

**AUDITORY-SEMANTIC DISTRACTION:
A PROCESS-ORIENTED APPROACH**

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This thesis is dedicated
to the memories of my Grandfather Herbert Scanlan (1920-1993)
and my Grandmother Josephine Scanlan (1927-2004)

PRESENTED PAPERS

1. *The findings from Series 1 of the present thesis were presented in the following oral and poster presentations:*

Oral Presentations:

Marsh, J. E., Banbury, S. P., & Jones, D. M. (June, 2005). Impairment of category-exemplar retrieval by auditory distraction: Semantic and episodic factors. 9th *European Congress of Psychology*, Granada, Spain.

Marsh, J. E., Hughes, R. W., & Jones, D. M. (April, 2006). Distraction in semantic memory from irrelevant auditory material: Inhibition, activation, and failure of source-monitoring. *Experimental Psychological Society (EPS) Conference*, Birmingham, UK.

Poster Presentation:

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SUMMARY

The present thesis examined whether the interference-by-process construct, as applied to auditory distraction during visual-verbal serial recall (the irrelevant sound effect, ISE), also holds as a useful framework for interpreting auditory-semantic distraction whereby performance on tasks requiring semantic focal processes is disrupted by the semantic properties of irrelevant sound. To address this goal, several semantic focal tasks were used in conjunction with manipulations of task-instruction and of the semantic properties of irrelevant sounds. Empirical Series 1 showed that episodic recall of lists comprising exemplars drawn from a single semantic-category was disrupted by the lexicality of the irrelevant items and their semantic similarity to the to-be-remembered exemplars, but only when the task-instructions emphasised free, not serial, recall and when the irrelevant category items were dominant exemplars of a category. Moreover this series also demonstrated that irrelevant category items are often included erroneously as responses, and that this is due to a breakdown in the source-monitoring process. These results provide evidence for the interference-by-process construct in that the semantic properties of speech disrupt semantic, and source-monitoring, processing in the focal task and may also produce interference through giving rise to inhibitory processes. Series 2 showed that the presence of semantic properties in the irrelevant sound impaired semantic categorization (or category-clustering) and category, and category-exemplar, recall in the episodic recall of lists of exemplars drawn from several semantic categories, but, like Series 1, failed to produce disruption when task-instruction demanded serial recall. This finding provides yet further evidence for a conflict between two semantic processes. Finally, Series 3 showed that the semantic, but not acoustic, properties of irrelevant sound impaired retrieval from semantic memory when the focal task required retrieval from a semantic-category (requiring semantic processing), but not phonemic- category (not necessitating semantic processing). The implications of the findings for other approaches to auditory-semantic distraction, and auditory distraction generally, are discussed.

Chapter 1

AUDITORY DISTRACTION: STRUCTURAL VERSUS PROCESS-BASED APPROACHES

Two major strands of research that were pivotal to the success of the cognitive revolution in the 1950-60s were those concerned with auditory selective attention (Broadbent 1958; Cherry, 1953; Treisman, 1960, 1964) and short-term memory (Baddeley, 1966; Conrad, 1964; G. A. Miller, 1956). As with cognitive psychology generally, theory in both domains has been dominated by a structuralist approach whereby explanations of behaviour are thought to reside in delineating the “contents” of the cognitive architecture (Roediger, Gallo, & Geraci, 2002). However, one body of work that cuts across these two literatures has suggested that an alternative, process-based, approach to attention and short-term memory may be more fruitful. Numerous studies have demonstrated that the mere presence of to-be-ignored sound markedly disrupts the short-term serial retention of lists of visual-verbal items (e.g., Colle & Welsh, 1976; Jones, 1993; LeCompte, 1994; Salamé & Baddeley, 1982). One class of explanation for such impairment adheres to classical, structuralist, approaches to short-term memory (e.g., Baddeley, 1986). Thus, common within this approach is the notion of interference due to the structural similarity between traces of relevant and irrelevant events coexisting within some bespoke short-term store (Neath, 2000; Salamé & Baddeley, 1982).

However, the available evidence—to be reviewed in the next sub-section—does not favour this approach. Instead, the data support an alternative account that owes more to process or skill-based views of selective attention (e.g., Allport, 1993; O. Neumann, 1996) than to classical theories of short-term memory. On this account, the impairment by irrelevant sound results from a conflict between two similar processes involved in the serial-organization of events (the *interference-by-process* account; Hughes & Jones, 2005; Jones, Beaman, & Macken, 1996; Jones & Tremblay, 2000).

It will be argued in the present chapter that the success of the interference-by-process approach in accounting for auditory distraction in the context of serial recall has raised doubts as to the veracity of structuralist approaches to short-term memory and to whether

attention and short-term memory should be considered as distinct as many theorists seem to believe (see Hughes & Jones, 2005). More specifically, the present chapter will show that the interference-by-process account has been very successful in the domain of serial short-term memory and has questioned the explanatory power, and indeed the existence, of storage constructs: That is, it will be shown that auditory distraction in the context of serial recall can be equally well, if not better explained, without recourse to temporary mnemonic stores (e.g., Jones, Nicholls, & Macken, 2004; Hughes & Jones, 2005). However, a possible limitation of the interference-by-process approach is that it has been rather paradigm-bound: support for the account is mainly derived from the work on serial recall.

The key question posed by the present thesis is this: “Does the interference-by-process framework apply to the attention-memory interface in a quite different domain?” The approach adopted is to exploit several paradigms that call for, either through instruction or spontaneous adoption, not serial, but semantic processing (involving processing of meaning) for retention or retrieval. The purpose of the thesis was to examine whether for semantic focal tasks, as with serial recall, irrelevant sounds produce disruption by interference-by-process. Like previous work with serial short-term memory, auditory distraction was used as a device to assess the breakdown of attentional selectivity at the intersection of perception and memory and to adjudicate between general structural (e.g., interference-by-content) and functional (e.g., interference-by-process) explanations of this breakdown.

In this introductory chapter, the key empirical features of the auditory distraction in the context of serial recall as well as the few studies on *auditory-semantic distraction*, that is, auditory distraction that is produced by the semantic properties (or meaning) of irrelevant sound, are described. Through the outlining of the empirical features of auditory distraction, the interference-by-content account will be described and evaluated and the evolution of the interference-by-process account will be traced with regard to setting the aim of the research in its broader context which is to pit structural (e.g., interference-by-content) approaches against functional (interference-by-process) accounts as explanations for breakdown in attentional selectivity and forgetting in the presence of task-irrelevant sound.

1.1 THE SERIAL RECALL PARADIGM

In the context of a typical irrelevant sound experiment, participants are presented (usually visually) with supra-span lists of seven to nine verbal items (e.g., digits, consonants) one at a time on a computer screen in the presence of various background sound conditions, one of which is typically a quiet control condition. Participants are instructed to recall the visual items in the order of presentation either immediately after presentation of the last item or following a relatively short (e.g., 7-10 s) retention interval. Participants are also informed that they will hear sound (usually presented over headphones) during some trials but that they should ignore it because it is irrelevant to the focal, serial recall task. The classical irrelevant sound effect (ISE; classical ISE is used hereafter to refer to disruption extraneous sound produces in the context of serial recall) refers to the appreciable increase in the number of errors in serial recall performance when irrelevant sound is presented either during the presentation of the to-be-remembered (TBR) items, during the retention interval, or during both these phases relative to performance in a quiet control condition (Colle & Welsh, 1976; Jones, Madden, & Miles, 1992; Jones & Macken, 1993; LeCompte, 1996; Salamé & Baddeley, 1982, 1989; Tremblay & Jones, 1998). The classical ISE is robust, only one-eighth of individuals appear invulnerable to the effect, and the detrimental effect of irrelevant sound can sometimes reach up to 30% - 50% (Ellermeier & Zimmer, 1997).

1.2 AUDITORY DISTRACTION IN SERIAL RECALL: EMPIRICAL CHARACTERISTICS AND THEORETICAL ACCOUNTS

1.2.1 Non-influential factors in the classical ISE

1.2.1.1 Intensity and coincidence of relevant and irrelevant material

None of the main accounts of the classical ISE place importance on the intensity of irrelevant sound or the precise coincidence of TBR and irrelevant items because these factors do not play a role in serial recall. For example, the classical ISE is equal in magnitude whether the irrelevant sound is 48 dB(A) or 76 dB(A) which are equivalent to a whisper and approximating a shout respectively (Colle, 1980; Ellermeier & Hellbrück,

1998; Salamé & Baddeley, 1987; Tremblay & Jones, 1999; but see Mortimer, Briscoe, & Jones, 2004, for developmental considerations). As will be outlined in more detail later (section 1.2.6.1), the meaning, or rather, semantic properties of irrelevant sound are also non-influential in that they do not modulate the classical ISE (e.g., Buchner, Irmen, & Erdfelder, 1996; Jones, Miles, & Page, 1990).

Moreover, the classical ISE also occurs with equivalent degree even when the presentation of TBR and irrelevant items do not coincide such as when the speech is presented during the retention (or rehearsal) interval (Miles, Jones, & Madden, 1991; see also, Macken, Mosdell, & Jones, 1999). Similarly, sandwiching irrelevant sound tokens between TBR tokens produces as much disruption as when both irrelevant and TBR tokens are presented concurrently (Jones, 1994; Salamé & Baddeley, 1982). The findings relating to the coincidence of TBR and irrelevant items are important in that they suggest that the classical ISE is not one that arises due to sensory or perceptual masking at some peripheral level despite their presentation in different sensory modalities. That is, the classical ISE cannot be ascribed to an attentional blink at encoding during the registration of TBR items (cf. Broadbent, 1982, 1983). Moreover, these findings that have shown that the classic ISE does not occur at a perceptual level (Miles et al., 1991; Salamé & Baddeley, 1982; see also Baddeley & Salamé, 1986; Burani, Vallar, & Bottini, 1991) suggest that the locus of disruption is not at encoding but at a post-perceptual level where the TBR information is retained. That is, it appears to be rehearsal of items—when the TBR items/their order is being refreshed and maintained—not encoding that is vulnerable to disruption: the comparable degree of disruption to serial recall performance that occurs whether the irrelevant items are presented during encoding or during an interpolated interval between presentation and test occurs because rehearsal takes place at both encoding and retention phases (Miles et al., 1991). This finding that the disruption produced by irrelevant sound occurred “within memory” was an important breakthrough that quite naturally, but erroneously (as will be demonstrated), led to the basing of initial explanations of the classical ISE (e.g., Salamé & Baddeley, 1982) on extant theories of short-term memory and the structural constructs, and notions, already being used to explain interference within short-term memory (Baddeley & Hitch, 1974; Baddeley, 1986).

1.3 Structural accounts of the classical ISE: 'Interference-by-content'

Early work on the classical ISE (Salamé & Baddeley, 1982) focused explanations of the impairment on the most dominant notion of interference within short-term memory that has been underpinned by the structuralist notion: that there is a limited capacity for the short-term retention of items which results from interference between TBR and irrelevant items that enter a hypothetical short-term memory store at approximately the same time. Moreover, the traditional structural view is that the degree of interference occurs to the extent that the identity of traces derived from TBR and irrelevant items within the short-term memory store is similar (i.e., that they share a level of representation; Salamé & Baddeley, 1982). This structural view, and the associated construct of item-interference, has permeated into more contemporary theorizing and mnemonic explanations of the classical ISE (e.g., Neath, 1999, 2000). Broadly, three structural accounts have been formulated to account for the classical ISE. Two of these accounts propose the classical ISE is caused by interference-by-content and will now be outlined and evaluated in light of empirical characteristics of the classical ISE.

1.3.1 The phonological store account

The phonological store account (Salamé & Baddeley, 1982) is based upon the modular architecture of the Working Memory model (Baddeley & Hitch, 1974). It should be noted here that the original conceptualization of 'phonological confusion' within the phonological store (Salamé & Baddeley, 1982), was based on a number of experiments in which various continuous or intermittent aperiodic or broadband sounds (e.g., white noise) had failed to produce disruption (e.g., Colle, 1976; but for an effect of intermittent white noise on the 'intake' of digits, see Salamé & Wittersheim, 1978) even when it was modulated by being 'pulsed' so as to give it the same sound intensity envelope as continuous speech (Salamé & Baddeley, 1987, 1989).

According to the phonological store, or phonological confusion, account irrelevant speech has privileged and obligatory access to a speech-specialised phonological store (originally thought to be a filter that blocked-out non-speech sounds) whilst TBR items enter the store through a grapheme-to-phoneme conversion process undertaken by the phonological loop and are then recycled through the store by sub-vocal rehearsal (see

Baddeley, 1986). According to this account the classical ISE arises due to confusion between the phonemes within the phonological store derived from the irrelevant sound sequence and similar phonemes extracted from the TBR material during sub-vocal rehearsal (Gathercole & Baddeley, 1993; Salamé & Baddeley, 1982, 1989). The precise mechanism by which the two sets of phonemes become confused remains to be further specified (Baddeley, 2000a; but see Page & Norris, 2003).

An early experiment (Salamé & Baddeley, 1982, Experiment 5) provided some support for this disruption-by-phonological-similarity idea: Sequences of irrelevant words that had the same phonemes as TBR integers (1-9) but with the onsets rearranged into a different order (e.g., *tun, gnu, tee, sore*) were comparably disruptive to serial recall performance compared with a sequence of spoken tokens that are semantically-similar (lexically identical) to the TBR integers (e.g., *one, two, three, four*) and both these sequences were more disruptive than sequences of phonologically dissimilar disyllabic words (e.g., *tennis, jelly, tippie*).

This particular view of the classical ISE, however, has now been undermined compellingly by several lines of evidence. For example, irrelevant sequences that are distinct from verbal TBR sequences such as non-speech irrelevant sounds (e.g., changing-state pure tones and instrumental music) can produce a classical ISE (Divin, Coyle, & D. T. T. James, 2000; Jones & Macken, 1993; Klatte, Kilcher, & Hellbrück, 1995; LeCompte, 1994; Neath, Surprenant, & LeCompte, 1998; Salamé, 1990; Salamé & Baddeley, 1989). This result suggests that speech is not a necessary condition to disrupt serial recall (see also Jones et al., 1992). In an early attempt to reconcile these findings within the phonological store account the ad hoc assumption was made that non-speech irrelevant sounds were disruptive because they had some resemblance to speech (e.g., they conveyed a speech-type spectrum; Salamé & Baddeley, 1989). That is, it was argued that pure tones and instrumental music were speech-like enough to be permitted into the phonological store wherein they have the same propensity as speech items to be confused with the TBR verbal items. However, the finding that sounds as sufficiently non-speech like as band-pass noise where center-frequency change from one burst to the next produce a classical ISE (Tremblay, Macken, & Jones, 2001) clearly undermine this assumption: This result implies that the classical ISE is not produced within a speech-

specialized discrete memory module (e.g., the phonological store; Baddeley, 1986) moreover this result also suggests that it is not a consequence of the engagement of a speech-processing mode (see also Tremblay, Nicholls, Alford, & Jones, 2000).

Furthermore several studies have shown that Salamé and Baddeley's (1982, Experiment 5) original experiment that demonstrated an effect of between-sequence phonological similarity fails to replicate both identically and conceptually (Bridges & Jones, 1996; Buchner et al., 1996; Jones & Macken, 1995a; Hughes & Jones, 2005; J. D. Larsen, Baddeley, & Andrade, 2000; LeCompte & Shaibe, 1997; Saito & Baddeley, 2004; Martin-Loeches, Schweinberger, & Sommer, 1997). For example, Jones and Macken (1995b) found that, rather than between-sequence phonological similarity being ultimately disruptive, the magnitude of disruption was most potent when there was an increased degree of phonological *dissimilarity* between tokens *within* the irrelevant stream. More recently, Hughes and Jones (2005) have refined the evidence that goes against the notion of between-sequence phonological similarity as the primary disruptive agent. They demonstrated that greater disruption can occur to serial recall if the TBR and irrelevant items are drawn from identical lexical sets (e.g., digits 1-8) compared to when the irrelevant items are drawn from a different set (e.g., consonants) but, importantly, *only* when the irrelevant items are in an order that is *incongruent* with the TBR items. Thus, although the similarity (in content) between the irrelevant and TBR streams of items is an ingredient of this effect at some level, it is order-incompatibility between the two sequences (arising as an emergent property of serially ordering the streams of items) rather than item similarity (e.g., in terms of phonemes) between the streams per se that ultimately produced the disruption.

1.3.1.2 Additional problems for the phonological store account

Further evidence against the idea that the phonological content of the irrelevant items is a sufficient condition for yielding the classical ISE has emerged in work demonstrating that sub-segmental, non-phonological, factors related to acoustical variation within the sound stream are central to determining disruption: An irrelevant sound that demonstrates appreciable variability in its spectral qualities such as timbre and pitch (but not intensity; see Tremblay & Jones, 1999) over the course of its temporal existence produces greater disruption than a sound that exhibits little or no variability on these dimensions. An

example of this 'changing-state effect' (Jones et al., 1992) is that an irrelevant sequence of changing consonants, e.g., 'c, h, j, t,' produces pronounced disruption whereas a sequence of a repeated consonants, e.g., 'c, c, c, c' produces little, if any, disruption. Similarly, a sequence of non-rhyming items, e.g., 'hat, cow, nest' produce much less disruption than a sequence of rhyming items, e.g., 'sea, flea, key' (Jones & Macken, 1995a). For any sound to be markedly disruptive, therefore, it appears that it must demonstrate not phonological content but acoustical changes from one perceptually-segmentable entity to adjacent entities. Thus, non-phonological sounds such as tones, providing they demonstrate changes in state, exhibit qualitative similarities with speech sounds in terms of their disruptive impact on serial recall performance (Divin et al., 2001; Elliott, 2002; Jones & Macken, 1993; Tremblay & Jones, 1998; LeCompte, 1995; Neath et al., 1998; Tremblay et al., 2001). The importance of acoustic changes is further emphasised by the findings that, speech and non-speech sounds that do not vary appreciably such as humming compared to singing, or continuous random pitch glides as compared with glides that are made segmentable by regular insertions of period of silence, are less, if at all, disruptive (Jones, Macken, & Murray, 1993; Morris, Jones, & Quayle, 1989).

Cues to segmentation, of course, do not simply rely on the presence of periods of quiet in the acoustic signal; other cues to segmentation exist in continuous sounds such as the naturally-occurring sharp transitions in acoustic energy in narrative speech. The importance of cues to segmentation is pointed to by experiments demonstrating that when these cues are less strong such as in filtered speech less disruption is produced (e.g., Jones, Alford, Bridges, Tremblay, & Macken, 1999; Tremblay et al., 2000). Moreover experiments using "babble" speech (Jones & Macken, 1995b; Kilcher & Hellbrück, 1993; Klatter & Hellbrück, 1993) also support the role of segmentation. In these experiments irrelevant sound comprising a single voice produces more pronounced disruption to serial recall performance when compared to irrelevant sound containing several voices. A single voice produces more disruption than several voices because an acoustic signal derived from a single voice contains a number of peaks and troughs of signal strength that can be used as a basis for segmentation whereas an acoustic signal comprising several voices (e.g., six; Jones & Macken, 1995b) contains less marked cues for

segmentation because the acoustic signal is closer to a constant amplitude. A further finding that can also be considered to highlight the importance of segmentation is that when an irrelevant sequence is confined to only four tokens, reversed speech that preserves the overall spectral features of forward speech but differs from forward speech in terms of its decay and rise times (and thus the abrupt onsets and sharp transitions in acoustic energy it conveys), is less disruptive than forward speech (LeCompte, C. B. Neely, & Wilson, 1997). This finding can be attributed to a reduction in the acoustical complexity (and thus cues for segmentation) of the sound stream produced by reversing the speech. It is, however, worth pointing out here that continuous reversed speech (e.g., narrative played backwards) is equally as disruptive as forward speech suggesting that continuity (or co-articulatory cues) may offset/restore some of the acoustic complexity (and cues to segmentation) lost through reversing single tokens such as words.

The importance of acoustic complexity in determining the degree of disruption has further been shown using a sinewave speech manipulation (Tremblay et al., 2000). Sinewave speech is a coarse-grained description of speech lacking phonetic detail. It is created through a kind of primitive synthesis whereby only the changing pattern (in terms of amplitude and frequency) of vocal tract resonances (formants) of natural speech are preserved in three (sometimes four) time-varying sinusoids which are then added together. Thus, a sinewave simulation of natural speech strips the natural speech signal of most of the fine-grained acoustic structure (or attributes) and therefore most of its acoustic complexity. Participants who are unaware that the sound is speech often perceive it as a series of computer beeps or whistling (Remez, Rubin, Pisoni, & Carrell, 1981). However, when participants are aware that they are listening to synthesized speech the pattern of variation imposed on the sinusoidal carriers is sufficient information for the perception of phonetic attributes despite the elimination of natural acoustic elements: When sinewave speech is perceived phonetically, all phoneme types are elicited and supra-segmental cues can be processed to extract meaning (Remez et al., 1981; Sheffert, Pisoni, Fellowes, & Remez, 2002).

To examine the effect of differentially perceiving sinewave speech, Tremblay et al. (2000) trained one group of participants to perceive sinewave stimulus as speech whilst others were instructed that the sinewave stimulus was merely computer beeps. The

results were unequivocal: it made no difference to the degree of disruption to serial performance whether or not participants were informed or trained to recognize that the sinewave stimuli were synthesized speech before being exposed to the stimuli as irrelevant sound during the serial recall task. Sinewave speech, however, produced less impairment to serial recall performance than natural speech supporting the idea that, as an acoustically less complex signal it conveys less changing-state information. As well as shedding light on the importance of the acoustic complexity of the sound in determining disruption to serial recall performance, these findings also offer further evidence that the classical ISE is not attributable to an interference-by-content due to the phonological content of the sound (cf. Salamé & Baddeley, 1982), nor the meaning of the irrelevant sound (both the phonological content and semantic properties of the speech would be extracted from the sinewave sound by the trained participants that performed comparably to the untrained participants when exposed to the sinewave stimuli as irrelevant sound in the serial recall task). Critically then, these findings demonstrate that the classical ISE does not depend on perception of the irrelevant sound as speech, nor is it the result of an engagement of any speech processing mode (Tremblay et al., 2000).

1.3.2 The Feature Model

Despite the considerable evidence against the mnemonic construct of interference by similarity of content, a more recent interference-by-content account has been proposed that, like the phonological store account, also exemplifies structural principles. The feature model has been developed by Neath (1999, 2000) from an extant mathematical 'feature' model of 'immediate' or short-term memory (Nairne, 1990). The feature model, like the phonological store account, proposes that irrelevant speech, as compared with non-speech, sound produces 'specialised' disruption. However, different from the phonological store account, the feature model explains the classical ISE through appealing to a seemingly ad hoc attentional construct.

The feature model assumes that traces of TBR and irrelevant items presented in a short-term memory task are represented as a set of modality-dependent features (e.g., indicating the sensory nature of inputs such as auditory versus visual presentation) and a set of modality-independent features (e.g., abstract, post-categorical features such as

phonology or lexical-semantic or categorical identity that are independent of the sensory nature of the input) within primary memory (a short-term memory store). The representation of an item can be disrupted through interference by representations of other items which enter the primary memory store in close temporal proximity (at the same time or shortly before or after). According to the key construct in this model, that of *feature-adoption*, when the value of a particular feature of one item mismatches the value of the same feature represented by another, the corresponding feature value of the TBR item will be altered changing the primary memory trace and thus the identity of that item. This feature-adoption process impairs recall via a feature-matching retrieval mechanism. More specifically, the retrieval mechanism of matching a primary memory trace to a correct item in secondary memory is impaired when primary memory representations are degraded: When this is the case primary memory traces fail as cues to retrieve (reintegrate) correct items from secondary memory wherein representations are non-corruptible. This failure of the matching mechanism results in loss of item information which in turn leads to loss of order information. It should be mentioned here that order information can also be lost by a second mechanism, a ‘perturbation’ process (e.g., Estes, 1972; Lee & Estes, 1977, 1981) whereby points in multidimensional space (representing serial positional information) can be selected out of order.

The feature model explains the classical ISE by means of the feature-adoption and *not* the perturbation process: Modality-independent features of irrelevant items overwrite corresponding, mismatching, features of TBR items when their presentation coincides with the covert or overt articulation (e.g. during rehearsal) of the TBR items. Moreover, this feature-adoption process only occurs with speech sounds (Neath, 2000; Neath & Surprenant, 2001) therefore, the feature model, like the phonological store account, construes the classical ISE as a between-sequence similarity effect at some level. The result of the feature adoption process is that it impairs the feature-matching retrieval mechanism described earlier which results in item loss and as a consequence, errors of order.

There are several short-comings to this approach perhaps the most major being the failure to simulate accurately the two main empirical signatures of the classical ISE, the changing-state effect (Jones et al., 1992; see Beaman, 2000) and that non-speech sounds

produce the impairment (Jones et al., 1999; Jones & Macken, 1993; Tremblay & Jones, 1998; Tremblay et al., 2001). In order to model the changing-state effect, recourse to an ‘attention’ construct is made by the addition of a parameter representing the net available resources or attention, a . This addition is made with the ad hoc assumption that a stream of single repeated items (e.g., steady-state stimuli) is easier to ignore—and thus will divert less attention from the serial recall task—than a stream of items that changes from one token to the next (e.g., changing-state stimuli; Neath, 2000). Thus changing-state irrelevant sounds create a dual-task or divided attention setting where ignoring sound acts as an additional task to the task of serial recall (e.g., Neath & Surprenant, 2001). Moreover, the feature model treats the classical ISE as found with speech, and non-speech, sounds as distinct: To model the impairment non-speech sounds produce on serial recall performance, adjustment is made only to the a parameter.

There are obvious problems with the model’s implementation of the changing-state effect and the non-speech effects. The first concerns data-fitting: with ad hoc adjustments to the arbitrary a parameter the model cannot fail to simulate the changing-state effect because, inevitably, manipulations of the a parameter will have the effect of increasing or decreasing the overall recall performance of the model. As with several computational models of memory it could be argued that such ‘tweaking’ of a parameter of the model in order to explain patterns of data disregards how human behaviour produces the same results (cf. Roberts & Pashler, 2000, 2002). Moreover, the general consensus that has emerged with regard to ‘attention’ is that it is not simply some single mechanism, resource, or set of resources (Allport, 1989, 1993; O. Neumann, 1987, 1989; Styles, 1997; Van der Heijden, 1992) therefore giving ‘attention’ such a major role in producing the changing-state effect without specifying what exactly the role of attention is within the model appears devoid of any theoretical rationale. Additionally there appears to be no way of identifying beforehand, in any empirically verifiable way, the extent to which a given irrelevant sound will use up the limited attentional resources during serial recall. This severely limits the predictive validity of the model. Second, treating the classical ISE obtained with non-speech sounds as qualitatively or functionally distinct from those found with speech rather contradicts the finding that speech and non-speech sounds show

qualitative similarities in their action in the context of visual-verbal serial recall (Jones & Macken, 1993; Jones & Tremblay, 2000).

A third problem concerns the legitimacy of the feature-adoption process. The way in which feature adoption is modelled means that steady state speech should also be disruptive but an effect of steady state sound is only sometimes found and when it is found it is usually of very small magnitude in comparison to that of the changing-state effect. That disruption does not occur consistently empirically with steady-state sound (e.g., Bridges & Jones, 1996; Jones & Macken, 1993; Jones et al., 1992; Macken, Tremblay, Houghton, Nicholls, & Jones, 2003) would appear to contravene feature adoption—at least in the ways outlined by Neath (1999, 2000)—as a primary mechanism of disruption. Fourth, the model embodies perturbation theory (Estes, 1972). Doubts have been expressed about perturbation theory: arguably because it offers only a redescription of the data in that it states only that items toward the beginning and at the end of the list are more likely to be recalled in their correct positions than those in the middle of the list without saying how the list itself is recalled (Norris, 2005). Fifth, there is ample evidence that the changing-state effect is not simply due to attention being recruited away from the primary task (Bridges & Jones, 1996; Jones, Macken, & Mosdell, 1997; Perham, Hughes, & Jones, 2006; Tremblay & Jones, 1998, these are detailed later in section 1.2.3.1).

Sixth, the feature model is not clear as to what a modality-independent ‘feature’ is, and this makes it difficult to see how the feature model could be tested empirically, therefore potentially decreasing the falsifiability of the model. To recap, a modality-independent feature, according to the model, represents phonology or categorical identity, but these do not appear to be one-to-one mappings (e.g., one feature is not equal to one phoneme). This can be seen from the way in which between-sequence phonological similarity is simulated within the model. In the feature model’s simulation, between-sequence phonological *dissimilarity* is modelled by setting half of the modality-independent features to unique values, whereas between-sequence phonological *similarity* involves setting half of the modality-independent features of the irrelevant items to the same value as a randomly determined list item. As Neath (2000, p. 412) suggested “The idea is that if two items have a similar sound (e.g., *ton* and *one*), half of the features of the TBR item are set to the same value as half of the features of the

irrelevant item, to indicate this shared property”. Thus, phonemes are not represented by features but are represented by a number of features, perhaps phones.

That phonemes are not represented by single features has been used as an explanation of why between-sequence phonological similarity is not disruptive. According to Neath, Farley, and Surprenant (2003) between-sequence phonological similarity is not disruptive “because the interference between irrelevant speech and the TBR items is not at the level of a phoneme, but rather is at the level of a feature” (for a contrary interpretation, see Tolan & Tehan, 2002). An earlier explanation, however, suggested that between-sequence phonological similarity is not disruptive, at least when there is no synchronization between the TBR and irrelevant items, because: “a primary memory trace could adopt features from any irrelevant speech item; for example, the item representing the digit three could adopt some features from the irrelevant item that rhymed with the digit *six*.” (Neath, 2000, p. 412). In other words between-sequence phonological similarity will not produce any effect because presentation of the TBR item will not co-occur with either the articulation or rehearsal of the phonologically similar irrelevant item. This explanation would seem to imply, however, that a between-sequence phonological similarity effect could emerge if phonologically similar, as compared with phonologically dissimilar, TBR and irrelevant items were presented such as to coincide with one another. However, on closer inspection the model appears to make the opposite prediction: If phonologically similar, compared to dissimilar, TBR and irrelevant items coincide less disruption is expected because those items would share a greater proportion of matching features leading to less feature adoption (cf. Tolan & Tehan, 2002). Whilst it may be possible to achieve coincidence between TBR and irrelevant items at presentation the account can be questioned on experimental grounds because it seems an insurmountable empirical challenge to achieve coincidence of phonologically similar TBR and irrelevant items every time a TBR item is articulated (particularly if this is done covertly) during rehearsal (Jones & Tremblay, 2000). Moreover, not only does this prediction—relating to between-sequence phonological similarity—escape empirical verification through appealing to rehearsal, elsewhere the role of rehearsal as a mechanistic explanation within the feature model is downplayed: “neither articulatory suppression nor irrelevant speech interferes with rehearsal: rather, they both add noise to

the memory representation” (Neath et al., 1998, p. 347). In short then, the model appears to eschew rather than explain the findings that between-sequence phonological similarity does not influence serial recall performance (Bridges & Jones, 1996; Buchner et al., 1996; LeCompte & Shaibe, 1997; but see Tolan & Tehan, 2002).

To summarize, the structural accounts that emphasize interference-by-content as the most potent causal factor of the classical ISE enjoy very scant support from empirical evidence. The bulk of the evidence actually directly opposes the structural approaches (e.g., Jones & Macken, 1993; Jones et al., 1995). Moreover, whilst the feature model supersedes the rather underspecified phonological store account of the classical ISE (e.g., Baddeley, 2000a) by fleshing out a specific interference-by-content mechanism, it can be criticized in comparison with the phonological store account, on the grounds that it disregards theoretical parsimoniousness and thoroughness particularly in relation to the role of selective attention. More specifically, the main interference-by-content mechanism, that of feature-adoption, is based on an empirically unstable effect whilst the changing-state effect is explained by resorting to an attentional factor in an arguably ad hoc manner. Another account will be outlined now that does not rely on interference-by-content but is nevertheless still underlain by structuralist assumptions. In contrast to the interference-by-content approaches this approach is narrower in its focus because it has been concerned mainly with offering a specific explanation as to why the magnitude of disruption produced by steady-state sounds is appreciably smaller (if they are at all disruptive) compared to that produced by changing-state sounds.

1.3.3 Attentional recruitment

The justification for including the attentional recruitment account as a structuralist approach is that the framework of attention-and-memory in which it is grounded supposes a “limited capacity” storage of the focus (or scope) of attention (e.g., of around 3-5 separate units or chunks, Cowan, 1995, 1999, 2001; Cowan et al., 2005). Within this framework, attentional recruitment refers to the specific mechanism responsible for producing the changing-state effect (Cowan, 1995). The ‘focus of attention’ concept refers to a highly activated and thus accessible subset of information (objects) that are permanently stored in long-term memory. In the context of visual-verbal serial recall, the

focus of attention is on the rehearsed, TBR items (no longer rehearsed items drop out of the focus of attention and thus their activation decays). Irrelevant tokens produce disruption because they recruit processing resources (or attention) away from TBR items by automatically attracting attention via an orienting response (an approach based on Sokolov's (1963) theory of a neural model). This withdrawal of processing or attentional resources from the primary task results in the TBR items losing activation and thus decreases their probability of successful recall.

This attentional recruitment account shares with the feature model the idea that changing-state sounds are simply more likely to capture attention from the primary task than steady-state sounds (Cowan, 1995; Elliott, 2002). More specifically, the attentional recruitment account assumes that habituation of ORs can rapidly occur to a steady-state sequence. This occurs because successive events contribute to a neural description (model) representing the pattern of stimulation: A neural model of repeated tokens can be easily fashioned due to constant repetition of the same irrelevant stimulus. In contrast, an accurate neural model and thus habituation of the ORs is less likely to occur when a sequence changes from one token to the next such as in changing-state sounds because in this case *each* successive token is construed as a novel event and thus is independently capable of capturing attention away from primary task, the consequence being impaired recall performance (Cowan, 1995).

The results of several recent experiments have been interpreted as indicating a role for attention in the classical ISE. First, Elliott (2002) showed that the ISE is larger with children than adults and suggested that the reason for this is that 'attentional control' is less developed in children than adults (Cowan, Nugent, Elliott, Ponomarev, & Saults, 1999). The problem with this explanation is that it is inherently circular: The ISE is larger in children than adults because they have less developed attentional control; children, in comparison to adults, have a less developed attentional control *therefore* they show a larger ISE. Also an implication of this explanation is that the classical ISE in adults is also underpinned by attentional capture, albeit to a lesser extent than in children. It is possible, however, that the interaction between the degree of disruption and stage of development observed by Elliott (2002) may be attributable to a qualitative rather than quantitative change in the mechanism producing disruption. Second, Buchner and his

colleagues (Buchner & Erdfelder, 2005; Buchner, Rothermund, Wentura, & Mehl, 2004) have recently shown that low frequency irrelevant words produce more disruption to serial recall performance than high frequency irrelevant words and that positively and negatively valenced irrelevant words produce more disruption than neutral irrelevant words, with more disruption from the negative irrelevant words. Buchner et al. argue that these findings reflect attentional capture: Rare or valent words recruit more attention and processing resources away from the TBR items than their control conditions, resulting in comparatively poorer serial recall performance. Again, however, this explanation falls victim to the same circularity as that manifest in Elliott's (2002) explanation with regard to the difference in magnitude of the ISE in children as compared with adults.

There are also a number of key empirical findings that cannot be reconciled within the attentional recruitment account of the classical ISE. An exhaustive review of these findings is beyond the scope of the current introduction but a brief outline of some will be explicated here. The primary findings that are at odds with the account pertain to habituation of ORs. During the course of a serial recall experiment participants can be repeatedly exposed to the same tokens presented in a number of different irrelevant sequences. According to the attentional recruitment account this massed exposure should quickly give rise to the fashioning of a neural model for those stimuli with the result being that those irrelevant tokens lose their disruptive potency during the course of the experiment: In other words the ORs and hence ISE within this model should gradually be reduced. However, empirically the classical ISE does not habituate within (Hellbrück, Kuwano, & Namba, 1996; Jones et al., 1997; Tremblay & Jones, 1998, but see Banbury & Berry, 1997), or between (Ellermeier & Zimmer, 1997; Hellbrück et al., 1996), experimental sessions in which the same irrelevant tokens are presented a number of times over. Moreover, recent research suggests that habituation does not occur even if participants have previously attended to the tokens within irrelevant sequences before being exposed to and ignoring them when they are later, subsequently presented as the irrelevant sequences as part of a serial recall task (Perham et al., 2006). Further evidence against the attentional recruitment account in relation to its notion of habituation of ORs are the "token dose", (Bridges & Jones, 1996) and "token set size" (Tremblay & Jones,

1998) effects (these effects and their implication for the attentional recruitment account are detailed in Jones (1999) and Hughes & Jones (2001)).

The attentional recruitment account also appears to predict that participants whom have a greater amount of ‘attentional resources’ and so-called volitional ‘control’ over their attention (as measured by high working memory capacity; e.g., A. R. A. Conway, Cowan, & Bunting, 2001; Kane, Bleckley, A. R. A. Conway, & Engle, 2001; Kane & Engle, 2000; Rosen & Engle, 1997) will show a smaller ISE. However, this does not appear to be the case: The level of serial recall performance in the presence of irrelevant sound does not appear to be modulated by measures of working memory capacity (cf., Beaman, 2004; Neath et al., 2003; but see Elliott, Barrilleaux, & Cowan, 2006; for evidence that other individual differences are correlated to the size of classical ISEs, see Macken, Phelps, & Jones, 2006, section 1.2.5.1.1). It should be noted here that just because the magnitude of the classical ISE is unrelated to so-called measures of attentional resources this should not preclude one from considering that the distracting effects of irrelevant material in other contexts may be related to whatever working memory capacity measures. Indeed, certain measures that might be considered an indication of attentional recruitment—such as recognising one’s name in the unattended channel in a dichotic listening task (Moray, 1959; N. L. Wood & Cowan, 1995)—have been shown to be related to working memory capacity, participants with low as compared with high working memory capacity are more likely to recognise their own name in the unattended channel (A. R. A. Conway, Cowan, & Bunting, 2001; for a related finding, see Beaman, 2004, Experiment 4).

Finally, a number of findings derived from recent research using deviant stimuli (Hughes, Vachon, & Jones, 2005; Hughes, Vachon, Linsmith, & Jones, 2006) further undermine the attentional recruitment account. The attentional recruitment account supposes that the changing-state effect results from the same mechanism—attentional capture—as that of auditory deviants. However, Hughes et al. (2005) have shown that the changing-state effect and the deviant effect are ‘additive’ and are thus separable effects. More specifically, according to the attentional recruitment account, if the successively changing irrelevant tokens were capturing attention then a deviant stimulus should exert less disruption in the context of a changing-state sequence compared to a steady-state

sequence. This is not the case: the deviant effect is additional to, and appears superimposed upon the changing-state effect. Further evidence that the deviant effect is qualitatively distinct from the changing-state effect has been gleaned from the finding that the deviant effect is found only during the encoding of the TBR items; it has no effect during retention (Hughes et al., 2005). Finally, the deviant effect occurs on a task (the missing item task, see section 1.2.5.1.2) that has been shown not to exhibit a changing-state effect. This suggests that the disruptive impact of deviant stimuli occurs independently of the changing-state effect which reinforces the assertion that, in contrast to the explanation offered by the attention recruitment account, the changing-state effect is not one that is produced because the successive elements in changing-state stimuli are somehow deviant, and thus likely to capture attention (Hughes et al., 2006).

In sum, the empirical support for the attentional recruitment account of the classical ISE is somewhat lacking and there are several key findings that directly contradict it. It is important to note here, however, that the concept of attentional recruitment or capture is itself valid to explain disruption by *deviant* stimuli in the context of serial recall tasks but it does not explain the changing-state effect per se (e.g., Hughes et al., 2005; however, even here there is empirical evidence that the precise formulation of the neural model is at odds with that proposed by Cowan, 1995). Moreover, for certain tasks ORs to irrelevant sound may habituate (e.g., Banbury & Berry, 1998; Culbert & Posner, 1960; Morris & Jones, 1990a). However, in serial recall tasks the propensity for sound to cause ORs can diminish but this seems to be the same for steady and changing-state sound suggesting that ORs may habituate but the changing-state effect will not habituate (Hughes et al., 2005). In short the *ISE does not, and will not, habituate* because the ISE is underpinned by a mechanism different from ORs, one that will be outlined in the forthcoming section.

1.4 Functional accounts of the classic ISE: 'Interference-by-process'

Rather than being produced as a consequence of the structure of memory or traces of items within memory, as is emphasised in the interference-by-content accounts, it is proposed in this section that the body of work on auditory distraction in the context of serial recall is best understood in terms of an interference-by-process approach. This

account eschews the central tenets of the mnemonic approaches that have tended to dominate (e.g., Salamé & Baddeley, 1982). For example, the construct of ‘item interference’ (either through interference due to the similarity in identity of TBR and ignored *items*, or disruption produced by successive *items* capturing attention (e.g., as in the attentional recruitment account)) in the cognitive system is replaced by the key construct that the disruption by sound is in terms of the similarity of processes applied to the TBR and irrelevant items at the *sequence* level. Rather than appealing to mnemonic constructs such as the modular assumption of storage structures in the mind/brain, the interference-by-process account has more recently reconstrued short-term memory by appealing to the action or output planning system as well as constructs that hold currency in the area of selective attention (Jones, Hughes, & Macken, 2006a, b; Jones et al., 2004; Hughes & Jones, 2005). That is, similar to the selection-for-action approach (see Allport, 1989, 1993; O. Neumann, 1989, 1996; Van der Heijden, 1992), the interference-by-process account has been couched in terms of ‘competition-for-action’ (Hughes & Jones, 2005): Briefly, irrelevant information that fits the skill of serial rehearsal (involved in the focal, serial recall task) must be prevented from controlling the actions involved in performing that skill. The cost of preventing irrelevant information from assuming control of that skill manifests as disruption in focal task performance.

1.4.1 The interference-by-process account of the classical ISE

In response to the failure of interference-by-content approaches (e.g., Salamé & Baddeley, 1982; Neath, 1999) to explain adequately the data on the classical ISE, a different approach, the interference-by-process account, has been evolved that emphasizes the findings that it is the acoustic properties, not phonological content, of an irrelevant sequence—specifically that it conveys an appreciable magnitude of acoustic variability over its time course—that produces impairment to serial recall performance (Jones, 1993; Jones et al., 1996; Jones & Tremblay, 2000; Macken, Tremblay, Alford, & Jones, 1999). Antithetic also to the attentional recruitment account, the interference-by-process account supposes that changing-state sound does not recruit attention, rather it is disruptive because the obligatory processing of the changes conveyed by its adjacent, constituent elements yield information pertaining to their order which interferes with the

process of retaining the correct order of the TBR items during serial rehearsal (Hughes & Jones, 2001; Jones, 1999; Jones et al., 1992; for a detailed overview, see Jones et al., 1996).

Central to the interference-by-process account is the concept of auditory streaming. Streaming (that referred to as non-schema, rather than schema-driven, streaming; see Bregman, 1990) or auditory grouping, part of the auditory scene analysis (e.g., Bregman, 1990), refers to a passive perceptual process that yields order information as a direct by-product of exposure to changing-state sequences. Part of the streaming process occurs when adjacent, consecutive elements within sound are compared to one another in order to decipher whether or not they are emitted from the same environmental origin. Successive sounds are grouped into a single stream or percept if the degree of change between each auditory event (in terms of pitch, frequency or timbre) is below a certain 'fission' threshold otherwise the events become segregated into separate streams or a dual-stream percept (i.e., fusion gives way to fission, see Van Noorden, 1975; see also Macken et al., 2003).

Two key assumptions of the changing-state account are that order information pertaining to the relatively distinct successive events are obligatorily encoded as a side-effect of integrating them into a single-stream or percept and that this process of auditory streaming occurs preattentively. In other words, auditory streaming and thus seriation should occur for the discrete changes between successive items whether the sound is attended, or is unattended (Bregman & Rudnick, 1975; Macken et al., 2003; Mondor & Terrio, 1998; Sussman et al., 1999; but see Carlyon, 2004; Carlyon, Cusack, Foxton, & Robertson, 2001). Thus, according to the interference-by-process view, the classical ISE reflects the conflict between two processes of seriation, one that is automatically (and hence involuntarily) applied to seriate elements of a changing-state irrelevant sound and another that is deliberately applied to the TBR items through the serial rehearsal process.

The interference-by-process account thus emphasizes the properties of sequences rather than items and is thus a view that is of opposite polarity to the structural, interference-by-content approach described in the preceding sections. On the interference-by-process account the disruptive potency of the acoustic properties of sound that yield seriation transcends the properties relating to the particular content of the TBR

and irrelevant streams of information. Critically, on the interference-by-process account appreciable disruption will *only* occur if *both* the primary task and the irrelevant sound involve seriation. In other words the interference-by-process account predicts that the degree of seriation in the sound (as conveyed by acoustical variation) and focal task are co-determinant of the amount of disruption produced to performance of the focal task. The two most convincing and convergent lines of evidence pertaining to this prediction of the interference-by-process account will now be outlined: That related to acoustic properties of the irrelevant sound that yield seriation via preattentive processes of *perceptual organization*, and that related to task sensitivity to disruption, particularly as it relates to the acute sensitivity to impairment of tasks that require seriation.

1.4.1.1 Perceptual organization

The interference-by-process account assumes that the degree of disruption produced by irrelevant sound will be modulated by factors associated with streaming. Concerning streaming, order information regarding elements of a sound are yielded only for sequences of elements that emanate from the same stream (Bregman, 1990). Moreover, up until a threshold of fission, there is a linear function whereby the larger the difference between successive elements of sound within a stream the stronger the order cues they convey. The threshold of fission is reached when the differences between successive items within a stream reaches a critical level and are segregated into separate streams, hence no longer conveying information pertaining to their order. Examples of the differences between successive items that produce stream segregation are sequences comprising of elements that are highly distinct such as a burst of white noise, a tone, a vowel sound and a buzz, the elements of such sequences are more difficult to report in order than sequences whose elements are only slightly distinct from one another such as a burst of white noise, a high pitch tone, a low pitch tone and a buzz (Broadbent & Ladefoged, 1959; Warren & Obuzek, 1972). Thus modest changes on a common ground from one element to the next in an irrelevant sequence give rise to more order information than sequences of very distinct elements.

A key finding that suggests that the classical ISE is intricately related to streaming, and thus supports the interference-by-process account, is that, up until a point of fission,

there is a non-monotonic relationship between the degree of difference between successive elements of an irrelevant sequence and its propensity to disrupt serial recall performance. More specifically, because the degree of change increases the availability of (and hence strength of) order information this finding supports the notion that the ISE is dependent on the presence of order information in the irrelevant sequence. For example, increasing the frequencies of successive tones from 0 to 2 to 5 semi-tones the degree of disruption to serial recall increases monotonically. However, when the separation distance is 10 semi-tones the degree of disruption starts to decrease (Jones et al., 1999). This change in the pattern of the disruption with 10 semi-tone differences corresponds to the critical point at which fission or stream segregation occurs (the higher and lower pitch tones form two separate streams) for the unattended sound rendering order information lacking and in turn the sequence comparatively ineffectual in its capability to disrupt serial recall.

