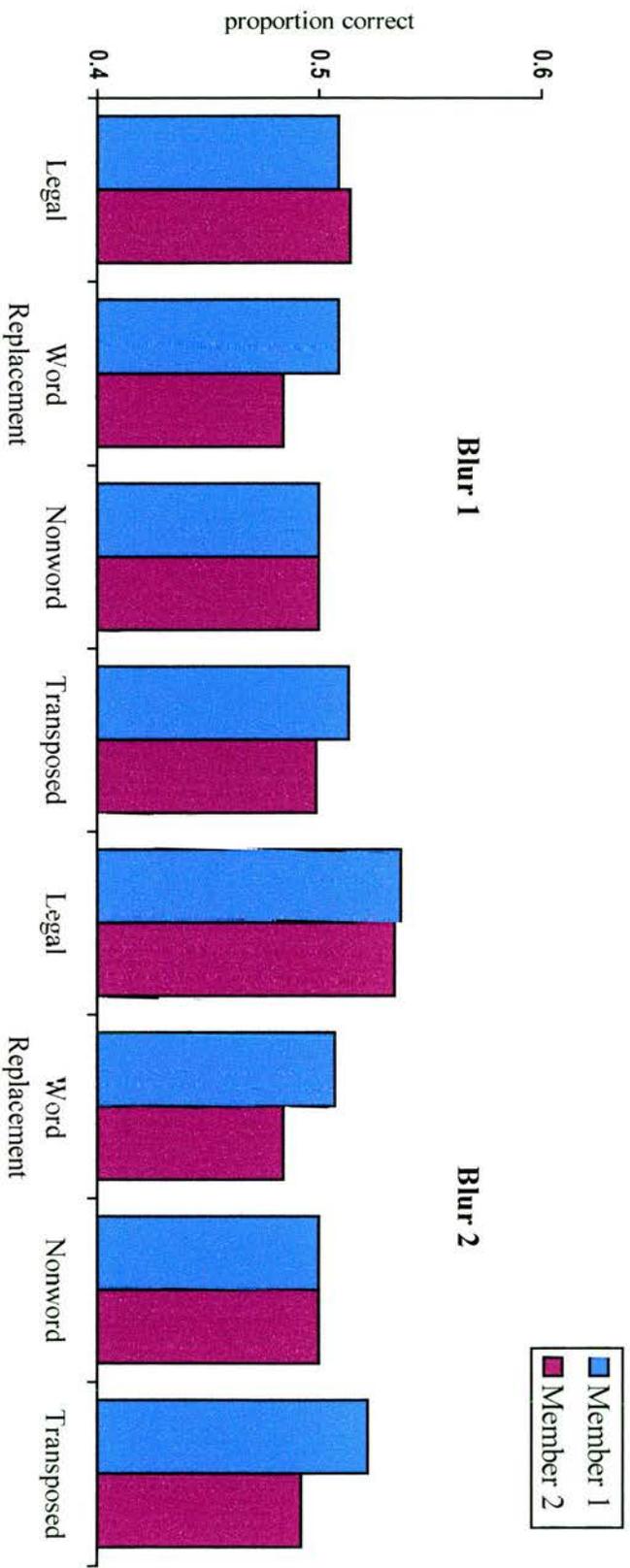


Figure 29. Response ratios for each contextual type in experiment 10.

Discussion.

The present experiment provides compelling evidence that words, when embedded in legal contexts, are identified more accurately because of enhanced recognition processing afforded by legal contexts. As the detailed visual information available from targets decreased the benefit derived from being in a legal phrase increased over all control conditions. In other words, recognition of targets in very low constraining legal contexts is affected less by stimulus degradation than all other context types. This finding has significant implications for four main issues often cited in sentential literature:

(1) The interaction with blur and context demonstrates that word recognition does not require detailed visual information but can be carried out accurately from very rudimentary, word blob like information. This basic visual processing is influenced by the context in which the degraded word target is embedded. Where that context is meaningful and legal the ability to utilise such basic information provided by blurred targets is enhanced over baseline sentences. The process of blurring the target words effectively removed much of the detailed featural information that target words normally provide but the targets were reported well above chance, even in nonword contexts with targets blurred to level 2. This must call into question any model of word recognition that relies on detailed featural information as the basic premise of word recognition.