The role of streaming in modulating the ISE has been shown further by manipulating the spatial location of irrelevant auditory stimuli. Powerful cues to stream segregation arise when the disparity between successive elements is manipulated by spatial location; sounds emanating from one spatial location tend to be grouped into a single percept (or stream) separate from those emanating from different locations. For example, a continuously-repeated loop of three syllables presented to both ears will form one stream and demonstrate sufficient variation so as to conform to the conditions for changing-state thus yielding order information and producing a marked ISE. However, when the presentation of the three syllable loop is changed such that one syllable arrives at the left ear (left stream) one at the right ear (right stream) and one to both ears (centre-of-head stream) at the same time, providing the rate of presentation is sufficient to give rise to streaming, the degree of disruption is substantially reduced. Here then, the syllable sequence, as a consequence of streaming, is partitioned into three separate steady-state streams each comprising one continuously repeated item and yielding no variation and thus order information (Jones & Macken, 1995c; see also Jones, Saint-Aubin, & Tremblay, 1999). It thus appears that in order for irrelevant sound to produce marked disruption, the acoustic changes it conveys must take place on common ground or rather a carrier common to the sound (say, one voice as compared with two and here one spatial

location as compared with two or three; see also Macken et al., 2003). This streaming by location effect is particularly problematic to interference-by-content accounts because in all aspects the content of the irrelevant tokens in each of the sound conditions are the same, only the spatial location and thus the probable perceptual organization that is generated by the sounds differ. This spatial-streaming effect is also at odds with the attentional recruitment account (Cowan, 1995) because this account appears to predict that there should be a monotonic relationship between the degree of change and disruption to recall. On this account, if anything, the opposite pattern to that found would be predicted: changes between items as well as by spatial location should produce more disruption than that produced between successive items emanating from only one spatial location.

Another empirical finding, the ‘token dose effect’ (Bridges & Jones, 1996) which refers to the linear relationship that is observed between the degree of disruption and the number of tokens presented per unit time, also cannot be accommodated within the attentional recruitment account. In fact the direction of the token dose effect is contra to that predicted by the attentional recruitment account. The attentional recruitment account supposes that the more times an irrelevant item is experienced the less likely ORs should occur (due to the formulation of an increasingly well-specified neural model) thus contrary to the token dose effect, performance should be better (or at least not worse) the higher the token dose. A related finding that also poses a problem for the attentional recruitment account is that a low-token set size sequence of alternatively presented irrelevant tokens (e.g., ‘*a, b, a, b, a, b...*’) produces no more disruption than a high-token set size sequence (e.g., ‘*a, b, c, d, a, b...*’) when presented within a trial (Tremblay & Jones, 1998). The attentional recruitment account predicts that the high token-dose sequence—contrary to this pattern of results—containing a greater number of *different* tokens, would increase the likelihood of eliciting ORs (and thus decrease the habituation rate) and that the low-token dose sequence will more quickly give rise to the development of a specified neural model (and habituation of ORs). Moreover the account predicts a monotonic increase in the degree of disruption as the token-set size increases, but this clearly does not occur (Tremblay & Jones, 1998).

Additional support for the role of streaming in the classical ISE has been gleaned from the finding that the ease of identifying the order of a set of rapidly, sequentially presented, successively changing items (e.g., vowels with or without formant transitions) is predictive of the degree of disruption those items produce to serial recall performance when they are presented as irrelevant sound (Macken et al., 2006). This finding is consistent with earlier work (Jones & Macken, 1995a) showing that phonologically similar irrelevant sequences produce less disruption than phonologically dissimilar sequences: the former are much harder to report in serial order than the latter. More recently, an experiment has indicated that the degree to which participants can automatically (but not deliberately) encode the order information of sound tokens in an attended task predicts the degree to which those stimuli produce disruption when later presented as irrelevant sound tokens in a serial recall task (Macken et al., 2006). On a similar theme, another study has shown that changing-state vowels produce more disruption than changing-state consonants (Hughes, Tremblay, & Jones, 2005). Although speculative, it is possible that because changing vowels, as compared with changing consonants, produce frequency changes reflecting the melodic aspect of speech and occur on a common timbre, they may yield comparatively stronger order cues.

1.4.1.2 Task sensitivity

Unique among the competing interference-by-process and interference-by-content explanations of the classical ISE, the interference-by-process account supposes that only tasks that call upon seriation as an efficient, or the only means or strategy, for performing a task, are disrupted by irrelevant sound (Beaman & Jones, 1997, 1998; Jones & Macken, 1993, but see LeCompte, 1994). In support of the interference-by-process account, the nature of the primary task *is* a significant factor in whether or not an ISE will be found. For a marked ISE to be consistently observed the focal task must necessitate or at least draw upon the seriation (rote or maintenance rehearsal) of material as an efficient item-retention strategy: of two tasks that make similar cognitive demands with the exception that one requires seriation (probe recall task) and one does not (missing-item task) only the task demanding seriation shows a changing-state ISE (Beaman & Jones, 1997, 1998; Henson, Hartley, Burgess, Hitch, & Flude, 2003; Jones & Macken, 1993).

Moreover, free recall tasks for unrelated words, or for consonants, sometimes show an ISE (e.g., Beaman & Jones, 1998; LeCompte, 1994; but see Richardson, 1984; Salamé & Baddeley, 1990) because, despite their nominal difference to serial recall, free recall tasks are often also underlain by seriation (Beaman & Jones, 1998). This disruption by irrelevant sound on a seriation strategy, adopted as part of free recall tasks, extends to more complex tasks such as free recall of passages of prose (Banbury & Berry, 1997, 1998). Additionally, the material to-be-seriated need not be verbal for a changing-state ISE to be found. For example, irrelevant sound disrupts memory for the correct sequence of dots presented in different spatial locations on a screen (Jones, Farrand, G. P. Stuart, & Morris, 1995). This finding of an ISE with a spatial analogue of the serial recall task again undermines the interference-by-content construct that the similarity between the content of TBR and irrelevant items produces the ISE (Salamé & Baddeley, 1982); one would be hard-pressed, in this instance, to find any kind of phonological similarity between the irrelevant sound and the TBR material.

That the recall task must be underpinned by seriation in order to be sensitive to disruption by irrelevant sound is also apparent from the absence of an ISE on perceptual tasks that have no memory component (e.g., Baddeley & Salamé, 1986; Burani, Vallar, & Bottini, 1991; for additional unpublished evidence, see Jones, 1993) or tasks that have non-serial memory components (e.g., Baddeley, Eldridge, & Lewis, 1981; Boyle & Coltheart, 1996; Richardson, 1984). This has been highlighted effectively by using a memory-updating task that required the putative role of the central executive (or controlled processing) and a seriation component (Morris & Jones, 1990b). In this task irrelevant sound impairs only the seriation component. These findings regarding task-sensitivity offer strong evidence against the attentional recruitment account. This account, like the interference-by-content account, offers an explanation of the classical ISE that is ‘task-process insensitive’. More specifically, in assuming that attention is a general, shared, cross-domain and thus ‘amodal’ resource (e.g., Cowan, 2001; see also Kane, Hambrick, Tuholski, Wilhelm, Payne, & Engle, 2004; Tombu & Jolicoeur, 2003), the account assumes that recruitment of attention via ORs should occur, and thus an ISE be found, with *any* task that requires a comparable memory load to serial recall. However, as has been illustrated the account cannot explain why only tasks that require seriation are

markedly disrupted by changing-state irrelevant sound (Beaman & Jones, 1997, 1998; Jones & Macken, 1993). Moreover the attentional recruitment account also appears to predict that tasks that require so-called “controlled attention” which is often mapped onto, or embodied in, executive function (e.g., Baddeley, 1986; Cowan, 1988, 1995) should be particularly disrupted by irrelevant sound. However, tasks that arguably require executive processing such as reading comprehension (e.g., Ericsson & Kintsch, 1995; Gathercole & Baddeley, 1993) often fail to show any disruption attributable to the acoustic variation of the sound (e.g., R. C. Martin, Wogalter, & Forlano, 1988; see also Morris & Jones, 1990b; see section 1.2.6.3.1).

Collectively, the empirical characteristics outlined in the preceding sections offer strong evidence in favour of the interference-by-process account. Empirical characteristics such as the effects of non-speech sounds (e.g., Jones & Macken, 1993), the modulation of the changing-state effect by manipulation of factors involving auditory streaming (Jones et al., 1999) and the peculiar sensitivity of tasks that involve seriation to disruption (e.g., Beaman & Jones, 1998) that cannot be explained by the structuralist accounts, can be explained within the functionalist account with a relatively few minor assumptions. Moreover that it is possible to predict the extent and degree of disruption to focal task-performance on the basis of properties of the focal task and irrelevant sound suggests that the interference-by-process account, in comparison to the attentional recruitment and interference-by-content accounts, also has a greater degree of predictive validity.

On a more conceptual level, the empirical findings suggesting that factors influencing perceptual organization affect short-term memory question the validity of the distinction that is often made between pre-categorical perceptual processes and post-categorical short-term memory processes. More specifically, the evidence argues against the traditional, structural notion that short-term retention of information is subserved by a discrete short-term or primary memory store that supposes a separation of short-term retention from pre-categorical perceptual processes (e.g., Atkinson & Shiffrin, 1968; G. D. A. Brown, Preece, & Hulme, 2000; Burgess & Hitch, 1992, 1999; Henson, 1998; Page & Norris, 1998). That the findings relating to perceptual organization suggest against a functional separation of perceptual and memorial processing, by extension, cast doubt on

the modularity assumption of interference on the basis of similarity of content within a short-term memory module (Neath, 2000; Salamé & Baddeley, 1982). Instead, these findings, along with more recent research (e.g., Jones et al., 2006a), suggest that perceptual and memorial processes are inextricably intertwined and support a nonmodular processing system whereby objects, and the way in which they interact, are the product of perceptual processes (Jones et al., 1996; Macken et al., 1999).

1.4.1.2.1 Is interference-by-process paradigm-bound?

Despite its success in explaining the empirical features associated with the classical ISE in the context of serial recall, one potential weakness of the interference-by-process account, is that the evidence on which, so far, it is based has been paradigm-bound, coming entirely from the serial recall setting. Is the interference-by-process construct therefore also paradigm-bound or is the construct also applicable to other domains of memory? In the following section empirical findings concerning auditory distraction in another cognitive domain, that involving semantic memory, will be outlined and upon reflection of this work it will be questioned whether the ISEs demonstrated in this setting can also be explained by the interference-by-process construct.

1.5 Auditory-semantic distraction

An emerging body of work has shown that irrelevant sounds which contain semantic content can have a detrimental effect on the performance of some focal tasks. In this section these semantic ISEs are reviewed and it will be shown that semantic ISEs are qualitatively distinct from the results in the context of serial recall in that disruption is produced by the semantic, not acoustic, properties of irrelevant sound. Moreover, it will be considered that semantic ISEs can be accommodated by the general construct of interference-by-process. In other words it will be shown that pronounced semantic ISEs tend to emerge only when the focal task requires semantic processing and, of course, the irrelevant sound demonstrates semantic properties.

1.5.1 Semanticity of sound is unimportant in the context of serial recall

The semanticity of irrelevant sound plays little, if any, role in the classical ISE. For example, meaningfulness (e.g., when it contains words in a language a participant comprehends). The one study showing an, albeit very small, effect of meaningfulness (LeCompte et al., 1997) has been criticised on methodological grounds (Jones, 1999; see also section 1.2.2.1.1). It has been found that the degree of disruption from speech presented in a participant's native language is comparable to that produced by reversed, and thus incomprehensible, speech and speech that is presented in a language the participant does not understand (Colle & Welsh, 1976; Colle, 1980; Jones & Macken, 1995c; Jones et al., 1990; LeCompte & Shaibe, 1997; Rouleau & Belleville, 1996; Salamé & Baddeley, 1982; see also Tremblay et al., 2000, Section 1.2.2.1.1).

In addition, between-sequence semantic similarity or rather the similarity in the semantic content between relevant (to-be-attended) and irrelevant (to-be-ignored) items (between-sequence semantic similarity) is also an unimportant factor. For example, Buchner et al. (1996) found that serial recall of lists of two-digit TBR numbers was no more disrupted by irrelevant two-digit numbers (that were not part of the TBR list) than it was by non-words that comprised the phonemes of the numbers, or word combinations whereby the phonemes of the irrelevant items were similar to those of the TBR numbers. Moreover, this same study showed that the "semantic distance" between the TBR and irrelevant items also played no role in the degree of interference: Irrelevant items that were within the same decade as the TBR numbers but 2 or 5 above or below, produced as much disruption as those drawn from 2 to 5 decades above or below the TBR numbers.

In other studies, however, there is a slight increase in the degree of disruption when semantic associates ("head"- "foot"), as compared to non-associates ("hill"- "foot"), are manipulated between-sequences (C. B. Neely & LeCompte, 1999, Experiment 1). Although recent studies (Buchner et al., 2004; Buchner & Erdfelder, 2005) have shown that valent and low frequency irrelevant words produce more disruption to serial recall than neutral and high frequency words respectively, it could be contended that these seemingly semantic irrelevant speech effects are qualitatively distinct from the classical serial recall effect. That is, in principle, one might agree with Buchner and colleagues that the frequency and valence effects are due to attentional recruitment (or capture, see

Section 1.2.4) and are akin to the “deviation” effect whereby an infrequent repetition of an item exerts a disruptive influence (Hughes et al., 2005). Notwithstanding these latter results, in the main evidence suggests that semanticity is not a cogent factor in the ISE.

Further indirect evidence against the role of meaning comes from findings that demonstrate that token to token level changes, not supra-segmental factors, produce disruption. That is, the same sequence of four consonants repeated over and over again produces a comparable degree of disruption to unpredictable combinations of the four-consonant sequences (Jones et al., 1992; Tremblay & Jones, 1998). Arguably, because the speech sounds of the repeated sequence could (at least theoretically) be organized into higher-order groupings—and this may take place in semantic analysis—supra-segmental (e.g., semantic) analysis does not appear to play a significant role in the classical ISE (Jones et al., 1992; Tremblay et al., 2000). Furthermore, because different irrelevant speech types (English narrative, Welsh narrative, and reversed English narrative) differ in their phonemic structure and familiarity of acoustic/phonetic sequence (or prosody), their functional equivalence in terms of producing disruption implies that some low level analysis of speech, or sound, produces the ISE. Thus, pattern-recognition mechanisms used for identifying speech sounds do not appear to play a significant role (see also Tremblay et al., 2000).

1.5.1.1 A semantic component within the focal task

A small body of research has begun to emerge that suggests that meaningful irrelevant speech and between-sequence semantic similarity produce interference in tasks other than serial recall (e.g., Jones et al., 1990; Oswald, Tremblay, & Jones, 2000). The commonality of these focal tasks that demonstrate semantic ISEs is that they call upon or encourage semantic processing because it is essential to, or facilitates, task performance. Thus, it appears that in order to show a substantial level of impairment from irrelevant semantic information, the primary task must demand a semantic level of analysis and processing. Logical reasoning suggests that an effect attributable to the meaningfulness of irrelevant sound in the context of serial recall does not ordinarily egress because typically items presented for serial recall (usually digits or consonants) are rather arbitrary and devoid of semantic content (and therefore processing) and as such there is no clash with

the semantic content (or processing thereof) applied involuntarily to the sound. However, it is also possible that an effect of meaningfulness may fail to emerge not because the TBR items are not semantically-rich, but that semantic processing is not necessary for effective focal task performance: the serial recall task can be performed adequately by using a seriation strategy.

1.5.1.2 Vulnerability to auditory-semantic distraction: Task and sound factors

It is worth mentioning here that there is some literature pertaining to the effects of irrelevant broadband (e.g., white noise) on tasks that require semantic processing (for overviews, see Eysenck, 1982; A. P. Smith & Jones, 1992). This literature was concerned mainly with the proposed notion that broadband noise caused a shift from processing the semantic or conceptual features of the TBR material to processing its lower level surface features or its temporal order (e.g., Dornic, 1975). These studies will not be described. However, it will suffice to say here that there is inconsistency in the evidence that white noise reduces the degree of semantic processing and efficiency of semantic retrieval (Eysenck & Eysenck, 1979; A. P. Smith, 1985a; A. P. Smith & Broadbent, 1981; A. P. Smith, Jones, & Broadbent, 1981). Notwithstanding the equivocal nature of the findings with broadband noise, one must not fail to consider that, in contrast to tasks that involve seriation, non-specific factors, perhaps due to arousal, may also play a role in disrupting performance on semantic tasks (e.g., Hygge, Boman, & Enmarker, 2003). Tasks that demonstrate semantic ISEs will now be outlined.

1.5.1.2.1 Reading comprehension

Particularly vulnerable to semantic interference from irrelevant sound are comprehension tasks that involve the extraction and retention of propositions from prose. Investigations of the effects of irrelevant sounds on reading comprehension, as well as pervading early research, have permeated more modern-day research (e.g., Furnham & Stanley, 2003; Furnham & Strbac, 2002). The early work in this area investigated the effects of background music and/or noise rather than meaningful speech per se on reading comprehension (e.g., Fogelson, 1973; Henderson, Crews, & Barlow, 1945; Kiger, 1989; Zimmer & Brachulis-Raymond, 1978). The results with music are equivocal: disruption

has been reported in some cases (Henderson et al., 1945) whilst in other cases there has been either no effect (e.g., Freeburne & Fleischer, 1952; Geringer & Nelson, 1979) or one of facilitation (e.g., Cash, El-Mallakh, Chamberlain, Bratton, & Li, 1997; Cockerton, Moore, & Norman, 1997; Hall, 1952; Kaltsounis, 1973; Kiger, 1989; Stanton, 1975). For example, Kiger (1989) showed that a highly repetitive synthesized piece of music with narrow tonal range significantly facilitated performance relative to a quiet control and a dissonant, rhythmically varied and highly dynamic piece which did not produce disruption relative to quiet (for another facilitatory effect of background (classical) music on spatial tasks, see the 'Mozart effect' (L. K. Miller & Schyb, 1989; Rauscher, Shaw, & Ky, 1993; but see Steele, Bass, & Crook, 1999). Such a finding suggests that acoustic factors do not seem to play a role in disrupting reading comprehension.

Whether background music is disruptive to reading comprehension tasks appears to depend upon individual differences as diverse as personality and intelligence (Daoussis & McKelvie, 1986; Fogelson, 1973; Furnham & Allass, 1999; Furnham & Bradley, 1997; Furnham & Stanley, 2003; Furnham & Strbac, 2002; Furnham, Trew, & Sneade, 1999; Hall, 1952) familiarity, preference and exposure to the musical piece (Burton, 1986; Etaugh & Michaels, 1975; Fogelson, 1973; Fontaine & Schwalm, 1979; Geringer & Nelson, 1979; Hilliard & Tolin, 1979; Parente, 1976; Stanton, 1975; Wolf & Weiner, 1972; Wolfe, 1982), prior and current study habits (Etaugh & Ptasnik, 1982; Furnham & Stanley, 2003) and the complexity of the reading task (Zimmer & Brachulis-Raymond, 1978).

1.5.1.2.1.1 Meaningful speech disrupts reading comprehension

In order for background music to be pronouncedly disruptive somewhat critical appears to be the presence of speech (e.g., lyrics) in the musical piece: Henderson et al. (1945) found that popular music containing lyrics was more disruptive to text comprehension than classical music which bestowed no disruption relative to a quiet control (but see, Furnham et al., 1999; Zimmer & Brachulis-Raymond, 1978). This suggested that it could be the semantic content or meaningfulness of the lyrics that produced the disruption to reading comprehension performance. Confirmation that the meaningfulness of irrelevant stimuli does indeed produce disruption in this setting was

provided by a later extensive investigation. R. C. Martin et al. (1988) showed that comprehension for text passages, following an interpolated visual search task, was disrupted if the passages had previously been read in the presence of a spoken prose passage (in English) or random English words compared to white noise, instrumental music and random tones (Experiment 1; see also Boman, 2004; Knez & Hygge, 2002). Furthermore sung and spoken English speech was equally disruptive compared to instrumental music (Experiment 2). Moreover, English speech was more disruptive of reading comprehension than Russian speech (Experiment 4; for a related finding, see Perham, Banbury, & Jones, 2005) and sequences of randomly presented meaningful words were more disruptive than phonologically-matched nonwords (Experiment 5).

However, in two experiments R. C. Martin et al. report some disruption from meaningless backgrounds such as Russian and non-words compared to quiet, but these meaningless speech conditions did not differ from a broadband noise condition. In this work, therefore, meaningless speech, unlike in the case of serial recall, was no more disruptive than broadband noise, and as such the changing-state, acoustic factors of the irrelevant sound stream that are so potently disruptive to serial recall, did not appear to influence comprehension *per se*; they also do not appear to be additive with the meaning of the irrelevant sound. Contrary to the findings of R. C. Martin et al. (1988), however, several studies have failed to demonstrate disruption attributable to meaningless irrelevant speech on reading comprehension tasks (e.g., Baddeley et al., 1981) suggesting that acoustic, as compared with semantic, effects of irrelevant sound on reading comprehension tasks may be less robust.

Further support for the impact of meaningful irrelevant speech on comprehension has been reported by Oswald et al. (2000; see also A. P. Smith, 1985b) who used Bransford and Franks' (1971) abstraction of linguistic ideas paradigm. They found that comprehension of sentences (or retention of propositions)—as revealed by errors in response to questions concerning the action and subject of sentences after they had been presented during an acquisition phase—was worse when the sentences were concurrently presented with meaningful and meaningless speech compared to quiet, with an additional effect for meaningful speech. Thus, comprehension was impaired by both meaningless and meaningful speech but the disruption was exacerbated when the irrelevant speech

contained semantic information. However, one drawback of this study is that because there was no broadband noise condition it is impossible to know whether meaningless speech produced disruption to comprehension via its acoustic factors or because it was simply noise (cf. R. C. Martin et al., 1988): It could be that meaningless speech is impairing seriation that may be required for text comprehension in this particular task and that the effect of meaningfulness is additive (e.g. Hughes & Jones, 2001) but because the lack of a broadband-noise condition, one cannot be certain.

Finally, Boman (2004) reports an effect attributable to meaningful irrelevant speech on a word comprehension task whereby participants were presented with 30 target words with four others presented alongside and were asked to choose which of these four was a synonym of the target word.

1.5.1.2.1.2 The importance of comprehension in the focal task

That the reading task involves retention of propositions and not just verbatim recall (or serial order retention) appears a necessary pre-requisite for an effect of meaning to be found. Tasks that can be accomplished by simply recalling a passage of text verbatim and thus with less 'weighting' on comprehension, fail to show an effect of meaning: meaningful and meaningless speech is equally disruptive to prose recall (e.g., Banbury & Berry, 1997, 1998).

1.5.1.2.2 Proof reading

Proof reading tasks are also disrupted by the meaning of irrelevant speech. Jones et al. (1990) for example, report that meaningful speech, as compared to reversed speech, disrupted detection of non-contextual errors (omissions and misspellings) but had no effect on the detection of contextual errors (grammatical errors and inappropriate words) regardless of the physical attributes of the irrelevant speech such as its intensity and spatial location. The effect, however, was positively related to the burden or load on short-term memory as defined by the size of the text display: Significantly fewer non-contextual errors (misspellings but not omissions) were found for meaningful speech relative to meaningless speech only when the display contained five lines of text as opposed to one.

An opposite finding to the one reported by Jones et al. (1990), however, was earlier reported. In this study (Weinstein, 1974; see also Weinstein, 1977), intermittent background teletype sound (70 dB(A)) impaired the detection of contextual (grammatical) errors leaving performance on non-contextual error detection (misspellings) intact. However, in accordance with the usual pattern of semantic interference effects this teletype noise did not impair recall of content of the proof read text: In other words, this meaningless sound did not impair comprehension of the text. Other tasks that essentially involve proof reading such as judgments of the grammaticality of written sentences appear to be unaffected by meaningless irrelevant speech and music (Boyle & Coltheart, 1996) which supports the notion that the acoustic properties of irrelevant sound often fail to influence semantic analysis of written sentences.

1.5.1.2.3 Writing

Other tasks that could conceivably involve processing of meaning such as word-processing have been shown to be disrupted by irrelevant music and speech (e.g., Ransdell & Gilroy, 2001; Ransdell, Levy, & Kellogg, 2002). Irrelevant music and speech impair essay writing fluency (as indexed by the number of words generated per minute with appropriate control for typing speed and word entries that are omitted from the final version) but have no effect of writing quality. Extensive investigation as to whether meaningful speech is more disruptive to essay writing than meaningless speech, however, is still awaited. Furthermore, Morris and Jones (1991) found that irrelevant speech increased omission error and task completion time for sentences cursively transcribed from visual display units but that there was no effect of meaning, reversed and forward speech having similar effects. Moreover the effect was confined to the transcription of sentences that were approximations of English (and thus ungrammatical) suggesting the effects of irrelevant speech appear only when the load on memory is high as is the case when remembering text lacking in redundancy. Similarly, Bell (2001, as cited in Beaman, 2005) reports that irrelevant auditory digits, compared to quiet, increase error for the computer-keyboard manual data-base entry of digit sequences read off data cards. However, in this case one cannot be sure if the effect was attributable to the meaning of

the sound, or rather between-stream semantic similarity between the focal task, and irrelevant material, because there was an absence of an appropriate control irrelevant sound condition (e.g., irrelevant consonants).

1.5.1.2.4. Problem solving, counting, and arithmetic

Performance on tasks that require problem solving or mental transformation may be susceptible to the semantic properties of irrelevant sound (e.g., Perham et al., 2005). For example, Graydon and Eysenck (1989) showed, using a verbal reasoning task, whereby a participant is given a sentence (e.g., “A precedes B”) and asked to verify whether the ordering of the sentence is correct given the ordering of two letters (“A, B”), that response times for verifying sentences was significantly slowed by irrelevant exemplars comprising the letters “A” and “B” relative to irrelevant digits “1” and “2”. This between-stream semantic similarity effect, however, was dependent on the difficulty of sentence verification: only a passive negative version of the reasoning task (e.g., “B is not followed by A”, “B is not preceded by A”) revealed an effect of letter distraction. Eysenck and Graydon (1989) have further shown a between-stream semantic similarity effect on a task involving letter transformation. The letter transformation task involves transforming letters by working a specified distance through the alphabet. For example, the task “N+2” involves the participant proceeding forward two letters through the alphabet giving “P” as the answer. On experimental trials the task included transforming four-letter problems such as “NQBF” which yields the answer “PSDH”. Comparing two sound conditions comprising blips and random letters against quiet, participants took longer to solve the tasks when the sound comprised irrelevant letters, as compared with tones, but only on more complex problems whereby the letter transformation involved proceeding four, instead of two, letters through the alphabet (Eysenck & Graydon, 1989). Moreover, this experiment revealed that individual differences may be important because a between-stream semantic similarity effect was only found for participants classified as neurotic introverts as compared with stable extraverts. However, one drawback with the letter transformation study is that in the comparison *dissimilar* sound condition, the irrelevant beeps were both non-speech items and steady-state (a fixed frequency tone was simply repeated). It seems obvious that a more appropriate dissimilar condition would

have been irrelevant digits or reversed letter tokens and the absence of these conditions calls into question the veracity of the between-stream semantic similarity effect in the context of the letter transformation task.

Several studies have shown an effect of irrelevant sound on counting (Buchner, Steffens, Irmen, & Wender, 1998; Graydon & Eysenck, 1989; Logie & Baddeley, 1987). Generally, between-stream semantic similarity is thought not to be responsible for the disruption of event counting (Buchner et al., 1998; cf. Logie & Baddeley, 1987). However, Graydon and Eysenck (1989) have shown that a more complex, counting backwards task is disrupted by between-stream semantic similarity. Irrelevant digits, as compared with letters, phonologically-matched nonwords (e.g., “tun”, “gnu”, cf. “one”, “two”) and electronic blips disrupted counting backwards relative to a quiet control but this interacts with task difficulty (e.g., whether the task requires counting backwards in ones or threes from a one, two, or three digit number). Irrelevant sound has also been shown to disrupt mental arithmetic in a different setting (Banbury & Berry, 1998; Furnham & Strbac, 2002; Hadlington, Bridges, & Beaman, 2006). However, for this task no more than a trend for a between-stream semantic similarity effect has been reported (Banbury & Berry, 1998, Experiment 2).

1.5.1.2.5 Picture-naming

Semantic interference from irrelevant auditory items during the lexicalization process in speech production has been shown in cross-modal forms of picture-word interference tasks. In the cross-modal picture interference task participants must name a picture orally as quickly as possible whilst ignoring auditory distractor words. As a general rule, picture naming is slowed by the auditory presentation of a distractor (e.g., “cat”) that is semantically related to a target picture (e.g., of a “dog”) as compared with a semantically unrelated distractor (e.g., “drill”; Damian & R. C. Martin, 1999; Meyer & Schriefers, 1991; Meyer & van der Meulen, 2000; Schriefers, Meyer, & Levelt, 1990; D. M. Stuart & Carrasco, 1993). This semantic interference effect, however, is critically dependent on the stimulus-onset asynchrony (SOA) between the presentation of the auditory word and the target picture. Semantic *inhibition* in picture naming appears to occur only when the semantically-related distractor is presented just prior to (SOA = -150 ms; Schriefers et al.,

1990; SOA = 200 ms, Damian & R. C. Martin, 1999), or synchronously with (SOA = 0 ms; Damian & R. C. Martin, 1999), the target picture. Common to many picture-naming theories, is that the delay in naming response reflects a cost of resolving the competition between two co-activated, semantically similar, words.

The nature of the SOA's are critically important within the picture-word naming task because the task can also reveal phonological *facilitation* in the latency of picture-word naming when the irrelevant auditory word (e.g., "goal") is phonologically similar to the target word (e.g., "goat"). This phonological facilitation has been found at varying SOAs (+ 200 ms, Damian & R. C. Martin, 1999; +150 ms, Schriefers et al., 1990; Jescheniak & Schriefers, 2001; -100 ms, Damian & R. C. Martin, 1999; -150 ms, Meyer & Schriefers, 1991; Jescheniak & Schriefers, 2001; - 300ms, Jescheniak & Schriefers, 2001; Starreveld, 2000; for phonological *inhibition* by irrelevant auditory items on the utterance of a target word, see Saito & Baddeley, 2004). In sum, unlike the case with the classical ISE, in the picture-word interference setting the degree of synchronicity between the irrelevant and relevant items in the picture-naming task plays a pivotal role in whether semantic interference and/or phonological facilitation are found.

1.5.1.2.6 Colour-naming

Semantic interference from irrelevant auditory items has been shown in cross-modal forms of Stroop-interference tasks. In the Stroop task, colour words are printed in an ink that is incompatible with the word and thus the naming response required. For example, the word "red" would be written in blue ink. Correctly naming the colour of the ink requires suppression of the automatic tendency to read the colour word. In cross-modal Stroop tasks the requirement is to name colour patches whilst ignoring auditorily presented colour words. Cowan and Barron (1987) demonstrated a cross-modal Stroop effect, showing that naming of both colour words written in black ink and colour words printed in different colour ink (Stroop interference material) on a stimulus card were significantly slowed if participants had to ignore colour words as compared with letters from the English alphabet, instrumental music, or the word 'the' repeated continuously during the task. Moreover, the effect was generalized and not specific to the identity of the target and distracting words because the effect occurred even though the auditory

colour words and visual colour words were drawn from non-overlapping sets. Cowan (1989) also showed the same associative interference in the naming of visually presented colour dots. This outcome, however, was not replicated in several experiments using exactly the same, or similar, materials and conditions (Miles & Jones, 1989; Miles, Madden, & Jones., 1989; see also Thackray & Jones, 1971; Thackray, Jones, & Touchstone, 1972).

Later cross-modal Stroop studies, however, have shown that, like the cross-modal picture-word interference task, the semantic interference effect depends on the coincidence of irrelevant and relevant material (Elliott & Cowan, 2001; Elliott, Cowan, & Valle-Inclan, 1998; Hanauer & Brooks, 2003; Roelofs, 2005; Shimada, 1990). For example, Elliott et al. (1998) compared the effects of spoken colour words (e.g., “blue”) and noncolour words (size adjectives, e.g. “long”) and compared with a quiet control condition on the naming of colour squares. The auditory stimuli were presented 500 ms before or simultaneously with the colour. Colour-naming latencies were longer in the spoken-colour-word condition than in the spoken-non-colour-word condition, and both were longer than those in the silence condition when this SOA = 0 msec only. Therefore, there had to be some simultaneous processing of the colour-name and colour square to lead to interference. More recently, Roelofs (2005) reported an impairment produced by colour-incongruent auditory distractors at -300, -200, -100, 0, and +100, but not at +200, and +300 SOA’s, with most naming interference at 0 (Roelofs, 2005; see also, Elliott et al., 1998; Jones & Hapeshi, 1991, as cited in Jones, 1993) an SOA range for semantic interference common to the auditory picture–word interference paradigm (Damian & R. C. Martin, 1999; Meyer & Schriefers, 1991; Schriefers et al., 1990). Other experiments have also shown that colour-word sounds presented at longer SOAs (-1000 ms) before the colour-word to-be-named is presented can facilitate (i.e. speed up) the naming response compared to control trials where broadband-noise-filled envelope are presented (Jones & Hapeshi, 1991, as cited in Jones, 1993).

In sum, the existence of Stroop-like picture-word interference and cross-modal colour–word Stroop interference are well established phenomena of auditory-semantic distraction. It has been argued that, unlike reading comprehension and serial and free recall tasks, these naming tasks may not require memory. That is, they require only the

naming of a single non-verbal visual stimulus (e.g., a colour square) on each trial (Elliott & Cowan, 2001). However, it is possible that naming tasks are to some degree similar to certain memory tasks (such as semantic free recall, see Section 1.2.6.3.7) in that they require the production of appropriate responses by isolating one memory representation from several activated alternatives (see M. C. Anderson & Bjork, 1994). The effects of auditory-semantic distraction, however, on semantic free recall tasks that are traditionally considered to involve a memory component will now be described.

1.5.1.2.7 Semantic free recall

Despite the compelling evidence against between-stream semantic similarity as an influential agent in disrupting visual-verbal serial recall (e.g., Buchner et al., 1996), three studies have reported between-stream semantic similarity effects on tasks requiring free recall of semantic information (Beaman, 2004, Experiment 4; C. B. Neely & LeCompte, 1999, Experiment 2; Watkins & Allender, 1987). For example, for two studies, recall performance for relatively long (16-item) TBR lists that comprise exemplars drawn from a single semantic category (e.g., “Birds”: “cuckoo”, “finch”), is poorer (in terms of greater item omission) when frequent items of the same, as compared with different, semantic-category (e.g., “robin” and “eagle” as opposed to “apple” and “banana”) are presented in a retention interval prior to recalling the list. Moreover, in these experiments, when participants are exposed auditorily to frequent non-list presented irrelevant items that are semantically related to the TBR exemplars they produce these responses at a rate greater than if they had not heard them (Beaman, 2004; C. B. Neely & LeCompte, 1999).

Similarly, in a semantic-category fluency task that requires direct retrieval from semantic memory, fewer instances of a category were produced in response to a category-name (e.g., “Vegetables”) when participants were instructed to ignore irrelevant items that correspond to that category (e.g., “carrot”, “potato”) as compared with those that belong to a different category (e.g., “dog”, “lion”; Watkins & Allender, 1987). Moreover, the semantically-unrelated irrelevant items in this study did not produce disruption relative to quiet, although there was a trend for impairment in one of the reported experiments (Watkins & Allender, 1987, Experiment 2). These category-exemplar fluency experiments cannot be classified as ones of selective attention because

participants were required to monitor the sound in order to avoid recalling the exemplars it contained. However, it is possible to propose that the semantic-category fluency task becomes one of selective attention after the words of the related irrelevant sound are known and thus monitoring of the sound is no longer required.

More recently, one study has used word fluency tasks that, at first glance, would appear to tap semantic memory (Hygge et al., 2003). In this study irrelevant road-traffic noise and meaningful speech produced comparable disruption on a task that involved generating ‘professions’ that begin with a particular letter (Hygge et al., 2003). This was not a typically semantic fluency task in that the response criterion was restricted to “Profession” words (e.g., “doctor”, “dentist”) that began with a certain letter: this likely leads to search processes based on lexical-phonemic as well as semantic associations and thus it remains to be seen whether a search for category-exemplars based purely upon semantic criteria would be vulnerable to an effect attributable to the meaning of irrelevant sound. Finally, auditory-semantic distraction in the form of a radio broadcast has been shown to slow the speed of access to semantic memory (Baddeley & Thomson, as cited in A. P. Smith 1985b).

1.6 Structural accounts of auditory-semantic distraction

In the main, structural accounts have been favoured as explanations of auditory-semantic distraction. Typically these are based on a limited capacity assumption, but as will be described, interference-by-content accounts are also possible. A brief overview of structural accounts of auditory-semantic distraction will now be outlined.

1.6.1 Resource accounts

These accounts tend to be framed with reference to the idea that there is an inherent limitation on part of the structure of the mind/brain system to process information. For example, Jones et al. (1990) based an explanation on a theory of attention due to Kahneman and Treisman (1984; see also Treisman, 1969). On this account processing deterioration occurs *only* when two streams of information share a similar level of analyses (or analysers) and this activity exceeds available resources. Moreover, the loss of capacity is manifest through ‘shedding’ of low levels of analysis required for other

parts of the task that do not necessarily demand semantic analysis (such as detection of non-contextual errors in a proof reading task). Several researchers have also formulated notions of auditory-semantic distraction with reference to a limited capacity assumption: Meaningful speech produces disruption because it: “taxes limited resources for semantic analysis” (Hygge et al., 2003, p. 13) or “taxes limited resources for parallel semantic processing” (Hygge et al., 2003; see also Oswald et al., 2000; see also Wickens, 2002).

The general idea of limited capacity, however, is underpinned by logical problems (Allport, 1989; O. Neumann, 1996; Van der Heijden, 1992) which makes the idea of an explanation based on a limited resource or resources for semantic processing considerably less attractive. Specifically, the notion of limited capacity rests upon an inference that a) evidence of unattended information failing to interfere with focal task performance indicates that b) this unattended information must be blocked from being processed and is therefore c) evidence for a limited processing capacity. Logically, this argument is incorrect and is an example of the ‘fallacy of affirming the consequence’ (Popper, 1959; Van der Heijden, 1992). The notion of ‘selective-processing-therefore-limited-capacity’ does not legitimately follow from ‘limited-capacity-therefore-selective-processing’ because limited capacity is an a-priori theoretical assumption; selective processing is what is observed. Moreover, in the context of semantic focal tasks, one cannot infer from the observation that semantic processing is disrupted or interfered with by irrelevant information that this is evidence for the existence of a limited resource (or even resources) for semantic processing because in reality this is just an a-priori theoretical assumption. Likewise one cannot use the notion of a limited resource or resources for semantic processing to explain why semantic processing is disrupted in the presence of meaningful speech because, again, the idea of limited capacity is just an a-priori theoretical assumption. Moreover, within the limited resource approaches it is never clear why resources (or capacity) become(s) limited (M.C. Anderson & Bjork, 1994; O. Neumann, 1987). In short, these limited capacity accounts are fundamentally circular and do little more than offer a redescription of the data they were designed to explain (see Allport, 1993).

1.6.2 Interference-by-content accounts

The classical, interference-by-content, view has been that interference-by-similarity directly causes impairment of focal task performance and is a passive side-effect of structural changes that result from the storing of new, similar, experiences in memory (J. R. Anderson, 1983; McGeoch, 1942; Mensink & Raaijmakers, 1988; Salamé & Baddeley, 1982). A classical view of interference-by-content could be formulated to explain the disruption attributable to the semantic properties of sound through the notion that the semantic representations of the TBR items are degraded, or made less accessible, simply as a function of their semantic similarity to the irrelevant items. The logical extension for interference-by-content accounts would be to suppose the existence of a short-term (Haarmann & Usher, 1999) or long-term (Baddeley, 1966) memory store wherein TBR information is held in a semantic, as opposed to phonological, form and is liable to be confused with, or degraded by, irrelevant semantic information that gains access to the same store to the degree that the TBR and irrelevant information is semantically similar.

However, whilst this classical interference-by-content account appears at least plausible in the context of episodic free recall tasks for semantic information (e.g., Beaman, 2004; C. B. Neely & LeCompte, 1999), it is difficult to conceive of how this mechanism of disruption could explain disruption attributable to the semantic properties of sound on more complex tasks such as reading comprehension (R. C. Martin et al., 1988; Oswald et al., 2000) and proof reading (Jones et al., 1990) whereby there appears to be very little degree of semantic similarity between the task-relevant and irrelevant material at the word or sentence level (R. C. Martin et al., 1988).

1.6.2.1 Additional Structural accounts

Other structural accounts have been favoured as explanations for auditory-semantic distraction. For example, in the case of studies concerning cross-modal semantic interference in picture naming, a currently favoured structural view is that of *lexical competition* (e.g., La Heij, Kuipers, & Starreveld, 2006; Levelt, Roelofs, & Meyer, 1999) which is framed within the architecture of a speech production model of the lexical access process. On this account lexical access proceeds from a pre-verbal semantic or

conceptual level to a pre-verbal lexical level of processing via a cascade of activation. The assumption, according to this model, is that both the irrelevant word and the picture have fast access to, and thus activate, conceptual representations and that distractor words have fast access to their lexical representations. Furthermore, at the conceptual or semantic level activation spreads between semantically related concepts and as a consequence all these activated concepts activate their corresponding names at the lexical level.

This structural architecture explains semantic interference with picture naming in the following way: the target picture (e.g., of a “dog”) strongly activates its conceptual representation (“dog”) and a cohort of semantically related representations (“cat”, “rabbit”) which also activate their lexical representations (but see Bloem, van den Boogard, & La Heij, 2004), while the accompanying auditory distractor word (“horse”) strongly activates its lexical representation. According to the *lexical competition* view (e.g., La Heij et al., 2006; Levelt, Roelofs, & Meyer, 1999) retrieval becomes delayed because of the competition at the lexical level between the pictures’ name and the distractor word. That is, when the picture and irrelevant word are semantically related, the lexical representation of the distractor word receives additional activation (e.g., is primed) due to the spread of activation from the pictures’ concept to the distractor words’ concept and from there to the lexical word. Semantic interference—or the increased latency in production of the picture-word name— reflects the time needed to overcome the resulting increase in competition at the lexical level.

More recently, however, it has been proposed that the hypothetical structural architecture of the lexical access process may not be necessary to explain semantic interference in picture-naming (Finkbeiner & Caramazza, 2006; Janssen, Schirm, & Caramazza, 2006; Miozzo & Caramazza, 2003). According to the *response selection* account (e.g., Miozzo & Caramazza, 2003) the articulators are obligatorily, and covertly, engaged by the distractor words (i.e., a covert response to a distractor word is unavoidably formulated) and interference arises at the point of deciding which of two articulatory programs should be excluded in order that a correct response may be produced. The delay in picture-naming produced by the semantic similarity of the distractor word and picture arises because the inadvertent response to the word distractor

has to be rejected or “blocked” before the response to the picture may be produced. Moreover, the effect is expressed because of the inherent limitation of the speech production system: namely that only one response can be produced over the output channel at any given time.

In sum, the structural accounts of auditory-semantic distraction phenomena, although simple in their appeal, do not appear to offer a complete and satisfactory account of some of the subtleties of the findings pertaining to the phenomenon. An alternative approach will now be conceived that attempts to apply the interference-by-process construct (e.g., Jones & Tremblay, 2000) as an explanation of auditory-semantic distraction.

1.7 An interference-by-process account of auditory-semantic distraction?

An alternative to the structural explanations is the possibility that findings of auditory-semantic distraction could, like those in the context of serial recall, be couched in terms of interference-by-process whereby focal task semantic processing is vitiated by the obligatory semantic processing of meaningful irrelevant sound (e.g., Banbury, Macken, Tremblay, & Jones, 2001; Oswald et al., 2000). This suggestion receives support from the central observation that the main feature of the focal tasks that are sensitive to auditory-semantic distraction is that they require semantic processing.

An interference-by-process account of auditory-semantic distraction would clearly avoid some of the problems associated with the resource-based, and interference-by-content approaches. For example, in eschewing the notion of a limited resource or resources for parallel semantic analysis it would hold an advantage over the limited-resource accounts (Hygge et al., 2003; Jones et al., 1990) by avoiding the circularity of this approach described earlier. Furthermore, an interference-by-process approach, as compared with an interference-by-content account, would appear to offer a better explanation of auditory-semantic distraction in the context of reading comprehension (R. C. Martin et al., 1988) and proof-reading (Jones et al., 1990) tasks whereby the similarity between the TBR material and irrelevant material does not appear to influence the degree of disruption. Moreover, the interference-by-process account could add to these strengths through the ‘borrowing’ of recent theoretical constructs used in the field of selective attention and memory retrieval (M. C. Anderson, 2003; M. C. Anderson & Bjork, 1994;

M. C. Anderson & J. H. Neely, 1996; Badre & Wagner, 2000; Wagner, 2002) to explain effects of auditory-semantic distraction that, at first glance, appear to be produced by interference-by-similarity-of-content, such as the between-stream semantic similarity effect in episodic free recall tasks for semantic information (e.g., Beaman, 2004; C. B. Neely & LeCompte, 1999).

More specifically, according to M. C. Anderson and colleagues, retrieval of semantic information from episodic (long-term) memory is likened to an act of selective attention that is internally focused. Here, search of memory begins with retrieval cues (e.g., “Fruit”) that tend to be underspecified preventing unimpeded selection of a ‘target’ response (e.g., “apple”). As a consequence of this underspecification, a number of candidate responses (“pear”, “banana”) become activated and thereby compete for retrieval (hence they are called ‘competitors’). Retrieval of the target response thus requires that the target item be isolated from its competitors. Anderson and colleagues (see e.g., Herrmann et al., 2001) suppose that this is achieved by the executive process of inhibiting the competitors. Inhibiting the competitors, however, has a consequence in that other items, sometimes TBR exemplars, that share the *same* features as the competitors, and *different* features from the target responses, also get inhibited resulting in their retrieval impairment (M. C. Anderson, Green, & McCulloch, 2000; M. C. Anderson & Spellman, 1995).

The logical implication of this account for the context of free recall tasks for semantic information (e.g., Beaman, 2004; C. B. Neely & LeCompte, 1999) is that irrelevant items can be thought of as competitors coming under inhibitory control from executive processes. Thus, rather than the between-stream semantic similarity effect being an effect attributable to interference-by-similarity-of-content, it can be thought of as evidence for interference-by-process in that it is the *active response inhibition process* that results in the inhibition of competitors and some target TBR items, thus decreasing their accessibility and causing forgetting of TBR material (see also Herrmann et al., 2001).

Another area of research that may point further support in the direction of an interference-by-process account of the effects of auditory-semantic distraction is that pertaining to the concept of activation/source-monitoring (M. K. Johnson, Hashtroudi, & Lindsay, 1993; Roediger, Balota, & Watson, 2001). More specifically, participants in

episodic-semantic free recall tasks, produce frequent, non-list items from the same category as TBR exemplars as responses at a greater rate when they are presented auditorily with those items as compared with control trials (e.g., Beaman, 2004). This is consistent with the idea of an error in the *source-monitoring process* whereby subconscious decision making *processes* are fallible in that they sometimes fail to identify the source of an activated memory (e.g., the spatial, temporal context in which the memory was experienced, in this case the modality in which it is perceived; M. K. Johnson et al., 1993; see Beaman, 2004).

In sum, an interference-by-process account would appear to offer a viable explanation of a number of findings reported in the context of auditory-semantic distraction that resource-based models and interference-by-content accounts struggle to explain. However, clearly what is required are more direct assessments of resource-based, interference-by-content, and interference-by-process constructs using irrelevant sounds that convey semantic properties and focal tasks that call upon semantic processing as standard.