(2) Sentential contexts seem capable of directly influencing the orthographic input system. This experiment measures accuracy between two visually similar alternatives, both of which are equally supported by the legal contexts thus, any improvement in performance relies on a more accurate resolution of the visual input. Specifically, correct

report ultimately depends on resolving the difference between two visually similar words both of which form a semantically and syntactically coherent representation in the legal condition (i.e., 'the room was *tidy*' or 'the room was *tiny*'). When the targets are preceded by legal contexts this distinction is easier to make despite the fact that the context did not bias in favour of either presented target.

(3) Many models (i.e., *plausibility checking mechanism*, Norris 1986; *the modular interactive model*, Potter, Moryadas Abrams & Noel, 1993; Potter, Stiefbold and Moryadas, 1998; *the logogen model*, Morton, 1969; *multistage activation model*, Besner & Smith, 1992; Stoltz & Neely, 1995) rest their description of the context x stimulus quality interaction on a predictive process. Experiment ten contradicts this claim by obtaining an interaction between blur and context with very low constraining sentences and a paradigm designed to overcome sophisticated guesswork. Under these testing conditions search based models predicted either no reliable difference between contextual conditions or a legal sentence disadvantage. This was not the case. Modification models could accommodate the present findings providing provision is made within the semantic system to constrain the possible alternatives forming at the orthographic level thus improving resolution of the visual input in the legal condition.

(4) Integration accounts suggest that legal contexts and their targets would form a meaningful representation in memory which would produce greater accuracy by 'stabilising' the target representation. This proposal would not improve accuracy between blur levels because the 'stability' afforded by formation of a meaningful representation would be similar between blur levels and the improved accuracy rests on the visual input being 'seen' more clearly.

In contrast to the findings of Experiment three, when targets were degraded performance in transposed sentences reflected that of word replacement and nonword contexts rather than legal contexts. One possible explanation for this is that when the visual input from the target becomes harder to resolve, the additional processing required by transposed sentences interferes with the formation of visual representations of targets. This interference would leave resolution or match with items activated within the orthographic input at a post-perceptual level as indicated by the bias ratios.

In summary, the findings of the present chapter provide further evidence that contextual influence on word recognition in sentences can take place at the visual input level and that the locus of contextual influence is the sentence level rather than the lexical level. This evidence can only be accommodated by a modified interactive model of word recognition and finds in favour of the *multistage activation model*.

CHAPTER EIGHT

This thesis addressed the modular interactive debate by examining the influence of legal sentence contexts on word recognition. This thesis presented findings reconcilable with both accounts depending on presentation methodology. In this respect it would appear that word recognition can be directly influenced by sentence level ruling out a weak modular account of word recognition. The main findings can be summarised as follows:

1. A legal sentence advantage was found for low constraining sentences providing sufficient time was allowed for context to exert its influence. At very fast contextual presentations only examination of response ratios indicated some contextual influence.
2. No contextual influence was found when legal sentences were of a repetitive nature. However, when visual matching of target and forced choice alternatives was suppressed, a legal sentence advantage was obtained.
3. A legal sentence advantage was found for highly constraining legal sentences in the absence of response bias. Predictable targets were reported more accurately in legal contexts than all other conditions without a corresponding fall in accuracy for unpredictable targets.
4. When the predictability of targets in legal sentences was made more salient there were no reliable differences between conditions. Response ratios showed bias in legal contexts with increased ratios for predictable targets and decreased ratios for unpredictable targets over baseline contexts.

5. When targets were blurred a legal sentence advantage was found. This advantage increased as visual stimulus quality decreased for highly constraining sentences. However, accuracy for unpredictable targets in legal contexts did not deteriorate as stimulus quality decreased.
6. A legal sentence advantage was found for blurred targets with very low constraining legal contexts with the advantage increasing as the stimulus quality of targets decreased.
7. When word order of legal contexts was disrupted by transposition in low constraining sentences, transposed sentences demonstrated an intermediate influence on word recognition. This influence disappeared when the low constraining stimuli were repetitive and when the constraining nature of the sentences was increased. However, responses to transposed sentences were more like legal sentences when the salience of predictability was increased and when targets were blurred for highly constraining sentences but not when targets were blurred in low constraining sentences. Overall transposed sentences produced results that were more consistent with post perceptual decisions than the results of legal sentences.
8. Targets that were blurred (removing a substantial proportion of detailed visual information) were recognised above chance in all contextual contexts.

8:1 The Sentence Superiority Effect

The first ramification of these findings for the modular interactive debate was found in experiment three which demonstrated that word recognition is improved in low

constraining legal sentences. From a weak modular perspective, low constraining sentences that contain little word association are incapable of improving word recognition. Forster (1981) suggested that low constraining sentences inhibited target word recognition when measured against a neutral baseline of word replacement contexts. In experiments three, six and ten legal contexts did little to define either member of a word pair, yet both members of the word pair were reported more accurately in legal contexts over word replacement and nonword contexts. Moreover, Duffy et al., (1989) and Forster (1981) suggested that sentential contexts were often measured against an inhibited baseline, thus producing apparent legal sentence advantages where none were truly merited. The findings of this thesis favour word replacement contexts as a more adequate baseline than standard neutral sentences, as suggested by Forster (1981). However, the findings of chapter three indicate that it is their repetitive nature that confounds word recognition and challenge the view of Forster (1981) and Duffy et. al. (1989) that this is due to the lack of constraints exerted by standard neutral sentences. In experiment five sentences which exert very little constraint on target recognition similar to standard neutral sentences (i.e., standard neutral, 'the next word will be ----', low constraining stimuli 'the horse was ----') produced results with no reliable differences between conditions. When the forced choice alternatives were presented in capitals to suppress visual cues (that may have concealed some contextual influence) the same stimuli produced a legal sentence advantage, as did the same type of stimuli in experiment three (i.e., 'the room was ----') when re-analysed alone. These findings provide substantial evidence that it is not the nature of low constraining sentences that produce inhibition effects in naming tasks but the number of times the same sentence is

repeated during an experimental session which produce interference in the manner described by West and Stanovich (1986). Moreover the lack of inhibition effects in experiment five indicate that repetition may eliminate contextual effects but not actually inhibit lexical access - rather it inhibits production of language. This indicates that a forced choice paradigm may be better suited to examine the effect of sentential contexts on lexical access. Chapters two and three provide evidence that word replacement and nonword contexts fulfil the role of baseline better than both standard neutral and no context conditions (single word presentations in experiments two and three). Thus, under the stringent testing conditions used in this thesis, low constraining sentence contexts do exert a facilitative influence on word recognition where the weak modular account predicts none.

8:2 What Stage of Processing is Affected by Legal Contexts?

The findings of this thesis present problems for weak modular accounts of word recognition in contexts in another respect. Several lines of evidence have been presented which indicate that sentence contexts can exert their influence at the visual input level. This is because several manipulations of visual components affected target report in legal contexts:

(1) Legal sentence advantages were obtained with both low and high constraining legal contexts where relatedness potential was low. Moreover, excluding experiments one and eight, there were very few errors to verbal reports of 'legality' and no response bias. This indicates that the legal stimuli formed legal, meaningful sentences with both target members and that participants were not completing the task by using legal contexts to

resolve partially processed information extracted from targets. Under these circumstances, where one condition produces greater accuracy than other conditions, the distinction between two visually similar word items is being resolved more efficiently in that condition. Thus, the evidence from experiments three, six, seven and ten indicate more efficient visual processing in legal conditions. This is particularly striking where contexts predict one member of the word pair, which is presented on half the legal trials, yet legal sentence advantages are obtained in the absence of response bias.

(2) Suppressing the use of visual matching in experiment six produced a legal sentence advantage where none had previously been obtained, indicating that limited visual cues (which could artificially enhance word recognition outwith lexical access) were being used to improved target accuracy in control conditions. Thus, where lexical access was required to transform lower case targets into upper case representations in order to accurately choose from the forced choice alternatives, legal sentence contexts enhanced word recognition over all other contexts in a rather dramatic fashion (from no reliable differences between conditions to $p < .001$).