1.8 INTERIM SUMMARY

A central observation in the irrelevant sound literature in the context of serial recall is that the interference occurs due to the acoustic, changing-state, properties of irrelevant sound. For the classical ISE the structural “interference-by-content” approach supposes that visually-presented TBR items become confused with, or are masked by, irrelevant items that gain access to a short-term or primary memory store. Thus, according to this account, interference occurs within a discrete limited-capacity module of the cognitive architecture, usually referred to as ‘short-term’, or ‘primary’ memory, to the extent that TBR and irrelevant items share some post-categorical features (Salamé & Baddeley, 1982; Neath, 2000). The attentional capture account posits that the ISE occurs because changes in the sound recruit attention away from the focal task (Cowan, 1995; Elliott & Cowan, 2002). Contra to these accounts, the interference-by-process account supposes that the effect is due to a clash between two similar processes of seriation (Jones, 1993, 1999; Jones et al., 1996; Jones & Tremblay, 2000). That is, the acoustical variation

generates order information as a by-product of preattentively organizing the sound sequence into a coherent auditory stream and this process corrupts the similar process of serializing the TBR items. As has been shown, the weight of evidence with serial recall favours the interference-by-process account.

However, a small body of work has shown auditory-semantic distraction whereby it is primarily the semantic properties of the irrelevant material that produce disruption (e.g., Jones et al., 1990; R. C. Martin et al., 1988). The tasks that are susceptible to auditory-semantic distraction, however, are mostly those that call upon semantic processing, suggesting that the construct of interference-by-process could also work in the setting of semantic focal tasks: here impairment in primary task performance could be conceived of as a conflict between two similar semantic processes. It was suggested, on the basis of the limited amount of research in the area, that the general concept of interference-by-process offered an equally plausible, if not better, account of auditory-semantic distraction than competing limited resources and interference-by-content accounts. However, it was also proposed that the limited empirical database on which this conclusion is formed requires expanding with more direct tests of the competing accounts using semantic focal tasks and irrelevant sounds that demonstrate semantic properties. The issues that are addressed in the following three empirical chapters will now be introduced.

1.9 PROLOGUE TO EMPIRICAL CHAPTERS

The broad aim of the three empirical series of the present thesis was to examine, and evaluate, within the context of semantic focal tasks and meaningful irrelevant speech, whether the construct of interference-by-process could explain auditory-semantic distraction. In doing this, the studies assess the veracity of the competing limited resources, interference-by-content and interference-by-process accounts to auditory-semantic distraction. A general overview of the issues to be addressed in each of the series will now be presented; a more specific discussion of the issues, however, will be found in the “introduction” sections of each individual empirical chapter.

1.9.1 Empirical Series 1 (Chapter 2)

Series 1 sought more direct evidence than heretofore that auditory-semantic distraction could be explained by the same unitary construct of interference-by-process that has been successful in explaining the findings from the serial recall setting. The first series had three aims: The first aim was to provide evidence that auditory-semantic distraction in tests of memory for lists of exemplars drawn from a single semantic category (e.g., “vegetables”) is functionally distinct, or qualitatively different, from that found in the context of serial short-term memory. Clearly, the validity of the interference-by-process account rests upon the notion that it is the semantic, rather than acoustic, properties of sound that chiefly produce the disruption in this setting. The approach adopted to assess whether this is the case was to include sinewave tokens (perceived as non-speech tokens; Tremblay et al., 2000), non-words, and words that were either semantically related, or unrelated, to the TBR exemplars. The general hypothesis was as follows: If, in the semantic free recall setting, the irrelevant items are producing disruption via their semantic properties then those properties, not the acoustic or phonological properties, of irrelevant tokens should determine the disruption to semantic free recall performance.

A second aim was to address whether auditory-semantic distraction in the context of semantic free recall tasks is best explained as a passive or a dynamic process. To elaborate, in this series the passive view of interference, embodied in the classical structural view of interference-by-similarity-of-content, is pitted against the dynamic, interference-by-process view as an explanation of auditory-semantic distraction. The approach adopted for this purpose again included an instructional manipulation to tease apart these two accounts of auditory-semantic distraction. The hypothesis, based on the interference-by-process account, tested in this series, was that a between-sequence semantic similarity effect will be found only when the task requires free, but not serial, recall. The alternative, competing hypothesis based upon the passive, interference-by-similarity-of-content view was that a between-sequence semantic similarity will occur regardless of task-processes. Moreover, this series also assessed the applicability to the auditory-semantic distraction findings of constructs such as inhibitory and activation

processes that have recently evolved in the context of selectivity in memory retrieval (e.g., M. C. Anderson, 2003).

A third aim of this series was to investigate the potential role that the activation/source-monitoring process (e.g., M. K. Johnson et al., 1993; Roediger, Balota, & Watson, 2001) plays in the apparition of a between-sequence semantic similarity effect. To test this, experimental manipulations were deployed that are traditionally thought to affect source-monitoring processes either in a facilitatory or inhibitory manner. The general hypothesis addressed in relation to this issue was that if errors of the source-monitoring process could explain the between-sequence semantic similarity effect of intrusion of semantically-related, non-list presented irrelevant words under conditions of between-sequence semantic similarity, the extent of intrusion would show patterns of results representative of the ease or difficulty of the source-monitoring process. Finally as a further tool in the endeavour to test this hypothesis, a confidence-rating task (S. M. Smith, Ward, Tindell, Sifonis, & Wilkenfield, 2000) was used to assess the degree of which participants made errors regarding the source of the items they recalled.

1.9.2 Empirical Series 2 (Chapter 3)

Series 2 sought further support for the validity of the interference-by-process construct as an explanation for auditory-semantic distraction by using a category-clustering paradigm that is generally accepted to induce semantic processing strategies (e.g., Bousfield, 1953). In this paradigm the task-relevant material consisted of lists comprising a number of exemplars (e.g., “lemon”, “wrench”) drawn from several different semantic categories (e.g., “fruit”, “tools”). The semantic component of the task is readily assessed by the phenomenon of category-clustering (and also the number of categories recalled) whereby exemplars are clustered together by semantic-category during recall (e.g., Bousfield, 1953; Burns & C. A. Brown, 2000). A primary hypothesis within this setting was that, if the semantic interference-by-process construct is true, the meaningfulness of the irrelevant sound may impair the clustering of category-exemplars (and the number of categories recalled) at output.

Moreover, another hypothesis, derived from the interference-by-process account, was that breakdown in attentional selectivity, and hence impairment of focal task

performance, may occur only when the task-relevant material and the irrelevant material meet the same processing criteria. This hypothesis was tested via manipulating retrieval instruction such that the task depended on either processing the episodic, serial order properties (via serial recall instruction), or semantic properties (via recall by category instructions), of the TBR list. More specifically the hypothesis was that semantic interference (effects of meaningfulness or between-sequence semantic similarity) may be demonstrated only when the TBR exemplars are retrieved by category—and thus with regard to the semantic properties of the list—but not with regard to their original serial order of presentation. In addition, this series lends itself to evaluating the interference-by-content and resource-based accounts of auditory distraction neither of which could explain how performance on given focal tasks could be so acutely sensitive to the nature of the dominant mental activity and the characteristics of the task-irrelevant sound.

1.9.3 Empirical Series 3 (Chapter 4)

The broad aim of the third and final series was to investigate the interference-by-process proposition more definitively by using a semantic focal task that taps semantic memory, and therefore processing, more directly. More specifically, one drawback of the tasks used in Series 1 and 2 (see also Beaman, 2004; C. B. Neely & LeCompte, 1999) are that they are episodic memory tasks for semantic information and could therefore be performed by strategies, such as seriation, that do not tap semantic processing. In this series the problem of this potential contamination by episodic strategies was avoided by using a semantic-category fluency task (e.g., Watkins & Allender, 1987; Bousfield & Sedgewick, 1944) that requires participants to generate category-exemplars, not from lists as in episodic memory tasks, but from general knowledge given a category cue (e.g., “Fruit”). This task again contrasted the interference-by-content, with the interference-by-process, account. The rationale here was that the classical interference-by-content account that requires the notion of storage in a short- or long-term memory module would not necessarily predict that the semantic-category fluency task would show any form of ISE. The main reasoning behind this is that semantic-category fluency task does not necessarily require the storage of traces in a memory module (however, it will be discussed in this series that participants must remember responses they have already

produced which, according to the structural approach, could imply storage of some kind). Alternatively, the interference-by-process account readily predicts a semantic ISE for the semantic-category fluency task because the focal task requires semantic retrieval processes.

The general hypothesis addressed in Series 3 then, was that semantic-category fluency should be impaired in the presence of meaningful, but not meaningless, irrelevant sound and that between-stream semantic similarity may also produce disruption. In the case of a between-stream semantic similarity effect, however, the hypothesis is that the effect is not produced by interference-by-similarity-of-content in terms of traces of items, but instead reflects interference-by-process whereby irrelevant items are inhibited causing inhibition and retrieval impairment of semantically similar items that are to-be-generated. An additional hypothesis also derived from the interference-by-process accounts was that auditory-semantic distraction will be observed only on the semantic-category fluency task that requires retrieval by semantic-category association, but not on a task that makes otherwise similar demands, but requires retrieval driven by phonemic cues, the phonemic-category fluency task.

Chapter 2

EMPIRICAL SERIES 1:

INVESTIGATING THE ROLE OF INHIBITORY AND SOURCE MONITORING PROCESSES IN AUDITORY-SEMANTIC DISTRACTION

2.1 ABSTRACT

Five experiments demonstrate auditory-semantic distraction in tests of memory for semantic category-exemplars. The effects of irrelevant sound on category-exemplar recall are shown to be functionally distinct from those found in the context of serial short-term memory by showing sensitivity to: the lexical-semantic, rather than acoustic, properties of sound (Experiments 1a & 1b) and between-sequence semantic similarity (Experiments 1-5) but only under conditions in which the task is free, not serial, recall (Experiment 3) and when the irrelevant sound items are dominant members of a semantic category (Experiment 4). The experiments also reveal evidence of a breakdown of, or errors in, the source-monitoring process under conditions of between-sequence similarity (Experiments 2-5). Results are discussed in terms of activation and inhibition accounts and support a dynamic, process-oriented, rather than a structurally-based, passive account of forgetting.

2.2 INTRODUCTION

One of the most influential constructs in memory research is *interference*: Forgetting, or a difficulty in remembering, a given stimulus or event (a ‘target’) is, at least in part, the result of encountering—either previously, simultaneously, or subsequently—other stimuli or events (‘competitors’) that are similar in some way to the target (see, e.g., Baddeley, 1986; M. C. Anderson, 2003; M. C. Anderson & J. H. Neely, 1996; McGeoch, 1942; Nairne, 1990, 2002; Neath, 2000). The classical view has been that such interference-by-similarity directly causes forgetting; that is, forgetting is a passive side-effect of structural changes that result from the storing of new, similar, experiences in memory (J. R. Anderson, 1983; McGeoch, 1942; Mensink & Raaijmakers, 1988; Salamé & Baddeley, 1982). However, an alternative, more functional, view that is gaining currency is that forgetting reflects the legacy of dynamic and adaptive selective attention processes—such as inhibition—(e.g., Houghton & Tipper, 1994) that are designed to *resolve* interference during the act of retrieval (M. C. Anderson, 2003; M. C. Anderson & Bjork, 1994).

This dynamic view of the interference-forgetting relationship (e.g., M. C. Anderson, 2003)—in its appeal to functional selective attention processes to account for memory phenomena—resonates with a perspective on memory and interference developed on the basis of a hitherto quite distinct line of research, namely, that concerned with the disruptive effects of to-be-ignored sound on visual-verbal short-term serial memory (e.g., Colle & Welsh, 1976; Jones et al., 1992; LeCompte, 1994; Macken et al., 1999; Salamé & Baddeley, 1982). The weight of evidence suggests that this classical ISE results from a dynamic interference-by-process and is not a passive side-effect of having similar items to remember and to ignore (Jones & Tremblay, 2000). However, interest in the present chapter centers on the possibility that when, unlike in serial recall, the focal memory task encourages semantic retrieval strategies, disruption from irrelevant sound is amenable to a classical, and simpler, ‘interference-by-content’ explanation (Beaman, 2004; C. B. Neely & LeCompte, 1999). The goals of the present series were to place on a more secure footing the possibly unique empirical signature of auditory distraction in the context of episodic short-term memory tasks that tap semantic memory structures and processes, and to examine how these effects might be reconciled with a dynamic process-oriented

approach to interference. As theoretical tools to guide in this endeavour, several well-established constructs from research on retrieval from long-term episodic and semantic memory are drawn upon (e.g., spreading activation and retrieval blocking: J. R. Anderson, 1983; false memory formation: Roediger et al., 2001; inhibition: M. C. Anderson, 2003) and meshed for the first time with current understanding of the ISE in serial recall (e.g., Hughes & Jones, 2005; Jones & Tremblay, 2000).

2.2.1 Irrelevant sound effect

A microcosm of the debate between structuralist and dynamic process-based views of memory and forgetting can be seen in the by-now relatively large literature on how the presence of irrelevant, to-be-ignored, sound markedly increases forgetting in a (usually visually-presented) serial recall task (e.g., Colle & Welsh, 1976; Ellermeier & Zimmer, 1997; Hughes & Jones, 2005; Jones & Macken, 1993; Salamé & Baddeley, 1982). The classical viewpoint, that forgetting can occur as a direct and passive consequence of the structural similarity between TBR and irrelevant episodes or stimuli (e.g., McGeoch, 1942), is clearly evident in several theoretical accounts of the ISE (Neath, 2000; Salamé & Baddeley, 1982). For example, one account based on the Working Memory model (Baddeley, 1986), posits that “phonological representations of memory items are liable to a partial loss from decay or interference from other phonological material” (Gathercole & Baddeley, 1993, p. 11), and the ISE is mediated by “the degree of phonological similarity between the irrelevant material and the memory items” (Gathercole & Baddeley, 1993, p. 13; Salamé & Baddeley, 1982). More recently, an account based on the Feature model of immediate memory (Nairne, 1990) supposes that the disruption is due, in part, to feature adoption: modality-independent features of the irrelevant items are automatically incorporated into, and hence corrupt, traces of TBR items (Neath, 2000). However, several strands of evidence converge to undermine the ‘interference-by-content’ approach to the ISE (see Jones & Tremblay, 2000). For example, non-speech sounds such as tones—which bear little or no resemblance to the TBR items—produce disruption that is qualitatively isomorphic with that from irrelevant speech (e.g., Jones & Macken, 1993; Tremblay & Jones, 1998; Tremblay et al., 2001).

A radically different account of the ISE denies that the content of the individual items comprising the relevant and irrelevant sequences is of any import and that the phenomenon is better captured by the maxim ‘interference-by-process’ rather than ‘interference-by-content’ (Jones & Tremblay, 2000). On the interference-by-process account, the key determinant of the disruption is the extent to which both the irrelevant sound and the focal memory task involve an ordering (or seriation) process (Jones, 1993; Jones et al., 1996). A key observation underpinning this account is the changing-state effect (Campbell, Beaman, & Berry, 2002; Hughes et al., 2005; Jones et al., 1992; Jones & Macken, 1993; LeCompte, 1995; Tremblay & Jones, 1998) whereby a sound sequence—regardless of whether it comprises speech or non-speech—that exhibits abrupt changes in acoustic properties (e.g., “*k v h q...*”, or a sequence of tones changing in frequency) is invariably more disruptive than a continuous or repeating stimulus (e.g., “*k k k...*”, or a repeated tone). It is assumed that the preattentive perception of acoustic changes between segmentable elements in the sound yields cues as to the order of those elements as a by-product of primitive, acoustic-based, perceptual organization processes (cf. Bregman, 1990; Macken et al., 2003). These irrelevant order cues conflict with the similar, but this time deliberate, seriation (or serial rehearsal) of the TBR items (Jones et al., 1996). In support of this view, the ability to passively encode the order of stimuli in an *attended* auditory sequence predicts the degree to which that sequence is disruptive when presented as irrelevant sound (Macken et al., 2006). Moreover, short-term memory tasks that do not involve or encourage the use of a serial rehearsal strategy are relatively invulnerable to disruption by changing-state sound (for a discussion, see Beaman & Jones, 1997).

In sum, results based on research using the serial recall paradigm favour a dynamic process-based, view of interference from irrelevant sound whilst approaches based on the classical view that interference occurs as a passive side-effect of structural similarity at the item-level between relevant and irrelevant material have been found wanting (Jones & Tremblay, 2000). A small body of research will be addressed now that has examined the effects of irrelevant speech on tasks that require or encourage semantic-based retrieval strategies or processes and that raise some doubts as to the generalisability of the interference-by-process approach (Jones & Tremblay, 2000): At first glance at least, for

these studies, the maxim ‘interference-by-content’ seems altogether more appropriate than ‘interference-by-process’.

2.2.2 Auditory-semantic distraction: Interference by content?

The mere presence of semantic content within the irrelevant sound has no influence on the degree to which it disrupts serial recall (Jones et al., 1990; but see Buchner et al., 2004). Moreover, a similarity between the semantic content of the individual items in the speech and in the TBR list also has very little, if any, effect (e.g., Buchner et al., 1996; LeCompte et al., 1997). Of course, these observations are entirely consistent with the interference-by-process view that the ISE is driven by the acoustic, rather than the post-categorical or modality-independent attributes of the sound. However, the absence of disruptive effects related to the semanticity of the sound in this paradigm may be a consequence of the fact that, typically, the TBR information is a relatively short list of semantically homogenous and relatively semantically-impooverished verbal items such as digits or letters (e.g., Beaman & Jones, 1997; Buchner et al., 1996; Hughes & Jones, 2003a, 2005; LeCompte & Shaibe, 1997; Salamé & Baddeley, 1982). Indeed, although there remains a great deal of debate as to the processes involved in the serial recall of such lists, there is a general consensus that semantic-based strategies or coding are not usually involved (e.g., Baddeley, 2002; Cowan, 1995; Jones et al., 2004; Jones et al., 2006a; Nairne, 1990, 2000). Thus, performance may be insensitive to the semanticity of irrelevant sound because the setting is not one that encourages or is amenable to the deployment of semantically-based encoding or retrieval strategies.

Indeed, there is a small number of studies that have found that the lexical-semantic character of the sound plays an important role in tasks that demand or at least promote the use of semantically-based processes (Beaman, 2004; Jones et al., 1990; R. C. Martin et al., 1988; C. B. Neely & LeCompte, 1999; Oswald et al., 2000). For example, in a *category-exemplar recall* task, in which a list of, say, 16 semantically-rich items (nouns) taken from a single semantic category are presented for free recall, between-sequence semantic similarity impairs performance (Beaman, 2004; C. B. Neely & LeCompte, 1999): The free recall of relatively low-dominance category-exemplars (e.g., “avocado”) is disrupted (as reflected in exemplar omissions) more by related, high-dominance,

irrelevant category-items (that are not included in the TBR list; e.g., “apple”) than by high-dominance, categorically-unrelated, irrelevant items (e.g., “hammer”). The presence of related, high-dominance, irrelevant category-items also results in a greater probability of those items being included in participants’ responses (i.e., intrusions) compared with a quiet condition or an ‘unrelated’ condition. Such results seem to be easily accommodated within an interference-by-content approach: The disruption in this case could be explained by the notion that the semantic representations of the TBR items are degraded or made less accessible as a function of their semantic similarity to the irrelevant items.

The purpose of the experiments that follow is to examine how general these semantic distraction effects might be—particularly in light of the limited amount of previous research on the issue—and to see how they might be reconciled with the dynamic, process-oriented, view developed for the more standard serial recall setting. Certainly, it seems reasonable to suggest that category-exemplar recall is likely to engage cognitive processes that are quite distinct from those of serial recall. Because the items for each given list are taken from a single semantic category and can be recalled in any order, performance is likely to be guided by a complex interplay of several semantic memory-driven processes including the deliberate generation of possible list-exemplars based on recognition of the category and automatic spreading activation in long-term semantic networks (J. R. Anderson & Bower, 1972; Bahrick, 1970; Gronlund & Shiffrin, 1986; Nairne, Riegler, & Serra, 1991; Wingfield et al., 1998). Indeed, the relatively fast rates of presentation used in the two previous studies using category-exemplar recall (Beaman, 2004; C. B. Neely & LeCompte, 1999)—two exemplars per second—could also be expected to promote a reliance on semantic activation as a primary encoding process (Anastasi, Rhodes, Marquez, & Velino, 2005; McDermott & Watson, 2001) or the use of ‘gist’ (meaning-based) rather than ‘verbatim’ (perceptual detail-based) traces of the exemplars (Anastasi et al., 2005; Brainerd, Wight, Reyna, & Payne, 2002; Gerken & S. M. Smith, 2004; Hicks & R. L. Marsh, 2001; Reyna & Brainerd, 1995).

Assuming, then, quite distinct processing in the category-exemplar recall task as compared with that in serial recall, what explanatory constructs might aid one in beginning to characterize ISEs in this setting as either a classical form of interference-by-similarity-of-content or, alternatively, a dynamic process-driven form of interference? As

a working framework, both the classical, structuralist-based, activation/blocking accounts (e.g., J. R. Anderson, 1983) and more contemporary, functionalist, inhibitory accounts (M. C. Anderson, 2003; M. C. Anderson & J. H. Neely, 1996; M. C. Anderson & Spellman, 1995) of retrieval from long-term episodic and semantic memory are drawn upon. For example, drawing upon activation/blocking accounts, it is possible that obligatory semantic activation of categorically-related irrelevant sound items acts to block access to TBR list category-exemplars thereby impairing their retrieval, just as occurs when the act of deliberately retrieving a target exemplar can block access to other target exemplars (J. R. Anderson, 1983; Rundus, 1973). Moreover, according to the resource-diffusion, activation/blocking approach (J. R. Anderson, 1983; Rundus, 1973; see M. C. Anderson & Bjork, 1994), high-dominance items produce greater retrieval interference because they are more likely than low(er)-dominance exemplars to receive resource-limited semantic activation due to their stronger pre-experimental association with the category. Thus, in the category-exemplar recall setting (Beaman, 2004; C. B. Neely & LeCompte, 1999), high-dominance irrelevant items may receive more of the total activation than low(er)-dominance target exemplars thereby robbing them of the activation required for retrieval.

According to inhibitory accounts, retrieval difficulty is not a passive side effect of patterns of activation but, rather, results from a dynamic process of inhibiting irrelevant category-items. On this approach, retrieval involving semantic memory can be thought of as a conceptually-, and internally-focused, selective attention process in which inhibition acts to prevent the retrieval process from being compelled away from target exemplars by stronger but response-irrelevant non-targets (M. C. Anderson & J. H. Neely, 1996; M. C. Anderson & Spellman, 1995). Hence, retrieval of target category-exemplars (e.g., “lance”, “dagger”) often begins with use of a relatively underspecified cue such as the category-name (e.g., “Weapons”) which serves to activate a number of non-target exemplars that are strongly related to that cue (e.g., “gun”, “sword”) via spreading activation. These high-dominance activated non-targets compete with lower-dominance relevant exemplars for retrieval thereby presenting a selection problem. Activated non-targets therefore come under inhibitory control to allow weaker exemplars to be retrieved. According to this approach, events or episodes are difficult to retrieve or

forgotten to the extent that they were previously non-target and hence to-be-inhibited events. Another factor that might be found to be at play in the category-exemplar recall/irrelevant sound setting is spreading inhibition whereby, like activation, inhibition of non-target category-items can spread, perhaps via associative links, to nodes representing target items (e.g., A. S. Brown, 1979; E. Neumann & DeSchepper, 1992; Hutchinson, 2002; Tipper & Driver, 1988; Walley & Weiden, 1973).

The present series of experiments begins by addressing whether the susceptibility of category-exemplar recall to disruption from irrelevant sound is qualitatively distinct from that of serial recall. Two views on this issue can be identified in the extant literature. One view is that there is no distinction at all between ISEs in the two settings: C. B. Neely and LeCompte (1999) took their observation of a between-sequence semantic similarity effect in the category-exemplar task as being indicative of an important role for the semanticity of the sound in the ISE *generally*. This view is highly questionable because, as noted earlier, the nature of the processes involved in recalling information in the two settings is likely to be quite different. A second, more plausible view, is that the effect of meaning of irrelevant sound in the category-exemplar recall task “is *additional* to the ‘standard’ effect of irrelevant speech” (Beaman, 2005, p. 1050; emphasis added). However, strictly speaking this view is also not warranted by the available evidence. The notion that there is a ‘standard’, acoustic-based ISE at play as well as an additional semantic effect is based on the finding that categorically-unrelated as well as categorically-related irrelevant items were found to disrupt category-exemplar recall compared to quiet (Beaman, 2004; C. B. Neely & LeCompte, 1999). However, the effect of categorically-unrelated irrelevant exemplars could, in this context, be attributable not to their acoustic character but instead to their lexical status and therefore—given that lexicality has no influence on the standard ISE (e.g., Buchner et al., 1996)—represent another distinct feature of auditory distraction in semantically-driven retrieval tasks. Experiment 1a, therefore, was designed to test whether or not the action of irrelevant sound in the context of semantically-driven episodic tasks is *entirely* distinct from that in the standard serial recall setting. In order to begin developing a theoretical framework for understanding semantic ISEs, the pattern of retrievals are scrutinized for any evidence that irrelevant sound in this setting modulates semantic activation and inhibitory processes.

2.3 EXPERIMENT 1A

Experiment 1a contrasted the effects on category-exemplar recall of presenting, during a retention interval, a sequence of irrelevant non-lexical auditory items—non-words and sinewave speech tokens—with that of presenting either a sequence of categorically-related, or a sequence of categorically-unrelated, word items. Inclusion of the non-word condition is necessary to determine whether the disruptive effect of unrelated category-items is an acoustic effect akin to that found in the serial recall setting or, alternatively, represents a lexicality effect which, like the effect of between-sequence similarity, would bolster the view that the action of irrelevant sound in this setting bears a unique empirical signature. The contrast between sinewave speech tokens and the non-words should also shed light on whether category-exemplar recall is susceptible to acoustic effects. Sinewave speech is a spectrally-reduced synthetic analogue of natural speech that comprises three (sometimes four) time-varying sinusoids that are added together. Sinewave speech discards all of the acoustic attributes of natural speech apart from the changing pattern of vocal resonances (formants). Unless participants are made aware the sound is speech it is often perceived as a series of computer bleeps, whistling, or radio interference (when participants are aware the sound is speech, however, comprehension of the stimulus is usually good; Remez et al., 1981). Sinewave speech, as an acoustically less-complex signal compared with natural speech (i.e., containing less changing-state information), produces less disruption to serial recall performance but nevertheless still produces pronounced impairment (Tremblay et al., 2000). If category-exemplar recall is liable to acoustic ISEs, then sinewave tokens should be disruptive, although possibly to a lesser extent than non-words.

2.3.1 Method

2.3.1.1 Participants

Seventy-two participants from Cardiff University took part in a mixed-factor design in exchange for course credit. All participants reported normal or corrected-to-normal vision and normal hearing and were native English speakers. The participants were randomly divided into three 24-participant groups: Non-word, Word, and Sinewave.

2.3.1.2 Apparatus and Materials

To-be-remembered material. These consisted of 30 lists, each of which comprised 16 exemplars from 30 taxonomic categories (e.g., “Vehicle”) chosen from the Battig and Montague (1969) norms. The items were the 9th to the 24th most frequently produced single-word responses to the category-name.

Irrelevant sound. The irrelevant material consisted of 30 lists each containing 8 exemplars (presented twice) from the same 30 categories chosen for the TBR lists. These were the 1st to the 8th most frequently produced, or highest output-dominance, response to the same thirty category names chosen for the TBR lists.

The order of presentation of the exemplars within each TBR, and irrelevant, list was random but this order was the same for each participant. Irrelevant items for the non-word group were modified version of the irrelevant item words: For any monosyllabic word, one vowel was changed (e.g., “gun” became “gan”) and for di- and poly-syllabic words, two and three vowels were changed, respectively (e.g., “pistol” becomes “pustal”, and “catapult” becomes “cutopalt”; cf. Calvo & Castillo, 1995). When it was not possible to change a vowel, a consonant was altered instead (cf. R. C. Martin et al., 1988, Experiment 5). Two random orders of the 8 items in each irrelevant sound sequence were generated and concatenated yielding a 16-item sequence, with a constraint that the 8th and 9th item in the sequence was not the same item.

For the irrelevant words and non-words, each item was digitally recorded in an even-pitched male voice and sampled with a 16-bit resolution, at a sampling rate of 44.1KHz using *Sound Forge 5* software (Sonic Inc., Madison, WI; 2000). Using the same software, each item was then digitally edited to 500 ms. For the Sinewave group, the word versions of the irrelevant exemplars were converted to sinewave versions using the program *Praat* (Boersma, 2001). This program produces sinewave speech by creating three frequency- and amplitude-modulated pure tones that correspond to (or copy) approximately the first three vocal tract resonance changes (i.e., formants) in the natural speech signal. This process of creating sinewave speech thus strips natural speech signal of: broadband formants; a regularly pulsed source; and the short-term acoustic products of vocalization (e.g., fine-grained formant structure). However, the sinusoidal signals do preserve the dynamic properties (e.g., supra-segmental features) of vocalization and speech utterances.

The irrelevant items were presented at approximately 65-70 dB(A) via stereo headphones that participants wore throughout the experiment. The 16 irrelevant items were presented without an inter-stimulus interval and thus each irrelevant sequence lasted 8 s. The order of items for each irrelevant sequence was the same regardless of whether they were words or whether they were non-word or sinewave versions of those words.

The visual TBR category-exemplars were presented centrally on a *Samsung Syncmaster 171S* PC screen running *SuperLab Pro* software. Each category-exemplar appeared in black 72-point *Times New Roman* font on a white background one immediately after another at a rate of two per second, thus each TBR list lasted 8 s.

2.3.1.3 Design

A mixed design was used with one between-participants factor and one within-participant factor. The between-participants factor was Sound Type and had three levels: word, non-word, and sinewave. The within-participants factor was Sound Condition of which there were three levels: (1) items categorically-unrelated to the TBR exemplars; (2) items categorically-related to the TBR exemplars; and (3) a quiet control condition. For all groups, the 30 TBR lists and 30 irrelevant sound sequences were divided into two 15-list sets. Based on the toss of a coin, half the participants in each group was assigned to one 15-list set and the other half was assigned to the other 15-list set. Each 15-list set was further subdivided into five blocks of three lists. Within each 3-list block, the TBR lists were assigned randomly to one of the 3 irrelevant sound conditions. The order of the three sound conditions within each 3-trial block was counterbalanced across participants such that an equal number of participants were assigned to each of the 6 possible order-permutations.

When a TBR list was assigned to the related irrelevant sound condition, the sound sequence corresponding to the category represented by that list was presented. When a TBR list was assigned to the unrelated irrelevant sound condition, the sound sequence was randomly chosen from the 15 categories not represented by the TBR list. When a TBR list was assigned to the quiet condition, no sound was presented.

2.3.1.4 Procedure

Participants were tested in groups of six with each participant seated in a separate screened-off cubicle with its own computer and display. Participants were seated at a

viewing distance of approximately 60 cm from the PC monitor upon which the category-exemplars were presented. Following the last TBR item of each list, there was an 8 s retention interval in which the word ‘WAIT’ appeared on the screen. For trials assigned to irrelevant sound conditions, an irrelevant sequence was presented during this retention interval. At the end of the retention interval, the word ‘WAIT’ was replaced by ‘RECALL’ and was presented throughout a 32 s retrieval period. Participants were instructed to focus on the visually-presented items and, once the prompt ‘RECALL’ appeared, to write down as many of the items from the TBR set as they could on recall sheets provided. They were also told to ignore any sounds they heard and that they would not be tested on its content at any point in the experiment. None of the groups were explicitly told that they would be ignoring speech.

Participants were informed that they would have 32 s to retrieve the items but that after 30 s a tone would sound to signal that the onset of the first item of the next list would appear in 2 s. The experiment lasted approximately 16 min.

2.3.2 Results

2.3.2.1 Correctly recalled exemplars

The raw recall data were scored according to a free recall criterion; an item was scored as correct regardless of whether its position in the recall protocol matched its position in the presented list. Figure 2.1 shows the overall probability of recall collapsed across serial position as a function of each sound condition and sound-version group. The most noteworthy aspect of the results based on inspection of Figure 2.1 is that, as well as replicating the between-sequence semantic similarity effect (Beaman, 2004; C. B. Neely & LeCompte, 1999), they establish the presence of an irrelevant sound lexicality effect in category-exemplar recall. For the word group, related irrelevant category-items disrupted recall compared to unrelated category-exemplars (i.e., a between-sequence semantic similarity effect). Also consistent with Beaman (2004) and C. B. Neely and LeCompte (1999) is the finding that, for this group, unrelated category-items produced disruption compared to quiet. However, critically, inclusion of the non-word group has allowed the discounting of the notion that this effect of unrelated irrelevant items compared to quiet reflects a standard, acoustic-based, ISE (cf. Beaman, 2004): Unrelated irrelevant non-

words—which can be assumed to be acoustically comparable to the unrelated irrelevant words—did not produce any impairment compared to quiet. An unexpected but somewhat intriguing result, however, is that non-words derived from related irrelevant category-items do indeed appear to impair recall compared to quiet. Two further observations based on the sinewave group buttresses the notion that, in stark contrast to the case with serial recall, irrelevant sound does not exert any acoustic-based disruption in the present setting: The sinewave group performed as well under irrelevant sound conditions (regardless of relatedness) as they—and the other groups—performed in quiet, and the acoustically more complex unrelated irrelevant non-words produced no more disruption than sinewave speech items.

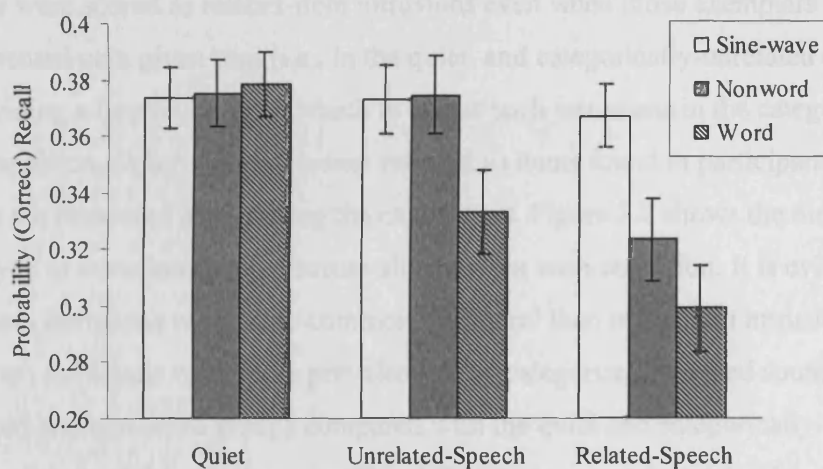


Figure 2.1 Mean probability of correct recall in the irrelevant sound conditions of Experiment 1a. Error bars depict the standard error of the means.

The reliability of the pattern of effects just described was confirmed by a 3 (Sound Type) \times 3 (Sound Condition) ANOVA on the overall probability of correct recall. There was no main effect of Sound Type ($p > .05$) but, critically, there was a main effect of Sound Condition, $F(2, 138) = 27.96$, $MSE = .001$, $p < .0001$, and a reliable Sound Type \times Sound Condition interaction, $F(2, 4) = 7.18$, $MSE = .001$, $p < .0001$. A simple effects analysis (LSD) revealed no sound effects for the sinewave group. However, for the word group, there were significant differences between quiet and the categorically-unrelated

condition ($p < .001$) and between the categorically-related- and categorically-unrelated conditions ($p < .005$). For the non-word group, however, whilst the categorically-related condition differed reliably from the other two sound conditions (both contrasts: $p < .001$), there was no reliable difference between quiet and the unrelated condition ($p > .05$). We turn now to analyze whether, and to what extent, participants' recall protocols were characterized by semantic intrusions, particularly semantic intrusions from the irrelevant sound in the category-related conditions.

2.3.2.2 Intrusion Data

An analysis was conducted on two types of intrusions in each sound condition for each sound type group. A *related-item intrusion* was a response that matched one of the 8 high-dominance items presented in the categorically-related sound condition. Such responses were scored as related-item intrusions even when those exemplars had not been presented on a given trial (i.e., in the quiet, and categorically-unrelated conditions) thus providing a baseline against which to assess such intrusions in the categorically-related condition. *Other-item intrusions* referred to items found in participants' output that were not presented at all during the experiment. Figure 2.2 shows the mean number of each type of intrusion (pooled across all trials) for each condition. It is evident that related-item intrusions were more common in general than other-item intrusions, and related-item intrusions were more prevalent in the categorically-related sound conditions of the word and non-word groups compared with the quiet and categorically-unrelated sound conditions of the same groups. This difference was not found for the sinewave group.

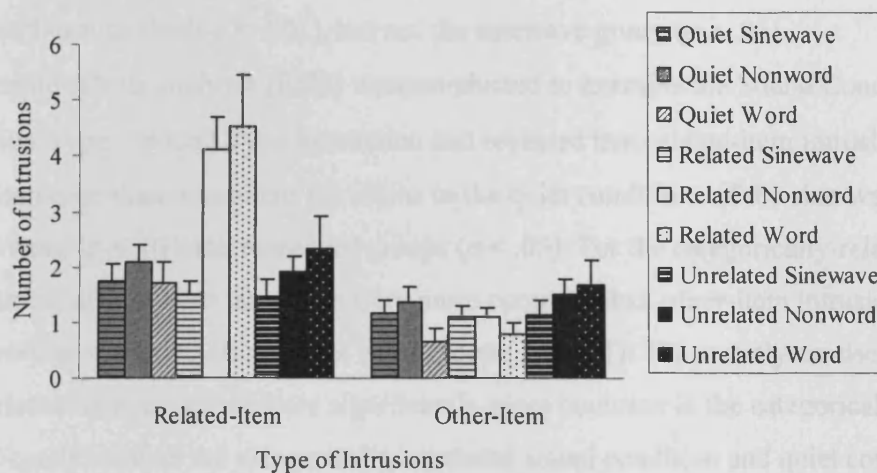


Figure 2.2 Mean number of related-exemplar and other-exemplar intrusions recalled in the irrelevant sound conditions of Experiment 1a. Error bars indicate the standard error of the means.

A 3 (Sound Condition) \times 2 (Intrusion Type) \times 3 (Sound Type) ANOVA confirmed a main effect of Sound Condition on the number of intrusions, $F(2, 138) = 10.19$, $MSE = 1.99$, $p < .001$, but no main effect of Sound Type ($F = 1.9$, $p > .05$). There was, however, a main effect of Intrusion Type, $F(1, 69) = 48.86$, $MSE = 3.28$, $p < .001$ and a Sound Condition \times Intrusion Type interaction, $F(2, 138) = 16.74$, $MSE = 2.32$, $p < .001$. Additionally, there were interactions between Sound Condition and Sound Type, $F(4, 138) = 4.77$, $MSE = 1.99$, $p < .001$; Intrusion Type and Sound Type, $F(2, 69) = 5.43$, $MSE = 3.28$, $p < .01$; and a three-way interaction between Sound Condition, Intrusion Type and Sound Type, $F(4, 138) = 4.37$, $MSE = 2.32$, $p < .005$.

The Sound Condition \times Intrusion Type interaction was decomposed using a simple effect analysis (LSD). This revealed that related-item intrusions tended to be more common than other-item intrusions regardless of Sound Condition (all $p < .05$) when data were collapsed across Sound Type. It was also found that related-item intrusions were more common in the categorically-related sound conditions compared with the categorically-unrelated sound conditions, and quiet conditions ($p < .001$). Further analysis of the significant Intrusion Type \times Sound Type interaction revealed that related-

item intrusions were, overall, more common than other-item intrusions in the non-word and word groups (both $p < .001$), but not the sinewave group ($p > .05$).

Simple effects analyses (LSD) were conducted to examine the Sound Condition \times Intrusion Type \times Sound Type interaction and revealed that related-item intrusions were more common than other-item intrusions in the quiet conditions of the sine-wave ($p = .106$), word ($p < .01$) and non-word groups ($p < .05$). For the categorically-related sound conditions, related-item intrusions were more common than other-item intrusions for the non-word group ($p < .001$) and the word group ($p < .001$). These analyses also revealed that related-item intrusions were significantly more common in the categorically-related sound condition than the categorically-unrelated sound condition and quiet condition (both $p < .001$) for the non-word group. This pattern was identical for the word group: related-item intrusions were more common in the categorically-related sound condition than the categorically-unrelated sound condition and the quiet condition (both $p < .001$).

In sum, the results of the intrusion analyses demonstrate that the presentation of categorically-related irrelevant items as words not only leads to greater omission of correct list-exemplars but also increases false recall of high-dominance items presented as irrelevant material, a finding consistent with previous results (Beaman, 2004; C. B. Neely & LeCompte, 1999). The analyses also showed that there is an increase in false recall when participants are presented with non-word but not sinewave versions of the categorically-related irrelevant items suggesting that non-word versions of categorically-related irrelevant sounds exert a functionally similar effect to the word versions.

2.3.2.3 Seriation Analysis

It was suggested in the Introduction of this chapter that the category-exemplar recall task may rely on distinct, semantic-based, recall processes and strategies whereas the serial recall setting is dominated by serial rehearsal and that this difference may be important in seeking to understand the possibly unique action of irrelevant sound in the two settings. To obtain, albeit indirectly, data regarding participants' use of serial rehearsal in the category-exemplar recall task we performed a pair-ordering analysis (see Beaman & Jones, 1998; Nairne et al., 1991) on participants' free recall protocols in the three Sound Type conditions. The pair-ordering measure yields an indication of the relative preservation of order of items in the TBR lists. For this analysis, adjacent items

in the recall protocol are considered as pairs. The number of pairs comprising adjacent items in correct serial order relative to one another are summed and divided by the number of pairs recalled in total. The analysis yields a score between 0 and 1, where a proportion score of .5 indicates that no serial order information was retained (for further details, see Beaman & Jones, 1998). There were no main effects or any interactions on this measure. Collapsed across Sound Type, the mean scores were .51 ($SD = .12$) in the quiet condition, .47 ($SD = .12$) in the categorically-unrelated sound condition and .49 ($SD = .14$) in the categorically-related sound condition.

The seriation analysis demonstrates that exemplar loss (or omission error) in category-exemplar recall was not associated with a loss of order information, because there was no evidence for any retention of serial order. This finding contrasts with previous studies of free recall of lists of semantically-unrelated words where item loss appears to be associated with the loss of order information, and in which disruption of the task by irrelevant sound is due to an increased loss of such information (Beaman & Jones, 1998; see also Chapter 3). Thus, in that setting, but not the current one, the impact of sound seems to take the same form as the standard ISE in serial recall.

2.4 EXPERIMENT 1B

Before turning to consider the implications of the results reported thus far, a follow-up experiment will be described which had two goals. The first goal was to determine whether category-exemplar recall is also disrupted if irrelevant sound is presented during rather than before the point at which participants are asked to start retrieving the list-exemplars. If so, it would provide yet further evidence that the action of irrelevant sound in this setting bears a unique empirical signature. This is because in the standard serial recall setting, irrelevant sound presented during the recall period exerts no effect (Miles et al., 1991). The second goal was to examine, given their novelty, whether both the irrelevant sound lexicality effect, and the disruptive effects of irrelevant non-words derived from categorically-related items, are replicable. In this experiment, therefore, the effects of the same non-word and word items used in Experiment 1a were compared but

this time by presenting them during the retrieval period in the absence of any retention interval.

2.4.1 Method

2.4.1.1 Participants

Seventy-two participants from Cardiff University took part in a mixed-factor design in exchange for course credit. All participants reported normal or corrected-to-normal vision and normal hearing and were native English speakers. The participants were randomly divided into two 36-participant groups: Non-word and Word.

2.4.1.2 Apparatus and Materials

These were the same as for Experiment 1a except that the sinewave materials were not used and each irrelevant sequence comprised a concatenation of four (rather than two as in Experiment 1a) different random orderings of eight irrelevant items thereby producing a 32 s sequence.

2.4.1.3 Design and Procedure

These aspects of the method were identical to Experiment 1a except that there were only two levels of the between-participants factor (Word and Non-word) and there was no retention interval: The word 'RECALL' appeared immediately after presentation of the last list exemplar and the irrelevant sound (when present) coincided with the 32 s retrieval period.

2.4.2 Results

Figure 2.3 shows the overall probability of recall collapsed across serial position for each sound-type group as a function of sound condition. The pattern of results mirrored that of Experiment 1a: A mixed ANOVA showed a main effect of Sound Condition, $F(2, 140) = 51.23$, $MSE = .001$, $p < .0001$, no between-participants main effect of Sound Type ($F = 2.5$, $p > .05$), but a reliable Sound Condition \times Sound Type interaction, $F(2, 140) = 4.43$, $MSE = .001$, $p < .05$. Simple effects analyses confirmed that for the word group there were reliable differences between the quiet and categorically-related conditions ($p < .001$), and between the categorically-related and unrelated conditions ($p < .001$). For the non-word group, however, only the contrasts between the categorically-related and

the other two conditions were reliable (both $p < .001$); that between quiet and the unrelated condition failed to reach significance ($p > .05$). In short, all three key findings from Experiment 1a were replicated here when the sound was presented during the retrieval period: the between-sequence semantic similarity effect, the irrelevant sound lexicality effect, and the disruptive effect of non-words derived from categorically-related irrelevant items.

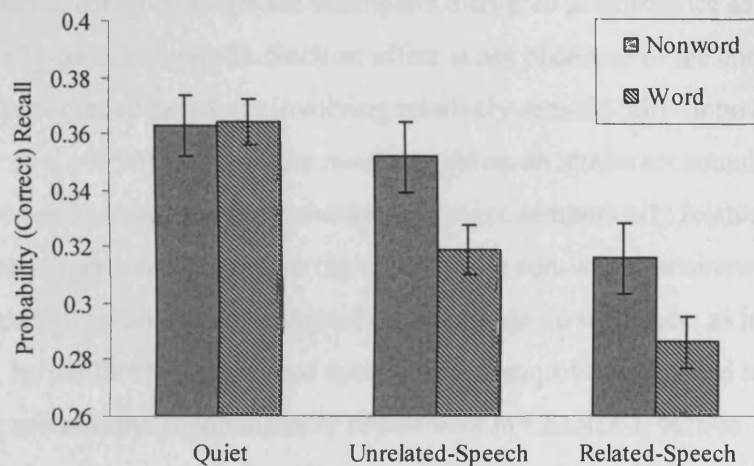


Figure 2.3 Mean probability of correct recall in the irrelevant sound conditions of Experiment 1b. Error bars illustrate the standard errors of the means.

A seriation analysis on the data from this experiment yielded scores that again indicated that the serial order of the list-exemplars were not retained in any of the sound conditions and thus that the disruptive action of irrelevant sound was not via its effect on serial order information. Collapsed across Sound Type conditions, the seriation scores were .47 ($SD = .15$) for the quiet condition, .46 ($SD = .12$) for the categorically-unrelated condition, and .47 ($SD = .15$) for the categorically-related condition. An intrusion analysis—which for the sake of brevity is not reported fully here—also yielded the same pattern of results as Experiment 1a.

2.5 Discussion (Experiments 1a and 1b)

Experiments 1a and 1b yielded several findings that converge on the notion that the action of irrelevant sound in the context of category-exemplar recall is—contrary to the suggestions of Beaman (2005) and C. B. Neely and LeCompte (1999)—entirely distinct from that observed in the serial recall setting. First, the results confirm those of two previous studies (Beaman, 2004; C. B. Neely & LeCompte, 1999) in demonstrating a between-sequence semantic similarity effect: Irrelevant words that were taken from the same semantic category as the list-exemplars disrupted performance as compared to categorically-unrelated words. Such an effect is not observed in the context of the standard serial recall paradigm involving relatively semantically-impooverished items (Buchner et al., 1996). Second, the results establish an irrelevant sound lexicality effect: Irrelevant words—regardless of whether they were semantically related to the list-exemplars—were more disruptive than (unrelated) non-words or sinewave speech tokens. Again, in serial recall, the lexicality of the sound has no influence, as indicated, for example, by the fact that backward speech is as disruptive as forward speech (Jones et al., 1990; see also the supplementary experiment in Chapter 3, section 3.3.2.4).