(3) Both low and high constraining sentences produced a legal sentence advantage when targets were blurred which increased as targets became more blurred. This finding was particularly striking at blur level two with highly constraining stimuli. These sentence contexts predicted one particular word (i.e., 'born to be *wild*') but on half the trials an unpredictable target was presented which was visually similar, particularly at blur 2 (i.e., 'born to be *mild*'). Yet, despite this potential pitfall, participants report the unpredictable *mild* as often in legal contexts as in control contexts. Any trace of post-perceptual processing, sophisticated guesswork, final selection stage processing or

ordered search would have biased legal contexts towards predictable targets. Thus, target report was based on the combination of visual information and contextual influence for a legal sentence advantage to have been obtained. Under the premise of interactive factors logic (Sternberg, 1969) the interaction between blur and context sites the visual level as the processing stage where legal sentence contexts exert their influence. Thus three lines of evidence point in the direction of the visual processing stage of word recognition being influenced by sentential contexts.

8:3 The Locus of Sentential Effects

The present findings also indicate that the locus of contextual influence is at the sentential level. From a weak modular perspective, word recognition in sentences can be facilitated in only two ways. (1) By word association, which spreads activation between items within the lexicon without violating modularity because the process remains internal to the lexicon. Semantic association can be ruled out on two counts. Firstly, low constraining legal sentences, which did little to define either word target, and which contained virtually no semantic or word association produced legal sentence advantages. This occurred even when targets were blurred to remove detailed visual information. Secondly, the highly constraining stimuli in this thesis were formed from well-known phrases, song titles and proverbs in order to suppress semantic or word association (i.e., ‘born to be *wild*’, ‘singing in the *rain*’, ‘shop till you *drop*’ and ‘as smooth as *silk*’). When independent judges were asked to complete the legal contexts they generated the predictable target on every occasion yet when independent judges were presented with the key word form each legal context and asked to report an associated word none of the

predictable targets were generated. For example, *born*, *singing*, *shop* and *smooth* did not generate *wild*, *rain*, *drop*, or *silk*, respectively. In light of this evidence we can conclude that semantic or word association was not a significant factor during processing of these stimuli, thus the locus of the contextual effect was at the sentence level and the legal sentence advantage violates the modularity perspective. (2) Alternatively, according to the weak modular perspective word recognition can be apparently improved in sentence contexts because the context enables sophisticated guesswork to be more efficient. Further, the Reicher-Wheeler task was used in all experiments reported in this thesis where all targets were appropriate, if not necessarily predictable, completions of their legal sentence contexts, yet there was a legal sentence advantage in experiments three, six, eight, nine and ten. This clearly rules out sophisticated guesswork based on both lexical and sentential constraints, especially where sentences predicted one forced choice alternative.

Another source of evidence that the locus of legal sentence contextual influence is at the semantic or conceptual level rather than the lexical level comes from experiments six, nine and ten. All these experiments found evidence that legal sentence contexts influence word recognition at a more abstract level than other contextual conditions - indicating that the locus of contextual influence is coming from a more abstract level of processing. Experiment six found that transposing the visual information provided by targets from lower to upper case produced a large legal sentence advantage where there had previously been no reliable differences between conditions. Experiments nine and ten found that legal contexts could make better use of very rudimentary visual information. Had the locus of these effects been lexical the factors of visual matching and blur would

have been additive across conditions. However, as all these visual factors were found to interact with legality it would appear that the locus of legal sentence influence is operating at a more abstract level of processing than the lexicon.