Third, the presence of a changing-state sequence of sounds was not—in stark contrast to the case with serial recall (e.g., Jones et al., 1992)—a sufficient condition for disruption in the current setting: Neither a changing-state sequence of (unrelated) non-words nor a changing-state sequence of sinewave speech tokens was endowed with any disruptive power as compared with quiet. Notably, however, non-words that were slight alterations of categorically-related irrelevant items were indeed disruptive (see below). Thus, the presence of sound per se is impotent in terms of disruptive power in the current setting unless that sound conveys meaning. Fourth, there was no evidence from seriation analyses that the sound disrupted performance by impairing the retention of the serial order of the list-exemplars (cf. Beaman & Jones, 1998). Indeed, even in quiet, participants' output protocols did not reflect the order of the presented items at above-chance levels, which is consistent with the hypothesis that the functional character of the category-exemplar recall task is quite different from that of serial recall. This result suggests that irrelevant sound in this setting does not disrupt a serial rehearsal process as has been argued to be the case in both serial recall and in free recall of a semantically-

heterogeneous list of words (Beaman & Jones, 1997, 1998) and also that when retrieving semantically homogenous lists, participant's capitalize on semantic activation or use semantic processes to encode and retrieve list-exemplars (e.g., Nairne et al., 1991), processes that are invulnerable to impairment via the acoustic properties of irrelevant sound. Indeed, it can be argued that the finding that high-dominance item-intrusions are more likely than lower-dominance intrusions regardless of whether they are presented or not as irrelevant sound, is a signature of the use of categorical information to facilitate retrieval (e.g., S. M. Smith et al., 2000). In sum, these results converge to suggest that semantic retrieval processes may be used during encoding and retrieval of list-exemplars and that these processes may be vulnerable to disruption by the semantic properties of the irrelevant sound.

However, one finding that does not immediately appear to gel with this analysis is that categorically-related irrelevant non-words produce disruption. To give a concrete example of this effect, the irrelevant sound sequences comprising "Weapons", consisting of non-words such as "clab" and "sword", were disruptive to the retrieval of "Weapon" category-exemplars but not of, say, exemplars of "Fruit". One potential interpretation of this 'related-non-word' effect is that the non-words are processed as words. For example, it is possible that category information generic to the list-exemplars activates a set of meaningful relations in semantic memory that can bias (or prime) the processing of the non-word irrelevant items as items from the relevant category. This view is supported by similar findings with sentence processing research: when meaning is activated in a sentence context it can bias the processing of a non-word as a word (e.g., Potter, Moryadas, Abrams, & Noel, 1993). Presumably, lexical-semantic processing will not occur for the non-word items that are categorically-unrelated to the relevant exemplars because the semantic context provided by the TBR lists in that condition do not match the category to which the word versions of the non-words belong. Additionally, some studies of false memory suggest that words can be erroneously recognized if non-words comprised of their bases are heard previously in lexical decision tasks (Dewhurst & Hitch, 1997; Wallace, Malone, & Spoo, 2000; Wallace, Stewart, Sherman, & Mellor, 1995). These findings have been explained by suggesting that non-words can implicitly activate the real words from which they are constructed (see also Forster & Hector,

2002). Thus, with regard to Experiments 1a and 1b, it could be that the categorically-unrelated non-words are also being processed to some degree semantically, but at levels that do not disrupt retrieval of the TBR items. These considerations serve to illustrate how an apparently phonological effect—disruption produced by non-words constructed from categorically-related words—may in fact be lexical-semantic.

The exemplar omission (henceforth termed forgetting) produced by the semantic content of irrelevant speech on the category-exemplar recall task is thus far consistent with the interference-by-content approach (e.g., Baddeley, 1966; Salamé & Baddeley, 1982). For example, it is possible that semantic representations of memory items are liable to a partial loss from decay or interference from other semantic material in a hypothetical store wherein semantic information is the sole currency (e.g., Baddeley, 1966, 2000b; Haarmann & Usher, 2001), and additionally, that the semantic ISE is further modulated by the degree of semantic similarity between the irrelevant material and the memory items. However, on this passive view of interference it is difficult to conceive how intrusion of related items could emerge in the categorically-related condition: Representations of TBR and irrelevant items in the categorically-related condition should be equally prone to decay or interference within the proposed store in which they are held. Thus, assuming false recall of the related irrelevant items is not due to the deliberate use of those items in a guessing strategy (cf. Beaman, 2004), it seems difficult to envisage how traces of the irrelevant items could remain intact and thus be recalled as belonging to the TBR list. Alternatively, recall of related irrelevant items could be evidence of confusing the modality in which the TBR and irrelevant items were presented (e.g., A. Larsen, McIlhagga, Baert, & Bundesen, 2003), something that is clearly not possible within accounts such as the Feature model (Neath, 2000) in which modality-dependent features of visual and auditory stimuli do not interfere with one another.

A seemingly more plausible alternative is that, in general, intrusions reflect a consequence of the strategy of capitalizing on semantic processes used in the category-exemplar recall task and are attributable not to interference-by-content but to *interference-with-process*, specifically, a breakdown in the source-monitoring process (e.g., M. K. Johnson et al., 1993; Roediger, Watson, McDermott, & Gallo, 2001). To

clarify, the semantic processing of irrelevant material interferes with decision processes that are particular to semantic tasks such as those that involve the recall of semantically-homogenous lists; that is, deciding whether an activated semantic-category item is internally generated (e.g., by thought) or externally presented, and in the case of external presentation, from which source. According to the activation/source monitoring framework (e.g., Roediger et al., 2001) processing semantically-related list items (e.g., “cat”, “sheep”) during study or test activates—either through automatic spreading activation (e.g., J. R. Anderson, 1983; Collins & Loftus, 1975) or more deliberate conscious activation via processing explicit associations (e.g., B. J. Underwood, 1965)—non-presented semantically related items common to the TBR items (e.g., “dog”, “goat”). Source confusion, and thus intrusion (or false memory formation), arises because participants fail to monitor that the source of activation of the non-target items are due to internal generation rather than their external presentation during study and as a consequence participants misattribute the activation of an item to its external occurrence (termed internal-external source-monitoring error, or breakdown in reality-monitoring; M. K. Johnson & Raye, 1981; M. K. Johnson et al., 1993; for an alternative account of false memory formation, see Brainerd et al., 2002).

The notion of internal-external source-monitoring error could explain the relative incidence of false recalls of high-dominance non-presented items—related-item intrusions—that occur in the quiet and categorically-unrelated conditions even when those items *were not* presented as irrelevant speech: Here, related-item intrusions may be the result of the relatively rapid study and test times in the category-exemplar recall task that may encourage source attribution based upon semantic activations that are occasionally not diagnostic of source (hence non-target items that are semantically activated by the list-exemplars get falsely recalled as belonging to the TBR list). Similarly, the increased incidence of intrusion of related-items in the categorically-related word (and non-word) conditions when the irrelevant items *are* presented could be ascribed to external-external source-monitoring error or ‘episodic confusion errors’ (S. M. Smith, Tindell, Pierce, Gilliland, & Gerken, 2001; S. M. Smith et al., 2000). That is, activation of related irrelevant items could leave records of events that did occur via external presentation, but they are remembered from the wrong episode (or source; that

belonging to the TBR list rather than the irrelevant speech source). Moreover, this could give rise to a type of modality confusion (e.g., Durso & M. K. Johnson, 1980; Henkel, Franklin, & M. K. Johnson, 2000; A. Larsen et al., 2003) whereby the familiarity that comes from the activation of heard category-items—in the categorically-related irrelevant sound conditions—could be indistinguishable from the familiarity that comes from the visual presentation of list-exemplars culminating in misattribution of auditory events to visual presentation.

Generally speaking, strategic source-monitoring processes tend to be poorly used by participants (e.g., McDermott & Roediger, 1998; R. L. Marsh, Landau, & Hicks, 1997; unless they are instructed otherwise, e.g., Hicks & R. L. Marsh, 1999; S. M. Smith et al., 2001; S. M. Smith et al., 2000): Most often the source of memories is identified relatively automatically without any conscious awareness of the decision making process involved (e.g., the R-1 process, see M. K. Johnson et al., 1993; M. K. Johnson, 1997). If relatively lax, automatic source-monitoring processes are adopted in Experiment 1a and 1b then it is easy to see how presenting TBR and irrelevant items from the same semantic category may lead to errors in the source-monitoring process (arguably, however, the source-monitoring process must also be reasonably efficient otherwise the level of confusion, and thus incidence of related-item intrusions would be much greater than that reported in Experiments 1a and 1b). Experiment 2 investigated whether related-item intrusions from categorically-related irrelevant sounds are consistent with the notion of a failure of the source-monitoring process by manipulating the temporal contiguity between the presentation of relevant exemplars and irrelevant items.

2.6 EXPERIMENT 2

According to the activation/source-monitoring framework (Roediger et al., 2001) non-presented items (e.g., high-dominance category-items) tend to be elicited or activated during the encoding of list items that are semantically related to them (e.g., Dewhurst, 2001; B. J. Underwood, 1965; high-dominance non-presented category-items may also come-to-mind during the retrieval of list category items, see S. M. Smith, Gerken, Pierce, & Choi, 2002). Activation of non-presented category-items via an

external source (e.g., irrelevant sound) may be more likely to be associated with encoding sources by virtue of the temporal contiguity of registration between those exemplars activated by relevant material and those items activated by irrelevant sound (for a similar rationale, see Hicks & Hancock, 2002). In other words, the activation of externally-presented items could be associated with the source of activation of the visually presented exemplars which trigger similar activation of the same category (it is also possible that irrelevant words become part of the context within which the TBR list was presented; see Barnhardt, Choi, Gerkens, & S. M. Smith, 2006). Experiment 2 tests a prediction that flows from this account: If intrusions of items from the categorically-related irrelevant sound reflect source-monitoring failure then the incidence of intrusion error should be a negative function of the degree of temporal contiguity between the presentation of the categorically-related relevant exemplars and irrelevant items: the further in time that irrelevant items are removed from the presentation period of relevant exemplars, the less their likelihood of being 'bound' with the source characteristics of the visually presented category-exemplars (see also Henkel, M. K. Johnson, & De Leonardis, 1998, and Mather, M. K. Johnson, & De Leonardis, 1999, for further suggestion that source memory is dependent on 'feature binding' during encoding).

Another question addressed in Experiment 2 is this: providing a failure of the source-monitoring process exists in the categorically-related irrelevant sound condition, is it also at the seat of forgetting (exemplar omission) in that condition? In other words, because accessibility and availability is increased through activation, the generation and retrieval of irrelevant-items may tend to arise (e.g., J. R. Anderson & Bower, 1972) and these may be recalled at the expense of list items, producing the forgetting. Moreover, since source confusions tend to occur for the more available and accessible high-dominance category-items as opposed to low-dominance items (A. S. Brown & Murphy, 1989; M. K. Johnson, Raye, Foley, & Foley, 1981; S. M. Smith et al., 2001), the erroneous retrieval of these items could impair recall of list-exemplars through activation/blocking (e.g., J. R. Anderson, 1983; a type of response competition, see McGeoch, 1942; see also Rundus, 1973) and/or persistent re-sampling (or perseveration) of the irrelevant items (e.g., Rosen & Engle, 1997; Rundus, 1973). Resampling or perseveration could increase the likelihood of participants reaching their 'stopping criterion' earlier (see Raaijmakers

& Shiffrin, 1981; Rundus, 1973), or decrease the retrieval time available for the TBR list-exemplars. If source confusion does occur, and is the cause of exemplar loss, one would expect forgetting and related-item intrusions to follow inverse patterns: forgetting should reduce as false recall increases.

2.6.1 Method

2.6.1.1 Participants

Seventy-two participants from Cardiff University took part in a mixed design in exchange for course credit. Each participant reported normal or corrected-to-normal vision, normal hearing and were native English speakers. None had taken part in Experiments 1a and 1b. Participants were randomly assigned to one of three between-participants groups: Presentation, retention, and test.

2.6.1.2 Apparatus and Materials

These were identical to the word groups of Experiments 1a and 1b.

2.6.1.3 Design

A mixed design was used with one between-participants and one within-participant factor. The between-participants factor was Sound Locus and had three levels, sound during: presentation, retention, and test. The within-participant factor was Sound Condition that comprised three levels: Sound categorically-related and unrelated to the TBR category and a quiet condition.

2.6.1.4 Procedure

This was the identical to Experiment 1a with the exceptions that the irrelevant sounds—depending on the allocated group—were presented either throughout the 8 s; when the relevant words were being visually-presented; concurrently during the 8 s period when ‘WAIT’ appeared on-screen; or during the first 8 s of the 30 s duration that the ‘RECALL’ cue was signalled.

2.6.2 Results

2.6.2.1 Correctly recalled exemplars

The raw recall data were scored (as in Experiments 1a and 1b) according to a free recall criterion. Table 2.1 shows the means for overall probability of recall collapsed

across serial position as a function of each sound condition and sound locus group. The most important aspect of the results is that the mean scores were similar for the sound conditions regardless of the locus at which the irrelevant items were presented.

Sound Condition	Presentation		Retention Interval		Test	
	Mean (SD)		Mean (SD)		Mean (SD)	
Quiet	.38	(.04)	.39	(.04)	.38	(.03)
Unrelated-Speech	.34	(.06)	.34	(.05)	.35	(.05)
Related-Speech	.30	(.06)	.30	(.06)	.32	(.07)

Table 2.1 Mean number of category-exemplars recalled in the irrelevant sound conditions as a function of locus of sound presentation in Experiment 2.

A 3 (Sound Condition) \times 3 (Sound Locus) ANOVA on the overall probability of correctly recalled items confirmed a main effect of Sound Condition, $F(2, 138) = 69.07$, $MSE = .002$, $p < .0001$. Follow-up post hoc testing (Fishers PLSD) revealed significant differences between quiet and unrelated ($p < .0001$), quiet and related ($p < .0001$) and between unrelated and related conditions ($p < .0001$). There was no between-participants main effect of Sound Locus ($p > .5$), nor an interaction between Sound Condition and Sound Locus ($p > .7$). Thus, these results show that the effect of between-sequence semantic similarity is found, and is similar in magnitude, regardless of the locus of sound presentation.

2.6.2.2 Intrusion Data

Intrusions were classified as per Experiment 1a and 1b for each sound condition of each sound locus group. Other-item intrusions were, like in Experiments 1a and 1b, very infrequent and highly variable. The mean values for the presentation, retention interval, and test groups respectively, were: .54 ($SD = .66$), .66 ($SD = 1.09$), .5 ($SD = .72$) for the quiet condition, .96 ($SD = 1.16$), 1.33 ($SD = 1.58$), and .83 ($SD = .96$) for the unrelated sound condition and .54 ($SD = .77$), .79 ($SD = .93$) and .33 ($SD = .56$) for the related

conditions. More interesting were the values for the related-item intrusions which can be seen in Figure 2.4. Inspection of Figure 2.4 shows that related-item intrusions were produced at a constant rate for the quiet and categorically-unrelated sound conditions regardless of the locus at which the sound was presented. However, the incidence of related-item intrusions in the categorically-related sound condition shows a declining 'stepwise' pattern in respect to the locus of sound presentation: the incidence of intrusions from the sound appears to decrease from presentation to retention, and then from retention to test.

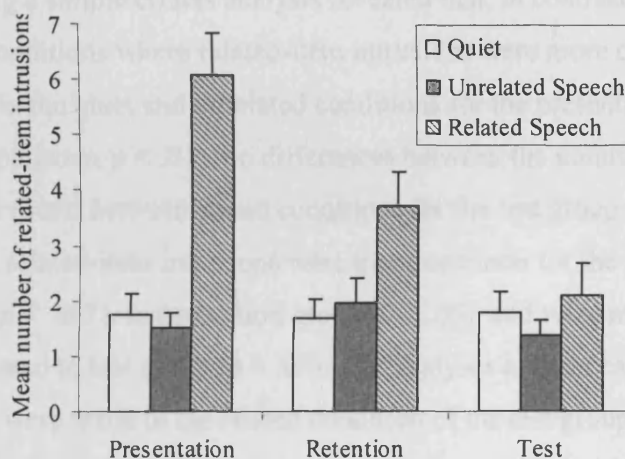


Figure 2.4 Mean number of related-item intrusions recalled as a function of the irrelevant sound conditions of Experiment 2. Error bars signify the standard error of the means.

A 3 (Sound Condition) \times 2 (Intrusion Type) \times 3 (Sound Locus) ANOVA on the number of intrusions revealed a main effect of Sound Condition, $F(2, 138) = 26.29$, $MSE = 1.93$, $p < .001$, and a main effect of Intrusion Type $F(1, 69) = 75.11$, $MSE = 4.22$, $p < .001$, and a main effect of Sound Locus, $F(2, 69) = 3.16$, $MSE = 6.89$, $p < .05$. There were also interactions between Sound Condition and Intrusion Type, $F(2, 138) = 36.43$, $MSE = 2.21$, $p < .001$; Sound Condition and Sound Locus, $F(4, 138) = 9.28$, $MSE = 1.93$, $p < .001$, and Intrusion Type and Sound Locus, $F(2, 69) = 3.51$, $MSE = 4.22$, $p < .001$. Critically, there was also a three-way interaction between Sound Condition, Intrusion Type, and Sound Locus, $F(4, 138) = 6.97$, $MSE = 2.20$, $p < .001$.

In general, the outcomes from decomposing the two-way interactions using a simple effects analysis (LSD) were the same as Experiments 1a and 1b. However, there was one important difference: Decomposition of the Sound Condition \times Sound Locus interaction revealed that, in contrast to the significant difference between the number of intrusions in the related condition as compared to the quiet and unrelated condition of the presentation and retention group (all comparisons, $p < .05$), the number of intrusions was no greater in the related condition as compared with the quiet and unrelated condition for the test group ($p > .05$).

Decomposition of the three-way, Sound Condition \times Intrusion Type \times Sound Locus interaction using a simple effects analysis revealed that, in contrast to the presentation and retention conditions where related-item intrusions were more common in the related condition than in the quiet and unrelated conditions for the presentation and retention group (all comparisons, $p < .01$), no differences between the number of related-item intrusions were found between sound conditions for the test group ($p > .05$). Finally, and most critically, related-item intrusions were more common for the presentation relative to the test group ($p < .001$), and retention group ($p < .05$), and were more common in the retention compared to test group ($p < .05$). The analyses also revealed that fewer other-item intrusions were made in the related condition of the test group, compared to the retention group ($p < .05$).

In sum, the intrusion data are similar in pattern and form to those reported in Experiments 1a and b. However, the results show that the likelihood of erroneously including categorically-related irrelevant items in free recall protocols is a positive function of the degree of temporal contiguity between the presentation of the relevant and irrelevant items.

2.6.3 Discussion

The results of Experiment 2 show that the degree of forgetting attributable to between-sequence semantic similarity is approximately the same regardless of the locus of sound presentation. However, intrusion of related-items presented as irrelevant sound in the categorically-related condition increased as a function of the degree of temporal contiguity between irrelevant items and relevant exemplars. The intrusion data are

consistent with the notion that related-item intrusions are a manifestation of a failure of the activation/source-monitoring process (e.g., Roediger et al., 2001), rather than passive interference-by-content, and that breakdown of, or inefficiencies in, the source-monitoring process may be independent of the mechanism, or process, that produces forgetting: if the two were related then one would expect false recall of related-items to rise as correct recall of exemplars fall: this was clearly not the case. The findings of Experiment 2 also tend to go against the possibility that the results of forgetting in the category-exemplar recall task are simply a consequence of activation-blocking or occlusion (J. R. Anderson, 1983; Mensink & Raaijmakers, 1988; Rundus, 1973; cf. M. C. Anderson & Bjork, 1994). On these structuralist accounts, retrieval of a categorically-related irrelevant item should strengthen the associative link between the item and its retrieval cue (in this case the cue is a self-generated use of the category-name) which is shared with the list-exemplars, and this should decrease the relative strength of association of list-exemplars with the retrieval cue making them difficult to retrieve. Furthermore, this alteration of link strength should increase the tendency for irrelevant items to be persistently retrieved again, thwarting attempts to retrieve TBR exemplars and eventually leading to a termination in the search process (e.g., Rundus, 1973). Occlusion models thus propose that forgetting should be positively related to the number of false recalls of irrelevant items, a pattern of results at odds with that obtained.

That the incidence of forgetting did not vary with the locus of sound presentation in category-exemplar recall suggests that the effect of lexicality and between-sequence semantic similarity impairs retrieval regardless of whether TBR exemplars are being encoded, retained, or retrieved. This pattern bolsters the view that irrelevant sound has a unique empirical signature in its action in the category-exemplar recall, as compared with serial recall, setting (cf. Miles et al., 1991).

The differences between the pattern of results for category-exemplar recall and serial-recall tasks are important inasmuch as they indicate that the two tasks are underpinned by different processes and that the impairment produced by different properties of irrelevant sound (acoustic or semantic) is sensitive to the processes used in the focal task (see also Chapter 3 and 4). That the degree of forgetting is influenced by the processes used to retain information argues against the passive, interference-by-content view that offers a

process-insensitive interpretation of forgetting, and instead favours a dynamic process-oriented view. Thus far, however, the evidence that the semantic ISEs found using the category-exemplar recall task are sensitive to the processing used in the focal task is rather indirect. Moreover, the passive view of interference-by-content could still be salvaged by supposing that, within a typical serial recall task, the content of the particular items TBR (e.g., consonants, digits) are not semantically-rich and thus the semantic properties of their individual traces will not be confused with the semantic content of irrelevant traces. The interference-by-content accounts, embodying the classical view of interference-by-similarity, however, appear to offer competing predictions of the outcome from an experiment in which the TBR items in the context of serial recall are semantically rich.

The Feature model (Nairne, 1990; Neath, 2000), for example, suggests that semantic content is represented as post-categorical, modality-independent features in the traces of TBR items which could conceivably make them liable to interference by the modality-independent, semantic features of other TBR and irrelevant items within a hypothetical primary memory store (e.g., Saint-Aubin & Poirier, 1995). However, the Feature model predicts the *absence* of a between-sequence semantic similarity effect regardless of task-instruction (Neath, 2000, Simulation 2; Neath et al., 2003). Alternatively, the Working Memory model (Baddeley, 1986) proposes that the TBR items in the context of serial recall are encoded phonologically, rather than semantically, and that the confusion, or degradation, occurs due to the phonological content of the traces of TBR and irrelevant items in the phonological store. Thus, according to the Working Memory model, only the phonological properties of irrelevant sound produce disruption when the task calls upon phonological encoding (e.g., Richardson, 1984).

However, the Working Memory model also supposes that, even though the task may require serial recall, when the list length grossly exceeds span (5-6 items) phonological encoding is abandoned and replaced by semantic encoding (Baddeley, 1966, 2000a; Baddeley & Salamé, 1986). Thus, the Working Memory model appears to predict a between-sequence semantic similarity effect that is attributable to passive, interference-by-content for above-span list lengths even though task instruction may require the retrieval of list items in serial order. Alternatively, according to the process-based view,

the semantic properties of the sound do not interfere with serial recall because, regardless of the length of the list (perhaps within an upper-bound range, e.g. 16-items; see Beaman & Jones, 1998) and whether or not the TBR items are amenable to extensive semantic analysis and/or are automatically activated in semantic memory (e.g., J. H. Neely & Kahan, 2001; Kriegstein, Eger, Kleinschmidt, & Giraud, 2003), if the focal task does not require the capitalization on semantic processing as a retrieval strategy it will not exhibit semantic interference-by-process. Experiment 3 sought to adjudicate more directly between the interference-by-content and dynamic, process-oriented, views of forgetting by manipulating task-instruction.

2.7 EXPERIMENT 3

Experiment 3 further investigates whether the forgetting produced by between-sequence semantic similarity in category-exemplar recall is produced by interference-by-content or interference-by-process by making use of a task-instructional manipulation (see also Chapter 3). Two different groups of participants were required to retrieve supra-span list items either according to their serial order (serial recall) or in any order (free recall). The classical view of interference-by-similarity-of-content offered by, for example, the Working Memory model (Baddeley, 1986; with reference to the assumption that semantic encoding takes place with supra-span lists regardless of retrieval instruction; Baddeley, 1966, 2000a; Baddeley & Salamé, 1986) proposes that the same outcome should emerge (e.g., disruption by between-sequence semantic similarity) regardless of whether the task requires free, or serial, recall. The process-based view of forgetting, however, predicts that only with free recall instruction—whereby semantic processing (e.g., semantic activation) can be used as a retrieval strategy—will there be a pronounced between-sequence semantic similarity effect. On this process-based account, between-sequence semantic similarity should not produce impairment when the task requires recall by serial order because the use of serial rehearsal in the focal task should lead to the emergence of a classical ISE whereby the acoustic, rather than the semantic properties of sound, assume their disruptive potency.

A further purpose of Experiment 3 was to assess again, and this time more directly, the notion that intrusions in the category-exemplar recall task reflect errors of the source-monitoring process. For this purpose, a confidence-rating task (e.g., S. M. Smith et al., 2000) was deployed whereby participants rated the confidence in which they thought that the exemplars they produced had been visually-presented as part of the TBR set. The confidence rating task should provide clues as to the degree and extent to which intrusions in the task reflect internal-external confusion and external-external episodic confusion as opposed to simply guessing.

2.7.1 Method

2.7.1.1 Participants

Forty-eight participants from Cardiff University took part in a mixed-factor design in return for course credit. All participants reported normal hearing and normal or corrected-to-normal vision, and were native English speakers. None had taken part in any of the previous experiments of this series. Participants were randomly assigned into two 24-participant groups: Free recall or serial recall.

2.7.1.2 Apparatus and Materials

These were similar to Experiment 1a with the following differences: 1) TBR and irrelevant material consisted of lists of category-exemplars selected from thirty-eight categories in the Yoon et al. (2004) norms. 2) Category-exemplars chosen for TBR lists comprised ten items from the 9th to the 18th most frequently produced single word responses to chosen category names. As in the preceding experiments, category-items chosen for irrelevant material comprised the eight most frequently produced responses to the category names.

2.7.1.3 Design

A mixed design was used with one between-participants factor and one within-participant factor. The between participants factor was 'Instruction Type' and had two levels: free recall and serial recall. Like the previous experiments, the within-participants factor was again Sound Condition. In contrast to the previous experiments, relevant exemplars were presented for 800 ms with an inter-stimulus interval (ISI – offset to onset) of 200 ms between successive exemplars.

2.7.1.4 Procedure

The procedure was the same as the previous experiments in this series apart from the following: 1) Participants were told that they would be presented with a total of eighteen, 10-word lists, wherein the ten words each belonged to a given semantic category; 2) Participants given free recall instructions were instructed to try and remember as many of these words in any order and retrieve them as such when the RECALL cue appeared whereas participants given serial recall instructions were instructed to remember the words according to their original order of presentation and to recall each exemplar by assigning it to its original serial position when the RECALL cue appeared. The serial recall group was also told that they could leave gaps in their recall protocols if necessary but were told that if they had a category-exemplar available to them for recall but could not remember the position, that they should guess the original position: it was thought that this would maximize the level of exemplar recall in this condition; 3) Recall sheets contained eighteen columns of ten rows each; participants given serial recall instructions were given specially prepared recall sheets with serial positions marked on them, the free-recall-instructed group had the same recall sheets but without the serial positions marked; 4) After participants had completed retrieval of the last list they were given a confidence-rating task (e.g., S. M. Smith et al., 2000): Participants were instructed to return to the beginning of their recall sheets and to indicate a confidence rating next to each exemplar they had written down relating to the certainty with which they thought an item had been *visually* presented. They were informed that a rating of 1 represented a complete guess, and 10 represented absolute certainty that the item had been visually presented. In total the experiment lasted approximately 45 min.

2.7.2 Results

2.7.2.1 Correctly recalled exemplars

The raw data for the free recall and serial recall task instructions were both scored using the free recall criterion, whilst only the data for serial recall task instructions were later scored with the serial recall criterion (cf. Beaman & Jones, 1998). With free recall scoring, a list-exemplar was marked as correct regardless of the position it occupied in a participants recall protocol. The typical scoring method—of marking a list-exemplar as

correct only if it appeared in its original presentation position in a participants' output protocol—was adopted for the serial recall criterion. Figure 2.5 shows the recall performance in each of the three irrelevant sound conditions collapsed across serial position for free recall and serial recall task instructions when scored with free recall criterion. As can be seen there is a compelling between-sequence semantic similarity effect for free recall, but not for the serial recall, instructions.

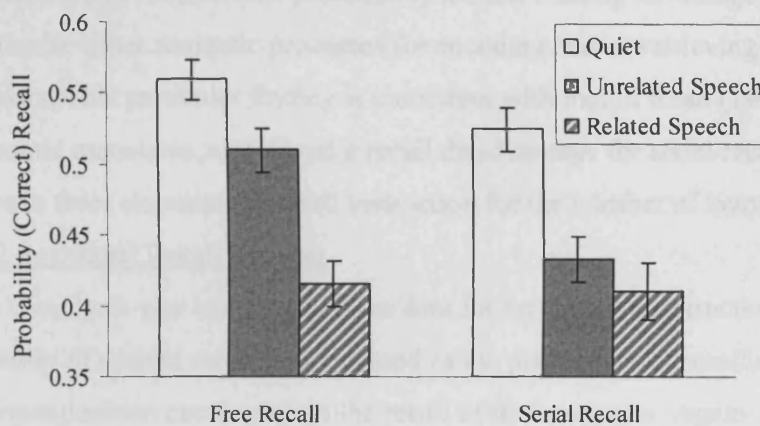


Figure 2.5 Mean probability of correct recall as a function of task instruction and the irrelevant sound conditions in Experiment 3. Error bars illustrate the standard error of the means.

A 3 (Sound Condition) \times 2 (Instruction Type) ANOVA on the data scored according to the free recall criterion revealed a main effect of Sound Condition, $F(2, 92) = 66.84$, $MSE = .003$, $p < .001$, a main effect of Instruction Type $F(1, 46) = 4.51$, $MSE = .013$, $p < .05$, and an interaction between these two factors, $F(2, 92) = 5.10$, $MSE = .003$, $p < .01$.

Interactions were decomposed with a simple effects analysis (LSD). Further investigation of the Sound Condition by Instruction Type interaction revealed significant differences between all three sound conditions for the free recall group (all $p < .001$), but significant differences were found only between the quiet and unrelated sound condition and between the quiet and related condition for the serial recall group (both $p < .001$); the difference between the unrelated and related conditions was not significant ($p > .2$). Thus, between-sequence semantic similarity only produced impairment when free, but not serial, recall instruction was instructed.

The same interaction analysis revealed that free recall instruction resulted in better recall than serial recall instruction for quiet ($p < .05$), and categorically-unrelated conditions ($p < .001$), but not for categorically-related irrelevant sound ($p > .05$). Thus the apparent advantage that free recall instruction conveys over serial recall instruction is wiped out by between-sequence semantic similarity. It is possible that the greater recall with free recall, compared to serial recall, instruction occurs because the rote rehearsal process that presumably underpins serial recall may be a relatively ineffective strategy compared to free recall which presumably includes taking advantage of semantic activation or other semantic processes for encoding and/or retrieving category-exemplars. This particular finding is consistent with that of Read (1996) who, using lists of semantic associates, also found a recall disadvantage for serial recall instruction relative to free (elaborative) recall instruction for the number of items correctly recalled.

2.7.2.2 Positional Recall Scoring

This analysis was computed on the data for serial recall instructions where the probability of correct recall was assessed as the probability of recalling an exemplar in the correct position contingent on the recall of that exemplar. Again, with this analysis, it is shown that there is no between-sequence semantic similarity effect. A 3(Sound Condition) \times 10 (Serial Position) ANOVA confirmed a main effect of Sound Condition, $F(2, 46) = 16.58$, $MSE = .00$, $p < .001$, and Serial Position, $F(9, 207) = 49.00$, $MSE = .001$, $p < .001$. The interaction between Sound Condition and Serial Position, however, just missed conventional levels of significance ($p = .06$).

These results with positional recall appear to support previous research demonstrating that memory for the position of items, not (necessarily) memory for the items themselves, is disrupted by irrelevant sound when serial rehearsal is the dominant mnemonic process. This is one hallmark of a classical, acoustic ISE (e.g., Beaman & Jones, 1998) and supports the notion that the acoustic, not semantic, properties of sound are impairing memory for the order of items in this setting.

2.7.2.3 Seriation Analysis

To ensure that the instructional manipulation was achieving its desired effect a pair-ordering analysis was conducted as in Experiment 1a. A 3 (Sound Condition) \times 2 (Instruction Type) ANOVA on pair-ordering scores revealed a significant main effect of

Instruction Type, $F(1, 46) = 188.38$, $MSE = .034$, $p < .001$, but there was no main effect of Sound Condition, $p > .2$, nor any interaction between Sound Condition and Instruction Type ($p > .05$). As desired, the pair-ordering scores indicated that serial recall instruction resulted in significantly greater ordered recall than free recall intrusion. These scores were .91 ($SD = .15$), .88 ($SD = .13$), and .89 ($SD = .13$) in the quiet, categorically-unrelated and categorically related sound conditions respectively, compared to scores of .49 ($SD = .12$), .45 ($SD = .10$) and .47 ($SD = .18$) for the same sound conditions with free recall instruction. The original order of the TBR items was retained at a rate reliably greater than chance for all sound conditions of the serial recall group ($t(23) = 22.71$, $p < .001$ (quiet); $t(23) = 23.52$, $p < .001$ (unrelated); $t(23) = 24.60$, $p < .001$ (related)) but not for the free recall group ($t(23) = -.80$, $p > .2$ (quiet)). In fact, for the categorically-unrelated and categorically-related sound conditions order information was preserved significantly *less* than chance ($t(23) = -20.72$, $p < .001$ (unrelated); $t(23) = -6.15$, $p < .001$ (related)).

Generally, the results with these seriation scores are consistent with Experiment 1a and 1b and lend support to the view that the sound effects reported in the context of category-exemplar (free) recall are qualitatively distinct to that found with serial recall and may be attributable to interference with a process other than seriation.

2.7.2.4 Confidence Ratings in Correctly Recalled Exemplars

Confidence ratings were generally higher under free recall instruction compared to serial recall instruction and appeared lower, compared to quiet, only for the sound conditions of the free recall group. The mean confidence ratings for the quiet, unrelated-speech and related-speech respectively were 9.59 ($SD = .3$), 9.28 ($SD = .51$), and 9.24 ($SD = .62$) for the free recall group and for the serial recall group they were 8.49 ($SD = 1.29$), 8.5 ($SD = 1.17$) and 8.56 ($SD = 1.12$). An ANOVA failed to reveal a main effect of Sound Condition on confidence ratings ($p > .18$). However, there was a between-participants main effect of Instruction Type, $F(1, 46) = 12.14$, $MSE = 2.148$, $p < .005$, and a significant interaction between Sound Condition and Instruction Type, $F(2, 92) = 3.13$, $MSE = .184$, $p < .05$. Decomposition of the Sound Condition \times Instruction Type interaction using a simple effects analysis (LSD) revealed significant differences between quiet and unrelated speech ($p < .05$) and between quiet and related speech ($p <$

.005) for the free recall instructions. There was, however, no difference between the confidence ratings for correctly recalled items as a function of sound condition for serial recall instructions.

These confidence ratings are a novel finding, they indicate that the presence of irrelevant sound during free, but not serial, recall produces a reduction in the confidence to which participants' rate that their correctly recalled items were originally visually-presented, but that this was not attributable to between-sequence similarity. Although speculative, it is possible that semantic activation of irrelevant items regardless of their category membership impairs the semantic activation of TBR items decreasing their familiarity and thus participants' confidence as to whether they were presented.

A simple effects analysis (LSD) for the Sound Condition \times Instruction Type interaction also showed that confidence ratings were generally higher with free recall, as compared with serial recall, instruction for all three sound conditions (all $p < .05$). This finding suggests that free recall, as contrasted with serial recall, instruction in general results in enhanced memory for TBR information regardless of the presence of irrelevant sound. It is possible that this could reflect the outcome of a spontaneous use of elaborate (e.g., of semantic processing) that gives rise to superior memory for the TBR items in free recall group. In line with this suggestion, it is possible that serial recall instruction leads to memory that is essentially 'speech-based' (e.g., Jones et al., 2004) and only viable over the short-term for memorizing sequential information. If this is indeed the case then it follows that memory for those exemplars will be poorer for serial, as compared with free, recall instruction.

The finding that serial recall instruction results in poorer meta-memory for correctly recalled items is partially consistent with previous research (e.g., Gardiner et al., 1994; but see Read, 1996) that has shown that rote (essentially serial) rehearsal enhances 'know' responses but not 'remember' responses, whereas elaborative (semantically-based) rehearsal enhances remember responses leaving know responses unchanged (but see Read, 1996). Know responses are described as those experiences where one can be confident that an item was presented but cannot mentally re-experience (remember) the event, and remember responses reflect those where the actual event of item presentation can be mentally recaptured (Tulving, 1985a; cf. Roediger & McDermott, 1995). The

proposed consistency of the confidence ratings results with prior research (e.g., Gardiner et al., 1994) requires the assumption that they tap 'remember' responses: this is entirely possible because the task requires remembering specific features of the presentation of items (e.g., that the items were *visually* presented). If this conclusion can be accepted, then the general reduction in confidence that serial, relative to free, recall instruction produces may be due to the relative absence of information required for remember responses for serial, as compared with free, recall.

2.7.2.5 Intrusion Data

Intrusions were classified as in Experiments 1 and 2. There were relatively few other-item intrusions, the number of these in the quiet, unrelated-speech and related-speech conditions respectively was .42 ($SD = .65$), .75 ($SD = 1.45$), and 1.33 ($SD = 1.76$) for free recall instruction, and .54 ($SD = .98$), .5 ($SD = .72$), and .83 ($SD = 1.31$) for serial recall instruction. Figure 2.6 shows the number of related-item intrusions as a function of sound condition for the two differentially instructed groups.

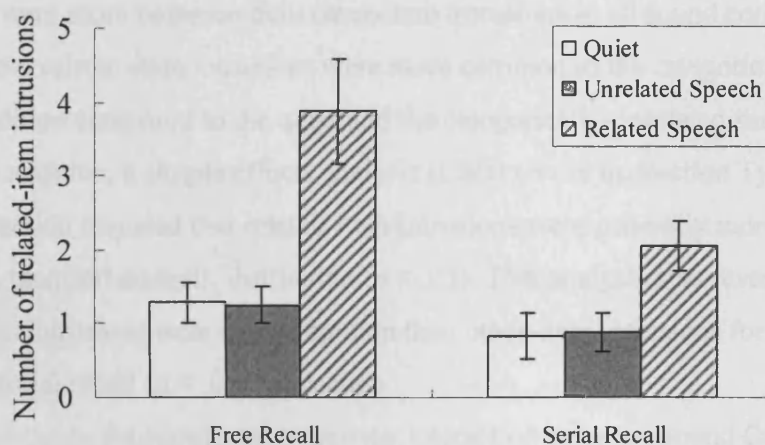


Figure 2.6 Mean number of related-item intrusions produced as function of task instruction and the irrelevant sound conditions in Experiment 3. Error bars represent the standard error of the means.

A 3 (Sound Condition) \times 2 (Instruction Type) \times 2 (Intrusion Type) ANOVA revealed a main effect of Sound Condition, $F(2, 92) = 24.97$, $MSE = 1.70$, $p < .001$, Instruction

Type, $F(1, 46) = 2.97$, $MSE = 8.4$, $p < .05$, and Intrusion Type, $F(1, 46) = 38.58$, $MSE = 1.59$, $p < .001$. There were also interactions between Sound Condition and Instruction Type, $F(2, 92) = 5.28$, $MSE = 1.70$, $p < .01$, Sound Condition and Intrusion Type, $F(2, 92) = 11.80$, $MSE = 1.05$, $p < .001$, Instruction Type and Intrusion Type, $F(1, 46) = 6.60$, $MSE = 1.60$, $p < .05$, and a three-way interaction between Sound Condition, Instruction Type, and Intrusion Type, $F(2, 92) = 3.17$, $MSE = 1.05$, $p < .05$.

A simple effects analysis (LSD) on the Sound Condition \times Instruction Type interaction revealed that, generally, more intrusions were made with free recall, as compared with serial recall, instruction for the categorically-related condition ($p < .05$). Moreover the analysis demonstrated that a greater number of intrusions were found in the categorically related condition compared to the quiet and categorically-unrelated sound condition (both $p < .001$) for free recall instruction. For serial recall instruction, however, the number of intrusions was greater for the categorically-related sound condition compared to the quiet condition only ($p < .05$).

A simple effects analysis (LSD) on the Sound Condition \times Intrusion Type interaction revealed the same pattern of effects as reported in Experiments 1 and 2: related-item intrusions were more common than other-item intrusions in all sound conditions (all $p < .05$), and that related-item intrusions were more common in the categorically-related sound condition compared to the quiet and the categorically-unrelated sound condition ($p < .001$). In addition, a simple effects analysis (LSD) on the Instruction Type \times Intrusion Type interaction revealed that related-item intrusions were generally more common with free recall, than serial recall, instruction ($p < .05$). This analysis also revealed that related-item intrusions were more common than other-item intrusions for free recall ($p < .001$) and serial recall ($p < .05$) instruction.

To investigate the significant three-way interaction between Sound Condition, Instruction Type, and Intrusion Type further a simple effects analysis (LSD) was performed. This showed that related-item intrusions were more common in the categorically-related sound condition compared to both the quiet and categorically-unrelated sound condition (both $p < .001$) for free recall instruction. For serial recall instruction related-item intrusions were more common in the categorically-related sound condition than the quiet condition only ($p < .05$). Also revealed was that related-item

intrusions were more common than other-item intrusions for free recall instruction in the quiet ($p < .001$), and categorically-related sound condition ($p < .001$), but for serial recall instructions related-item intrusions were significantly more common than other-item intrusions for the categorically-related sound condition only ($p < .05$). Finally, the simple effects analysis also revealed that related-item intrusions were more common with free recall than serial recall instruction in the categorically-related irrelevant sound condition ($p < .05$). There was also a trend for a similar result in the quiet conditions ($p = .13$).

This latter finding can be considered as further evidence that for the notion that the number of intrusions from the categorically-related irrelevant sound reflects a breakdown (or errors) in the external-external source-monitoring process. Since retrieval via semantic activation (or processing) is likely to occur more extensively with free recall, as compared with serial recall instruction, there is a greater requirement, and more likely to be a failure in free recall, to monitor that the source of activation for category-items is attributable to visual, and not auditory, presentation.

In sum these intrusion data suggest that free recall, rather than serial recall, is more likely to be influenced by the false recall of high-dominance related-items regardless of whether or not they are presented as irrelevant sound. It can be argued the finding that high-dominance items intrude more often than other, or low-dominance items, is a signature of the use categorical information to facilitate retrieval (e.g., S. M. Smith et al., 2000). The fact that high-dominance items are intruded differentially more than other-items *only* when they are presented as auditory distractors in serial recall is in line with the suggestion that category information is not used as extensively in serial recall than as it is in free recall.

2.7.2.6 Confidence Ratings in Intrusions

Confidence ratings in intrusions were generally lower than that of correctly recalled items, and tended to be greater with free recall than serial recall instructions. The modal confidence ratings for related-item intrusions when free recall is instructed were 10 for the quiet condition, 4 for the categorically-unrelated sound condition, and 10 for the categorically-related sound condition. For serial recall instructions they were 2 for the quiet condition, 4 for categorically-unrelated sound condition, and 1 for the categorically-related sound condition. The mean scores for the related-item intrusions

with free recall instructions were 5.59 for the quiet condition, 4.31 for the categorically-unrelated sound condition, and 6.42 for the categorically-related sound condition. For serial recall instructions the mean scores were 3.95 for the quiet condition, 4.24 for the categorically-unrelated sound condition, and 3.90 for the categorically-related sound condition. Unfortunately, as a consequence of the number of intrusions being low in the sound conditions the mean confidence ratings were considered too variable to qualify for statistical analysis.

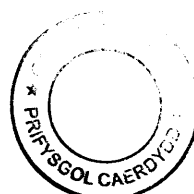
These meta-memory data suggest that some guess work occurs in both the category-exemplar recall and serial recall task. However, it seems reasonable to conclude that intrusions of related-items in the quiet conditions are more likely to be false recall (episodic confusion) with free recall as compared with serial recall instruction. It also appears obvious that some of the related-item intrusions in the categorically-related irrelevant sound condition of the free recall group are actually false memories produced by external-external source confusion. A further interesting finding was that the nature of memory for the related-item intrusions with serial recall instructions seems to have a different phenomenological basis from those obtained with free recall instructions: a greater number of related-items produced with serial recall instructions were rated as guesses. One possible explanation of this is that participants given serial recall instructions were using (and were aware of producing) items presented as related sound opportunistically as guesses perhaps due to the difficulty in remembering the supra-span lists in sequence.

2.7.3 Discussion

Experiment 3 showed that the between-sequence semantic similarity effect on forgetting depends upon task instruction and may thus be task-process sensitive: an effect of between-sequence semantic similarity was found only when task instruction emphasised free recall which presumably involves retrieval based upon semantic processes such as automatic semantic activation. The results of Experiment 3 support the interference-by-process view whilst directly contradicting the idea that forgetting is a consequence of the passive existence of traces in a memory module wherein confusion can occur between the traces of TBR and irrelevant items to the extent to which they are

represented by the similar, post-categorical, semantic features (e.g., Salamé & Baddeley, 1982). The Working Memory model (Baddeley, 1986), for example, appears to predict an effect of between-sequence semantic similarity regardless of whether the task requires free or serial recall, whilst the Feature model (Neath, 2000) does not predict an effect of between-sequence semantic similarity in either free or serial recall tasks. The results of Experiment 3 are useful in they provide further support against the idea that extant serial recall tasks have failed to capture between-sequence semantic similarity effects simply because the TBR items were not semantically rich (e.g., Buchner et al., 1996) and therefore not amenable to semantic processing: Strongly associated material was used in Experiment 3 and there was still a failure to find a between-sequence semantic similarity effect. Moreover, the failure of between-sequence semantic similarity to produce disruption with serial recall instruction is consistent with the notion that semantic processing (e.g., semantic activation) is not necessarily taken advantage of for serial recall and thus interference-by-process at a semantic level is less likely to occur.

The false recall (intrusion) data also shed light on the conception than semantic processing is used less for retrieval when task instruction emphasises recall in serial order. Fewer intrusions from the categorically-related irrelevant sound were made when the task required serial recall in comparison to free recall. Moreover, the intrusions made for the serial recall group were rated with lower confidence of being seen previously than the same intrusions for the free recall group. Such a finding is consistent with the activation/source-monitoring framework (Roediger et al., 2001) because, on this account, the less that semantic activation is used for retrieval, the less is the likelihood of misattributing the activation of that event to its external presentation. This false recall result is also consistent with fuzzy trace theory (Reyna & Brainerd, 1995) and the notion of item-specific processing (Hunt & McDaniel, 1993) whereby the extrapolated idea is that serial recall instructions encourage the use and formation of verbatim representations (through articulatory processing) that may include perceptual detail about source which will aid the source monitoring process thus decreasing internal-external and external-external confusion and protecting against the formation of false memories (Brainerd, Reyna, & Brandse, 1995; Hicks & R. L. Marsh, 2001; McCabe, Presmanes, Robertson, & S. M. Smith, 2004; Reyna & Brainerd, 1995). An alternative explanation is that rote



rehearsal of events boosts the familiarity of those events relative to the non-rehearsed irrelevant events providing distinguishable cues as to their existence in the TBR set (cf. Dobbins, Kroll, & Yonelinas, 2004). In any case, it could be argued that serial rehearsal of events increases the discriminability of those events from those not presented or those presented from a different source (cf. M. K. Johnson, Raye, & Durso, 1980). Some prior evidence supports this conclusion (Read, 1996) in showing that internal-external false recall of non-presented associates is lower when rote repetition (i.e., serial rehearsal) relative to free recall is instructed. It should be mentioned here, however, that whilst source differentiation appeared better for free recall compared to serial recall instruction, free recall led to better meta-memory for the TBR exemplars which is possibly due to adoption of elaborative semantic processing in that condition.