The evidence provided by transposed sentences adds additional weight to this proposal. Where the low constraining sentences of experiment three were concerned, transposed sentences exerted an intermediate contextual effect on target performance, improving word recognition over nonword contexts but not over word replacement contexts. However, when contextual influence was dependent on word order, transposed sentences produced similar levels of performance to both visually matched control contexts. Thus, where predictability depended on word order no contextual influence was found but where word order was less important, and legality less easy to detect, there was a residual legal effect. This thesis, therefore, has provided evidence supporting the proposal of Tannenhouse and Lucas (1987; see also Fischler, 1977; Lupker, 1984) that the locus of semantic influence is at the semantic/conceptual level and refuting the proposal of Ratcliffe (1987) that pure semantics are a lexical property. This is because phrases such as ‘born to be’ did indeed prime the word *wild* more than the phrase ‘be born to’. According to Tannenhouse and Lucas, this would occur because phrases such as *large dog* (i.e., born to be) become concepts only when the words are properly combined and are meaningless when transposed into *dog large* (i.e., be born to). Therefore, taken together the evidence from this thesis indicates that the locus of the legal sentence advantage was out with the lexicon, thus violating the weak modularity perspective.

This is not to deny that spreading activation within the lexicon takes place, nor that it has no place in sentential effects but that it is insufficient to account for all

sentential effects. It does however, support two proposals put forward in the introductory chapter. Namely, the proposal of Duffy et al., (1989; Foss and Ross, 1983; Sharkey & Sharkey, 1987, 1992) that that the sum of activation on a target is not necessarily equal to the sum of individual parts of the sentence. This is particularly relevant where low constraining sentences are concerned as 'the room was ----' would be unlikely to produce a semantic set yet produced a legal sentence advantage. This was most probably achieved by constraints exerted by contexts limiting activation from the visual input within the semantic system by constraining the purely visually defined possibilities (i.e., *tidy*, *tiny*, *tide* and *tody*). However, the present findings contradict the additional proposal that this activation takes place only after lexical access in a post-perceptual integration process.

The present findings support the proposal of Hess, Foss and Carroll (1995) which states that readers may be particularly sensitive to coherence relations at the highest level that the materials permit. Therefore, when passages are presented this is the level at which coherence is sought, not at the sentence level. However, when sentences are presented this is the level at which coherence is sought, thus single word priming studies require semantic word association where sentences do not. This would explain why neither experiment nine or ten produced a three way interaction between context, member and stimulus quality. Single words require predictions to be made in order that context can exert an influence on target word recognition, however, sentence contexts do not require predictions to be made, only that activation be spread throughout a network to channel the information accumulating from the orthographic input system. Thus low relatedness potentials do not produce context effects in semantic priming studies where the cost of operating this processing load is deemed too high by the system. However,

when sentence contexts are the highest level of material presented then an automatic component of contextual influence that uses less processing is used at low relatedness potentials. This component does not inhibit unpredictable targets in legal contexts in the same way as incorrect predictions regarding unrelated words in single word priming. When the salience of the relationship between predictable targets and their legal contexts is increased (experiment eight), predictions are made and responses to unpredictable targets in legal contexts deteriorate as they do in single word priming studies. Thus, although the findings of this thesis confirm the proposal of Hess et al., (1995) that contextual effects are carried out at the highest level possible the findings contradict the auxiliary proposal that ease of integration affects speed of target report.

8:4 The Dependence of Semantic Influence on Sentence Coherence

What the proposals of Duffy et. al., (1989) and Hess et. al., (1995) have in common is their explanation for the often-reported lack of contextual effects for transposed contexts (i.e., O'Seaghdha, 1989, 1997; Simpson, et al., 1989). Under the circumstances proposed by Duffy et al., (1989), the lack of facilitative effects found in scrambled sentences are due to the failure of the constraining influence (or checking mechanism) in incoherent sentences. Similarly, under the circumstances proposed by Hess et al., when the target coheres with a continuously shifting global discourse representation it is easily integrated and, therefore, responded to faster than words that do not cohere. However, the findings of transposed sentences in this thesis are more complex than this and merit being listed per experiment with reference to their response ratios before discussion.