Thus far the foregoing experiments undermine the classical, passive interference-by-similarity-of-content account of forgetting and thus appear to support an interference-by-process account. However, alternative structural accounts of the foregoing data are possible. For example, obligatory semantic activation of the high-dominance categorically-related irrelevant items could, by receiving more of a resource-limited source of activation due to their stronger pre-experiment association with the category, block access to the lower-dominance target list-exemplars thereby impairing their retrieval by robbing them of activation (e.g., J. R. Anderson, 1983). The results of Experiment 3 could be explained by assuming that a decrement in activation would impair free recall performance whereby semantic activation may be used as encoding or retrieval strategy but will not affect serial recall performance whereby semantic activation may not be used. These structural, blocking accounts, however, were found wanting with regard to Experiment 2. Consistent with these findings, however, is a dynamic, process-oriented approach (M. C. Anderson, 2003). On this approach high-dominance, non-target items produce forgetting due to inhibition. More specifically, high-dominance items compete with target exemplars for retrieval and the resolution of this competition requires that the competing items be inhibited. Forgetting thus reflects either an overhead of exerting inhibition, or the inhibition of target exemplars by virtue of the fact that they share similar features with the competing items (e.g., M. C. Anderson et al., 2000; M. C. Anderson & Spellman, 1995).

The foregoing experiments have all used high-dominance items as irrelevant sound. Activation, and other semantic retrieval, theories propose that high-dominance items produce more forgetting because they are inherently more retrievable than the lower-dominance items (J. R. Anderson, 1983; M. C. Anderson, 2003; Rundus, 1973). Similarly, failures in source-monitoring occur more for high-dominance as compared with low-dominance items for the same reason. Experiment 4 investigates whether the forgetting and false recall produced by between-sequence semantic similarity is consistent with activation/blocking and semantic retrieval theories by using low-dominance category-items as irrelevant sound.

2.8 EXPERIMENT 4

Several retrieval models subscribe to the notion of strength-dependent competition culminating in the ‘blocking’ or occlusion of weaker responses (e.g., J. R. Anderson, 1983; Mensink & Raaijmakers, 1988; Nelson, Schreiber, & McEvoy, 1992; Rundus, 1973; Raaijmakers & Shiffrin, 1980, 1981) or their inhibition due to them competing for retrieval (e.g., M. C. Anderson & Bjork, 1994). If these accounts are an adequate interpretation of the data in the category-exemplar recall setting then one would expect high-dominance, but not necessarily low-dominance, categorically-related irrelevant items to produce a between-sequence semantic similarity effect. Indeed, several studies have shown that forgetting, or impairment in retrieval, is related to the dominance of activated competitors within memory (M. C. Anderson et al., 1994; Bäuml, 1998; Bäuml, Kissler, & Rak, 2002; Shivde & M. C. Anderson, 2001; but see A. S. Brown et al., 1985; A. S. Brown, Zoccoli, & Leahy, 2005; Wentura & Frings, 2005; Williams & Zachs, 2001).

Moreover, false recalls—and hence source monitoring failure—tend to be more for high-dominance as opposed to low-dominance items (A. S. Brown & Murphy, 1989; Dewhurst, 2001; M. K. Johnson et al., 1981; S. M. Smith et al., 2000). As an explanation of this dominance effect with false recall, it has been argued (e.g., M. K. Johnson et al., 1981) that source identification is harder for memories that are activated automatically (e.g., high-dominance category-exemplars) relative to those that would otherwise require

a greater degree of cognitive operation such as that involved in a hypothetically more effortful search of memory, or activation via voluntary control, to access low-dominance category-exemplars. Details of cognitive operations arguably provide cues as to the source of the memories (externally or internally generated), thus monitoring the source of low-dominance exemplars tends to be better (M. K. Johnson et al., 1981; Rabinowitz, 1989). If the category-exemplar recall task mirrors extant findings with source monitoring then external-external source monitoring errors (intrusions from the categorically-related irrelevant sound) should be fewer when the irrelevant items are low-dominance compared to when they are high-dominance. Moreover, there should be fewer intrusion errors that correspond to the low-dominance irrelevant items regardless of sound condition because these items are less likely to be retrieved during either the encoding or retrieval of list items (e.g., S. M. Smith et al., 2000).

2.8.1 Method

2.8.1.1 Participants

Twenty-four participants from Cardiff University took part in return for course credit. All participants reported normal hearing and normal or corrected-to-normal vision, and were native English speakers. None had taken part in any of the previous experiments of this series.

2.8.1.2 Apparatus and Materials

These were identical to Experiment 3 with the following difference: For irrelevant items eight items (e.g., “lichee”, “prune”) were selected from amongst the lowest dominance items listed in response to each chosen category-names in the Yoon et al. (2004) norms. The selection criteria included avoidance of responses adjudged unlikely to be known by the participant population (e.g., “rambutan”).

2.8.1.3 Design

A repeated measures design was used with one within-participant factor which was, as in Experiments 1-3, ‘Sound Condition’.

2.8.1.4 Procedure

The procedure was identical to Experiment 3 for the free recall instructed group.

2.8.2 Results

2.8.2.1 Correctly recalled exemplars

Figure 2.7 shows the overall probability of recall collapsed across serial position for TBR list-exemplars as a function of each sound condition. Also included in the table are the comparison scores from the high-dominance free recall group of Experiment 3. Figure 2.7 shows that generally irrelevant sound appeared to lower correct recall but that there was no between-sequence semantic similarity effect for the low-dominance group.

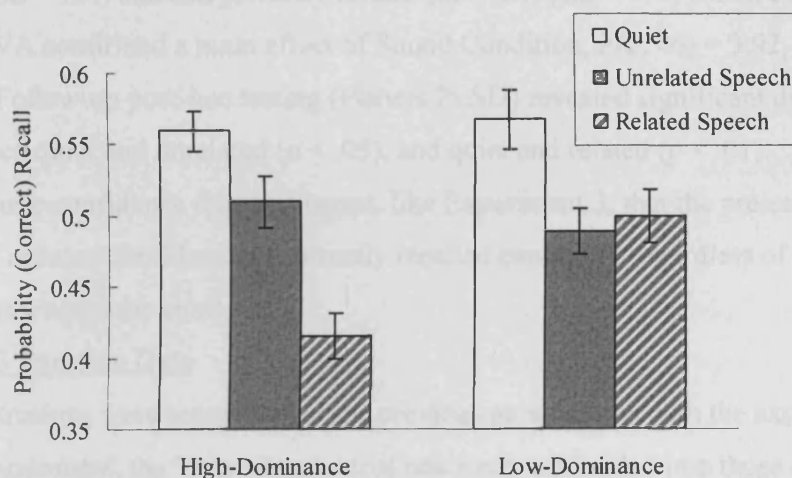


Figure 2.7 Mean probability of correct recall as a function of distractor dominance and the irrelevant sound conditions in Experiment 4. Error bars depict the standard error of the means.

An ANOVA on the overall probability of correctly recalled items confirmed a main effect of Sound Condition, $F(2, 46) = 15.41$, $MSE = .003$, $p < .001$. Post-hoc testing (Fishers PLSD) revealed significant differences between quiet and categorically-related sound ($p < .0001$), and quiet and categorically-unrelated sound ($p < .0001$), but no difference between categorically-unrelated, and categorically-related, sound ($p > .4$). When the free recall condition of Experiment 3 was used as a control for the dominance level of irrelevant items, ANOVA revealed a main effect of Sound Condition, $F(2, 92) = 54.71$, $MSE = .003$, $p < .001$, and an interaction between Sound Condition and Dominance Level, $F(2, 92) = 14.29$, $MSE = .003$, $p < .001$. There was no overall main effect of Dominance Level ($p > .27$).

A simple effects analysis (LSD) for the interaction between Sound Condition and Dominance Level revealed a significant effect of output dominance for the categorically-related sound condition of the high-dominance ($p < .001$), but not low-dominance ($p > .4$), group. The analysis also showed that the means of the related condition for the high-, and low-, dominance groups were significantly different ($p < .001$).

2.8.2.2 Confidence Ratings in Correctly Recalled Exemplars

As in the previous experiment mean confidence ratings for correctly recalled exemplars were higher in quiet ($M = 9.20$, $SD = .30$) than in categorically-unrelated ($M = 9.02$, $SD = .64$) and categorically-related ($M = 8.95$, $SD = .74$) sound conditions. An ANOVA confirmed a main effect of Sound Condition, $F(2, 46) = 3.92$, $MSE = .219$, $p = .027$. Follow-up post-hoc testing (Fishers PLSD) revealed significant differences between quiet and unrelated ($p < .05$), and quiet and related ($p < .01$).

These confidence ratings suggest, like Experiment 3, that the presence of irrelevant sound reduces confidence in correctly recalled exemplars regardless of between-sequence semantic similarity.

2.8.2.3 Intrusion Data

Intrusions were scored as per the previous experiments with the exception that, for this experiment, the 'other-item' intrusions were subdivided into those *low-dominance* related-item intrusions presented as irrelevant sounds in the related sound condition, and all other intrusions. The mean number of all intrusions can be seen in Table 2.2, contrasted with comparison conditions drawn from the free recall group of Experiment 3. Inspection of the means in Table 2.2 shows that in Experiment 4, the incidence of high-dominance related-item intrusions tends to be greater than low-dominance related-item intrusions and other-item intrusions. Table 2.2 also shows that the incidence of low-dominance related-item intrusions is notably low in the quiet and unrelated sound condition, as is the incidence of this type of intrusion when presented as part of the irrelevant sound, a mean number score of approximately .5 intrusions per participant.

	Quiet			Unrelated-Speech			Related-Speech		
	RI	RI	OI	RI	RI	OI	RI	RI	OI
	High	Low		High	Low		High	Low	
Low-	1.46	.25	.36	1.42	.08	.58	1.38	.54	.50
Dominance	(1.47)	(.53)	(.82)	(1.18)	(.41)	(1.06)	(1.21)	(.88)	(.66)
High-	1.29	.13	.29	1.25	.13	.63	3.88	.08	1.25
Dominance	(1.33)	(.34)	(.55)	(1.19)	(.34)	(1.28)	(3.5)	(.28)	1.67

Table 2.2 Mean number of related-item (RI) and other-item (OI) intrusions as a function of distractor dominance and the irrelevant sound conditions in Experiment 4.

A 3 (Sound Condition) \times 3 (Intrusion Type) ANOVA failed to reveal a main effect of Sound Condition ($p = .6$), there was, however, a main effect of Intrusion Type $F(2, 46) = 32.72$, $MSE = .80$, $p < .001$, but no interaction between Intrusion Type and Sound Condition ($p > .05$). Follow-up post hoc testing (Fishers PLSD) revealed that high-dominance related-item intrusions were more common than both low-dominance related-item intrusions ($p < .001$) and other-item intrusions ($p < .001$). However, there was no difference between low-dominance related-item, and other-item, intrusions ($p = .19$). As can be seen in Table 2.2, the number of intrusions for low-dominance related-item intrusions was low, and too few to subject to an ANOVA with the between-participants Dominance Level variable included. Although the incidence of low-dominance related-item intrusions was greater in the categorically-related condition when they were presented as irrelevant sound, they were erroneously included much less frequently than high-dominance related-item intrusions when presented as categorically-related irrelevant sound in Experiment 3.

2.8.2.4 Confidence Ratings in Intrusions

Confidence ratings in intrusions were again lower than those for veridical recall. The mean scores for the high-dominance related-item intrusions were 5.01 for the quiet condition, 5.32 for the categorically-unrelated sound condition, and 4.94 in the categorically-related sound condition. Confidence ratings for low-dominance related-item intrusions were 2.80 in quiet, 2.50 in unrelated and 3.15 in related. Confidence for other-item intrusions were: 3.30 in quiet, 3.19 in unrelated, and 3.15 for related. Thus it seems participants whom recalled the low-dominance related-item intrusions were not confident that those items had been visually presented: Participants were actually more confident that high-dominance related items had been presented when, in fact, they were not presented in any condition of the experiment.

2.8.2.5 Seriation Analysis

Because Experiment 3 showed that serial recall instructions negated the effect of between-sequence semantic similarity, the failure to obtain a between-sequence semantic similarity effect in the present experiment could have been due to greater spontaneous use of serial rehearsal in the present experiments compared with Experiment 3. However, seriation scores suggested that this was not the case because the mean scores in quiet ($M = .47, SD = .13$), unrelated irrelevant sound ($M = .45, SD = .14$), and related irrelevant sound ($M = .48, SD = .13$) were actually not significantly different from those in Experiment 3: An ANOVA revealed no main effect of Sound Condition on seriation scores when included separately ($p > .05$) or together with the free recall group of Experiment 3 ($p > .05$), there was also no between participants main effect of Dominance Level in this latter analysis ($p > .05$) and no with Sound Condition and Dominance Level ($p > .05$).

2.8.3 Discussion

The results of Experiment 4 support the notion that the forgetting that is produced by between-sequence semantic similarity in Experiment 1-3 must be attributable to the dominance of those items: the low-dominance irrelevant items in the current experiment failed to produce a between-sequence semantic similarity effect. This finding is consistent with strength-dependent competition models such as activation/blocking

models (e.g. J. R. Anderson, 1983) that predict a dominance effect by assuming that the high-dominance irrelevant items rob the relevant exemplars of the activation required for retrieval. Similarly, dynamic, process-based inhibitory accounts (e.g., M. C. Anderson, 2003) propose that dominant category-items interfere more with retrieval than low-dominance items and therefore require inhibition from competing with list-exemplars for retrieval: thus in terms of this account, forgetting could be a cost of using retrieval inhibition as an executive control process.

The lower degree of apparent source-monitoring failure in Experiment 4 also suggests that the external-external source confusion observed in Experiments 1-3 is related to the dominance of categorically-related irrelevant items. This finding is consistent with prior studies that have shown source-monitoring to be worse for high-dominance, as compared with lower-dominance category-exemplars (e.g., A. S. Brown & Murphy, 1989; Dewhurst, 2001; M. K. Johnson et al., 1981; S. M. Smith et al., 2000). Unfortunately, however, the low level of false recall in Experiments 2-4 is such that meaningful analysis of meta-memory decision data was precluded. One known way of increasing false memory formation is to delay the memory test (McDermott, 1996; S. M. Smith et al., 2000; Thapar & McDermott, 2001). Delaying the memory test is thought to increase false memory formation because it decreases reliance on episodic information that may include item-specific information or verbatim traces and increases reliance on semantic activation or gist information as retrieval strategies (McDermott, 1996; Reyna & Brainerd, 1995). Experiment 5 delayed the memory test in order to induce a greater level of false recall in all sound conditions in a bid to enable inferential analyses to be performed on a concomitant, increased level of meta-memory decision data.

2.9 EXPERIMENT 5

Experiment 5 investigated retrieval with delay using a cued recall design in which participants receive a number of pre-cued category lists one after another and are then cued to recall each in turn (e.g., S. M. Smith et al., 2000). Delay was used in an attempt to increase the degree of false recall for all three sound conditions in order to run inferential statistics on meta-memory data for intrusions.

2.9.1 Method

2.9.1.1 Participants

Twenty-four participants from Cardiff University participated in return for course credit. Each participant reported normal or corrected-to-normal vision and normal hearing and was a native English speaker.

2.9.1.2 Apparatus and Materials

These were identical to those used for the free recall group of Experiment 3.

2.9.1.3 Design

A repeated measures design was used with one within-participant factor. The within-participant factor was, like prior experiments of the series, 'Sound Condition'.

2.9.1.4 Procedure

The procedure was the same as Experiment 3 for free recall instructions apart from the following exceptions: Before the onset of the exemplar presentations for each category, the category-name was shown for 3 s, and subsequently each of the ten category-exemplars were presented for 1 s consecutively with no inter-stimulus intervals. There was a 5 s pause between each list. After presentation of *all* eighteen categories, the category-names were then re-presented as cues to recall each list. The eighteen cued recall tests were given in the same order as the studied lists, thus the interval between study and test of a category was approximately 6 min for the first category. A 3 s pause was given after each cued recall test. The category-name appeared on the screen for 1 min. A tone sounded and a screen appeared to indicate to participants that their retrieval time for a particular category was up; after this, on-screen instructions then appeared and participants were instructed to press a button for the next category-name to appear. To ensure semantic analysis, participants were asked to think of how each category member fitted within the semantic-category. Irrelevant category-items were presented contiguously with the presentation of the list-exemplars.

2.9.2 Results

2.9.2.1 Correctly recalled exemplars

The raw recall data for Experiment 5 were scored according to free recall criterion. The mean probability of recall for the quiet, categorically-unrelated and categorically

related conditions was .39 ($SD = 1.3$), .34 ($SD = 1.4$), and .28 ($SD = 1.2$). Thus, like Experiments 1-4, both categorically-related and categorically-unrelated items appear disruptive to recall with the categorically-related items producing greater impairment.

An ANOVA on the overall probability of correctly recalled items confirmed a main effect of Sound Condition, $F(2, 46) = 21.12$, $MSE = .080$, $p < .001$. Post hoc testing (Fishers PLSD) revealed significant differences between quiet and categorically-related sound ($p < .0001$), quiet and categorically-unrelated sound ($p < .001$), and critically also between categorically-unrelated, and categorically-related, sound conditions (both, $p < .001$). These data are consistent with the foregoing experiments and suggest that the same effects obtain after a delay than during immediate recall or recall following a short retention interval (8 s).

2.9.2.2 Confidence Ratings in Correctly Recalled Exemplars

An ANOVA on the confidence in correctly recalled exemplars revealed a main effect of Sound Condition, $F(2, 46) = 5.26$, $MSE = .96$, $p < .01$, and further post-hoc testing (Fishers PLSD) revealed that participants were more confident that their responses were visually presented in quiet ($M = 8.7$, $SD = .08$), compared to the categorically-unrelated condition ($M = 8.2$, $SD = 1.2$; $p < .05$), and the categorically-related condition ($M = 7.8$, $SD = 1.6$; $p < .005$). Thus, like Experiments 3 and 4 have shown, sound depressed confidence ratings in correct recall but this was not influenced by between-sequence semantic similarity.

2.9.2.3 Intrusion Data

Intrusions were classified as for the foregoing experiments. The mean number of other-item intrusions recalled for the quiet, categorically-unrelated, and categorically-related, sound conditions respectively, was 2.46 ($SD = 3.56$), 3.83 ($SD = 2.96$), and 2.54 ($SD = 3.4$). The number of related-item intrusions was more numerous in all sound conditions as can be seen in Figure 2.8. As can be seen, the rate of intrusions was elevated beyond that in the foregoing experiments suggesting that delaying recall had the desired effect. Moreover, related-item intrusions were greater in number when participants were presented auditorily with those words in the categorically-related sound condition, compared to the quiet and categorically-unrelated sound conditions whereby the items were not presented.

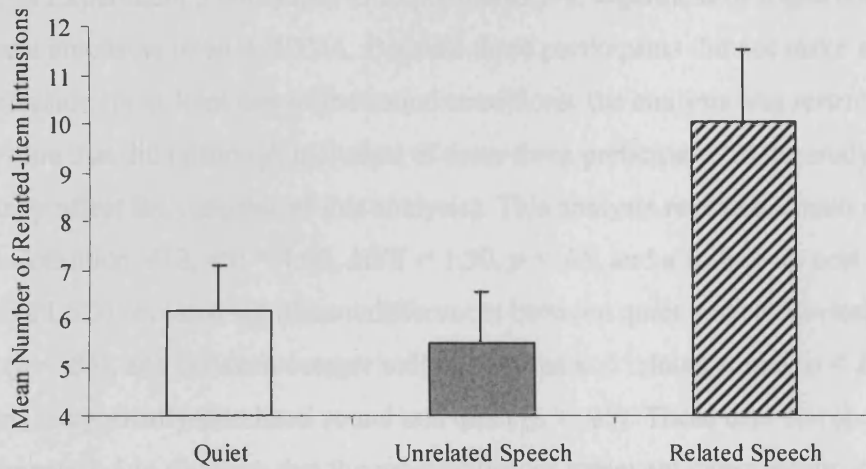


Figure 2.8 Mean number of related-item intrusions as a function of irrelevant sound condition in Experiment 5. Error bars represent the standard error of the means.

A 3 (Sound Condition) \times 2 (Intrusion Type) ANOVA confirmed a main effect of Sound Condition on the number of intrusions, $F(2, 46) = 6.54$, $MSE = 8.18$, $p = .003$. There was also a main effect of Intrusion Type, $F(1, 23) = 49.39$, $MSE = 13.40$, $p < .001$, and also a Sound Condition \times Intrusion Type interaction, $F(2, 46) = 14.17$, $MSE = 7.42$, $p < .001$. The Sound Condition \times Intrusion Type interaction was decomposed with a simple effect analysis (LSD). This revealed that related-item intrusions were more common than other-item intrusions for the quiet ($p < .001$) and the categorically-related sound condition ($p < .001$). The difference also approached significance for the categorically-unrelated sound condition ($p = .062$). Importantly, the simple effects analysis also revealed that related-item intrusions were more common in the categorically-related sound condition relative to the categorically-unrelated sound condition ($p < .001$), and quiet condition ($p < .005$).

2.9.2.4 Confidence Ratings in Intrusions

Participant's confidence ratings in related-item intrusions—contingent on them making one or more of such intrusions in each of the sound conditions—were higher in the categorically-related sound condition ($M = 5.70$, $SD = 1.90$) than in the quiet ($M = 4.63$, $SD = 1.74$) and categorically-unrelated sound conditions ($M = 4.46$, $SD = 1.90$). Critically, because false recall—or the number of related-item intrusions—was much

greater in Experiment 5 compared to Experiments 1-4, regardless of sound condition, the data were amenable to an ANOVA. Because three participants did not make a related-item intrusion for at least one of the sound conditions, the analysis was restricted to the twenty-one that did (although inclusion of these three participants in the analysis did not materially affect the outcome of this analysis). This analysis revealed a main effect of Sound Condition, $F(2, 40) = 4.60$, $MSE = 1.50$, $p < .05$, and a follow-up post hoc test (Fishers PLSD) revealed significant differences between quiet and categorically-related sound ($p < .05$), and between categorically-unrelated and related sound ($p < .01$), but not between categorically-unrelated sound and quiet ($p > .05$). These data corroborate that of Experiments 2-4 in showing that the presentation of irrelevant categorically items during the presentation of related, TBR category-exemplars leads to an external-external source-monitoring error that, in the case of Experiment 5, is manifest during later cued-recall of the category.

2.9.3 Discussion

In essence, the results of Experiment 5 demonstrate that the forgetting of list-exemplars and source-monitoring failure, as produced by between-sequence similarity, can occur regardless of the presence of a relatively long delay (6 min+) in recall. Moreover, Experiment 5 enabled inferential statistics to be performed on the meta-memory decision data, something that heretofore could not be conducted in Experiments 2-4 due to a relatively low level of false recall in the control sound conditions. Analysis of these data provided further confirmation that between-sequence semantic similarity does indeed produce error in the source-monitoring process. This result is consistent with activation/source monitoring theory (e.g., Roediger et al., 2001) whereby concurrent activation of semantically related, TBR and irrelevant items could give rise to confusion as regards to the source of that activation and hence false memory formation. Although the task differed from Experiments 1-4 in that it involved cued-recall, the processes underpinning the task may be similar: Indeed, some researchers (e.g., Gillund & Shiffrin, 1984) propose that free recall is essentially a type of cued recall.

3. GENERAL DISCUSSION

The results of the current series can be summarized as follows: Experiments 1a and 1b demonstrated that it is the lexical-semantic, rather than the acoustic, properties of irrelevant sound played during a retention period, or throughout retrieval, that produces forgetting of list-exemplars in category-exemplar recall. Experiments 1a and 1b also provide evidence that serial rehearsal was an unlikely output strategy for category-exemplar recall, suggesting that this forgetting, produced by the semantic properties of irrelevant sound, is qualitatively and functionally distinct from the forgetting produced by the acoustic properties of the sound, the classical ISE, in the short-term, serial recall setting. Experiments 1a and 1b also replicated previous research with category-exemplar recall in showing that the forgetting and false recall of extra-list-exemplars is greater when irrelevant sound comprises high-dominance category-items that are related, as opposed to unrelated, to the TBR category-exemplars (Beaman, 2004; C. B. Neely & LeCompte, 1999).

Experiment 2 provided independent evidence that source-monitoring failure explains part of the pattern of data produced by between-sequence semantic similarity. Specifically, the effect of source-monitoring failure was not one that influenced the degree of forgetting, rather, it increased the false recall of the extra-list, high-dominance related items presented as irrelevant sound. That is, the false recall of related irrelevant-items increased as the temporal contiguity between the TBR and the related irrelevant items was increased, whilst forgetting remained constant. Experiment 3 revealed that the forgetting produced by between-sequence semantic similarity was task-process sensitive: when task instructions emphasised recall in serial-order, between-sequence semantic similarity did not produce forgetting. Experiment 3 also demonstrated an attenuation of source-monitoring error with serial, relative to free, recall instruction.

Experiment 4 demonstrated that the forgetting and source-monitoring error produced by between-sequence semantic similarity is critically dependent on the dominance of the categorically-related irrelevant items: Low-dominance items failed to produce forgetting and greatly reduced the incidence of source-monitoring error. Additionally, Experiments 3 and 4 confirmed that false recalls from categorically-related irrelevant sound were not

simply guesses as participants rate those recalls—with regard to whether or not they were originally visually presented as part of the TBR set—with higher levels of confidence as compared with control conditions where those items were not presented as irrelevant sound.

One problem with Experiments 3 and 4 was that there were too few intrusions in the control conditions to subject the confidence ratings to the statistical analysis necessary to investigate whether there are reliable differences for the meta-memory decision data between these conditions. This problem was solved in Experiment 5 whereby the level of false recall in the all conditions was boosted by using a delayed, cued-recall test. Results of Experiment 5 confirmed that source monitoring failure, as indicated by the confidence-ratings as to whether irrelevant-exemplars were presented visually as part to the TBR set during study, was indeed more common with between-sequence semantic similarity. Moreover, this experiment also demonstrated that the forgetting produced by between-sequence semantic similarity occurs over longer retention intervals. Finally, Experiments 3-5 also demonstrated that the presence of irrelevant sound, regardless of between-sequence semantic similarity, reduced confidence ratings that the exemplars recalled correctly were visually presented.

The foregoing experiments provide insight into the nature of the effects of irrelevant sound on category-exemplar recall tasks. For example, in this setting the disruption produced by irrelevant sound is qualitatively distinct from that in the serial recall setting in that it appears to be produced exclusively by the semantic, not acoustic, properties of the irrelevant stimuli. This argues against the idea of some form of ‘general distraction’ effect whereby any irrelevant sound disrupts performance on any focal task (e.g., Cowan, 1995; but see LeCompte, 1996) and furthermore implies that the acoustic and semantic properties of irrelevant sound in the context of category-exemplar recall do not appear to combine additively to determine forgetting (cf. Hughes & Jones, 2001). Such a finding also appears to indicate that serial, or rote, rehearsal is not usually involved in retaining TBR items in the category-exemplar recall task. However, that rote rehearsal is not involved does not mean that another kind of rehearsal, perhaps semantic or elaborative, is involved. Indeed, supposing that there is a rehearsal cohort in category-exemplar recall (cf. E. J. Marsh & Bower, 2004) that stabilizes, or becomes more automatized, over time

(e.g., Macken et al., 1999; Neath & Surprenant, 2001), one could explain the lower rate of false recall of related-items at test compared to presentation and encoding by assuming that, by virtue of its stability, the rehearsal cohort becomes less vulnerable over time to intrusion from irrelevant items. In support of this idea, it appears that a short period of quiet before retrieval in the presence of categorically-related irrelevant items can lead to better discrimination of what was TBR: when retrieval was without a retention period—as in Experiment 1b—there was still a greater number of related-item intrusions from the categorically-related irrelevant sound compared to control conditions, but this pattern did not emerge when the retention interval was present, as in Experiment 2.

The results reported here refute the structural notion of passive interference-by-similarity-of-content within a short-term or long-term store because the effect of between-sequence semantic similarity is task-process sensitive. A further, as yet unmentioned, result that also appears to undermine the classical, structural assumption is that relating to the degree of forgetting produced by between-sequence semantic similarity regardless of whether recall is delayed. On classical structural accounts (e.g., Glanzer & Cunitz, 1966; Glanzer, 1972; Postman & Phillips, 1965), delaying the recall phase should remove the relative influence of a hypothetical phonological short-term memory store or the use of short-term episodic memory such as that for serial order. As such, it can be reasoned that presenting a number of category lists in turn would lead to the short-term store being occupied by items from one category list independently of the others, thus when participants are cued for retrieval of the first list, output would be from a proposed long-term memory store whereby the semantic meaning of TBR items is held. If this were true, one would expect a greater between-sequence semantic similarity effect with delayed recall. The effect of between-sequence semantic similarity, however, is approximately the same in Experiment 3, with an 8 s delay as it is in Experiment 5 with a 6 min+ delay (between-sequence semantic similarity gives rise to a 18.6% reduction in performance with the short delay, and a 18.5% reduction with the 6min+ delay). This clearly undermines the notion that the two tasks are performed through differential use of two hypothetical stores with different properties.

Another account that also appears to be weakened by the findings reported in the present series is that of attentional capture (Cowan, 1995). On this account irrelevant

sound should give rise to orienting responses (OR) which capture attention away from the primary task regardless of nature of the focal task. A great deal of prior evidence (e.g., Jones et al., 1997; Tremblay & Jones, 1998), as well as that yielded by Experiments 1a and 1b where a general distraction effect was not found, argues against this explanation. Furthermore, it is possible that the attentional capture account would also predict an effect of between-sequence semantic similarity regardless of whether the focal task requires free, or serial, recall simply because between-sequence semantic similarity gives rise to ORs (based upon priming of semantic features, cf. Cowan, 1995). If this was the case, however, then it would be reasonable to suspect that between-sequence semantic similarity would ‘capture’ attention even when the task requires serial recall. That is, if the priming of semantic features is underpinned by automatic semantic priming (e.g., J. H. Neely, 1976) a between-sequence semantic similarity would be expected even when serial recall is emphasised because automatic semantic priming occurs ‘full blown’ regardless of the focal task (see J. H. Neely & Kahan, 2001; but see M. S. Brown, Roberts, & Besner, 2001).

The entirety of the findings outlined in the foregoing experiments cannot be explained by passive, structural, blocking theories (e.g., J. R. Anderson, 1983; Mensink & Raaijmakers, 1988; Rundus, 1973). The results of Experiment 2, for example, suggest against a blocking theory in demonstrating that the degree of false recall of irrelevant items did not influence the degree of forgetting. Moreover, the activation-blocking model, that attempts to explain forgetting through appealing to activation as a limited resource, suffers generally from a disaffection with the view of limited resources because it is not explained how a resource or resources are or become(s) limited (M. C. Anderson & Bjork, 1994; O. Neumann, 1987; see Hughes & Jones, 2005).

The results reported in Experiments 1-5 can be explained, in contrast to structural explanations, by a dynamic interference-by-process account (Hughes & Jones, 2005; Jones et al., 1996; Jones & Tremblay, 2000). More specifically, the compatibility of the findings reported in Experiment 1-5 with the interference-by-process account hinges upon the notion that forgetting is caused by the *process* of inhibition that resolves interference (Hughes & Jones, 2005). This view is derived from an account of ‘selectivity in long-term memory retrieval’ offered by M. C. Anderson and colleagues

(M. C. Anderson & J. H. Neely, 1996). According to this approach, high-dominance non-target items compete with list-exemplars for retrieval and an executive process of inhibition is required to prevent, or reduce, this competition. This inhibitory account readily explains the majority of findings reported using the category-exemplar recall task. For example, semantic activation of categorically-related, high-dominance, but not low-dominance, irrelevant items that are pre-experimentally more strongly related to the target category than the TBR list-exemplars could be considered as increasing the competition that those irrelevant items exert on the retrieval of lower-dominance list-exemplars. This increased competition requires the need for selectivity: selection must ensure that those activated irrelevant category-items are inhibited from retrieval (in other words the inhibition that is exercised as part of the executive control process during retrieval as standard is augmented by a voluntary or automatic inhibition during the presence of categorically-related irrelevant items). It seems reasonable to conclude that this requirement for selection (and thus inhibition) in the categorically-related irrelevant sound conditions, can confer a residual cost to the retrieval of related relevant exemplars perhaps due to spreading inhibition from the irrelevant-items to the TBR exemplars (e.g., A. S. Brown, 1979; E. Neumann & DeSchepper, 1992; E. Neumann, Cherau, Hood, & Steinnagel, 1993; Hutchinson, 2002; Lupiáñez, Rueda, Ruz, & Tudela, 2001; Martindale, 1981; Ortells & Tudela, 1996; Tipper & Driver, 1988; Walley & Weiden, 1973) or due to their “accidental inhibition” due to erroneous retrievals of irrelevant items (see M. C. Anderson & J. H. Neely, 1996). It is also possible that residual costs could also occur for the retrieval of unrelated relevant exemplars if one also considers that activated semantic representations of unrelated irrelevant category-items are also subject to inhibition.

This process-based, inhibitory account also explains the finding that between-sequence semantic similarity effects are task-process dependent (Experiment 3). Here, the emphasis on serial recall instruction would not require inhibiting active semantic representations because those representations may not compete for recall (order information in the context of serial recall, however, may be inhibited; see Hughes & Jones, 2003a). However, with free recall instructions where arguably retrieval is based somewhat on activated semantic representations, those activated representations must be inhibited because they compete for retrieval (M. C. Anderson, 2003).

An overarching account of the between-sequence semantic similarity findings with category-exemplar recall, however, requires inclusion of a source-monitoring process in addition to an inhibitory process. Prior evidence that two mechanisms (or processes) play a role in the category-exemplar recall task has been provided previously by Beaman (2004, Experiment 4) who demonstrated that participants with low, as compared with high, Working Memory Capacity demonstrated more false recall of related-items from speech in the category-exemplar recall task but demonstrated a comparable degree of forgetting. These findings are consistent with the notion that forgetting is produced by an inhibitory mechanism whilst false recall may be attributable to separate mechanism, shown here in Experiments 2-5 to be due to the fallibility of the source-monitoring process (but for evidence that false memories can be inhibited, see Balota et al., 1999; Bäuml, & Kuhbandner, 2003; Kimball & Bjork, 2002; Starns & Hicks, 2004; Watson, McDermott, & Balota, 2004; Watson, Bunting, Poole, & A. R. A. Conway, 2005).

In sum, the results reported in this series suggest that between-sequence semantic similarity produces overheads associated with the forgetting of relevant exemplars and the false recall of irrelevant items. Moreover, they support the notion that forgetting is functional and process-based rather than due to the structure or content of competing representations. It should be mentioned, however, that it is obvious that at some level the content of TBR and irrelevant items must drive the nature of the affected processes (in order to give rise to source-monitoring error and inhibition). The critical point, however, is that these results that at first glance appear to be interference-by-content may actually be ascribed to interference-by-process.

Chapter 3
EMPIRICAL SERIES 2:
INTERFERENCE BY PROCESS NOT INTERFERENCE BY CONTENT
DETERMINES AUDITORY-SEMANTIC DISTRACTION

3.1 ABSTRACT

Three experiments investigated auditory distraction during tests of memory for semantic information. Meaningful irrelevant speech disrupted the free recall of semantic category-exemplars regardless of whether the speech coincided with presentation, test, or both phases of the task (Experiment 6) but, importantly, only when instructions emphasised recall by category rather than by serial order (Experiment 7). Moreover, the disruption was greater when the irrelevant speech was semantically related to the TBR material but again only under category-recall instructions (Experiment 8). The results favour a functional, interference-by-process, approach rather than a structural, interference-by-content, approach to the breakdown of attentional selectivity.

3.2 INTRODUCTION

One of the key research questions relating to attentional selectivity is: Why does irrelevant information jeopardize goal-driven behaviour? Latterly, an *interference-by-process* approach to attentional selectivity (Hughes & Jones, 2005; Jones & Tremblay, 2000) has provided a framework within which a range of findings can be understood. The account holds that focal task processing—that demanded by the primary task—is compromised to the extent that irrelevant information is subject to a similar process. By this account, interference from the irrelevant information is the result of a conflict between two processes: one applied deliberately to the primary task, the other automatically to irrelevant material. Thus, the nature and extent of interference is a joint product of the character of the primary task and the nature of the potentially-distracting information. For instance, the interference-by-process approach has been very successful in providing an account of a number of findings in relation to the effect of background sound on serial recall (e.g., Hughes & Jones, 2005; Jones & Tremblay, 2000). The present series continues the attempt—initiated in Series 1—to apply the interference-by-process construct to auditory-semantic distraction again by using a short-term episodic retrieval task that involves semantic memory. The interference-by-process account suggests that distraction in the case of serial recall and with semantic focal tasks will be qualitatively distinct, but the available evidence on the matter is equivocal.

Studies of the effect of to-be-ignored auditory stimuli are a particularly apposite way of examining the interference-by-process approach. A major class of studies from which evidence about the impact of auditory distraction on cognitive performance has so far been gleaned is that concerned with the effects of irrelevant auditory stimuli on visual-verbal serial recall. Here, the processing of sound appears to be obligatory, particularly those processes associated with perceptual organization, resulting in easily replicable disruption of serial recall of substantial magnitude (for stability and effect size statistics, see Ellermeier & Zimmer, 1997). This classical ISE (e.g., Colle & Welsh, 1976; Salamé & Baddeley, 1982; Jones & Macken, 1993; Neath, 2000) is construed within an interference-by-process account as follows: The preattentive processing of sound generates serial order information (order cues) which conflicts with the processes

underpinning the primary, serial recall, task which also involves a serial organization process.

The interference-by-process approach avoids problems associated with the traditional view of some limited attentional capacity or attentional resource that imposes the need for selection (e.g., Cowan, 1995; Elliott, 2002; Neath, 2000; Page & Norris, 2003). Instead, the interference-by-process approach concedes that selection is the problem to be solved (not the solution) and limitations in performance (including susceptibility to disruption from irrelevant information) are the adaptive consequence of resolving that selection problem (Hughes & Jones, 2005; for an extensive discussion, see Allport, 1993; O. Neumann, 1996). Selection is needed to prevent (block or inhibit) other simultaneously competing information or processes from controlling behaviour (or action) at the expense of the relevant information or process (Hughes & Jones, 2005). Set against this process-based view of the ISE is a structuralist account (e.g., Gathercole & Baddeley, 1993; Neath, 2000; Salamé & Baddeley, 1982) which assumes that the ISE reflects a consequence of auditory stimuli gaining access to the same representational space as the TBR items (e.g., phonological store, Gathercole & Baddeley, 1993; primary memory, Neath, 2000). Here, the magnitude of the disruption is dictated by the structural similarity between the irrelevant and relevant items (henceforth dubbed ‘interference-by-content’). However, this approach has been undermined compellingly by research showing that the breakdown of attentional selectivity in the classical ISE is not determined by the structure (or content) of irrelevant auditory stimuli at the item-level. Neither the phonological characteristics of the sound nor the mere presence of semantic content in the irrelevant speech (e.g., words in English narrative; henceforth termed ‘meaningfulness’) dictate the magnitude of the disruption, nor does the phonological or semantic similarity between the to-be-attended and to-be-ignored events (Buchner et al., 1996; Jones & Macken, 1993; Jones et al., 1990; J. D. Larsen et al., 2000; Rouleau & Belleville, 1996; Salamé & Baddeley, 1982; but see Buchner et al., 2004; C. B. Neely & LeCompte, 1999). Rather, the degree of disruption is a joint product of the obligatory perceptual processing of the acoustic attributes of the sound and the goal-directed skill-based rehearsal processes involved in the primary task. Thus, these particular effects on

serial recall are only evident in tasks calling upon serial recall, not upon memory tasks generally (e.g., Beaman & Jones, 1997).

One confirmed prediction made by this interference-by-process account is that, as noted, the semantic content of the sound will have no influence on serial recall. However, there is a subset of studies in which the meaning of the irrelevant sound has been shown to be important (Beaman, 2004; Jones et al., 1990; R. C. Martin et al., 1988; C. B. Neely & LeCompte, 1999; Oswald et al., 2000; see also Chapter 2). However, it is possible that in these cases the tasks are not ones purely of serial recall in that they embody some degree of semantic processing and the results arising from them hence form a distinct class. This feature, not the mere presence of semantic content of the irrelevant sound, determines the “semantic” ISE. Thus, these cases may in fact be extensions of the general case of interference-by-process, that is, the disruption can be understood as a conflict between two semantic processes just as is the case with two serial processes in the classical case.

Evidence is suggestive of such an interpretation, but definitive support for it is lacking. Two previous studies (Beaman, 2004, Experiment 4; C. B. Neely & LeCompte, 1999, Experiment 2; see also Chapter 2) have demonstrated that tasks involving free-recall of semantically-rich word sequences are among those that are likely to be susceptible to disruption by the semantic character of irrelevant auditory material. However, in these studies, it is not clear whether semantic processing was the dominant, or only, means by which these tasks could be undertaken, and in no case was the interference-by-process account offered as a possible explanatory framework (cf. Chapter 2).

In the studies that follow these findings are extended and attempts to clarify the extent to which semantic processing is responsible for the degree of disruption by meaningful irrelevant sound are reported. A setting is used in which exemplars (e.g., “strawberry”, “pigeon”) from several semantic categories (e.g., “Fruit”, “Birds”) are presented for recall. It is well established that when a relatively long, semantically-categorizable list (‘categorizable’ in the sense that the list contains a number of exemplars from several semantic categories that are randomly organized during study and hence not ‘categorized’) is presented, participants tend to cluster the exemplars by semantic

category spontaneously (without instruction to do so) at a greater-than-chance level at test (e.g., Bousfield, 1953; Jenkins & Russell, 1952; A. P. Smith et al., 1981). This semantic category-clustering (henceforth termed “semantic-categorization”) implies *secondary organization* whereby participants bring to bear pre-existing conceptual relationships or semantic associations to guide encoding and retrieval of episodic information which is distinct from *primary organization* whereby the organization is veridical to the serial order of the list (Tulving, 1964, 1968; see also Howard & Kahana, 2002). The use of categorizable lists is considered to hold advantages over the use of list of words drawn from a single semantic category—such as those used in Series 1 of the present thesis—because: a) they are more likely to recruit semantic processes or reliance on semantic category knowledge as an organizational principle and b) they yield measures of semantic processing as reflected in the degree of semantic-organization of the responses produced at test. The purpose of the present study, therefore, was to examine whether the meaningfulness of irrelevant speech interferes with semantic organization and retrieval patterns for free-recall of categorizable word-lists.

3.3. EXPERIMENT 6

The first experiment examined whether greater disruption would be produced by meaningful compared with meaningless speech; an effect of English narrative is contrasted to the effect of the same narrative reversed. Reversing speech removes phonetic properties that allow lexical access, and thus semantic processing (Sheffert, et al, 2002). Given that the meaningfulness of speech does not influence the classical ISE in the context of serial recall, an effect of meaningfulness in the present context would imply that focal semantic processing is peculiarly susceptible to meaningful irrelevant speech, lending support to the interference-by-process account.

While it is acknowledged that encoding and retrieval processes involved in the processing of categorizable lists are inter-dependent—probably sharing overlapping, similar processes (e.g., Tulving & Thomson, 1973; Watkins & Tulving, 1975)—whether the irrelevant speech coincided with presentation or test (or both) was also manipulated

with a view to exploring whether encoding or retrieval was the most sensitive phase of the task.

3.3.1 Method

3.3.1.1 Participants

Seventy-two participants from Cardiff University took part in return for course credit. Each participant reported normal or corrected-to-normal vision and normal hearing and was a native English speaker. Participants were randomly assigned to one of three between-participants groups related to the timing of the exposure to irrelevant sound: Presentation-only, test-only, or presentation-and-test.

3.3.1.2 Apparatus and Materials

To-be-remembered material. Eight instances were chosen from each of 72 categories in the Yoon et al. (2004) norms in order to construct 18 lists of 32 words, each list having 4 categories. Categories chosen had minimal category-exemplar overlap, and exemplars and categories were not repeated between or within lists in order to diminish the effects of proactive interference (e.g., Craik & Birtwistle, 1971). The exemplars chosen were sampled outside of the 10 most frequently produced instances so as to reduce the likelihood that items could be recalled by simple free association or guessing (e.g., Shuell, 1969).

Categories were randomly assigned to each list but with the constraint that associated categories (e.g., “Flowers” and “Trees”) did not appear together. Category-exemplars within each list were arranged pseudo-randomly, so that no two members of the same category were presented adjacently and that each category was represented equally in each quarter of the list.

Irrelevant sound. The meaningful speech was English narrative taken from a political essay, recorded in a female voice and sampled with a 16-bit resolution, at a sampling rate of 44.1kHz using *Sound Forge 5* software (Sonic Inc., Madison, WI; 2000). The recording was reversed using *Sound Forge 5* to create meaningless speech. The speech in each of the irrelevant sound conditions was played to participants at 65-70 dB(A) via stereo headphones that were worn throughout the experiment. The forward speech recording, which was approximately 3 min 40 s, was split into two files, one to be

presented at encoding (1 min 40 s), and one to be presented at recall (2 min). These two files were then reversed independently. This process meant that exactly the same sounds would be presented when played at respective stages for the presentation-only and test-only group, as for the presentation-and-test group.

3.3.1.3 Design

A mixed design was used with one between- and one within-participant factor. The within-participant factor was ‘Sound Condition’ of which there were three levels: forward speech, reversed speech, and quiet. The between-participants factor was ‘Locus’ of which there were also three levels: presentation-only, test-only, and presentation-and-test. The 18 TBR lists were randomized but presented in a fixed order for each participant in each group. The sound conditions were randomized as follows: The 18 lists were divided into six blocks. In each block the three lists were randomly assigned to one of the three speech conditions. To control for order effects, the order of irrelevant speech conditions within each block was counterbalanced across participants such that the six possible orderings of conditions were encountered by an equal number of participants within each group.

3.3.1.4 Procedure

Participants were seated at a viewing distance of approximately 60 cm from a *PC* monitor on which category-exemplars were displayed in a central position. Lists of category-exemplars appeared in lower case black 72-point *Times New Roman* font one word at a time against a white background. Each word appeared for 2 s with an inter-stimulus interval of 1 s. Retrieval was immediate with the end of the list being notified by the visual appearance of a red ‘RECALL’ cue to initiate recall.

Participants were tested in small groups of six participants. Participants were seated in individual cubicles equipped with a *Samsung Syncmaster 171S PC* and display. They were informed that they would be presented with eighteen 32-word lists, and that each list would be presented one word at a time on the computer monitor from which they were asked to memorize as many words as possible and write the words they remembered down in the order which they recalled them on recall sheets when a ‘RECALL’ cue appeared on the screen. Recall sheets contained eighteen columns of thirty-two rows each. One practice trial was presented before the experimental trials. Participants were

not explicitly told that the lists were categorizable. Participants were informed that they would have 2 min to retrieve as much as they could of the list and that after this time a tone would sound to signal the beginning of the next list (some 5 s later). Participants were instructed to ignore any sound that they heard through the headphones and were told that they would not be tested on its content at any point in the experiment. The experiment lasted approximately 1 hr.

3.3.2 Results

3.3.2.1 Recall Measures

Recall measures came in three forms: the total number of exemplars correctly recalled, the mean total number of exemplars per category correctly recalled, and the number of categories recalled (contingent on recalling one word from a category). Each recall measure was analyzed using a 3×3 mixed analysis of variance (ANOVA) with sound condition (sound) as a within-participant variable and locus of sound presentation (locus) as the between-participants variable. Other types of response (e.g., intrusions) were so low as to defy statistical analysis.