1. Low constraining sentences presented for 150ms. No effect of context. When the members of word pairs were split into member one and two to form the response ratios, ratios were greater for member one than word replacement, nonword and legal contexts while response ratios for member two were poorer than legal contexts but similar to baselines.
2. Low constraining sentences presented for 240ms. No difference between contextual conditions but response ratios for both members than their baseline nonword counterparts.
3. Low constraining sentences presented for two and five seconds. Increased performance for targets in transposed contexts over baseline nonword with no response bias. However, both response ratios were greater than baseline.
4. Low constraining sentences of a similar concrete nature, presented for two seconds. No effect of context, however, response ratios were greater for member one than member two in transposed contexts and member one was above baseline while member two fell below baseline.
5. Repeat of experiment five with visual matching controlled for by presenting forced choice alternatives in uppercase. Legal sentence advantage but transposed sentences behaved similar to baselines in both accuracy and response ratios.
6. High constraining sentences, relatedness potential 0.25. Legal sentence advantage with no response bias. Transposed sentences behaved like control sentences with no contextual influence in the accuracy data or response ratio

data, except that predictable targets were reported more accurately than unpredictable targets.

7. High constraining sentences, relatedness potential 0.5. No main effect of context and an interaction with member. Both legal and transposed predictable targets were reported more accurately than baseline, with a corresponding decrease for unpredictable targets. Bias analysis showed a strong response bias for transposed sentences where the response ratios for unpredictable targets were lower than those of legal sentences.
8. High constraining sentences with blurred targets. Performance was greater for targets in transposed sentences when blurred to level two than both control contexts and predictable targets were reported more accurately than unpredictable. Response ratios showed bias at both blur levels. Thus, transposed sentence showed an intermediate contextual effect.
9. Low constraining sentences with blurred targets. Despite a legal sentence advantage where both members showed greater response ratios than baseline. transposed sentences showed no contextual influence in the accuracy analysis or response ratios.

Thus, the findings for transposed sentences were very mixed across experiments in this thesis. However, two prevailing trends emerge; (1) transposed sentences do exert contextual influence under some circumstances and (2) there is more likely to be response bias in transposed sentences than in legal sentences. The transposed sentences demonstrate that syntactic assignment is not an early and immutable aspect of contextual influence as suggested by O'Seaghda (1989, 1997). In experiment one, where contexts

were presented for 150 ms, transposed sentences were often reported as legal which suggested that word order was subordinate to meaning extraction and that legality per se may not be the cause of the disruption to contextual effects for transposed sentences found elsewhere (i.e., O'Seaghda, 1989, 1997; Simpson et al., 1989). When the duration of the context was increased to two and five seconds in experiment three, transposed sentences behaved like legal sentences demonstrating a clear contextual influence in both accuracy and response ratios. This proposal that disruption to contextual influence is not due to legality per se is further supported by the different pattern of results with highly constraining transposed sentences between experiment seven and nine when the visual information provided by targets was changed from clear to blurred. In experiment seven, the results of the transposed sentences were similar to control conditions, when the targets were blurred transposed sentences produced contextual influence and response bias. When the low constraining sentences were presented in experiment three, transposed sentences showed an intermediate contextual effect. When the targets were blurred in experiment ten transposed sentences showed no contextual influence. In both these cases the pattern of results changed for transposed sentences when the visual input was altered but legality and word order were not. The findings of experiment seven were taken to support the proposal of Tannenhaus and Lucas (1984) that contextual influence arises from concept representations rather than intralexical associations. This proposal is not compromised by the finding of contextual effects when targets were blurred because if contextual effects were reliant on word order, syntax or intralexical processes the results would not have altered between experiments. What does seem apparent from these findings is that the effects produced by transposed sentences are separable from legal

effects, provided sufficient time is allowed for illegality to be fully recognised. Clearly the nature of the processes underlying transposed sentences requires significant research. However, the findings of this thesis provides an insight into the rich processing that disrupting word order creates and emphasises the value of transposed sentences as a means of elucidating the very nature of word recognition in sentential contexts.

8:5 Integration Accounts

Several authors suggest that sentence contexts appear to facilitate word recognition because related contexts improve the ease and speed of the integration process which in turn improves responses to targets in ways which do not reflect the processes that underlie word recognition (Hess, Foss & Carroll, 1995; O'Seaghdha, 1989, 1997; Sharkey & Sharkey, 1992). The present findings present several lines of evidence that compromise this proposal; (1) Integration would be more likely to affect speed of report rather than accuracy, yet legal sentence advantages were found in experiments three, six, seven, nine and ten. Moreover, this legal sentence advantage occurred with highly constraining sentences where predictable targets would have been integrated with much more ease than unpredictable targets, yet there was no inhibition for unpredictable targets in legal contexts.

(2) Low constraining sentences were more accurate than word replacement contexts in experiments three, six and ten. According to Forster (1981) the integration of this type of sentence would have created inhibition by increasing the processing load when compared to word replacement contexts where integration would not be required. Similarly, contrary to the proposal of Duffy et al. (1989) and Forster (1981), repetitive

stimuli similar to standard neutral sentences produced no inhibition in experiment five and a legal sentence advantage when visual matching was suppressed. Moreover, even at 150ms there was no legal sentence inhibition while increasing the duration from two to five seconds (experiment three) produced a legal sentence advantage at both durations.

(3) If integration had been the source of legal sentence advantages in this thesis, controlling for such visual cues as visual matching and manipulating target degradation would have had little impact on target performance except as an additive factor. The fact that these purely visual factors interacted with context producing larger legal effects when target visual conditions became more stringent strongly indicates that context exerts its effects at the visual level not at an integration level. Forming a meaningful representation of ‘the horse was lame’ could aid response speed but it is hard to understand how forming such a representation could aid accuracy when the forced choice alternatives *LAME* and *TAME* appeared, unless ‘lame’ had not been as fully encoded in control conditions. In which case, forming a meaningful representation would appear to aid encoding. This point is further clarified with reference to blurred targets because the meaning representation formed from ‘it began to flop’ would be the same regardless of blur level, yet performance accuracy improved as blur level increased compared to baseline. Moreover, when targets were predictable from their legal contexts an integration account cannot explain why the formation of a meaningful representation did not result in more reports of ‘born to be *wild*’ and less reports of ‘born to be *mild*’ as stimulus quality decreased. In fact, the latter finding can only be explained satisfactorily with reference to the context facilitating the uptake of visual information, all other proposals would predict response bias in legal contexts. These findings do not suggest

that integration does not take place and is measured in such tasks as naming and eye-fixation durations. What the results of the present thesis strongly indicate is that integration, in itself, is insufficient to account for the effects of context on word recognition. In fact the present findings suggest that its measurement in naming and perhaps eye fixation durations may conceal the true nature of contextual influence.

8:6 Theoretical Models

Taken together, the findings of this thesis rule out a weak modular account of word recognition in sentences. The findings also rule out modified modular models of word recognition in contexts, which place the burden of contextual influence at a final selection stage (i.e., *plausibility checking mechanism*, Norris (1986); *the modular interactive model*, Potter, et al., 1993, 1998). In direct contrast to the findings of Potter et al. (1993, 1998), highly constraining sentence contexts did not produce response bias in favour of predictable targets when unpredictable targets were visually similar. Moreover, the low constraining sentences produced results which could not be accommodated by expectancy or search based models. Thus the findings favour a modified interactive model of word recognition.

The main thrust of this thesis was to examine sentence contexts in circumstances where interactive processing would be recognised easily, if it occurred. To date sentential research has concentrated on complex manipulations of content with the result that some of the fundamental issues concerning the modular/interactive debate have been largely ignored. Consequently, a large body of research exists that can be explained by opposing theoretical perspectives. Throughout the majority of this thesis relatedness potential was

low, which produced results entirely consistent with a weak interactive model of word recognition. When relatedness potential was increased in chapter six, however, the findings were consistent with the proposals of modified modular accounts of word recognition in contexts. Since sentential contexts appear to exert influence at the visual level some circumstances and at the decision or selection stage in others, it would appear that word recognition in sentence context is governed by an ‘intelligent’ perceptual system. Moreover, this dual process requires a weak interactive model of contextual influence that can accommodate both the automatic and attentional (or apparently weak modular decision based) components found in this thesis for a comprehensive and parsimonious description of contextual influence. The dual pathways of the *multistage activation model* (Besner & Smith, 1992; Smith, Besner & Miyoshi, 1994; Stolz & Neely, 1995) provides such an explanation.