Table 3.1 shows the results of the various recall measures in the three sound conditions. The ANOVAs for all recall measures failed to reveal significant sound \times locus interactions (all $p > .05$) indicating that the same pattern of results was found regardless of the locus of sound presentation. Section A of Table 3.1 shows the mean scores for the total number of items correctly recalled in each condition. These generally show that performance was better in quiet than reversed speech, which in turn was better than forward speech. An ANOVA confirmed a main effect of sound condition on the total number of category-exemplars correctly recalled, $F(2, 138) = 39.062$, $MSE = 1.625$, $p < .001$, with post hoc tests (Fisher's PLSD) revealing significant differences between quiet and reversed speech ($p < .001$), quiet and forward speech ($p < .001$) and between reversed and forward speech ($p < .001$). The same pattern of means was also evident when considering the number of items per category recalled (Section B of Table 3.1): Performance in quiet was better than in reversed speech, which in turn was better than in forward speech. An ANOVA revealed a main effect of sound on the number of exemplars recalled per category recalled, $F(2, 138) = 26.23$, $MSE = .098$, $p < .001$, with

post hoc tests (Fisher's PLSD) revealing significant differences between quiet and reversed speech ($p < .001$), quiet and forward speech ($p < .001$), and reversed and forward speech ($p < .005$). However, the pattern of results was different for the number of categories recalled (Section C of Table 3.1). Here, the means for performance in forward speech were lower than those for the reversed speech and quiet conditions, which in turn were similar to each other. An ANOVA revealed a main effect of sound on the number of categories recalled, $F(2, 138) = 14.946$, $MSE = .030$, $p < .001$. However, in contrast to the other recall measures, post hoc testing (Fisher's PLSD) revealed significant differences between quiet and forward speech ($p < .001$), and between reversed and forward speech only ($p < .001$).

Sound Condition	Presentation Only	Test Only	Presentation & Test
	Mean (SD)	Mean (SD)	Mean (SD)
<u>A) Total Number of Category-Exemplars Correctly Recalled:</u>			
Quiet	15.41 (3.26)	15.29 (2.73)	15.92 (2.75)
Reversed Speech	14.38 (2.87)	14.59 (3.15)	15.25 (3.16)
Forward Speech	13.52 (3.32)	13.51 (2.75)	13.85 (3.20)
<u>B) Number of Exemplars Recalled Per Category Correctly Recalled:</u>			
Quiet	4.07 (0.66)	4.05 (0.59)	4.28 (0.63)
Reversed Speech	3.91 (0.57)	3.87 (0.69)	3.99 (0.72)
Forward Speech	3.72 (0.71)	3.75 (0.62)	3.75 (.072)
<u>C) Number of Categories Correctly Recalled:</u>			
Quiet	3.77 (0.29)	3.76 (0.18)	3.74 (0.24)
Reversed Speech	3.65 (0.28)	3.74 (0.30)	3.81 (0.22)
Forward Speech	3.61 (0.31)	3.59 (0.28)	3.64 (0.27)
<u>D) Z Scores:</u>			
Quiet	3.28 (1.24)	3.82 (1.18)	3.70 (1.32)
Reversed Speech	3.27 (0.96)	3.66 (1.28)	3.53 (1.40)
Forward Speech	2.95 (1.08)	3.30 (1.27)	3.19 (1.41)

Table 3.1 Mean recall and clustering measure as a function of irrelevant sound condition and locus of sound presentation in Experiment 1.

3.3.2.2 Clustering Measure

Whilst there are several potential ways of measuring semantic-categorization (for a review, see Murphy, 1979), the present analyses was restricted to the Z score (Frankel & Cole, 1971; Hudson & Dunn, 1969). These were calculated with all repeat and intrusion errors removed. Section D of Table 3.1 shows the mean clustering measure for each sound condition. The Z score means are lower in both sound conditions than in the quiet condition, and lower in the forward speech compared to reversed speech condition. An ANOVA confirmed a main effect of sound on Z scores, $F(2, 138) = 13.472$, $MSE = .299$, $p < .001$, but no sound \times locus interaction ($p > .05$). Follow-up post hoc tests (Fisher's PLSD) revealed significant differences between quiet and forward speech ($p < .001$), and between reversed and forward speech ($p < .005$), but not between quiet and reversed speech ($p > .05$). Thus, forward speech reduced the level of semantic-categorization as measured by the Z score.

The results of the recall measures, and the Z score clustering measure, suggest that there is an impairment to semantic free recall tasks that is attributable to the meaningfulness of irrelevant speech, given that semantic content is the principal difference between the forward and reversed speech conditions. There is, however, some degree of disruption produced by reversed speech that is not easily explained if the free recall task engaged a purely semantic processing retrieval strategy: reversed speech without semantic content should fail to produce disruption. One possibility is that this is an effect on the serial component of recall. When participants are instructed to free recall, they may adopt a serial rehearsal strategy, at least in part (e.g., Beaman & Jones, 1998). Several analyses that measure whether participants preserved input-order were performed but for the sake of brevity (and because each measure produced the same outcome) only one is detailed here.

3.3.2.3 Seriation Measure

The pair-wise associations test was adopted as the seriation measure because this is the most lenient of the seriation measures (see Beaman & Jones, 1998; Nairne et al., 1991). Original input order was maintained at above chance levels in the quiet condition, $t(71) = 4.34$, $p < .001$, reversed speech condition, $t(71) = 5.45$, $p < .001$, and the forward speech condition, $t(71) = 2.94$, $p < .01$. An ANOVA, however, failed to find a main effect

of sound on the amount of pair-wise information retained ($p > .1$, quiet = .526, reversed speech = .528, forward speech = .519) and there was also no interaction with locus ($p > .05$). Thus, although participants were using some degree of seriation, this appeared unaffected by the presence of irrelevant speech.

3.3.2.4 Supplementary Experiment

In order to check on what effect the irrelevant materials used in Experiment 6 would have on serial recall, a supplementary experiment was undertaken, one not reported in full here for economy of exposition, that involved a standard visually-presented serial recall task (for a procedure, see Hughes & Jones, 2005) with the irrelevant sound stimuli used in Experiment 6. A within-participant design was used with 18 participants from the same population as Experiment 6. This supplementary experiment revealed no effect of meaning thus replicating Jones et al. (1990) with the particular materials used in Experiment 6: The mean probability of correct recall, marked with the strict serial recall criterion and collapsed across serial position, did not differ between the reversed speech condition ($M = .67$, $SD = .13$) and the forward speech condition ($M = .66$, $SD = .11$), but both these means were significantly lower than those in the quiet condition ($M = .78$, $SD = .12$; $p < .001$).

3.3.3 Discussion

Experiment 6 investigated whether the meaningfulness of irrelevant speech could interfere with the free recall of semantically-categorizable lists. The results clearly confirmed this to be the case: Whilst both irrelevant speech conditions decreased the overall number of exemplars recalled, and the number of exemplars recalled by category, meaningful irrelevant speech was more disruptive and, unlike meaningless speech, also produced disruption to the number of categories recalled and the degree of semantic-categorization demonstrated in the free recall protocols. These effects were found regardless of the locus of irrelevant speech presentation within the task. A supplementary experiment (see Section 3.3.2.4) showed that the effect of meaningfulness in Experiment 6 did not arise due to the presence of semantic content in the speech per se. Rather, the effect of meaningfulness appears better explained as a conflict of semantic processing that emerges when the primary task required a degree of such processing. The best

indication of an impairment of semantic processing produced by the meaningful irrelevant speech is that meaningful speech produces a reduction in the semantic categorization of the TBR material and also reduces the number of categories recalled: both these recall measures are thought to reflect semantic or “relational” processing (Basden, Basden, Bryner, & Thomas, 1997; Burns & C. A. Brown, 2000; Hunt & McDaniel, 1993; Hunt & Seta, 1984). The reduction in the number of categories reflects, possibly, a failure to establish adequately, or use at retrieval, higher-order semantic encodings that can be used as a retrieval plan for enabling inter-category transitions (e.g., Bower, Clark, Lesgold, & Winzenz, 1969). One of these semantic encoding strategies might involve forging some kind of semantic association between category-exemplars (e.g., “pigeon”, “chisel”) or categories (e.g., “Birds”, “Tools”) where pre-experimentally there is none (cf. Wingfield, Kahana, & Linfield, 1998). There is also the possibility that the meaningful speech impairs semantic generation of category-names or exemplars during encoding or retrieval (see Chapter 4).

That irrelevant speech disrupts performance regardless of its locus of presentation is interesting for two reasons. First, that the same effect occurs at test as at presentation, and presentation and test, suggests that the impairment is not entirely due to a problem related to encoding or retention (and hence the availability of the exemplars) because the encoding of list-exemplars should, having taken place in quiet, be unaffected by the sound during test. The problem at test, therefore, appears to be a form of disruption related to accessibility, perhaps caused by the forgetting of, or impairment in generating, semantic retrieval cues. Second, because the duration of exposure to sound was less in the presentation-only and test-only group than in the presentation-and-test group, the disruption appears to be independent of token-dose (Bridges & Jones, 1996). Why did the presentation-and-test condition fail to exhibit greater disruption to performance than when the sound was confined to either presentation or test? One possibility is that whatever disadvantage might have been evident due to the greater token-dose in the presentation-and-test condition, this disadvantage may have been offset by an advantage conferred by the contextual similarity across study and test in this condition (e.g., S. M. Smith, 1985).

At first glance, it is surprising that meaningless irrelevant speech produces any disruption at all to the semantic free recall task: According to the interference-by-process approach, reversed speech, lacking semantic content, should not compete for the semantic processes involved in performing the free recall task. However, the task is unlikely to be process-pure (for a related discussion in a different context, see Jacoby, 1991). If so, meaningless speech might interfere with the seriation component not the semantic-categorization component, whilst meaningful speech could interfere with both semantic-categorization and seriation. Although the analysis concerning whether seriation was used and disrupted by irrelevant speech yielded negative results, it is possible that the analysis was simply too insensitive to detect disruption of seriation by irrelevant speech. In Experiment 7, therefore, the question of whether irrelevant speech is disruptive of seriation and semantic categorization was addressed further by changing the emphasis on these components using instruction.

3.4. EXPERIMENT 7

In an attempt to better separate the relative influences of semantic and serial organization strategies a task-instruction manipulation was used (Perham & Jones, 2006; Weist & Crawford, 1973): By instructing one group of participants to recall in serial order, and another to recall by category, the degree to which different characteristics of irrelevant speech used in Experiment 6 are disrupting a given retrieval strategy can be assessed.

If the effects of the meaningfulness of speech in Experiment 6 are due to semantic processing of the TBR material, then it would be expected that semantic effects of irrelevant speech will be found when participants are instructed to retrieve the TBR material according to semantic-category but not when instructed to recall in serial order. Shorter lists (16-exemplars) were used than in Experiment 6 to facilitate the instructed use of a serial recall strategy.

3.4.1 Method

3.4.1.1 Participants

Thirty-six individuals from Cardiff University (none of whom took part in Experiment 6) participated for course credit. Each reported normal hearing and normal or corrected-to-normal vision and was a native English speaker. Participants were randomly assigned to one of the between-participants groups: semantic-categorization or seriation instructions.

3.4.1.2 Apparatus and Materials

These were similar to Experiment 6 with the following exception: Four single-word exemplars were chosen from the 11th to 14th most frequently produced responses for each of the 72 categories chosen from the Yoon et al. (2004) norms. These were combined as in Experiment 1 to create 18 lists of 16 words each, each list having 4 categories.

3.4.1.3 Design

A mixed design was used with one between- and one within-participant factor. The between-participants factor was 'Task Instruction' of which there were two levels: semantic-categorization and seriation. The within-participant factor was 'Sound Condition' as in Experiment 6.

3.4.1.4 Procedure

The procedure was the same as Experiment 6 apart from the following: Participants were informed that they would be presented with a total of 18 lists of words that each contained 16 exemplars, 4 from each of 4 different semantic categories. Participants given semantic-categorization instructions were asked to try to remember as many words as possible by semantically-categorizing them and writing them down according to their categories when the RECALL cue appeared: Participants were told to write down the exemplars in the order that they came to mind, and to attempt to recall all the exemplars they could remember from one category, exhausting that category, before moving on, and doing the same with the next category and so on. They were also told that if they could remember any individual words after the semantic-category clusters they should write them at the end of the clusters.

Participants given seriation instructions were instructed to try and remember the words in their original order of presentation and to recall each exemplar by assigning it to

its original serial position when the RECALL cue appeared. To maximise the level of exemplar recall, participants in the seriation group were instructed that they could leave gaps if necessary but were also told that if they had a list-exemplar available to them for recall, but could not remember the position, that they should guess the original position.

Recall sheets contained eighteen columns of sixteen rows each. Participants given seriation instructions were given specially prepared recall sheets with serial positions marked on them, whilst the group instructed to categorize had the same recall sheets but without the serial positions marked. Participants were explicitly instructed to ignore any sound that they might hear during the task. Sounds were presented throughout the presentation and test phases. Because the list length was halved for this experiment the retrieval time allotted for each list was, on this occasion, 1 min.

3.4.2 Results

3.4.2.1 Recall Measures

Recall measures are distinguished as in Experiment 1. Section A of Table 3.2 shows the total number of category-exemplars recalled. Performance in quiet is clearly superior to performance in the speech conditions. Consistent with the interference-by-process approach, performance in forward speech was poorer than that in reversed speech for the semantic-categorization but not the seriation group.

A 3 (sound) \times 2 (instructions) ANOVA confirmed a main effect of sound, $F(2, 68) = 69.31$, $MSE = .655$, $p < .001$. There was no main effect of task instruction ($p > .05$). However, there was a significant interaction between sound and task instruction, $F(2, 68) = 14.76$, $MSE = .655$, $p < .001$, whereby the disruptive effects of meaningfulness arose when the retrieval strategy required semantic-categorization but not when it required seriation.

Simple effects analyses (LSD) revealed significant differences between quiet and the reversed and forward speech conditions for semantic-categorization and seriation instructions ($p < .001$). Additionally, there was a significant difference between reversed and forward speech for the semantic-categorization group only ($p < .001$). The simple effects analyses also revealed that recall performance for the semantic-categorization

group exceeded that of the seriation group in the quiet condition and the reversed speech condition (both $p < .05$).

Sound Condition	Categorization Mean (SD)	Seriation Mean (SD)
A) <u>Total Number of Category-Exemplars Correctly Recalled:</u>		
Quiet	10.40 (2.00)	8.93 (2.09)
Reversed Speech	9.33 (1.82)	7.74 (1.71)
Forward Speech	7.29 (1.76)	7.55 (1.80)
B) <u>Number of Exemplars Recalled Per Category Correctly Recalled:</u>		
Quiet	2.84 (0.34)	2.24 (0.50)
Reversed Speech	2.54 (0.23)	1.95 (0.43)
Forward Speech	2.38 (0.35)	1.92 (0.42)
C) <u>Number of Categories Correctly Recalled:</u>		
Quiet	3.75 (0.10)	3.99 (0.04)
Reversed Speech	3.69 (0.56)	3.97 (0.12)
Forward Speech	2.98 (0.46)	3.96 (0.12)
D) <u>Seriation Scores:</u>		
Quiet	0.54 (0.05)	0.90 (0.05)
Reversed Speech	0.51 (0.07)	0.87 (0.10)
Forward Speech	0.51 (0.07)	0.88 (0.08)

Table 3.2 Mean recall and seriation measures as a function of irrelevant sound condition and task-instruction in Experiment 7.

The mean number of exemplars recalled per category recalled can be seen in Section B of Table 3.2. In general, this was greater for the semantic-categorization than seriation instructed group, and less in the speech conditions than the quiet condition. The means were also higher for the reversed, relative to forward, speech condition. An ANOVA on these means revealed a main effect of sound $F(2, 68) = 29.84, MSE = .050, p < .001$, and a main effect of task-instruction, $F(1, 34) = 22.88, MSE = .351, p < .001$, but no interaction between sound and task instruction ($p > .05$). Post hoc tests (Fisher's PLSD) revealed significant differences between quiet and reversed speech, and quiet and forward speech (both $p < .001$). The difference between reversed and forward speech also approached significance ($p = .068$). Other types of recall response (e.g., intrusions) were, as in Experiment 6, so low as to defy statistical analysis.

Section C of Table 3.2 shows the mean number of categories recalled. In general, category recall was better for seriation than semantic-categorization. For the semantic-categorization group, fewer categories were recalled in the forward speech compared to reversed speech and quiet conditions. Interpretation of this particular aspect of the results is complicated by the fact that the number of categories recalled was at ceiling in the seriation group. The reason for this is that recalling the first four presented exemplars in their original presentation positions (as is required under seriation instruction) would guarantee category recall for all categories represented on the TBR lists. Despite this complication, the pattern of results for the semantic-categorization group appears to be consistent with Experiment 6: Meaningful speech, as compared with meaningless speech, disrupted the number of categories correctly recalled. Confirming this, an ANOVA restricted to the semantic-categorization group revealed a main effect of sound on the number of categories recalled, $F(2, 34) = 58.96, MSE = .056, p < .001$, with post hoc tests (Fisher's PLSD) revealing significant differences between quiet and forward speech and between reversed and forward speech (both $p < .001$).

3.4.2.2 Clustering Measure

The mean Z scores were lower in the reversed speech ($M = 2.70, SD = 0.75$) and forward speech ($M = 1.81, SD = 0.76$) conditions compared to the quiet condition ($M = 3.13, SD = 0.78$) and were lower in the forward compared to reversed speech conditions. An ANOVA revealed a main effect of sound on Z scores, $F(2, 34) = 57.33, MSE = .141$,

$p < .001$. Post hoc testing (Fisher's PLSD) revealed significant differences between quiet and reversed speech, and between quiet and forward speech ($p < .001$). There was also a significant difference between reversed and forward speech ($p < .005$). Thus, the degree of semantic-organization was impaired by meaningful speech as compared with meaningless speech.

3.4.2.3 Seriation Measure

The pairwise association scores can be observed in Section D of Table 3.2. Generally it is evident that seriation scores were greater with seriation than with semantic-categorization instructions. Seriation scores were also lower in the sound conditions even for the categorization group, but this did not appear to be influenced by the meaningfulness of irrelevant speech. An ANOVA revealed a main effect of sound on pairwise association scores, $F(2, 68) = 4.91$, $MSE = .003$, $p = .01$, and a main effect of task-instruction, $F(1, 34) = 334.01$, $MSE = .011$, $p < .001$, but no interaction between these two variables, ($p > .05$). Post hoc testing (Fisher's PLSD) revealed significant differences between quiet and reversed speech ($p < .005$) and between quiet and forward speech ($p < .05$). It thus appears that seriation is disrupted both during categorization and seriation strategies which may explain why reversed speech had a disruptive effect in Experiment 6.

3.4.3 Discussion

Experiment 7 revealed that semantic effects of irrelevant speech—in terms of its meaningfulness—appear to be process- rather than content-sensitive. The semantic processing of irrelevant speech seems to interfere only when the primary task requires semantic processing. Consistent with Experiment 6, meaningful speech, as compared with meaningless speech, produced greater disruption to the total number of exemplars recalled, and it also produced semantic interference that was specific to the number of categories recalled and the degree of semantic-categorization demonstrated in the recall protocols. The results so far, therefore, provide further support for the interpretation of auditory distraction as process-based (e.g., Jones & Tremblay, 2000) as opposed to structural or content-based (e.g., Gathercole & Baddeley, 1993; Neath, 2000).

One surprising, but illuminating, finding from Experiment 7 was that seriation appeared to contribute to some degree to the semantic-categorization strategy and that this element of seriation is reduced by irrelevant speech. This result appears to support the notion that a number of processes operate simultaneously when encoding and/or retrieving semantically-categorizable lists (e.g., Ashcraft, Kellas, & Keller, 1976; Pellegrino & Battig, 1974) and that seriation and semantic-categorization may not necessarily be incompatible (cf. Postman, 1972; Wetherick, 1975, 1976) and are probably interlaced. That seriation contributes even when a semantic-categorization strategy is adopted meshes neatly with the finding that meaningless speech exerts a disruptive effect: this can be interpreted as the apparition of a classical ISE whereby processing serial order in the primary task is susceptible to disruption from preattentive processing of order yielded by meaningful and meaningless irrelevant speech alike.

3.5 EXPERIMENT 8

The results reported thus far in this series of experiments are generally consistent with the notion that the semantic processing required by the primary task can be disrupted by semantic processing of the irrelevant speech. In Experiment 8 the interference-by-process account is once again scrutinized. This is done so this time not by manipulating the meaningfulness of the speech per se but rather its semantic similarity to the TBR exemplars (see also Chapter 3). When irrelevant items and TBR category-exemplars are drawn from the same semantic category (e.g., “Birds”), high-dominance irrelevant items (‘robin,’ ‘sparrow’) as plausible retrieval candidates, can be considered to compete with the TBR exemplars (e.g., “finch,” “duck”) for retrieval (e.g., M. C. Anderson & Bjork, 1994). Thus, an executive, inhibitory process must be initiated to avoid selecting the irrelevant items. An effect attributable specifically to between-sequence semantic similarity could thus be explained not as due to the similarity between the content of TBR and irrelevant items, but as due to the result of functional, selective attention processes that act to inhibit highly compatible responses from being retrieved (see M. C. Anderson, 2003). This suggests that between-sequence semantic similarity should be disruptive when the process involved in the primary task requires semantic processing, but not when

the process involves serial rehearsal. In Experiment 8, support for this process-based interpretation of between-sequence auditory-semantic distraction was sought by manipulating task-instructions (as in Experiment 7) as well as between-sequence semantic similarity. If between-sequence semantic similarity impairs semantic-categorization, but not serial recall, then this result would again favor a process-based, as opposed to a content-based, account of auditory distraction.

3.5.1 Method

3.5.1.1 Participants

Sixty participants from Cardiff University took part in Experiment 8. None had taken part in Experiments 6 or 7. Each participant reported normal hearing and normal or corrected-to-normal vision and was a native English speaker. Participants were randomly assigned to one of the between-participants groups: semantic-categorization or seriation instructions.

3.5.1.2 Apparatus and Materials

These were similar to Experiment 7 with the following differences: Eight exemplars were chosen from each of 60 categories in the Van Overschelde, Rawson, and Dunlosky (2004) norms. The 4 highest-dominant items from each category were used for the irrelevant items, whilst the TBR exemplars were chosen from the 11th to 14th positions. The 60 categories were sorted into 12 pools of 5 categories between which there was no obvious semantic relation. For the related trials, the category presented as sound matched one of the 4 categories represented in the TBR list. For the unrelated trials, the sound consisted of the category in each pool that was not represented on the TBR list. The presence of any given category as part of the TBR list and related and unrelated sound was counterbalanced between participants. This procedure resulted in the construction of 12 categorized lists, 4 to be used for each of the related, unrelated and quiet conditions.

3.5.1.3 Design

A mixed design was used with one between- and one within-participant factor. The between-participants factor was task instruction as in Experiment 7. The within-participants factor was 'Irrelevant Sound Relatedness' of which there were three levels:

1) Speech categorically-unrelated to the TBR material; 2) categorically-related speech; and 3) quiet.

3.5.1.4 Procedure

The procedure was the same as Experiment 2 with the exception of the following: Participants were informed that they would be presented with a total of 12 lists of words that each contained a total of 16 exemplars, 4 from each of 4 different semantic categories, and response sheets contained 12 columns of 16 rows each.

3.5.2 Results

3.5.2.1 Recall Measures

Recall measures are the same as in Experiments 6 and 7. Section A of Table 3.3 shows the total number of category-exemplars recalled. It is evident that performance in both speech conditions was poorer than quiet regardless of task-instruction. Moreover, performance in related speech was poorer than performance in unrelated speech for the semantic-categorization, but not the seriation, group. A 3 (sound) x 2 (instructions) ANOVA confirmed a main effect of sound, $F(2, 116) = 37.74$, $MSE = .781$, $p < .001$, and task-instruction, $F(1, 58) = 7.66$, $MSE = 5.2$, $p < .01$, and an interaction between these variables, $F(2, 116) = 3.94$, $MSE = .78$, $p < .05$. Simple effects analyses (LSD) revealed that, regardless of task-instruction condition, there were significant differences between quiet and unrelated speech ($p < .001$) and between quiet and related speech ($p < .001$). Additionally, there was a significant difference between the unrelated and related speech conditions but only for the semantic-categorization group ($p < .01$). This analysis also revealed that recall performance for the semantic-categorization group exceeded that of the seriation group in the quiet condition ($p < .001$), and the unrelated speech condition ($p < .05$).

To summarize the results for the total number of category-exemplars recalled, generally more category-exemplars were retrieved with semantic-categorization compared with seriation instructions, and disruptive effects of semantic similarity arose only when the retrieval strategy required semantic-categorization.

Sound Condition	Categorization	Seriation
	Mean (SD)	Mean (SD)
A) <u>Total Number of Category-Exemplars Correctly Recalled:</u>		
Quiet	9.89 (1.16)	8.54 (1.27)
Unrelated Speech	8.72 (1.27)	7.68 (1.61)
Related Speech	8.09 (1.91)	7.64 (1.30)
B) <u>Number of Exemplars Recalled Per Category Correctly Recalled:</u>		
Quiet	2.53 (0.28)	2.17 (0.36)
Unrelated Speech	2.51 (0.30)	1.94 (0.39)
Related Speech	2.33 (0.39)	1.92 (0.32)
C) <u>Number of Categories Correctly Recalled:</u>		
Quiet	3.93 (0.27)	3.95 (0.12)
Unrelated Speech	3.48 (0.35)	3.97 (0.09)
Related Speech	3.45 (0.42)	3.98 (0.01)
D) <u>Seriation Scores:</u>		
Quiet	0.53 (0.08)	0.91 (0.05)
Unrelated Speech	0.48 (0.10)	0.84 (0.08)
Related Speech	0.48 (0.08)	0.82 (0.09)

Table 3.3 Mean recall and seriation measures as a function of irrelevant sound condition and task-instruction in Experiment 3.

The mean number of exemplars recalled per category recalled is shown in Section B of Table 3.3. In general, this was greater for the semantic-categorization than seriation

instructed group, and was smaller in the speech conditions than in the quiet condition. Moreover, the means in the related speech condition were lower than those in the unrelated speech condition. An ANOVA on these data revealed a main effect of sound, $F(2, 116) = 15.86$, $MSE = .046$, $p < .001$, and also a main effect of group, $F(1, 58) = 34.05$, $MSE = .261$, $p < .001$, and an interaction between these variables, $F(2, 116) = 4.05$, $MSE = .046$, $p < .05$. Simple effects analyses (LSD) revealed significant differences between quiet and unrelated speech ($p < .001$), and quiet and related speech ($p < .001$) but not between unrelated and related speech ($p > .05$) for the seriation group. For the semantic-categorization group, there were significant differences between quiet and related speech ($p = .001$), and between unrelated and related speech conditions ($p < .005$).

Section C of Table 3.3 shows the mean number of categories recalled. In general, category recall was better for seriation than semantic-categorization. For the semantic-categorization groups there was a loss of categories in the speech conditions which was evident for both the unrelated and related speech conditions. As with Experiment 2 there was a ceiling effect for the number of categories recalled in the seriation group thus again the analysis was restricted to the semantic-categorization group. An ANOVA revealed a main effect of sound on the number of categories recalled, $F(2, 58) = 25.81$, $MSE = .082$, $p < .001$, with post hoc tests (Fisher's PLSD) revealing significant differences between quiet and unrelated speech, and quiet and related speech ($p < .001$) but not between unrelated and related speech conditions ($p > .05$).

An intriguing question with regard to Experiment 8 is this: Is the additional disruption produced by related speech in the categorization group attributable to an impairment specific to the recall of the category that matches the irrelevant items in that condition? To examine this, the number of category-exemplars recalled per category was averaged across the three categories that did not match the irrelevant items and these means were compared with the mean number of exemplars recalled from the category that did. The resulting means were 2.34 ($SD = .41$) for the non-matching categories and 2.27 ($SD = .53$) for the matching category. A paired t -test revealed the impairment was not specific to the recall of that category ($p > .05$). Thus, there was no disruption specific to the retrieval of TBR category-exemplars that matched the irrelevant items.

Intrusions were much lower than that reported in the between-sequence semantic similarity experiments of Series 1 of the current thesis. The mean number of intrusions that matched one of those presented as irrelevant sound (related-item intrusions) was .38 ($SD = .58$) for quiet, .33 ($SD = .48$) for unrelated speech and .42 ($SD = .50$) for related speech for the semantic-categorization group, and for the serial recall group the means were .21 ($SD = .41$) for quiet, .25 ($SD = .44$) for unrelated speech and .25 ($SD = .53$) for related speech. These mean numbers of intrusions were too low to subject to statistical analysis but examination of the means suggests that, unlike reported in Series 1, between-sequence semantic similarity did not appear to influence the degree of intrusion of irrelevant items (or induce source-monitoring errors to a great degree). This difference between the results of Experiment 8 as compared with the experiments presented in Series 1 may be attributable to methodological differences (see section 5.3.1.2 of the General Discussion)

3.5.2.2 Clustering Measure

The mean Z scores were lower in the unrelated speech ($M = 2.61$, $SD = 0.79$) and related speech ($M = 2.33$, $SD = 0.94$) conditions than in the quiet condition ($M = 3.15$, $SD = 0.66$) and also appeared to be lower in the related compared to unrelated speech condition. An ANOVA revealed a main effect of sound on Z scores, $F(2, 58) = 19.15$, $MSE = .274$, $p < .001$. Post hoc testing (Fisher's PLSD) revealed significant differences between quiet and unrelated speech ($p < .001$), quiet and related speech ($p < .001$), and between unrelated and related speech ($p < .05$). Thus the degree of semantic-categorization was impaired by both unrelated and related speech, with greater impairment produced by related, in comparison to unrelated, speech.

3.5.2.3 Seriation Measure

The pairwise association scores can be seen in Section D of Table 3.3. Generally, these seriation scores were greater for the seriation instruction group in comparison to semantic-categorization instruction group. Seriation scores were also lower in the sound conditions but this did not appear to be influenced by between-sequence semantic similarity. An ANOVA revealed a main effect of sound, $F(2, 116) = 12.96$, $MSE = .005$, $p < .001$, a main effect of instructions $F(1, 58) = 690.32$, $MSE = .008$, $p < .001$, but no interaction between these variables, $p > .05$. Post hoc testing (Fisher's PLSD) revealed

significant differences between quiet and the two speech conditions (both $p < .001$). This result, coupled with that of Experiment 7, suggests that seriation is disrupted during both categorization and seriation strategies.

3.5.3 Discussion

Whilst replicating the key features of Experiment 7, Experiment 8 also adds to the few findings that have demonstrated between-sequence semantic similarity effects in semantic free recall tasks (Beaman, 2004; C. B. Neely & LeCompte, 1999; see also Chapters 2 and 4). The results confirmed that between-sequence semantic distraction occurs only when semantic processing is part of the retrieval strategy (see also Chapter 2 and 4). Such a finding harmonizes with the notion that the impairment produced by between-sequence semantic similarity is better explained in terms of a process-oriented approach than by a content-based approach to auditory distraction. Indeed, one finding that appears particularly supportive of the process-based view is the lack of category-specific impairment within the between-sequence semantic similarity effect for the semantic-categorization group. That is, the disruption produced by irrelevant items that matched one of the TBR categories was not confined to that matching category (for category-specific impairment in a different context, see Mueller & Watkins, 1977; Watkins & Allender, 1987). If disruption was somehow produced as a passive side-effect of the structural similarity of irrelevant and TBR items within a representational space (e.g., Gathercole & Baddeley, 1993; Neath, 2000), then a category-specific impairment might have been expected.

A process-oriented interpretation of the non-category specific impairment produced by between-sequence semantic similarity can be outlined as follows: If one assumes that the items presented as irrelevant speech in the related condition are consistently reactivating irrelevant information that is semantically-related to part of the TBR material then disruption to retrieval is likely to occur. More specifically, in order to retrieve categorizable lists successfully (regardless of the presence of irrelevant speech) participants must somehow 'disengage' from processing, or retrieving, one given category to initiate retrieval of the next. Such disengagement may be compromised by related irrelevant speech that consistently activates, or reactivates, a previously recalled,

or impending (to-be-recalled) category, leading to that category competing with the other list-categories for recall. Because of this, it is possible that a greater degree of inhibition is required to avoid returning to a category, or initiating recall of a new category when one has not yet been exhausted. Impairment in recalling exemplars from the categories that do not match the irrelevant speech can thus be thought of as a cost of the requirement to resolve this competition through the process of inhibition. One further reason as to why there is no impairment specific to the category matching that represented by the irrelevant speech is that the task encourages integration of categorically-related to-be-recalled exemplars (e.g., by way of forming inter-item associations). Such integration is a well-known boundary condition in reducing inhibition of exemplars specific to a semantic category (M. C. Anderson & McCulloch, 1999).

3.6 GENERAL DISCUSSION

The results of the current series can be summarized as follows: Experiment 6 demonstrated that the meaningfulness of irrelevant speech produces greater disruption to the free recall of categorizable word lists than meaningless speech, regardless of the locus of speech presentation. This experiment also revealed that the pattern of semantic interference shows a unique characteristic; it affects the recall of categories as well as the degree of semantic-categorization demonstrated at test. A supplementary experiment demonstrated (see Section 3.3.2.4) that this effect of meaningfulness is unlikely to be produced by the semantic content capturing attention away from the primary task because there was no effect attributable to the meaningfulness of speech on the serial recall task. Experiments 7 and 8 revealed that effects of meaningfulness, and of between-sequence semantic similarity, are found only when semantic-categorization is adopted by the participant and not when serial order is used as an organizing strategy. However, these experiments did reveal that seriation was, at least to some extent, involved in the primary task, and that this was disrupted by the irrelevant speech. Experiment 8 revealed that between-sequence semantic similarity produces additional disruption to the total number of exemplars recalled, the number of exemplars per category recalled and the degree of semantic-categorization observed but has no effect on the amount of categories recalled.

The results of all the experiments reported here can be accounted for within the interference-by-process approach to attentional selectivity (Hughes & Jones, 2005; Jones & Tremblay, 2000). The interference-by-process view holds that in the case of the classical ISE the processing of serial order in the sound is in conflict with the processing of serial order in the primary task. This approach explains why neither the meaningfulness of irrelevant speech nor between-sequence semantic similarity plays a role in the disruption when serial recall is instructed (Experiments 7 and 8): In this case it is the information that the irrelevant sound yields about serial order, not its meaning, that conflicts with the serially ordering of information in the focal task.

The interference-by-process approach also explains why the meaning of speech becomes disruptive to the performance of free recall tasks only when semantic processing or semantic-categorization is an obvious or instructed strategy (Experiments 6, 7, and 8). When the primary task involves semantic-categorization, or semantic retrieval processes—unlike the case with serial recall—processing the irrelevant semantic information disrupts focal task performance.

One potentially problematic finding for the interference-by-process approach is that meaningless irrelevant speech disrupted recall of categorizable lists when semantic-categorization was either spontaneously adopted (Experiment 6) or instructed (Experiments 7 and 8). However, seriation analyses have shown that even when semantic-categorization is adopted primarily as a retrieval strategy, recall of lists representing a number of semantic categories appear to rely, to some extent, on the representation of the serial order of the TBR exemplars which would be expected to be vulnerable to disruption via the classical ISE.

That between-sequence semantic similarity produces more interference than mere meaningfulness is particularly supportive of the interference-by-process account: The irrelevant speech in this case specifies responses that are likely to compete for with list items for retrieval and thus require inhibition, a resultant cost of this being reflected in the impairment to focal task performance.

The functional, interference-by-process approach to the breakdown of attentional selectivity contrasts with structural, interference-by-content, accounts (e.g., Neath, 2000; Gathercole & Baddeley, 1993) that assume that it is the content of the TBR and irrelevant

material that govern the degree of disruption. That the disruption observed in the context of semantic tasks is determined by processes that are brought to bear to meet the demands of the instructed retrieval strategy (Experiments 7 and 8) suggests it is the process, rather than content, that dictates the degree and type of disruption from irrelevant speech. This view of the impairment produced by irrelevant auditory stimuli is consistent with a functionalist approach to memory generally which advocates that the goals of the individual and the retrieval environment (instructions, cues, task demands) play a critical role in remembering and forgetting (e.g., Humphreys, Bain, & Pike, 1989; Toth & Hunt, 1999), and according to which attempts to delineate the “structure(s)” of memory is an ill-founded endeavor.

The process-oriented approach also seems to provide a better interpretation of the results reported here than attentional resource-based accounts of disruption from irrelevant sound (Cowan, 1995; Elliott, 2002; Neath, 2000; Page & Norris, 2003). According to these accounts, disruption of a primary task is due to the sound capturing attention away from the memory task. In essence, these accounts assume that the presence of irrelevant speech creates a dual task setting in which ignoring speech acts as a secondary task, drawing away ‘resources’ from the memory task. Although the present results are reminiscent of those found with divided attention studies that have used similar paradigms (Baddeley, Eldridge, Lewis, & Thomson, 1984; Cinan, 2003; Moscovitch, 1994; Park, A. D. Smith, Dudley, & Lafonza, 1989), to conclude that the semantic content was simply creating a divided attention setting appears to be inadequate because meaningful speech does not disrupt serial recall of digits (current supplementary experiment), nor did it disrupt performance when participants were instructed to recall categorizable lists in serial order (Experiment 7 and 8). In sum, attentional resource-based accounts are too general; they are ill-equipped to account for the acute sensitivity of ISEs to the nature of the prevailing mental activity.

One challenge that flows from the view that the disruption reported in the present experiments is produced by a conflict between the semantic processing of the sound and semantic processing in the focal task is to identify more precisely the nature of that focal semantic processing. This is because it is likely that a number of diverse semantic processes contribute to performance on the semantic-categorization task, any of which

could be potentially disrupted by the meaning of irrelevant speech. For example, semantic processing is required in the task for: identifying the categorical structure of the list (Belleza, Cheesman & Reddy, 1977; Murphy, 1979); reorganizing list-exemplars to encode and rehearse same-category-exemplars together (demonstrated using ‘thinking aloud’ techniques, e.g., Rundus, 1971; Weist, 1972; but see Watkins & Peynircioglu, 1982); coupling semantic retrieval and rehearsal processes; same-category-exemplars (e.g., “dog”, “horse”) may be automatically (e.g., by spreading activation; J. R. Anderson, 1983; Collins & Loftus, 1975), or deliberately, retrieved and rehearsed together upon presentation of a related category-exemplar (“bear”) after intervening unrelated category-exemplars (e.g., Allen, 1968; Greitzer, 1976; Wallace, 1970; Weist & Crawford, 1973; G. Wood & B. J. Underwood, 1967); lexical cross-referencing (Kintsch, 1970; Weist & Crawford, 1973); cued search of LTM (Gronlund & Shiffrin, 1986; Raaijmakers & Shiffrin, 1981); formation, strengthening, or tagging associative pathways between exemplars (J. R. Anderson, 1972), and generating list, or candidate list, category names and exemplars for retrieval or search of long-term lexical or semantic memory (e.g., Bahrick, 1970; Gronlund & Shiffrin, 1986; Kintsch, 1970; Pollio, Mahoney, & Green, 1974; Raaijmakers & Shiffrin, 1981). Although there is already evidence that the latter generative process is susceptible to disruption (see Chapter 4), a much more fine-grained analysis of which of the other semantic processes are disrupted is required.

In conclusion, the disruption produced by irrelevant auditory stimuli is much better captured by a functional, process-oriented approach (e.g., Hughes & Jones, 2005; Jones & Tremblay, 2000) than either a structural (or content-based) approach (e.g., Gathercole & Baddeley, 1993; Neath, 2000) or an attentional resource-based approach (e.g., Cowan, 1995; Elliott, 2002; Neath, 2000; Page & Norris, 2003). It is argued that the strength of the interference-by-process approach derives from its denial that attentional selectivity is imposed by some shortfall of the cognitive system as held by structuralist approaches (e.g., a limitation on processing or a limited attentional resource or set of resources). Instead, the relationship between selectivity and limited capacity is turned on its head: A human performer’s limited capacity (in an empirical sense) reflects the achievement of selective attention mechanisms designed to ensure that only task-relevant information assumes the control of goal-directed action, an achievement that gives the *illusion* of a

limited capacity in the sense of a hypothetical property of the mind. The qualitatively different impairments that are produced by different aspects of irrelevant auditory stimuli (e.g., semantic or acoustic) in different settings (e.g., serial recall versus category-exemplar recall) are the manifestation of an interference-by-process that arises when the TBR and irrelevant material are processed in similar ways.

Chapter 4
EMPIRICAL SERIES 3:
AUDITORY-SEMANTIC DISTRACTION DURING RETRIEVAL FROM
SEMANTIC MEMORY

4.1 ABSTRACT

An auditory-semantic distraction effect is reported in which retrieval from semantic memory is disrupted by the meaning of task-irrelevant sound. Auditory-semantic stimuli disrupted verbal semantic-category fluency in three experiments. The disruption to the generation of category-exemplars from semantic memory was produced by the lexical-semantic, rather than acoustic, properties of the irrelevant sound and this lexical-semantic effect was exacerbated by semantic similarity between the target category and task-irrelevant material. The results also suggest that the disruption is not one that affects general executive processing as there were no effects attributable to the meaning of task-irrelevant sound on verbal phonemic-category fluency that makes similar executive demands as semantic-category fluency. Results are interpreted as reflecting an interference-by-process between two streams of semantic information.

4.2 INTRODUCTION

As a general rule, studies demonstrating auditory-semantic distraction have used episodic-semantic retrieval tasks where the task is to retrieve a subset of visually-presented exemplars drawn from a semantic category or categories (e.g., Beaman, 2004; see also Chapter 1 and 2). Although auditory-semantic distraction for episodic-semantic retrieval tasks have been ascribed to the irrelevant information producing a semantic interference-by-processes (see Chapters 2 and 3), the tasks are sometimes shown to be underpinned by non-semantic, episodic processes such as serial rehearsal that are co-opted in the service of retaining TBR information (see Chapter 3). Thus, the studies demonstrating auditory-semantic distraction that are cited as evidence for a semantic interference-by-process are based upon paradigms that yield impure measures of semantic processing (episodic retrieval in these cases is “semantically-mediated”). In the present series, for the first time, auditory-semantic distraction is demonstrated in semantic-category fluency tasks that require retrieval from semantic memory that is largely devoid of an episodic component, and these findings are considered in terms of a semantic interference-by-process approach.

One of the most popular and productive ways of construing semantic memory has been in terms of one or more sets or networks of semantic features or properties that represent the meanings of concepts (e.g., J. R. Anderson, 1983; Collins & Loftus, 1975; Collins & Quillian, 1970; E. E. Smith, Shoben, & Rips, 1974). For example, localist spreading activation frameworks (e.g., ACT*; J. R. Anderson, 1983; Collins & Loftus, 1975) liken human memory to a massively interconnected network of ‘holistic’ nodes representing concepts such as category-cues and category-exemplars wherein processing a word activates a concept node corresponding to its meaning. Furthermore, such activation leads to activation spreading, through learned associations, to related concept nodes representing other semantically-related words within a localised network of semantic associates, thus facilitating the subsequent processing and retrieval of those concepts (e.g., McClelland & Rumelhart, 1987). Other distributed connectionist accounts (e.g., Masson, 1995) assume that each concept is represented by a particular pattern of activity over a large as opposed to single number of (holistic) processing units, and that

related concepts are represented by similar, overlapping, patterns of activity. According to these latter feature-based models, each unit can be thought of as encoding a particular semantic feature (e.g., “round”, “juicy”) that are part of many concepts (e.g., Masson, 1995; E. E. Smith & Medin, 1981). Thus, feature-based theories assume that semantic memory comprises collections of features representing shared attributes. Whilst the goal in the present article was not to help adjudicate between these two broad approaches to semantic memory (c.f. Hutchinson, 2003), the key constructs from the semantic memory literature are drawn upon generally as a conceptual framework within which to study whether, and how, the process of retrieval from semantic memory is disrupted by meaningful to-be-ignored and thus ‘irrelevant’ sound.

One important construct in the domain of semantic retrieval is inhibition (e.g., Bäuml, 2002; S. K. Johnson & M. C. Anderson, 2004): Competition between possible retrieval candidates becomes resolved by inhibitory processes that enable successful retrieval of target items while preventing retrieval of activated non-target words that are associatively or categorically-related to targets but that were either non-presented or were presented but were non-targets for the memory test in question (e.g., M. C. Anderson, 2003). In the present article, the methodology typical for such studies in which the semantic-category connections of the study materials are manipulated is departed from and instead the lexical-semantic content of irrelevant sound is manipulated: particularly the intimacy of its association with the to-be-retrieved knowledge.

A rich seam of evidence demonstrates that irrelevant sound disrupts visual-verbal serial short-term memory: the classical ISE (e.g., Colle & Welsh, 1976; Salamé & Baddeley, 1982; Jones & Macken, 1993). The classical ISE has been interpreted as being the result of interference-by-process: Obligatory, preattentive processing of irrelevant sound yields order cues (serial order information) that conflict with the deliberate serial organization processes supporting the primary, serial recall task. Here, then, interference-by-process is encountered because the obligatory processing of the sound yields similar information (a stream of order cues) to the focal task process of serially rehearsing TBR items (Hughes & Jones, 2005; Jones, 1993; Jones et al., 1996; Jones & Tremblay, 2000; Macken et al., 2006). From this work it is shown that the classical ISE is a ‘sequence-level effect’ rather than an ‘item-level effect’ in that it is the sub-lexical and sub-

phonemic, acoustic properties of irrelevant sound that yield a sequence of order cues that determines impairment to serial recall (e.g., Jones & Macken, 1993).

Whilst there is ample evidence that the classical ISE is a sequence-level effect, there is a small volume of evidence that suggests impairment can occur at the lexical-semantic item-level: Meaningful irrelevant sound disrupts performance on semantic tasks (Baddeley & Thomson, as cited in A. P. Smith, 1985b; Beaman, 2004; Jones et al., 1990; R. C. Martin et al., 1988; C. B. Neely & LeCompte, 1999; Oswald et al., 2000; A. P. Smith, 1985b; see also Chapters 2 and 3). For example, in an episodic category-exemplar recall task between-sequence semantic similarity impairs performance: non list-presented irrelevant category-items (e.g., “saw”) that are related to list-exemplars (e.g., “chisel”) produce more disruption than categorically-unrelated irrelevant items (e.g., “igloo”; C. B. Neely & LeCompte, 1999; Beaman, 2004; see Chapters 2 and 3). For these studies showing lexical-semantic item-level effects, the maxim ‘interference-by-content’ would, at first blush, seem altogether more appropriate than interference-by-process.

However, it would be premature to conclude that these findings are explicable by interference-by-content. One possibility is that these item-level auditory-semantic distraction effects are not ones of identity per se but that they reflect a conflict in semantic processing that arises due to a joint function of the semantic content in the irrelevant sound and the focal task activity: In other words it is that semantic processing is involved in the primary task that makes the task vulnerable to impairment attributable to the semantic properties of the irrelevant items. From this standpoint auditory-semantic distraction effects are readily explicable in terms of the same interference-by-process construct as the classical ISE: the disruption can be understood as a conflict between the semantic processing of TBR and irrelevant items. For a full understanding of auditory-semantic distraction, however, it seems that an acknowledgement of the role that structural factors (content of representations) is required, more so than is the case with the classical ISE. For example, it is generally assumed that semantic activation of concepts within a semantic network (in semantic network accounts) can reduce activation spread to other concepts making them more difficult to retrieve and/or inhibit (e.g., in the case that the irrelevant items are semantically-associated to the relevant exemplars, a ‘fan effect’ or “resource diffusion” can emerge; J. R. Anderson, 1983). However, it may

ultimately be the *process* of inhibition exercised as part of the executive (or voluntary) control during retrieval that is responsible for forgetting, either through inhibition of irrelevant items that compete with relevant exemplars for retrieval (e.g., M. C. Anderson, 2003), or through automatic spreading inhibition from those competing items to other items in the same localised (or distributed) network (e.g., E. Neumann et al., 1993). Thus, the lexical-semantic item-level effects are an indirect influence of inhibition rather than a consequence of the identity of the irrelevant items per se (see also Chapter 3).

A note of caution must be sounded, however, in relation to these studies of auditory-semantic distraction because they are not pure tests of semantic retrieval: they are episodic memory tasks in which the use of rote rehearsal (or seriation) can be used in tandem with capitalizing on semantic activation as a retrieval strategy (see Chapters 2 and 3). That seriation is involved is useful in explaining why meaningless speech sometimes produces disruption on tasks that conceivably demand semantic retrieval strategies (see Chapter 3). However, that seriation is used to some degree for these tasks may mask the disruption to semantic activation (and consequently retrieval) that is produced by the activation of irrelevant and TBR items within the same network. One way around this potential masking (by the spontaneous use of strategies such as seriation) in episodic tasks is to use a task that a) requires semantic processing but no, or at least little in the way of, episodic processes, and b) is thought to reflect activation and search in semantic networks. The semantic-category fluency task (e.g., Bousfield & Sedgewick, 1944; Rosen & Engle, 1997; Troyer, Moscovitch, Winocur, Alexander, & Stuss, 1998) seems to lend itself well for this purpose.

In the semantic-category-fluency task participants are required to generate category-exemplars given a semantic-category name as a retrieval cue (Butler, Rorsman, Hill, & Tuma, 1993; Troyer et al., 1998). Therefore, the semantic-category fluency task does not involve list memory and is thus not heavily dependent on episodic information. Instead it requires accessing of, and retrieval from, semantic memory in a more direct fashion. This is advantageous because it rules out the use of episodic information or episodic retrieval strategies (such as seriation) that can be used as an alternative to semantic strategies (such as category-exemplar generation) for recalling list-exemplars (e.g., Graesser & Mandler, 1978). Another advantage of using the semantic-category fluency task, is that there is

indirect evidence that the task does not involve serial short-term memory which is known to be vulnerable to the acoustic effects of irrelevant sound in the classical ISE (Jones & Macken, 1993): Concurrent, interference tasks such as syncopated finger tapping and articulatory suppression which are known to disrupt short-term serial recall (Jones et al., 1995; J. D. Larsen & Baddeley, 2003; Macken & Jones, 1995) produce little, if any, disruption to the generation of exemplars in semantic-category fluency tasks (Baddeley et al., 1984; Moscovitch, 1994; Troyer et al., 1998). This suggests that the task is not underpinned by a seriation process and thus if irrelevant sounds were found to be disruptive in this setting the effect is likely to be qualitatively distinct from that obtained with serial recall.

Studies assessing whether the semantic properties of irrelevant sound disrupt retrieval from semantic memory, such as that required for semantic category-fluency, are sparse. Although there is one report suggesting that the speed of access to semantic memory is impaired by meaningful irrelevant sound (Baddeley & Thomson, as cited in A. P. Smith, 1985b), only two published studies appear to have investigated the effects of meaningful irrelevant sound on semantic-category fluency. The first demonstrated that meaningful, conversational irrelevant sound disrupted category fluency (Hygge et al., 2003). In this study, however, the meaningful irrelevant sound used was only as disruptive as the effects of irrelevant road traffic noise, suggesting an acoustic-based effect rather than one related to meaning. However, the failure to find an effect of meaning in this study may have been due to: the use of a small target set for recall ("Professions" beginning with a certain letter), to the repetition of the category-name across sound conditions which could potentially generate cross-trial interference; and some contamination of phonemic-category fluency (recall of words beginning with a certain letter) with semantic category-fluency (recall from a semantic category). Phonemic category-fluency in comparison to semantic category-fluency makes less demand on accessing semantic memory and thus semantic processing (e.g., Troyer et al., 1998) which suggests that this particular task is not a pure measure of semantic processing and as a consequence the task may have been less sensitive to yielding a disruptive semantic effect of irrelevant sound.

The second study (Watkins & Allender, 1987) was one of divided, rather than selective, attention and found that semantic-category fluency was impaired by speech

comprising exemplars that were categorically-related to the semantic category-name for which responses were to be retrieved, suggesting an effect attributable only to the semantic similarity between the stream of responses to-be-generated and the irrelevant items (and thus not mere meaningfulness). However, this study found a non-significant trend for disruption produced by categorically-unrelated items (Watkins & Allender, 1987, Experiment 2) which suggests the possibility that significant disruption due to meaningfulness could emerge given more experimental power. The central purpose of the present study was to examine whether the meaning of irrelevant sound produces a semantic interference-by-process, impairing direct retrieval from semantic memory using the semantic-category fluency task.

4.3 EXPERIMENT 9

The first experiment tests whether greater disruption to semantic-category fluency would be found from exposure to meaningful compared with meaningless speech. This was achieved simply through contrasting English narrative with a reversed version of the same narrative. Reversing the narrative reorganizes phonetic properties that enable lexical access and semantic processing (Sheffert et al., 2002). The particular meaningful and meaningless speech used here has previously been shown to produce comparable disruption in the context of serial recall (see Chapter 2), thus an effect of meaning would further imply that focal semantic retrieval processes are peculiarly susceptible to meaningful irrelevant sound, lending support to the interference-by-process account.

Moreover, it was expected that if the semantic-category fluency task is a relatively pure measure of semantic processing (in other words largely uncontaminated by episodic factors) then meaningful, but not meaningless, irrelevant speech will produce pronounced disruption. Such a finding would add weight to the idea that disruption to focal semantic processes by semantic properties of the sound are due to a semantic interference-by-process and that the interference-by-process associated with episodic serial short-term memory tasks is qualitatively distinct, reflecting an interference between two sources of serially ordered information. In addition, finding any effect attributable to irrelevant sound would be problematic for structural accounts based upon interference-by-content

because, as previously mentioned, episodic short-term memory (e.g., for content) appears to play little role in the semantic-category fluency task (although admittedly there must be some form of episodic memory in order to avoid self-repetition of responses).

4.3.1 Method

4.3.1.1 Participants

Thirty students at Cardiff University took part in return for course credit. Each participant reported normal of corrected-to-normal vision and normal hearing and was a native English speaker.

4.3.1.2 Apparatus and Materials

To-be-generated material. Twenty-one category-names were selected from the Battig and Montague (1969) norms. Categories chosen had minimal category-exemplar overlap. Categories were presented in a pseudo-random order with the constraint that strongly associated categories did not appear consecutively.

Irrelevant Sound. The meaningful speech comprised English narrative taken from a political essay, recorded in a female voice and sampled with a 16-bit resolution, at a rate of 44.1kHz using *SoundForge 5* software (Sonic Inc., Madison, WI; 2000). The recording was reversed using the same software to create meaningless speech. The speech in each of the irrelevant sound conditions was played to participants at 65-70dB(A) via stereo headphones that were worn throughout the experiment. The meaningful speech recording was 1 min long.

4.3.1.3 Design

A within-participant design was used with one factor, 'Sound Condition' incorporating three levels: forward speech, reversed speech, and quiet. The 21 category names were randomised but presented in a fixed order for each participant. The speech conditions were randomized, with the order of the irrelevant sounds being counterbalanced across participants.

4.3.1.4 Procedure

Participants were seated at a viewing distance of approximately 60 cm from a *PC* monitor on which category-names were displayed in a central position. Category-names appeared in lower-case black 72-point *Times New Roman* font against a white

background. Each category-name appeared for 1 min. Retrieval was immediate following the onset of the category-name.

Participants were tested in small groups of six participants. Participants were seated in individual cubicles that were equipped with a *Samsung Syncmaster 17IS PC* and display. They were informed that they would be presented with twenty-one category names and that each category name would be presented one at a time on the computer monitor. Participants were asked to generate as many words as possible and write them down in the order in which they generated them on recall sheets. One practise trial was presented before the experimental trials. Participants were informed that they would have 1 min to generate as many words as they could and that after this time a tone would sound to signal the onset of the next list (some 5 s later). Participants were instructed to ignore any sound that they heard through the headphones and were told that they would not be tested on its content at any point in the experiment. The experiment lasted approximately 30 min.

4.3.2 Results

Recall measures came in the form of the total number of exemplars recalled, this measure excluded inappropriate responses (words adjudicated not to be from the semantic category tested) and repeats (listing the same category-exemplar more than once). Figure 1 shows the results for the number of exemplars recalled. Generally the means were lower in the speech conditions compared to the quiet condition. In addition the means for the forward speech condition were lower than those for the quiet and reversed speech condition. An ANOVA confirmed a main effect of Sound Condition on the total number of exemplars retrieved, $F(2, 58) = 15.19$, $MSE = .82$, $p < .001$, with post hoc tests (Fisher's PLSD) revealing significant differences between the quiet and forward speech conditions ($p < .001$), and between the forward and reverse speech conditions ($p < .001$), only. The mean number of repeated responses was .5 ($SD = .78$) for quiet, .47 ($SD = .73$) for reversed speech and .43 ($SD = .68$) for forward speech. The magnitude of repeated responses were therefore broadly similar across sound conditions but was so low as to defy statistical analysis.

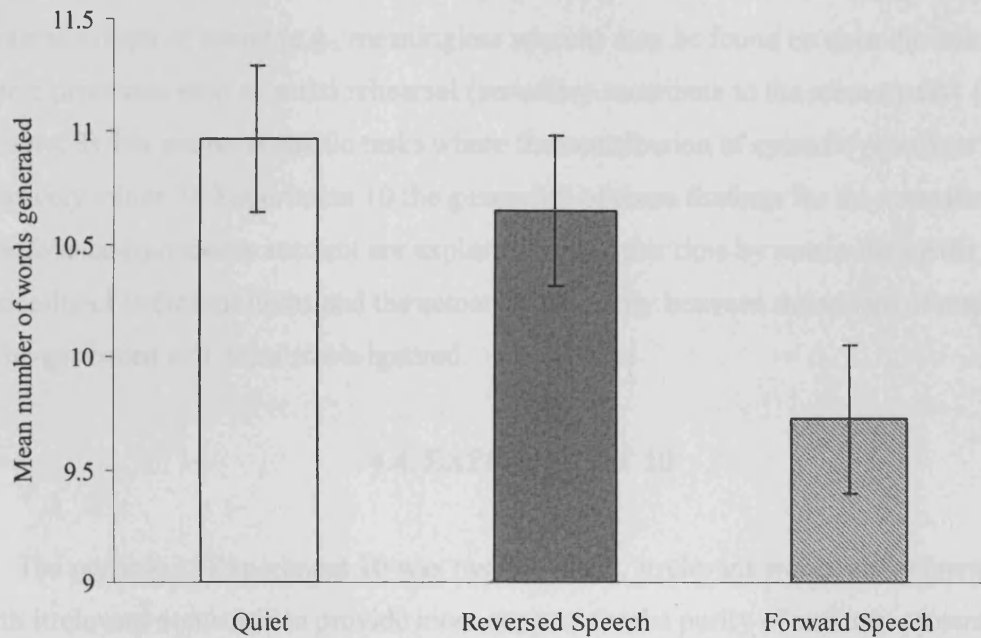


Figure 3.1 Mean number of category-exemplars generated in the irrelevant sound conditions of Experiment 1. Error bars show the standard error of the means.

4.3.3 Discussion

Experiment 9 investigated whether the semantic properties, or rather the meaningfulness, of irrelevant speech would disrupt the semantic retrieval of semantic category-exemplars. The results demonstrated unequivocally that this was the case: meaningful speech, but not meaningless, speech was disruptive, reducing the number of category-exemplars retrieved from semantic memory. That the effect of meaningfulness was one that is not due to the presence of semantic content in the speech per se is supported by evidence that the exact meaningful and meaningless speech used in this experiment produce comparable disruption to a task involving visual-verbal serial recall (see Chapter 2). Thus, it appears that the effect of meaningfulness reported in this experiment is not due to the semantic properties of the irrelevant sound simply being more likely to capture attention away from the focal task (cf. Buchner et al., 2004; Cowan, 1995). Moreover, that meaningless sound fails to disrupt semantic-category fluency is indicative of a possible dissociation between the effects produced by the

different properties of irrelevant sound on episodic retrieval tasks that involve memory for semantic information and tasks that tap semantic retrieval more directly: Disruptive acoustic effects of sound (e.g., meaningless speech) may be found on episodic tasks where processes such as serial rehearsal (seriation) contribute to the memory task (see Chapter 3), but not on semantic tasks where the contribution of episodic processes is relatively minor. In Experiment 10 the generality of these findings for the semantic interference-by-process account are explored further this time by manipulating the lexicality of irrelevant items and the semantic similarity between the stream of responses to-be-generated and items to-be-ignored.

4.4. EXPERIMENT 10

The purpose of Experiment 10 was twofold. First, irrelevant words were compared with irrelevant nonwords to provide more support for the purity of auditory-semantic distraction effect obtained in Experiment 9 by demonstrating a potential lexical-semantic effect (see also Chapter 3). This was deemed important because reversing speech, as used in Experiment 1, renders it dissimilar to forward speech in other ways such as its meaningfulness. For example, reversing speech removes both the semantic and phonemic properties (relating to intonation and familiar sounds) of speech (Calvo & Castillo, 1995). For this reason nonwords may be a better control for lexicality than reversed speech. This issue was also considered important because a study reported by Watkins and Allender (1987; Experiment 2) has shown a trend for meaningful speech—comprising items categorically-unrelated to those to-be-generated—to disrupt semantic category-fluency. Although, as previously noted, this study was one of divided, rather than selective, attention and it is quite plausible that this difference between Watkins and Allender's study and Experiment 9 of the present series may have produced the apparent discrepancy in terms of findings. Experiment 10 thus sought to address this issue by requiring selective, rather than divided, attention by not instructing participants to monitor the sound.

Second, the applicability of semantic network theories and the semantic interference-by-process account to the present findings was examined further, this time by

manipulating the semantic similarity of the irrelevant sound in relation to the material to-be-generated from semantic memory. This issue was considered important because, in terms of spreading activation theories, activating one (usually high-dominance) exemplar associated with a category-cue or source node decreases activation that all the others associated to that cue receive, making those exemplars more difficult to retrieve (the fan effect or resource diffusion; J. R. Anderson, 1983; for a similar notion of strength-dependent competition, see Rundus, 1973). Likewise, the interference-by-process view is that irrelevant items offer retrieval competition to the to-be-generated exemplars when they are drawn from the same category and thus selective processes (e.g., inhibition) are required in order to prevent those irrelevant items from being retrieved (e.g., M. C. Anderson, 2003; M. C. Anderson & Bjork, 1994; see Chapter 3).

4.4.1 Method

4.4.1.1 Participants

Seventy-two individuals from Cardiff University (none of whom took part in Experiment 9) participated for course credit. Each reported normal hearing and normal or corrected-to-normal vision and was a native English speaker. Participants were randomly assigned to one of the two between-participants groups: Word or nonword.

4.4.1.2 Apparatus and Materials

To-be-generated material. Thirty-six category-names were selected from the Battig and Montague (1969) norms with the same criteria as in Experiment 9. The presentation of the category-names, and the items within the irrelevant sound was pseudo-randomly determined, as in Experiment 9, but was the same fixed order for each participant.

Irrelevant Sound. Irrelevant sounds comprised four words chosen from the 1st to the 8th most dominant responses to the thirty-six category-names chosen. This number of irrelevant items was adopted to minimise the possible strategy of attending to the categorically-related irrelevant items and producing those items (the use of four items is also consistent with that used by Watkins & Allender, 1987, Experiment 2). Exemplars were recorded in a male voice sampled with a 16-bit resolution at a rate of 44.1kHz using *SoundForge 5* software (Sonic Inc., Madison, WI, 2000). Each item was edited to 500

msec. Nonwords were constructed from words (as described in Chapter 2) and recorded in the same fashion as word stimuli.

Exemplars for the irrelevant word and nonword sounds were randomized by creating all 24 blocks of 4 items and selecting them in a pseudo-random fashion until the desired sample duration of 60 s was obtained. This ensured that each item was evenly distributed throughout the 60 s sample duration. The irrelevant sounds were presented at a rate of 2 words per second. The delivery of the irrelevant sounds and category-name presentations was the same as in Experiment 9.

4.4.1.3 Design

A mixed design was used with one between-participants factor (Sound Version: word and nonword) and one within-participants factor with three levels (Sound Condition: quiet, unrelated-, and related-to the to-be-recalled category).

The category-names and irrelevant sounds were divided into 2 groups of 18 each. An equal number of participants from each group received each of the 2 sets of 18 category-names. The 18 category-names were divided into six blocks of three names each. In each block, the category-names were randomly assigned to one of the three irrelevant sound conditions (ensuring that associated categories were not presented adjacently or as to-be-generated and irrelevant sounds in the same trial). To control for order effects, the order of irrelevant sounds within each block was counterbalanced across participants such that the six possible orderings of conditions were encountered by equal numbers of participants within each group.

When a category-name was assigned to a related sound condition the categorically-related sound was presented throughout the duration the corresponding category-name appeared. When assigned to an unrelated sound condition, the sound was randomly selected from one of the eighteen categorically-unrelated sounds that were not represented by any of the 18 category-names for that group.

4.4.1.4 Procedure

The procedure was the same as for Experiment 9.

4.4.2 Results

4.4.2.1 Exemplars recalled

Recall measures included the number of words generated and the number of items generated that matched those presented in the irrelevant sound. Because participants were told to ignore the auditorily presented items, but were not explicitly told that they could not recall them, they were included as correct responses in the number of exemplars recalled analysis. The mean number of words generated per minute for all sound conditions and sound versions is shown in Section A of Table 4.1. Generally, performance was poorer in the irrelevant sound conditions than quiet. Semantic-category fluency performance in the categorically-related irrelevant sound conditions appear worse than in the categorically-unrelated irrelevant sound conditions—which in turn appear to be associated with poorer performance when compared to quiet—particularly for the word group. A 3 (Sound Condition) \times 2 (Sound Version) ANOVA confirmed a main effect of Sound Condition, $F(2, 140) = 23.07$, $MSE = 2.49$, $p < .0001$. There was also a between-participants main effect of Sound Version, $F(1, 70) = 4.81$, $MSE = 6.62$, $p < .05$, and critically, a significant interaction between Sound Condition and Sound Version factors, $F(2, 140) = 3.25$, $MSE = 2.49$, $p < .05$. Simple effects analysis (LSD) conducted to investigate this interaction, revealed significant differences between the quiet and categorically-unrelated and categorically-related sound conditions (both $p < .001$), and between the categorically-unrelated and categorically-related sound conditions ($p < .01$) for the word group. However, for the nonword group the difference was significant between the categorically-related and categorically-unrelated sound conditions ($p < .05$), and between the categorically-related sound, and quiet, conditions ($p < .005$), only. The number of repeat errors were .53 ($SD = .76$) and .64 ($SD = .88$), for the quiet conditions of the word and nonword groups respectively, .58 ($SD = .75$) and .58 ($SD = .67$) for the categorically-unrelated sound conditions and .47 ($SD = .62$) and .61 ($SD = .79$) for the categorically-related sound conditions. Like Experiment 9, these mean numbers were too few to subject to a statistical analysis.

These results support that of Experiment 9 in showing that the semantic properties of irrelevant sound impairs semantic-category fluency performance, the novel finding from

Experiment 10 is that this lexical-semantic effect is exacerbated by the semantic similarity between the relevant, and irrelevant, material.

Sound Condition	Word	Nonword
	Mean (SD)	Mean (SD)
A) <u>Number of Category-Exemplars Generated</u>		
Quiet	10.58 (1.79)	10.58 (1.76)
Unrelated Speech	9.29 (1.96)	10.47 (2.17)
Related Speech	8.25 (2.33)	9.37 (1.71)
B) <u>Number of Irrelevant Items Recalled</u>		
Quiet	2.64 (0.47)	2.76 (0.37)
Unrelated Speech	2.49 (0.55)	2.77 (0.57)
Related Speech	1.56 (0.97)	2.30 (0.59)

Table 4.1 Mean recall and intrusion measures as a function of irrelevant sound condition and sound version in Experiment 8.

4.4.2.2 Irrelevant items recalled

Related-item intrusions for Experiment 10 were scored for the four high output-dominance items presented to participants as irrelevant items on each trial of the categorically-related conditions. Section B of Table 4.1 shows the mean total number of related-item intrusions for each sound condition for the nonword and word groups: As can be seen, recall of related-item intrusions tended to be greater for the quiet than sound conditions, with lowest recall of these items for the categorically-related sound conditions. Moreover, exposure to the related-items in the categorically-related sound conditions appears to decrease the recall of those items relative to the quiet and unrelated conditions. A 3 (Sound Condition) \times 2 (Sound Version) ANOVA confirmed a main effect of Sound Condition on the incidence of related-item intrusions, $F(2, 140) = 42.17$, MSE

= .31, $p < .001$. There was also a between-participants main effect of Sound Version, $F(1, 70) = 15.28$, $MSE = 7.98$, $p < .001$. The interaction between Sound Condition and Sound Version was also significant, $F(2, 140) = 6.02$, $MSE = .31$, $p = .003$. Simple effects analysis (LSD) directed to the interaction revealed that significantly fewer related-irrelevant items were recalled in the categorically-related sound condition compared to the quiet and categorically-unrelated conditions (both $p < .001$) for the word group. These comparisons were also significant for the nonword group (both $p < .005$).

In sum, these data for intrusions illustrate that concurrent auditory presentation of irrelevant related items during category-exemplar retrieval from semantic memory results in their inhibition from retrieval: this is the case for both word and nonword versions of the related irrelevant items which suggests that the two versions may be producing similar effects on retrieval.

4.4.3 Discussion

Experiment 10 replicated the key feature of Experiment 9 in showing that the semantic, not acoustic, properties of irrelevant sound disrupt semantic-category fluency. Experiment 10 also imparts a novel finding in the context of this series, that between-stream semantic similarity increases the degree of disruption to semantic retrieval (for similar results in episodic tasks, see Beaman, 2004; C. B. Neely & LeCompte, 1999; see Chapters 2 and 3). At first glance, one surprising finding from Experiment 2 was that nonwords that were derived from categorically-related irrelevant words produced disruption. However, a similar finding to this is reported in Chapter 2 (Experiments 1a and 1b) of the present thesis. In that chapter it was argued that the related non-words functioned as words due to priming produced by the relevant, attended category information: this argument is maintained for the current experiment.

The between-stream semantic similarity effect reported in Experiment 10 is consistent with semantic network theories (e.g., J. R. Anderson, 1983) and the interference-by-process approach (see Chapters 2 and 3). More specifically, the irrelevant items used in Experiment 10 were high-dominance items of their respective semantic categories (meaning they were among the first items that are produced given the category-name in norming studies; e.g., Battig & Montague, 1969). The activation of high-dominance

exemplars within semantic networks accounts can rob activation from other semantically related lower-output dominance items thus impairing their accessibility (J. R. Anderson, 1983; for a very similar account, see Rundus, 1973). Likewise, in terms of the interference-by-process account dominant irrelevant items, being very representative of the semantic category, may offer competition to the to-be-generated words for retrieval, thus requiring inhibition in order to recall other lower-dominance exemplars. A resultant cost of this inhibition may be that it spreads to other to-be-generated exemplars from the same semantic category impairing their accessibility (e.g., features or nodes of to-be-generated exemplars could be suppressed as a consequence of inhibiting features of the irrelevant items; M. C. Anderson, 2003; M. C. Anderson, Green, & McCulloch, 2000; M. C. Anderson & Spellman, 1995; S. K. Johnson & M. C. Anderson, 2004; E. Neumann et al., 1993). There is some suggestion that the related irrelevant items are indeed inhibited in Experiment 10 as they are recalled less frequently in the categorically-related condition than in the control quiet and categorically-unrelated conditions.

However, one potential criticism of Experiment 10 is that, despite intention, the experiment may *not* have turned out to be one of selective attention, at least in the case of the categorically-related condition. More specifically, if participants are told to ignore irrelevant sound when it comprises items categorically-related to a target category, they may attend to the speech to deliberately withhold the irrelevant items from retrieval. Thus, the task becomes one of divided, rather than selective, attention (cf. Watkins & Allender, 1987) and as a consequence fewer exemplars may be generated from a target category simply due to a loss of retrieval time through the monitoring of the irrelevant items. There are however two findings that may aid to ruling this simple explanation out. First, Watkins and Allender (1987; Experiment 4) demonstrated that between-stream semantic similarity remains disruptive even if participants are exposed to categorically-related sound, and write down, the contents of the sound before beginning the task.

Second, if participants were really monitoring the sound to avoid writing down its content it may be expected that they would be successful at avoiding recall of *all* of the irrelevant items. The analysis of the data from Experiment 10 however, revealed that this pattern was not found, participants still retrieved on average over half of the related irrelevant items compared to the baseline quiet condition. Nevertheless, despite these

objections to an explanation based on reduced retrieval time, it would be useful to provide further evidence that the between-stream semantic similarity effect is not simply a consequence of lost retrieval time resultant from the spontaneous monitoring of irrelevant sound. One way in which this can be done is to use irrelevant items that are derived from a category that is semantically-associated with the target category (e.g., presenting “Fruits”, “apple” and “banana” when the target category is “Vegetables”). In this case irrelevant items are still related to to-be-generated exemplars but are no longer appropriate responses and thus they may no longer have to be monitored.

There is a good deal of evidence that exemplars that are drawn from a category associatively related to a target can impair processing/responding. For example, decision processes are slowed with the presentation of negative instances of categories: Deciding that an exemplar of a “Flower” category (e.g., ‘crocus’) is not a member of the “Tree” category takes longer than deciding that “hammer” is not a member of the “Tree” category (Baddeley et al., 1984; Dewhurst & Hitch, 1999; Schaeffer & Wallace, 1969). As mentioned previously, most models of semantic memory implement semantics as patterns of activation across feature or concept nodes (e.g., Nelson, Bennet, & Leibert, 1997; Plaut & Shallice, 1993; Lund & Burgess, 1996). In such models, nodes that share many of the same features are ‘semantic neighbours’ and the spread of activation reflects the number of shared features and via this feature overlap other words become activated. By definition, associated categories such as “fruits” and “vegetables” share semantic properties (e.g., both vegetables and fruits can be round or long; people cook them; most are edible; can be available for purchase at green grocers, may have seeds, and so on; thus cross-categorically “apple” may prime “potato”). This suggests that, within semantic network theories, associated categories have more associative linkages (or overlapping features) between their category-exemplars than non-associated category-exemplars do and thus should, if activated, proffer more competition to retrieval of associated than non-associated category-exemplars (for neurological evidence that associated categories may share localised semantic networks, see Crutch & Warrington, 2003; Samson & Pillon, 2003). Moreover, in terms of semantic network theories it is feasible that this spread of activation between associated categories can impair processing if retrieval requires to be focused on one from a subset of associatively activated exemplars (e.g., “potato” is

harder to retrieve when “banana” and “peach” are active through the concept of resource diffusion; J. R. Anderson, 1983).

Another interesting facet of the semantic-category fluency task which may contribute to analytic clarity is that it is thought to require two components, one is thought to be an automatic, associative component reflecting how semantic memory is organized (e.g., Bousfield & Sedgewick, 1944; Cardebat, Demonet, Celsis, & Puel, 1996; Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Tranel, Damasio, & Damasio, 1997; Warrington & Shallice, 1984). This component—which is often attributed to spreading activation—appears to map onto what has been termed ‘clustering’ (see Troyer et al., 1998) and is arguably reflected in a phenomenon known as ‘response-bursting’: this refers to the rapid production of words within sub-semantic categories (“mouse”, “gerbil”, “guinea pig”) relative to longer latencies for the production of words between semantic sub-categories (“gerbil”, “tiger”; Bousfield & Sedgewick, 1944). Clustering has been used to refer to the number of items recalled from the same sub-category (e.g., “Animals”: “Rodents”) adjacently and is thus reflected in cluster size. Another component thought to underpin semantic category-fluency is a more deliberate search for sub-categories which has been ascribed executive function and may be reflected in ‘switching’ which generally refers to the number of shifts between semantic subcategories (Troyer et al., 1998, although, there is some suggestion that switching may also be underpinned by semantic processing and is therefore not purely an executive process, see Mayr, 2002). Experiment 11A explored whether auditory-semantic distraction has a disruptive effect on clustering and/or switching components.

4.5 EXPERIMENT 11A

To reiterate, in this experiment between-stream similarity was again assessed but this time by manipulating the categorical-association between the category-items to be ignored and the category responses to be generated. In this experiment the response mode was changed from Experiments 9 and 10 to oral recall. Oral responding was used to investigate the purported clustering and switching components (which can be investigated by analysing time-based responses) of the output sequence with a view to investigating

which, if any, of these components suffers disruption due to the meaning of irrelevant sound. Time-based measures of clustering and switching were supplemented with judges' ratings of the same measures based upon adjudication of the relatedness between adjacent words in each participant's output protocols (see Rosen & Engle, 1997).

4.5.1 Method

4.5.1.1 Participants

Thirty-six undergraduate students at Cardiff University, all reporting normal or corrected-to-normal vision and normal hearing, participated in the experiment in return for course credit. All were native English speakers. None had taken part in the previous experiments of this series.

4.5.1.2 Apparatus and Materials

To-be-generated material. Nine pairs of associated categories (e.g., "Fruits" – "Vegetables", "Flowers" – "Trees"), and hence category-names were selected from the Van Overschelde, Rawson, and Dunlosky (2004) norms.

Irrelevant Sound. Irrelevant sounds comprised the ten most dominant responses to the eighteen category-names chosen and were sampled and edited as in Experiment 10. Exemplars were created using 12 random orders of the ten items and selecting these in pseudo-random fashion ensuring that an irrelevant item was not duplicated in an adjacent position.

4.5.1.3 Design

A within-participant design was used with one factor, 'Sound Condition' incorporating three levels: associated-category speech, non-associated-category speech, and quiet.

The category-names and irrelevant sounds were counterbalanced between-participants such that each category name and sound appeared as equally as often as to-be-generated and to-be-ignored as an associated and non-associated category.

4.5.1.4 Procedure

Generally, this was the same as in the previous experiments with the following exceptions. 1) Participants were tested individually in a soundproof laboratory. 2) Rather than writing responses, participants were asked to make oral responses which were

recorded at a sampling rate of 44.1 kHz using *SoundForge 5* (Sonic Inc., Madison, WI, 2000) software. 3) A further difference in relation to the previous experiments was that there were three trials, one for each sound condition. 4) A final difference was that the allocated time for retrieval was 2 min. The experiment took approximately 7 min.

4.5.1.4.1 Scoring

The audio files for each participant were transcribed and inter-response times were measured precisely using *SoundForge 5* (Sonic Inc., Madison, WI, 2000). Inter-response time-based analysis of clustering has previously been assessed using a number of ways, usually the analysis is based upon inter-response times for longer output sequences (e.g., 10 min or more) than the ones used in the current experiment (e.g., Gruenewald & Lockhead, 1980; Graesser & Mandler, 1978; Rosen & Engle, 1997). Because the statistical clustering measures typically used are designed for, and are more sensitive to, longer output sequences (Rosen, personal communication) clustering of responses was assessed in another way: by marking any adjacent responses that occurred within less than 67% of the median downtime for all responses made by a participant as a cluster (e.g., Kurtz & Gentner, 2001) whereby the downtime was calculated as the inter-response time between two responses. Two judges also analysed the transcribed output protocols to determine clustering based upon identifying sub-category semantic relatedness between adjacently recalled exemplars. Sub-category switches were scored whenever there was a transition from one sub-category to another and this scoring method also counted single words (see Troyer et al., 1997).

4.5.2 Results

Recall measures came in the form of: the total number of exemplars recalled (calculated with disregard of inappropriate responses and repeats), the number and size of clusters, and sub-category switches.

4.5.2.1 Exemplars recalled

The total number of category-exemplars generated were lower in the non-associated-category condition ($M = 14.25$, $SD = 6.34$) and the associated-category condition ($M = 12.28$, $SD = 3.84$) compared to the quiet condition ($M = 17.06$, $SD = 7.05$) and were lower in the associated compared to non-associated-category conditions. An ANOVA

confirmed a main effect of Sound Condition on the total number of exemplars retrieved $F(2, 70) = 9.65$, $MSE = 21.51$, $p < .01$. Post hoc testing (Fishers PLSD) revealed significant differences between quiet and non-associated-category speech ($p < .01$), and between non-associated- and associated-category speech ($p < .05$). The mean number of repeat errors was $.56$ ($SD = 1.2$) for quiet, $.53$ ($SD = .93$) for non-associated-category speech and $.58$ ($SD = .94$) for associated-category speech. This number of repeats was thus comparable between conditions but was so low as to avoid statistical analysis. The cumulative responses can be seen in Figure 4.2 which demonstrates that impairment attributable to associated-category sound is evident throughout the response curve.

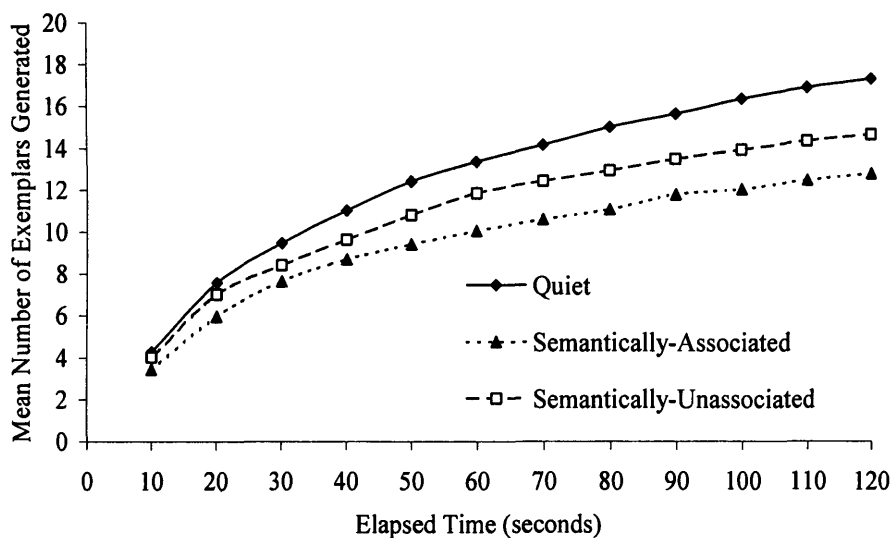


Figure 4.2 Mean cumulative number of exemplars generated over a 2 min retrieval period for the 3 conditions in Experiment 11a.

4.5.2.2 Clustering

The number of clusters generated, based upon the inter-response timing measures were fewer in the non-associated category condition ($M = 3.06$, $SD = 1.47$) and the associated-category condition ($M = 2.27$, $SD = 1.49$) compared to the quiet condition ($M = 3.11$, $SD = 1.88$) and were lower in the associated compared to non-associated-category condition. An ANOVA revealed a main effect of Sound Condition on the number of clusters accessed, $F(2, 70) = 4.01$, $MSE = 1.95$, $p < .05$. Post hoc testing (Fisher's PLSD) revealed significant difference between quiet and associated category speech ($p < .05$) and between associated and non-associated category speech ($p < .05$). However, there

was no effect of Sound Condition on the size of these clusters (quiet = 2.75 ($SD = .96$), non-associated category = 2.50 ($SD = .79$), associated category = 2.78 ($SD = .76$), $p > .05$).

These results based upon response timings were supplemented with the measures obtained through the two judges' scorings. With these measures, the number of clusters recalled was 3.53 ($SD = 2.23$) for quiet, 3.28 ($SD = 1.98$) for non-associated-category, and 2.22 ($SD = 1.62$) for the associated-category condition. An ANOVA revealed a main effect of Sound Condition on the number of clusters accessed, $F(2, 70) = 7.06$, $MSE = 2.45$, $p < .05$. Post hoc testing (Fisher's PLSD) revealed significant difference between quiet and associated-category speech ($p < .05$) and between associated- and non-associated-category speech ($p < .05$). Mean cluster sizes were 2.28 ($SD = .86$) for quiet, 2.17 ($SD = .50$) for the non-associated and 1.94 ($SD = .86$) for the associated category condition. An ANOVA, however, failed to reveal an effect of Sound Condition on cluster size ($p > .05$).

4.5.2.3 Switching

Generally, fewer switches were made in the sound conditions than in the quiet condition: The number of switching scores based upon the response timings was 12.33 ($SD = 5.76$) in quiet, 9.83 ($SD = 4.99$) in non-associated category and 8.77 ($SD = 3.39$) in associated category conditions. An ANOVA on switching scores confirmed a main effect of Sound Condition, $F(2, 70) = 8.511$, $MSE = 14.10$, $p < .01$, with post hoc testing (Fisher's PLSD) revealing significant differences between quiet and non-associated conditions ($p < .01$), quiet and associated conditions ($p < .01$), but not between non-associated and associated conditions ($p > .05$). These results were supplemented with the judges' scores: the mean switching scores from that analysis was 11.58 ($SD = 4.15$) for quiet, 9.97 ($SD = 4.30$) for the non-associated category condition and 9.64 ($SD = 3.05$) for the associated category condition. For these switching scores derived from judges ratings, an ANOVA revealed a main effect of sound condition on switching scores, $F(2, 70) = 3.29$, $MSE = 11.85$, $p < .05$, with post hoc testing (Fisher's PLSD) revealing significant differences between quiet and non-associated sound conditions ($p < .05$) and between quiet and associated sound conditions ($p < .05$), but not between non-associated and associated sound conditions ($p > .05$).

4.6 EXPERIMENT 11B

Prior to discussing Experiment 11A, Experiment 11B is reported. Experiment 11B was conducted because requiring oral responding could have changed the nature of the task. For example, presentation of irrelevant sound during oral recall could impair response produced feedback which may increase the requirement for the monitoring of previous responses and as a consequence increase sampling error (Gardiner, Passmore, Heriott, & Klee, 1977). For this reason it is possible that with oral recall some episodic record of previously made responses is required and formed (to aid monitoring) and that this episodic record of previously made responses is susceptible to disruption by irrelevant sound. Although response-produced impairment of auditory feedback usually occurs more with high intensity sounds (e.g., Gardiner et al., 1977) this study was nevertheless conducted to see whether, as in Experiments 9 and 10, it was the semantic properties of irrelevant sound that chiefly disrupted oral retrieval from semantic memory. This was achieved by simply reversing the associated-category irrelevant sound materials from Experiment 11A to make meaningless irrelevant sound. Experiment 11B used an identical procedure to 11A.

4.6.1 Method

4.6.1.1 Participants

Thirty-six undergraduate students at Cardiff University, all reporting normal or corrected to normal vision and normal hearing, participated in the experiment in return for a small honorarium. All were native English speakers. None had taken part in the previous experiments reported in this series.

4.6.1.2 Apparatus and Materials

These were the same as Experiment 11a with the exception that the related irrelevant sound material was reversed to create meaningless irrelevant sounds.

4.6.1.3 Design

A within-participant design was used with one factor, 'Sound Condition' incorporating three levels: forward speech, reversed speech, and quiet.

4.6.1.4 Procedure

This was the same as in Experiment 11a.

4.6.2 Results

For economy of exposition here only the total number of exemplars recalled are reported (without including inappropriate responses and repeats). The mean number of category-exemplars generated for the sound conditions was 14.92 ($SD = 5.89$) for quiet, 14.47 ($SD = 6.72$) for reversed speech, and 12.19 ($SD = 4.66$) for forward speech. An ANOVA on the number of category-exemplars generated revealed a main effect of Sound Condition, $F(2, 70) = 3.32$, $MSE = 23.13$, $p < .05$, with post hoc testing (Fisher's PLSD) revealed significant differences between quiet and forward speech ($p < .05$), and between reversed and forward speech ($p < .05$), but no difference between quiet and reversed speech ($p > .05$). Generally then, the main results of Experiment 9, 10, and 11A were replicated: Semantic-category fluency is disrupted by the semantic, not acoustic, properties of irrelevant sound.

4.6.3 Discussion of Experiments 11A and 11B

Experiments 11A and 11B replicate the previous experiments reported in this series by showing that semantic category-fluency is disrupted by the semantic properties of irrelevant sound. Furthermore, Experiment 11A demonstrates a between-stream semantic similarity effect whereby irrelevant items selected from a category associated to that from which exemplars were to be retrieved reduced fluency to a greater extent than when irrelevant items were not so associated. That between-stream semantic similarity impairs semantic-category fluency even when those items are inappropriate to the generation task—and thus no longer require monitoring—suggests that the between-stream similarity effect is not caused simply by a spontaneous monitoring of the irrelevant sound leaving less time for the retrieval of appropriate category-exemplars. The impairment produced by between-stream similarity, however, was restricted to the total number of exemplars generated and not the clustering and switching sub-components of semantic-category fluency. The switching subcomponent was disrupted equally regardless of whether or not there was a semantic association between the exemplars to-be-generated

and the items to-be-ignored. However, the relatedness between the irrelevant and to-be-generated material did appear to influence the number of sub-categories (clusters) generated relative to the quiet and non-associated condition. It appears that the impairment produced by irrelevant semantic information is related to the finding of (and switching to) new sub-categories rather than producing exemplars from within those sub-categories once they are found. This is consistent with the notion that semantic activation of one concept within a semantic network can make other concepts less accessible, but that there is a relatively automatic retrieval of words (and thus limited scope for disruption) once a concept is discovered (e.g., Gruenewald & Lockhead, 1980; Rosen & Engle, 1997).

This finding of impaired switching is also compatible with the semantic interference-by-process approach whereby the activation of irrelevant semantic information has to be inhibited with the associated overhead being manifest as a disruption of the search and retrieval processes involving semantic memory. The additional disruption produced by between-stream semantic similarity may be related to the inhibition of features of to-be-generated exemplars attributable to the inhibition of irrelevant items that possess similar semantic properties to those items (e.g., M. C. Anderson, 2003; E. Neumann et al., 1993). It is possible that this spreading inhibition makes sub-categories that contain those items, and hence their features, more difficult to access. Arguably the impairment of retrieval reflects a consequence of preventing the associated irrelevant category-items from being retrieved because, being associated with the to-be-generated category, they are more compatible with the responses required by the task in comparison to the non-associated irrelevant category-items (see Chapters 2 and 3).

However, caution should be expressed here with regard to considering that the impairment of switching is caused by a semantic interference-by-process because a reduction in switching, with relatively preserved clustering, could also indicate a pattern of disruption that is not necessarily produced by an impairment of semantic processes in the focal task. More specifically, there is a tension within the semantic-category fluency literature, between researchers who argue switching is a predominately semantically-based process (e.g., Mayr, 2002; Mayr & Kiegel, 2000) and those who, instead, attribute the switching component to primarily executive, and not semantic, processes (e.g., Troyer

et al., 1997). One connotation of switching as a purely executive process is that the meaning of irrelevant sound disrupts switching via impairing executive rather than semantic processes. Of course this conceptualisation of the impairment appears to be at odds with the notion that the disruption to semantic-category fluency is produced by activation of irrelevant semantic information in semantic networks and/or semantic interference-by-process.

The idea that the meaning of irrelevant sound produces disruption to executive processing resonates with a view that susceptibility to disruption is produced because the meaning of irrelevant sound is simply hard to ignore, capturing attention, and thus reducing the resources available for controlled processing, essentially creating a divided attention task (Buchner et al., 2004; Cowan, 1995; Neath & Surprenant, 2001). On this view, because switching is thought to be a “controlled” process—involved in the active search of semantic memory (for sub-categories, sub-domains or semantic fields)—that is regulated by executive processing or function, and thought to involve hypothetical cognitive resources (Troyer et al., 1998), harder to ignore sounds should usurp the purported cognitive resources required for controlled processing (e.g., Cowan, 1995; Neath, 2000) leading to the detriment of switching performance found on the focal task, a pattern of results that is on the face of it consistent with that found in Experiment 11a.

There are, however, several arguments against the idea that meaningful sound is simply hard to ignore (see Chapters 2 and 3). For example, the meaning of irrelevant sound and between-sequence semantic similarity does not impair recall of semantically rich lists (such as those composed from one, or a number of, semantic categories) if participants are instructed to recall those lists in serial order (see Chapters 2 and 3). Thus, it seems to be that it is the similarity between the processes applied to the focal task and sound that produce the disruption and not the semantic content of the irrelevant sound per se. Most relevant to the semantic-category fluency task, however, is that meaningful irrelevant sound in the previous experiments reported in this series had no effect on repetition error, a measure thought to require hypothetically ‘attentionally-demanding’ executive processes: If meaningful irrelevant sound decreased executive processes such as monitoring (or suppression) of previous responses then one would expect an increment in repetition error for meaningful, and between-stream semantic similarity, conditions

(e.g., Rosen & Engle, 1997). The results of Experiment 9-11, however, have demonstrated that this is not the case.

Despite this evidence that the meaning of irrelevant sound is not disruptive simply because it is ‘attention-grabbing’ or likely to usurp the hypothetical processing resources supposedly required for executive or controlled processes, Experiment 12 sought more empirical support that, in the context of verbal fluency tasks, it is simply not the case that meaningful irrelevant sound captures attention and reduces supposed executive processing.

4.7 EXPERIMENT 12

One argument is that the effect of auditory-semantic distraction arises because the semantic content per se is distracting and the deficit in fluency performance is thus attributable to a breakdown in the executive control mechanisms responsible for ‘effortful’ retrieval. How can one be sure that the semantic properties of the sound are interfering with semantic and not merely executive processes? One way is to use a task that is at least, if not more, demanding of purported executive processes than semantic-category fluency, but that does not require extensive search in semantic domains, retrieval by semantic association, or the integrity of semantic associations, namely, a phonemic-category fluency task (Henry, Crawford, & Phillips, 2004).

Phonemic-category fluency is often set against semantic-category fluency and involves generating words that begin with a certain letter such as *f*, *a*, and *s* (Bentin, 1968; Borkowski, Benton, & Spreen, 1967; Troyer, Moscovitch, & Winocur, 1997). Thus, unlike semantic-category fluency, phonemic-category fluency is based upon initial letter sounds and the phonemic properties of words and thus requires search for items and retrieval cues based upon lexical representations, as opposed to generation of words from a super-ordinate category using semantic associations in semantic memory (Rohrer, Salmon, Wixted & Paulsen, 1999). Thus, the type of cuing involved in phonemic-category fluency is based upon abstract or novel rules and is thus not entirely semantic (but see Schwartz, Baldo, Graves, & Brugger, 2003), instead it arguably involves the ability to suppress the habit of using words according to their meaning (Perret, 1974).

In the present context, phonemic-category fluency is an appropriate foil to set against semantic-category fluency because it requires more, if not comparable, degrees, of 'executive' processing: both tasks arguably require "effortful" (self-initiated) retrieval processes, response initiation, shifting mental set (switching between sub-categories), self-monitoring and inhibition of previously made responses, inhibition of irrelevant responses, and organization of verbal retrieval (Crawford & Henry, 2005; Milner, 1995; Ramier & Hécaen, 1970). Indeed, Rosser and Hodges (1994) have argued that phonemic- and semantic-category fluency require identical executive processes. However, it has been suggested that the hypothetical sub-components that underpin phonemic- and semantic-category fluency differ in terms of the amount of hypothetical cognitive resources they require: The switching sub-component in phonemic-category fluency, as opposed to semantic-category fluency, arguably requires more in the way of 'cognitive resources' (e.g., Troyer et al., 1997). Evidence for this notion has been garnered from the findings that divided attention tasks such as concurrent, sequential finger tapping impair phonemic-category fluency whereas semantic-category fluency appears relatively immune to interference from this type of secondary task (Moscovitch, 1994; Troyer et al., 1997).