Stolz and Neely (1995) proposed that priming would utilise pathway A but where factors such as relatedness potential and stimulus degradation were concerned priming would be carried out via pathway B (see introductory chapter). However, the findings of this thesis indicate that sentential contexts use pathway A when relatedness potential is low. This is because all the indications are that word recognition is carried out using stimulus driven information except where highly constraining legal sentences are presented with fillers to increase the salience of predictability. If less data driven information were being used via pathway B, similar biasing effects may have been found together with no apparent contextual effects in the accuracy analyses.

In particular, the use of pathway B would have resulted in: (1) response bias when blurred targets were presented in highly constraining legal sentences and (2) an

interaction between stimulus quality, context and member. As far as low constraining legal sentences are concerned, the use of pathway B would most likely have resulted in no contextual influence because data driven information was necessary to distinguish between the visually similar alternatives. In fact the use of pathway B in low constraining contexts could have resulted in a legal sentence disadvantage because participants would have been making choices on less visual information. It would appear, therefore, that word recognition in sentence contexts is carried out by monitoring the semantic system for pre-activated candidates in the case of highly constraining sentences and for constraining the possible alternatives when low constraining sentences are presented. However, when the relationship between context and targets is made more salient by increasing relatedness potential then an attentional mechanism comes into operation and pathway B is used to reduce the amount of visual information required. Pathway B would have the effect of increasing speed of processing in the normal reading process where words could be expected to comply with memory based representations more often than not. However, where there are confounding factors such as ambiguity or unexpected completions then this processing route reduces accuracy. Stolz and Neely (1995) found additive effects of context and stimulus quality at low relatedness potentials in a single word priming paradigm which led them to conclude that feedback from the semantic system into the orthographic system stops at low relatedness potentials. The present findings suggest that this is because pathway A is used rather than because the system stops processing. It is probable that sentence contexts have a greater capacity to form meaningful representations than single words and exert a greater activation in the semantic system. Neither experiments nine or ten produced an interaction between

stimulus quality, context and member, which corresponds to the overadditive effect in single word recognition where context represents related and unrelated items. This interaction would likely have produced bias in this paradigm and would have reflected the use of pathway B similar to the findings where relatedness potential was high. If it were possible to find an adequate neutral baseline for single word priming paradigms, then context may interact with baseline and stimulus quality indicating the use of pathway A. Thus, it is possible that pathway A was being used in Stolz and Neely's low relatedness potential experiments, as it appears to have been in the present thesis.

8:7 Basic Visual Cues

There is one major problem concerning the initial stages of visual input in the *multistage activation model*. Experiments nine and ten demonstrate that word recognition can be carried out on the basis of much more rudimentary visual information than letter fragments. To some extent the model acknowledges this possibility in that a cascading process of letter fragments, letters, words and morphemes are described as entering the orthographic system. However, it seems clear, not only that word recognition can be carried out without detailed letter fragment information but that legal contexts can make more use of this limited information than other contexts.

8:8 Conclusion

In conclusion, I have argued that models of contextual effects on word recognition must take into account an interactive component, an attentional component and holistic processing of word information. The findings of this thesis suggest that legal

sentence contexts are capable of improving word recognition in sentences in ways that are compatible with increased sensitivity to visual information. However, this does not indicate that sophisticated guesswork and attentional mechanisms play an important role contextual influence on word recognition as biasing effects were found when predictability was made more salient. Thus a dual process model is required. The *multistage activation model* fits well with the present findings providing pathway A governs the automatic perceptual process and an attentional mechanism brings into operation pathway B which reduces the amount of visual information necessary for word recognition in the orthographic system. Moreover, this thesis has found that the precise mechanisms of transposed sentence processing are far more complex than previous research has indicated. This thesis has gone some way towards finding a more comprehensive model of the reading process although future research is need to clarify and expand the proposals put forward in order to form an integrated model of the rich processes involved in reading.

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