If one considers that task-irrelevant sound (particularly meaningful sound) also uses up hypothetical cognitive resources, akin to a secondary task (e.g., Cowan, 1995; Neath & Surprenant, 2001) then one may expect phonemic-category fluency not only to show an effect of irrelevant sound but also one attributable to its meaning: That is, if semantic irrelevant speech is simply producing, say, shifts in attention (e.g., Cowan, 1995) that can be somehow prevented by deploying other cognitive resources then it could reasonably be expected that meaningful irrelevant sound will produce disruption to the phonemic-category fluency task that hypothetically demands more of those resources in comparison to the semantic-category fluency task. Additionally, if an effect attributable to the meaning of speech fails to arise with phonemic-category fluency, then there is further, albeit indirect, support for the idea that semantic category-fluency, and its underpinning sub-components (e.g., those involved in switching) are ones that involve semantic processes (Mayr, 2002; Mayr & Kiegel, 2000) that may be liable only to disruption from the semantic processing and activation of irrelevant material.

4.7.1 Method

4.7.1.1 Participants

Thirty-six undergraduate students at Cardiff University, all reporting normal or corrected-to-normal vision and normal hearing, participated in the experiment in return for a small honorarium. All were native English speakers. None had taken part in the previous experiments reported in this series.

4.7.1.2 Apparatus and Materials

To-be-generated material. The letters “F”, “A”, and “S” were used as letter cues for the phonemic-category fluency task.

Irrelevant sound. Irrelevant sounds comprised the ten most dominant responses to the “Vegetable” semantic category. These were chosen because the sounds produced disruption on the semantic-category fluency task even when presented as non-associated sounds, and none of the items began with the same initial letter as any of the letter cues.

4.7.1.3 Design

A within-participant design was used with one factor, ‘Sound Condition’ incorporating three levels: forward speech, reversed speech, and quiet. The order of presentation of letter cues was fixed with the presentation of irrelevant sound randomized. An equal number of participants (6) were presented with each of the six random orders of the irrelevant sounds.

4.7.1.4 Procedure

This was generally the same as Experiment 11A and 11B with the exception that participants were required to orally-generate words in response to the initial letter cues “f”, “a”, and “s”.

4.7.1.4.1 Scoring

The audio files for each participant were transcribed and marked for number of clusters, cluster sizes and switches. The rules for phonemic clusters were words starting with the same initial two letters (e.g., *fall* and *fault*), words that rhymed (e.g., *sale*, *scale*, *shale*), words that had the same first and last sounds, differing by only a vowel sound regardless of the actual spelling (e.g., *sand*, *sound*, *summed*), and homonyms (e.g., *sail*, *sale*). Cluster size was calculated as the number of adjacent words produced that fulfilled

one of these phonemic cluster criteria. Switches were recorded by totalling the number of transitions between different clusters and the number of isolated responses.

4.7.2 Results

Recall measures were the same as in Experiment 11A.

4.7.2.1 Exemplars recalled

The mean number of words generated for the sound conditions was 21.47 ($SD = 5.35$) for quiet, 19.22 ($SD = 5.20$) for reversed speech, and 20.08 ($SD = 6.34$) for forward speech. Despite the apparent difference in means, an ANOVA failed to reveal a significant effect of Sound Condition on the number of words generated ($p = .21$). Moreover, the pattern of results suggested that, if anything, meaningless speech was slightly more disruptive to phonemic-category fluency. The mean number of repeat errors was .47 ($SD = .65$) for quiet, .50 ($SD = .88$) for reversed speech and .53 ($SD = .88$) for meaningful speech. These were too few, however, to qualify for statistical analysis.

4.7.2.2 Clustering

The mean number of clusters was 3.25 ($SD = 1.63$) for quiet, 3.06 ($SD = 1.71$) for reversed speech and 3.5 ($SD = 1.93$) for meaningful speech. An ANOVA revealed that there was no effect of Sound Condition on the number of clusters generated ($p = .55$). In addition, there was also no difference in the size of these clusters (quiet, $M = 2.35$, $SD = 0.40$; reversed speech, $M = 2.42$, $SD = 0.62$; forward speech, $M = 2.34$, $SD = 0.54$; $p = .74$).

4.7.2.3 Switching

Switching scores were 16.89 ($SD = 5.12$) in quiet, 15.06 ($SD = 4.66$) in reverse speech, and 15.33 ($SD = 5.17$) in forward speech. Despite the switching scores being lower in the sound conditions relative to quiet, an ANOVA failed to reveal a significant effect of Sound Condition on switching scores ($p = .26$).

4.7.3 Discussion

The results of Experiment 12 are especially revealing. They demonstrate that phonemic-category fluency, as compared with semantic-category fluency appears invulnerable to disruption via the semantic properties of irrelevant sound. Moreover, that

reversed speech also had no effect suggests that phonemic-category fluency is resistant to acoustic effects of irrelevant sound, which further indicates that it might not be underlain by seriation (or serial rehearsal; see Beaman & Jones, 1997). That phonemic-category fluency is unimpaired by meaningful speech also suggests that the executive processing *per se* that is similarly purportedly involved in both fluency tasks is invulnerable to the meaning, and also to the acoustic properties, of irrelevant sound. Moreover, this result further supports the suggestion that switching in semantic-category fluency is underpinned by semantic retrieval as well as executive processes (Mayr, 2002; Mayr & Kiegel, 2000) and that these semantic processes are vulnerable to disruption via the concurrent semantic processing of irrelevant sound.

The finding that irrelevant sound failed to disrupt phonemic-category fluency is at odds with accounts that suppose that the disruption of performance of a focal task is produced to the extent that irrelevant sounds divert attention away from the primary task (Cowan, 1995; Elliott, 2002; see also, Neath, 2000). The findings of Experiment 12 are consistent, however, with both semantic network theories (e.g., J. R. Anderson, 1983) and the semantic interference-by-process account (see Chapters 2 and 3). In terms of the semantic network theories, the phonemic-category fluency task is not prone to disruption via the activation of irrelevant semantic information because, arguably, search for sub-categories and exemplars in the task is not based, at least entirely, upon such semantic activation, but is instead based upon phonological information such as initial letter sounds (but see Schwartz et al., 2003). Moreover, the semantic interference-by-process approach supposes that meaningful speech does not disrupt the phonemic-category fluency task because the irrelevant sound does not convey information that is compatible with the process involved in the focal task (e.g., generating words with a particular initial sound).

4.8. GENERAL DISCUSSION

The results of the current series can be summarized as follows. Experiment 9 demonstrated that the meaningfulness of irrelevant sound produces disruption to the generation of exemplars in the semantic-category fluency task. This experiment also

revealed that the task was immune to any disruption produced by the acoustic properties of sound because reversed, and hence meaningless, speech failed to affect semantic-category fluency. Experiment 10 confirmed this lexical-semantic effect, and also revealed an additional effect of between-stream semantic similarity over and above the lexical-semantic effect: semantic-category fluency was greater impaired by irrelevant material that belonged to the same, as compared with a semantic category different, as that to-be-generated.

Using oral responding, Experiment 11A revealed an effect of between-stream semantic similarity when the irrelevant material was associatively-related, as opposed to non-associated, to the to-be-generated material, suggesting that the between-stream semantic similarity effect reported in Experiment 10 is not simply due to lost retrieval time produced by the spontaneous monitoring of the categorically-related irrelevant sound to avoid recalling its contents. Moreover, Experiment 11B demonstrated that changing the response mode did not alter the type of disruption observed: The semantic, but not acoustic, properties of irrelevant sound thus produce disruption regardless of oral or written response modes. In addition, Experiment 11A showed that the switching, but not clustering, sub-component of semantic-category fluency is disrupted by meaningful irrelevant sound, and that fewer sub-categories were generated in the between-stream semantic similarity condition relative to the quiet and semantically-dissimilar condition.

Finally, Experiment 12 revealed that the semantic properties of irrelevant sound have no effect of phonemic-category fluency including its associated sub-components such as switching and clustering. The results of Experiment 12 thus suggest that the semantic properties of irrelevant sound interfered with semantic, rather than executive, components of switching in Experiment 11A. Additionally, other measures associated with disrupted executive function such as increased repetition did not occur in the presence of semantic irrelevant sound.

The results of the foregoing experiments can be accounted for within semantic network theories (e.g., J. R. Anderson, 1983) as described earlier and the interference-by-process approach (Hughes & Jones, 2005; Jones & Tremblay, 2000; see Chapters 2 and 3). The interference-by-process view, for example, holds that the processing of information conveyed by the irrelevant sound is in conflict with the processing of

information in the primary task. Thus, when the primary task requires semantic retrieval processes, processing the irrelevant semantic information extracted from the sound will interfere. On the interference-by-process account, phonemic-category fluency is not disrupted by the semantic properties of irrelevant sound because, in this case, the sound does not specify information that is compatible with the processing involved in the primary task (e.g., generating words with the same initial sound). However, this account suggests that phonemic-category fluency may be particularly impaired by irrelevant items that convey strong initial letter sounds. For example, hearing “phone” or “pharmacy” may impair retrieval of words beginning with the letter “F” because, at some level, processing this information is similar to the processing required in the focal task of generating a subset of words beginning with the same initial sound but starting with a different initial letter, “F”. It is also possible that a similar effect may emerge on tasks such as rhyme-category fluency (e.g., Shaywitz, Pugh, & Constable, 1995): More specifically, the ability to generate rhyming words may be impaired by processing irrelevant items that share a strong rhyming cue with each other or with the responses to-be-generated (cf. J. E. Marsh & Jones, 2006).

Of course it is possible that the phonemic-category fluency task failed to reveal disruption attributable to the semantic properties of irrelevant sound for a reason other than the lack of a semantic interference-by-process. For example, one might suppose that because there are a larger set of available responses to retrieve the task is simply easier than semantic-category fluency. In other words, one might consider that more hypothetical executive resources are required to access the exemplars in semantic-category fluency as, being a smaller set, remaining exemplars are harder to retrieve once a subset have already been produced (e.g., Rundus, 1973). However, recent evidence suggests that the opposite is true. For example, Thompson-Schill and Kan (2000; see also Diaz, Sailor, Cheung, & Kuslansky, 2004) have shown that hypothetical ‘executive resources’ are in greater demand when semantic or phonemic cues are less constrained (e.g., “S” or “Animals”) as opposed to more constrained (“STA” or “Farm Animals”) suggesting that it is more, not less, difficult when the set of available responses is large rather than small. Moreover, other research suggests that phonemic-category fluency is actually a more demanding task than semantic-category fluency (e.g., Troyer et al., 1997)

which also indicates against a simple explanation that the disruption produced by meaningful irrelevant sound interacts with task difficulty (cf. Graydon & Eysenck, 1989).

That the switching sub-component of phonemic-category fluency is not disrupted by the semantic properties of irrelevant sound, whereas the same sub-component in semantic-category fluency is, suggests that it is a semantic interference-by-process that underpins the disruption, not disruption, or breakdown of, executive processing per se. Interestingly, a similar issue regarding whether or not semantic or executive processes are primarily disrupted in semantic-category fluency has arisen in the work on dementia of the Alzheimer's type (see Henry, Crawford, & Phillips, 2004). The pertinent issue in this literature is that the impairment in semantic-category fluency associated with Alzheimer's dementia may *not* be evidence for degradation of, and retrieval based on, semantic associations as some researchers argue (e.g., Cherkow & Bub, 1990; Grober, Buschke, Kawas, & Fuld, 1985; Hodges, Salmon, & Butters, 1992) but could simply arise as a consequence of a breakdown of executive, controlled, processing that is used to access unimpaired semantic memory (e.g., Balota & Ferraro, 1996; Grande, McGlinchey-Berroth, Milberg, & D'Esposito, 1996). Patients with dementia of the Alzheimer's type, for example, not only show patterns of deficits that indicate problems with semantic memory retrieval, they also exhibit patterns of disruption that indicate impairment of other lexical retrieval processes. For example, Alzheimer's patients may show impairment to both phonemic- and semantic-category fluency (e.g., Nebes, D. C. Martin, & Horn, 1984; Suhr & R. D. Jones, 1998). However, a recent meta-analysis (Henry et al., 2004) has revealed that, for participants with Alzheimer's dementia, executive processes may be impaired in both phonemic- and semantic-category fluency, but that semantic-category fluency is disproportionately (i.e., more prominently) impaired (see Butters, Granholm, Salmon, Grant, & Wolfe, 1987; Monsch et al., 1992; Monsch et al., 1997; Rohrer et al., 1999; but see Baldo & Shimamura, 1998; Henry & Crawford, 2004). This finding is taken as evidence that Alzheimer's dementia disrupts normal semantic cognitive processes over and above its effect on executive processes.

One insight from the studies with Alzheimer's patients in regard to the foregoing experimental series is that they offer more evidence that semantic- and phonemic-category fluency are disproportionately underpinned by semantic and executive processes

and that these can be differentially, or uniquely, disrupted by neurological or empirical factors. Thus, these findings mesh neatly with those of the current experimental series that demonstrate that meaningful sound uniquely impairs the semantic processing component of semantic-category fluency.

In terms of explaining the results of Experiments 9-11, there is, on the face of it, little to choose between the account offered by semantic network theories and that offered by the semantic interference-by-process approach. Indeed, the primary difference between the two approaches is that the latter supposes inhibition is recruited to solve selection (and competition) and yields forgetting as a by-product of the functional process used to solve the selection problem, whilst the former propose that forgetting (or failure to access events) is attributable to a reduction in limited resources for activation. Thus, on the semantic network accounts, forgetting is a passive side effect of changing patterns of activation within a structural network. Some might regard the idea of a specialized inhibitory mechanism as an unnecessary additional construct with regard to theoretical parsimony (see M. C. Anderson & Bjork, 1994). However, the semantic network accounts are prey to the general alienation of the received view of limited resources that exists on the grounds that it is seldom explained how a resource or resources become(s) limited (M. C. Anderson & Bjork, 1994; O. Neumann, 1987). As M. C. Anderson and Bjork (1994, pp. 319) put it: "To the extent that limited-capacity assumptions are necessary to implement non-inhibitory mechanisms, and to the extent that those assumptions bury inhibitory processes, non-inhibitory models may not be more parsimonious". Moreover, semantic network theories appear to distress how it is that competing memories can be prevented from being retrieved enabling retrieval of a target-memory, and what the consequences are for resolving this competition (see M. C. Anderson, 2003).

The disaffection expressed here with resource-based views is of a similar character to that applied generically to attentional resource-based accounts of disruption from irrelevant sound (Cowan, 1995; Elliott, 2002; Neath, 2000; Page & Norris, 2003). On these accounts it could be argued that the semantic properties of the irrelevant sound in the present experimental series produce disruption through creating a divided attention experiment by capturing attention away from the memory task. At some level there are

similarities with the disruptive effects attributable to the disruption produced by semantic irrelevant sounds and those reported with studies deploying secondary tasks (e.g., Baddeley et al., 1984; Rosen & Engle, 1997; see Chapter 3). On the other hand though, there are clear differences, among these are that semantic-category fluency is not disrupted by secondary tasks (unless they involve placing a concurrent load on memory; Baddeley, et al., 1984; Moscovitch, 1994; Rosen & Engle, 1997; Troyer et al., 1997) and that phonemic-category fluency tends to be disrupted by any secondary task (regardless of whether it involves a concurrent memory load; Moscovitch, 1994; Troyer et al., 1997). Both these findings with secondary tasks are at odds with the pattern of results obtained in the foregoing series: if ignoring meaningful sound operates as a secondary task it would be expected that disruption would be found for phonemic-category fluency but not semantic-category fluency, the reverse of this expected pattern was found. In short, attentional resource-based accounts do not appear well specified enough to explain why different ISEs are so acutely sensitive to the nature of the dominant mental activity.

This lack of specification is also a problem with structural, interference-by-content accounts. The traditional interference-by-content accounts (Salamé & Baddeley, 1993; Neath, 2000) propose that the disruption irrelevant sound produces is, at some level, attributable to the structural similarity of the irrelevant and TBR items that coexist within a hypothetical representational, mnemonic space. A considerable body of research suggests this is not the case for serial recall (see Jones, 1999, for a review). Moreover, in the context of semantic-category fluency, interference-by-content could only occur if one assumes the repositing of responses in a hypothetical short-term store after being produced, and that meaningful sound produces traces that are more similar to relevant exemplars than meaningless sound. However, if disruption occurred with this supposed short-term storage then one might expect an increment in repetition in the meaningful sound condition, this did not occur.

Despite evidence against interference-by-content accounts, it is possible that content or structure plays a role in the impairment produced by meaningful irrelevant sound. For example, that a structured semantic network exists of concepts relating to features, category names and exemplars appears well accepted (M. C. Anderson & Bjork, 1994). Moreover it is also commonly accepted that spreading activation can occur between

representations within the semantic network leading to those representations competing for retrieval (M. C. Anderson & Bjork, 1994). Critically, however, it is not the similarity in content between to-be-generated and irrelevant items per se that produces impairment of retrieval of to-be-generated material, but an inhibitory process aimed to resolve the competition for retrieval that irrelevant responses offer to relevant events (e.g., M. C. Anderson et al., 2000). On this interference-by-process view then, executive processes may be the cause of the retrieval disruption produced by between-stream semantic similarity but not because they are somehow corrupted (or that hypothetical cognitive resources for their effective functioning are reduced) but that they are brought into action when an irrelevant sound conveys information that is compatible with the responses involved in the primary task. In other words, in the case of semantic tasks, it is semantic competition that invokes the need for executive process mechanisms such as inhibition (in the case of serial recall tasks it may well be that competition between serial-ordered representations of the relevant exemplars and irrelevant items also requires resolution via executive mechanisms; see Hughes & Jones, 2003a, 2005). In short, it is thus not the semantic content of the sound per se that has a disruptive impact on executive processing.

In sum, extant work on auditory distraction with serial recall and the majority of work on auditory-semantic distraction, including that reported here, can be better reconciled within an interference-by-process approach (e.g., Hughes & Jones, 2005; Jones & Tremblay, 2000; see Chapters 2 and 3) than either a mnemonic (or content-based) approach (e.g., Neath, 2000; Salamé & Baddeley, 1982) or an attention resource-based approach (e.g., Cowan, 1995; Elliott, 2002; Neath, 2000; Page & Norris, 2003). The qualitatively different impairments that arise through exposure to different irrelevant auditory stimuli (semantic or acoustic) in different settings (episodic retrieval of order versus semantic retrieval of category-exemplars) reflect disruption at the interface between selective attention and memory. That is, these impairments are the manifestation of selective mechanisms that operate to prevent information appropriate to processes required for, but inappropriate to the specific processing requirements of, performing a given focal task.

Chapter 5

GENERAL OVERVIEW AND THEORETICAL IMPLICATIONS

5.1 SUMMARY OF AIMS, MAIN EMPIRICAL RESULTS AND CONCLUSIONS OF THE EMPIRICAL SERIES

5.1.1 Aims of the thesis

Broadly, the present thesis aimed to investigate whether the interference-by-process account of auditory distraction in the context of serial recall (e.g., Jones et al., 1996) could also apply to tasks requiring semantic processing. Semantic focal tasks were used to investigate the way in which irrelevant auditory-semantic information disrupts performance on tasks requiring semantic processing (e.g., Martin et al., 1988; Oswald et al., 2000). In Chapter 1, it was claimed that the interference-by-process construct provides an equally acceptable, if not more plausible, account of auditory-semantic distraction than either an interference-by-content approach (Neath, 2000; Salamé & Baddeley, 1982) or an attentional resource approach (Cowan, 1995; see also Neath, 2000). Moreover, it was argued that in line with the interference-by-process account, the semantic character of irrelevant sound produces disruption only when the focal task induces semantic processing and, in conjunction with the ignored sound, mobilizes source-monitoring (M. K. Johnston et al., 1993) and inhibitory processes (M. C. Anderson, 2003) that would otherwise not (at least not by necessity) operate. It was argued that auditory-semantic distraction is a consequence of using semantic focal processes, source-monitoring, and inhibitory, processes that are under certain circumstances fallible; that is negatively affected by the semantic properties of irrelevant sound. Three empirical series were then reported each investigating the viability of the interference-by-process approach to auditory-semantic distraction whilst critically assessing the veracity of the interference-by-content and attentional resource accounts and, by extension, the functional and structural approaches upon which, respectively, they are based.

5.1.2 Summary of main results

5.1.2.1 Series 1 (Chapter 2)

The three main aims of Series 1 were to: (1) establish whether the auditory-semantic effects demonstrated previously using lists containing exemplars drawn from a single semantic category was the result of auditory-semantic distraction, or due to the acoustic properties of the irrelevant sound; (2) investigate the role that source-monitoring and inhibitory processes play in auditory-semantic distraction; (3) evaluate whether focal task processes influence auditory-semantic distraction; and (4) assess whether forgetting in the context of auditory-semantic distraction is best understood as a passive or dynamic process. The findings from Series 1 were that: (a) an irrelevant auditory sequence must convey semantic properties to disrupt the free recall of semantic-category lists suggesting that the ISE in this setting is functionally distinct from that in the serial recall setting; (b) between-sequence semantic similarity increases the fallibility of a source-monitoring process and may lead to the recruitment of inhibitory processes to prevent retrieval of semantically-related irrelevant items, but only when the irrelevant items are high-dominance; (c) the effects of between-sequence semantic similarity are driven by focal task processes because strategies associated with free, but not serial, recall exacerbate forgetting and source-monitoring error; (d) the forgetting produced by auditory-semantic distraction (particularly that due to between-sequence semantic similarity) is best interpreted as a dynamic, rather than passive, process and supports an interference-by-process rather than interference-by-content or attentional resource-based approach to auditory-semantic distraction.

5.1.2.3 Series 2 (Chapter 3)

The main aim of Series 2 was to further investigate the semantic interference-by-process, as opposed to interference-by-content or attentional resource-based, construct using an episodic-semantic recall task, and task-instructions (semantic-categorization) that are generally considered as being more representative, and demanding, of semantic processing than the task used in Series 1. This series provided compelling evidence for the semantic interference-by-process construct in showing that the semantic properties of irrelevant sound, including between-sequence semantic similarity, disrupted recall only when semantic processing (semantic-categorization) was adopted for the focal task.

5.1.2.4 Series 3 (Chapter 4)

The final empirical series examined the semantic interference-by-process construct using a semantic task (semantic-category fluency) that is thought to be minimally contaminated by an episodic memory component (Graesser & Mandler, 1978). The impetus for the approach adopted in Series 3 was the fact that episodic processes such as seriation could be used in the episodic-semantic tasks used in Series 1 and 2, and that the potential use of these processes renders the tasks adopted in these series relatively impure measures of semantic processing in comparison to the semantic-category fluency task. The evidence gleaned from this series was that the semantic, but not acoustic, properties of irrelevant sound disrupt the generation of exemplars from semantic memory. Moreover, this series provided evidence that semantic generation of category-exemplars is further impaired when the irrelevant information is semantically similar to the semantic knowledge to-be-generated. Consistent with the semantic interference-by-process account, the semantic properties of irrelevant sound failed to disrupt a task—that of phonemic-category fluency—that makes similar cognitive demands to semantic-category fluency but without the requirement for semantic retrieval processes.

Each of these three sets of results was interpreted within the interference-by-process approach to auditory-semantic distraction. The following section includes an assembly of the conclusions drawn from each empirical chapter; the aim of this is to clarify how source-monitoring processes, inhibitory processes, and semantic processes interplay to bring about the pattern of performance associated with auditory-semantic distraction.

5.1.3 Summary of conclusions: The interplay of episodic and semantic factors in auditory-semantic distraction

Within the interference-by-process approach, the effects of auditory distraction *generally* are proposed to result from the similar processes that are applied deliberately to the focal task material and automatically to the irrelevant material. In the case of serial recall these conflicting processes are ones of seriation. However, for semantic focal tasks the conflict is between two semantic processes. In addition to the susceptibility to disruption of semantic focal processes by the semantic processing of irrelevant sound when there is no semantic similarity between the irrelevant and to-be-recalled sources of

information, two other processes are involved in the case of between-sequence semantic similarity: those relating to source-monitoring and inhibition. With between-sequence semantic similarity, source-monitoring processes must operate in order to separate three episodic sources of memories: those that arise due to externally presented events via the visual modality, those that are externally presented auditorily, and those that are internally generated. This source-monitoring process is by no means inerrable (e.g., M. K. Johnson et al., 1993), and between-sequence semantic similarity can be considered to increase the fallibility of the process; that is, the source-monitoring process can become more prone to error when irrelevant items are presented from the same category as to-be-recalled exemplars. The second, a more functional process, inhibition, is likely to be marshaled because related irrelevant items are potential retrieval targets that must be prevented from being selected. Inhibition, like source-monitoring is also not error-free, nor is it cost free: Inhibition of irrelevant items from a semantic category could, for example, spread to to-be-recalled exemplars making them more difficult to retrieve (it is also possible that erroneous retrieval of these irrelevant items can inhibit to-be-recalled exemplars). Moreover, the functional utility of using inhibition—in terms of avoiding selecting irrelevant items—may also carry an overhead in that it can have an associated cost reflected in reduced recall performance (see Hughes & Jones, 2005).

5.2 GENERAL IMPLICATIONS

5.2.1 Implications for theories of auditory-distraction

Several of the findings reported in the present thesis directly, or indirectly, address the debate between functional, interference-by-process approaches (Jones & Tremblay, 2000) and structural interference-by-content accounts (Neath, 2000; Salamé & Baddeley, 1982) and between interference-by-process and attentional resource-based (Cowan, 1995; Elliott, 2002) approaches.

5.2.1.1 Interference by process or content?

The central issue here is whether the impairment to focal task performance that occurs in the presence of meaningful irrelevant sound is impelled by the fact that there are two concurrent semantic processes operating simultaneously or whether the semantic

content of the irrelevant sound, in some manner, vitiates the representations of TBR exemplars. The evidence that semantic effects are dependent on the nature of the focal task in all three series reported here clearly undermines the passive view of interference-by-content inasmuch as it lends support to a central assumption of the interference-by-process account: that auditory-semantic distraction will arise only when the primary task requires semantic processing. However, proponents of the interference-by-content accounts could argue that the semantic properties (or features) of irrelevant items will not produce impairment when the focal task involves non-semantic strategies such as seriation because, when this is the case, the semantic content of to-be-recalled items may not be represented in the mnemonic traces of those items. This view appears inadequate, however, given that there is ample evidence that the semantic properties of TBR exemplars are registered regardless of the nature of the primary task (J. H. Neely & Kahan, 2001; Kriegstein et al., 2003). The interference-by-process account gives a less rigid account than this inferred interference-by-content account in that it assumes that the semantic properties of TBR and ignored words can be represented (e.g., the meanings of both sets of words can be activated) but these semantic representations will not interfere with one another if the primary task does not involve processing the semantic attributes of these representations. Similarly, the process account also supposes that another type of analysis, perceptual organization (or streaming) of irrelevant sound, will occur regardless of whether the focal task requires a similar seriation process or a dissimilar process but will only produce disruption (or a classical ISE) if the focal task requires seriation.

The findings of Series 1-3 also suggest against the idea of a passive, interference-by-similarity-of-content within separate long-term, or indeed short-term, memory stores or in a buffer that is sensitive to the semantic similarity between representations (e.g., Glanzer, 1972; Haarmann & Usher, 2001). More specifically, with regard to between-sequence semantic similarity, impairment by irrelevant items cannot simply be produced as the result of some passive storage of similar traces within a memory module because focal task processes determine the effect (see Experiments 3, 8, 11, and 12). Moreover, Series 1 and 3 provided support for the notion that the decrement in performance produced by between-sequence semantic similarity is due, in a large part, to source-monitoring and possibly inhibitory processes. Because source-monitoring and inhibitory processes could

occur regardless of 'storage', the findings of Series 1-3 might be taken as evidence that the idea of a separate phonological short-term store (Baddeley, 1986) and episodic-semantic long-term store (e.g., Glanzer, 1972) or even a semantic short-term memory store or buffer (Baddeley, 2000b; Haarmann & Usher, 2001) is superfluous. Indeed, the semantic-category fluency task used in Series 3, whereby the notion of episodic-semantic 'storage' is at best debatable, revealed a robust between-stream semantic (or associative-category) similarity effect.

In sum, the findings of Series 1-3 are consistent with the interference-by-process construct but the interference-by-content accounts are damaged by the findings in three ways: (a) the evidence that auditory-semantic distraction is determined by focal task processing is at odds with the task-process insensitivity assumption of these accounts; (b) it seems that neither of the interference-by-similarity-of-content accounts can provide an explanation for the role that source monitoring and possible inhibitory processes play in the between-sequence semantic similarity effects reported in Series 1-3, and (c) the accounts have difficulty explaining how direct retrieval from semantic knowledge (e.g., without necessitating an episodic component or store) can be susceptible to auditory-semantic distraction.

5.2.1.2 Interference by process or attentional resource-based approaches?

The claim that auditory-semantic distraction reported in Series 1-3 is produced by interference-by-process assumes that the semantic content of irrelevant sound does not reduce hypothetical attentional resources simply by capturing attention away from the primary task or generally by creating a divided attention setting. There are already ample lines of evidence to suggest that the semantic properties of irrelevant sound do not ordinarily capture attention; typically, for example, reversed and forward English narrative produce comparable disruption in serial recall settings (Jones et al., 1990; see also the supplementary experiment in Series 2). However, an attentional resource approach based on the concept of attentional capture could account for between-sequence semantic similarity effects by proposing that they are driven by ORs to the primed semantic features of the irrelevant items (cf. Cowan, 1995). This account, however, has several drawbacks; the first is that one might expect that, if this semantic feature priming is based upon automatic spreading activation, ORs to the semantic features of irrelevant

sound would occur regardless of the nature of focal task processing because automatic spreading activation occurs ‘full blown’ no matter what the primary task processing consists of (J. H. Neely & Kahan, 2001, but see M. S. Brown et al., 2001). The second drawback for the attentional capture account relates to its failure to explain the lexicality effect demonstrated in Experiments 1A, 1B and 10 whereby the semantic properties of irrelevant items that are *unrelated* to the to-be-recalled material produce disruption: In this case semantically-based disruption occurs in the absence of any priming of the semantic features of irrelevant items.

Further compelling evidence against the attentional resource-based approach is that the characteristics of the breakdown in performance produced by auditory-semantic distraction do not resemble the pattern of performance decrements observed in secondary (or divided attention) task settings. The most salient example of this comes from Series 3 where it was demonstrated that the supposedly attentionally-demanding phonemic-category fluency task remained invulnerable to auditory-semantic distraction (Experiment 12), but the more automatic (i.e., not as attentionally-demanding), semantic-category fluency task was susceptible to pronounced disruption (Experiment 9-11). Moreover, several other measures undermine the notion that ignoring sound acts as a secondary task. For example, the number of repetition errors and false recalls that are typically produced by secondary tasks (Perez-Mata, Read, & Diges, 2002; Rosen & Engle, 1997) remained unaltered in the presence of meaningful irrelevant sound when it was unrelated to the to-be-recalled material (see Experiments 1-12).

The intent for the next section is to outline, and seek reconciliation for, a number of apparent divergences in the data across the series reported in the current thesis.

5.3. OUTSTANDING ISSUES OF INTERPRETATION

5.3.1 Discrepancies between the findings of Series 1 and 2

5.3.1.1 The role of seriation

A somewhat surprising result that appears discrepant between Series 1 and 2 is that in the former Series, a serial recall strategy does not appear to be involved, unless instructed, whereas in the latter a seriation strategy appeared to be involved, at least to

some extent regardless of task-instruction. Why might this be the case? One possible answer is that the comparatively slower rate of presentation in Series 2 as compared with Series 1 allowed a seriation strategy to emerge. Another answer may lie in the blocked versus random organization of the category-exemplars in the TBR lists. Blocking the category-exemplars in each list as in Series 1 means that TBR exemplars not only prime each other during presentation but that they also act as an organizational aid (Rappold & Hastroudi, 1991). However, with random presentation of category-exemplars, as in Series 2, this adjacent-exemplar priming will *not* occur and the semantic-organization is not already inbuilt into the list structure; participants have to mentally re-organize the list into the constituent semantic-categories. This requires semantic focal processing to identify the categories which may not always be successful, forcing participants presented with randomized, as opposed to blocked, lists to revert back to the serial organization of the list (cf. Wetherick, 1976).

Another possibility as to why there are dissimilarities in seriation scores between experiments is that there could sometimes be a misrepresentation of participants preferring one particular type of organizational strategy over another (e.g., seriation over categorization; essentially a sampling error) which can have the effect of boosting a particular organization score in one experiment relative to another and also changing the apparent susceptibility of the task to disruption by the different properties (acoustic or semantic) of irrelevant sound. The role of organizational strategies in determining disruption from different properties of irrelevant sound (semantic or acoustic) is an, as yet, under-researched area that promises to be very informative (cf. Perham & Jones, 2006). Some extant research suggests that individual differences in preferred organizational strategy can have a pronounced effect on the susceptibility to impairment in different experimental settings. A good example of this comes from research that has investigated whether part-list cuing inhibition is the result of strategy disruption (Basden, Basden, & Stephens, 2002; Serra & Nairne, 2000). In this research (e.g., Basden et al., 2002), participants are presented with 8- or 16-item TBR lists at study. Then, during test, participants are sometimes presented with cues consisting of a number of items that are either in an order that is congruent or incongruent to their order in the study list. Order-incongruent cues produce more disruption than congruent and no cue conditions, whereas

order-congruent cues produce a facilitatory effect relative to the no cue condition. This suggests that the retrieval cues force a serial order of recall that conflicts with a participants' retrieval plan. Whether this impairment produced by order-incongruent cues is manifest, however, is critically dependent upon whether participants fall into a category of low- or high-seriators as defined by a median split: Recall performance of high-seriators who rely on seriation is profoundly disrupted by the order-incongruence of cues whereas recall performance of low seriators, who do not rely on seriation as a retrieval strategy, is not disrupted. This suggests that the order-incongruent retrieval cues did not interfere with the non serial-recall strategy used by low-seriators.

In short, the research on strategy disruption (Basden et al., 2002), as outlined above, suggests that participants classified as high-seriators often show disruption by competing serial structures (the order-incongruence of the retrieval cues) whereas low-seriators do not. The relevance to the auditory-distraction literature is that the preattentive processing of irrelevant sound is also thought to give rise to a serial structure that competes with the serial organization of the TBR material (e.g., Jones et al., 1996). Thus, using this logic, high-seriators, as compared with low-seriators, may show greater classical (acoustic) ISEs on a nominally free recall task. On the same logic, it is possible that low-seriators will demonstrate a more pronounced semantic ISE if, of course, their encoding or retrieval strategy involves semantic processes. Similarly, it is possible to divide participants into categorizers and seriators (e.g., Mandler, 1969) or low- and high-categorizers based upon a median split (e.g., S. C. Brown, Conover, Flores, & Goodman, 1991). Again using these participant groups, it would be predicted that participants who spontaneously adopt semantic categorization, or use semantic categorization to preferential extent, will demonstrate a semantic ISE of greater magnitude. In sum, the preferred organizational strategy of participants may well explain why the acoustic properties of sound can sometimes disrupt nominally semantic focal tasks (as in Experiments 6-8) and the semantic properties of sound can sometimes disrupt tasks requiring memory for serial order (cf. Hanley & Bakapoulou, 2003).

5.3.1.2 Levels of false recall

Another question that needs addressing is this: Why are false recalls—both in control conditions and in conditions of between-sequence semantic similarity—more numerous

in the experiments reported in Series 1 as compared with Series 2? There are a variety of variables that could give rise to the discrepancy in the false recall rate between these two series. First, the lists in Series 1, as compared to Series 2, were blocked by semantic-category. Blocking, versus random, presentation of semantic category-exemplars is well known to have a pronounced effect on retrieval: Blocking exemplars by category (or theme) increases correct recall (e.g., Rappold & Hashtroudi, 1991) and clustering (D'Agostino, 1969; Toggia, Hinman, Dayton, & Catalano, 1997) but can also increase false recalls (McDermott, 1996; Toggia, Neuschatz, & Goodwin, 1999; Tussing & Greene, 1997). Thus, it could be that the blocking method of presentation used for the lists included in Series 1 increases reliance on relational or semantic information that in turn leads to a greater chance of both internally generating or activating exemplars and erroneously retrieving irrelevant items due to source confusion. With random, as compared with blocked, presentation intervening items from different categories can reduce semantic activation of a given category. For example, the word "cabbage" intervening between "drill" and "saw" can drive the activation level down in the "Tools" category (the "intervening item" or "interposition effect"; Deacon, Hewitt, & Tammy, 1998). A reduction in semantic activation of a semantic-category has the consequence that the generation of non-presented items would have been less likely to occur in Experiment 8 than in Experiments 1-5 which in turn suggests that the chances of source-monitoring error in Experiment 8 will be reduced. Random, as opposed to blocked, presentation, of category-exemplars along with instructions to categorize in Experiment 8, as compared with free recall in Experiments 1-5, may also lead to the task being driven more by the veridical, as opposed to gist, representations of the stimuli list (cf. Brainerd et al., 2002). That is, one can imagine that with random presentation the task might require a series of "recollective" acts whereby on presentation of an exemplar from a category (e.g., "sheep") participants strategically recover related category-exemplars that have preceded the exemplar (e.g., "bear", "giraffe") despite intervening exemplars from an unrelated category (e.g., "hammer"; cf. Greitzer, 1976). This 'strategic' recovery of TBR exemplars will of course minimise erroneous generation of non-presented exemplars. Second, it is possible that false recall is lower in Experiments 1-5 than in Experiment 8 because of the increased use of a seriation strategy in the latter experiment.

In support of this assertion, it was shown in Experiment 3 that the chain-like structure that is derived from serial rehearsal may protect against the occurrence of false recalls (see also Read, 1996).

Third, the number of category-exemplars belonging to a particular category was much greater in the experiments reported in Series 1 (16 in Experiments 1-2, 10 in Experiments 3-5) compared to Series 2 (4 in Experiment 8). Because the number of related items presented per list is positively correlated with the incidence of false memory (e.g., Robinson & Roediger, 1997) it is not at all surprising that false recall is lower in Experiment 8 than Experiments 1-5. A fourth factor likely to be of central importance is the rate of exemplar presentation used in Series 1 and 2: Faster presentation rates were used in Series 1 (500 ms per exemplar with no ISI) as compared with Series 2 (1 s per exemplar with 1 s isi). Faster rates of presentation are acknowledged to increase false recall and thus source-monitoring failure (McDermott & Watson, 2001; Toggia et al., 1999) possibly via increasing reliance on gist memory or semantic activation, whereas slower presentation allows the encoding of verbatim information or item-specific detail that is likely to differentiate the source of activated memories (Brainerd et al., 2002; McDermott & Watson, 2001). A fifth possibility is that the degree of exposure to related irrelevant items may also have an effect. In the experiments reported in Series 1, exposure to irrelevant sound is relatively brief as compared with that in Experiment 8 in Series 3. Moreover, in Experiment 8 participants were presented with random permutations of four irrelevant category-items throughout the presentation and retrieval phases of the experiment. In this case it may be that source information for irrelevant items has a chance to accrue—due to their greater exposure as compared with the experiments reported in Series 1—making source-confusion errors less likely to occur.

Of course, each and every factor mentioned above can be manipulated independently in future experiments to determine its effect but one must not be nescient to the possibility that some of these manipulations may be inherently problematic. For example, blocking by semantic-category a categorized list that contains six exemplars from each of four semantic categories can render the list-clustered semantic-category-exemplars somewhat like 'subordinate' lists within the main list. It seems plausible that this presentation format could give rise to the adoption of a seriation strategy for each

subordinate list whereby the exemplars from each category are rehearsed in serial order: Thus, a manipulation to increase semantic or relational processing could actually prove to result in greater episodic processing of serial order.

5.3.2 Discrepancies between the findings of Series 1 and 3

5.3.2.1 Impairment of generation and false recall

Under control conditions (e.g., not conditions of between-sequence semantic similarity), false recalls are characterised by the automatic generation of non-presented exemplars (e.g., Dewhurst, Barry, & Holmes, 2005; Dewhurst, Barry, Swannel, Holmes, & Bathurst, 2006). Experiment 10 demonstrates that meaningful sound that is unrelated to the to-be-recalled category interferes with the generation of exemplars from semantic memory. In light of this result, one might question why meaningful sound fails to reduce false recall? The answer to this question may be that meaningful irrelevant sound disproportionately disrupts the generation of low-dominance, as compared with high-dominance, exemplars. Indeed, Experiment 10 demonstrated that although meaningful sound numerically reduced the number of high-dominance exemplars generated from a semantic-category this was not statistically significant against the control, quiet condition. If it is true that the retrieval of low-dominance exemplars is selectively, or disproportionately, affected by meaningful sound, then the degree of false recall will remain unchanged between quiet and categorically-unrelated sound conditions as found in Experiments 1-5. More specifically, because source-monitoring errors occur more for high-dominance as opposed to low-dominance category-exemplars (e.g., Dewhurst, 2001) and the generation of these high-dominance exemplars is relatively unaffected by meaningful sound (Experiment 10) false recalls of high-dominance exemplars will persistently emerge.

This assumption—that meaningful sound does not produce much impairment of the generation of high-dominance exemplars—is, however, based upon one experiment and a more direct line of research assessing the nature of the relationship between impaired category-exemplar generation and false memories would be fruitful particularly because there are salient differences between the methods used in the experiments of Series 1 and those typically used for false memory research. One potentially important difference relates to the number of so-called “critical items” omitted from the TBR list: In false

memory experiments usually only one or two are withheld (e.g., Roediger & McDermott, 1995; S. M. Smith et al., 2001) but in the experiments reported in this thesis eight to ten exemplars were omitted (due to those items being presented as irrelevant sound on related trials). It seems plausible that any modulation to false recall by meaningful irrelevant sound could be obscured by omitting as many as eight to ten exemplars because participants could simply deploy a retrieval heuristic; that is, participants may recognize that most of the frequent exemplars that they generate are unlikely to be presented on the TBR list and thus they can be “edited” before retrieval. It is thus possible that if one or two items, as compared with eight to ten, were omitted from TBR lists, then one may observe changes to the rate of false recall as influenced by meaningful sound.

5.3.2.2 Category-specific and associated-category impairment

Another apparent peculiarity between the results of Series 1 and Series 3 is that in Series 3 dominant irrelevant items from a category associated to the to-be-recalled category (e.g., “Vegetables” when the to-be-recalled category is “Fruit”) impair retrieval from semantic memory (Experiment 11A) but low-dominance exemplars selected from the same category as that to-be-recalled does not impair free recall performance on an episodic-semantic task (Experiment 4). One possible explanation is that the episodic-semantic task allows for a greater degree of integration between to-be-recalled exemplars before their production: Integration has been shown to protect against impairment such that inhibition of target responses by irrelevant information is less likely to occur (M. C. Anderson et al., 2000; Bäuml & Aslan, 2006).

An additional possibility is that disruption produced by high-dominance irrelevant items from a category associated to one from which responses are to-be-generated is confined to the retrieval of low-dominance exemplars. Thus, low-dominance irrelevant items may not produce retrieval disruption simply because the episodic-semantic free recall experiment (Experiment 4) used TBR exemplars that were higher in dominance than the same-category to-be-ignored items. It is possible that if to-be-ignored and TBR category-exemplars shared a low-level of dominance that a between-sequence semantic-category similarity effect could emerge, along with a weaker effect due to the semantic association between exemplars drawn from similar semantic categories (“Fruits” and

“Vegetables”). Studies are currently being undertaken that aim to assess whether such a “graded similarity effect” is dependent on the degree of congruence between the dominance of TBR and to-be-ignored category-exemplars.

Having dealt with issues and implications regarding the apparent discrepancies between the results obtained in the current thesis, the next subsection considers broader implications of, and issues raised by, the key findings of the thesis.

5.4 BROADER IMPLICATIONS AND ISSUES

5.4.1 Extent of preattentive processing of sound

5.4.1.1 Post-categorical processing of ignored sound?

Logically, to produce disruption on focal task performance, the semantic properties of ignored information must have produced activation of lexical meaning. This is compatible with the notion of late, rather than early, selection. That is, rather than being confined to the processing of rudimentary physical properties, irrelevant linguistic stimuli are processed to the level of their meaning. However, does this semantic analysis take place preattentively? In contrast to ample evidence that perceptual analysis of ignored sound, such as the processes involved in auditory-streaming, take place preattentively (Macken et al., 2003; Sussman, Horváth, Winkler, & Orr, 2006), that semantic analysis can take place without attention is a controversial issue (see Holender, 1986; Lachter, Forster, & Ruthruff, 2004; Pashler, 1998). The methodologies or task-settings used to assess the disruptive impact due to the semantic properties of irrelevant sound demonstrated in the present thesis cannot be seen to satisfy the stringent criteria of ensuring that to-be-ignored information remains unattended. Unlike focal serial recall tasks the paradigms used in Series 1-3 of the present thesis are unlikely to be characterized by the unrelenting, attentionally-demanding serial rehearsal process common of serial recall. As such, the semantic properties of the hypothetically unattended information in Series 1-3 could be processed due to *attention slippage* or *switching* (see Lachter et al., 2004) as opposed to obligatory, automatic processing whilst attention is focused elsewhere.

Ensuring that attention slippage never occurs is extremely difficult (Rivenez, Darwin, & Guillaume, 2006) but indirect clues as to how often this is likely to occur for the tasks used in the present thesis can be assessed by using measures of Working Memory capacity (Beaman, 2004; Conway et al., 2001). Low Working Memory capacity participants demonstrate more ORs (essentially attentional slippage) to their names that are embedded in the irrelevant channel of dichotic listening tasks (Conway et al., 2001). As such, low Working Memory capacity participants might be expected to show a larger semantic ISE. There is already some evidence that Working Memory capacity plays a role in semantic ISEs. Using an identical task to that used in Experiments 1-2 of the current thesis, Beaman (2004, Experiment 4) for example, found that low, as compared with high, Working Memory capacity participants included more of the related, high-dominance irrelevant items as responses despite demonstrating comparable levels of between-sequence semantic similarity-induced forgetting.

It should be mentioned here, however, that even if the conflict by semantic process is inevitably shown not to occur at a preattentive level for the tasks used in the current thesis, this should not detract from the importance of these phenomena of auditory-semantic distraction: the auditory information is still irrelevant—as is emphasised by the experimenter and written task-instructions—yet it cannot be prevented from impeding and corrupting focal task processing.

Supposing that the meaning of ignored words is indeed processed, two prominent questions are: In what manner are ignored words semantically processed? And how do ignored words bring about disruption to the processing of to-be-remembered words? According to the non-selective access hypothesis (G. Underwood, 1981), unattended words gain access to the lexicon regardless of the relationship with the target stimulus but the effect of between-sequence semantic similarity arises during processes after recognition. According to this hypothesis, candidate affected processes include selection of the recognized lexical token, and selection of the response. More specifically, when two stimuli, one a target word, another an unattended word, activate their lexical representations one of them must be selected as the basis for the organization of the response. Between-sequence semantic dissimilarity does not have a robust effect on the selection of an appropriate lexical token in comparison to between-sequence similarity,

because the two sources of activation in the lexicon point to semantically distant words and thus their separation poses little processing difficulty. However, when the unattended and attended material is associated then the selection of the target—or its separation from activated unrelated items—may be impeded by the activity caused by its near neighbour.

According to G. Underwood and Everatt (1996) different effects of unattended items that are unrelated or related to those TBR items are produced due to effects on different stages of processing: The disruption produced by between-sequence semantic similarity, for example, could be thought to have its effect at a processing stage whereby lexical entries are accessed (via automatic spreading activation), whereas unrelated words may affect a processing stage whereby a target has to be selected in preparation for a response.

Taking for granted the notion that the meaning of the irrelevant sound material is processed, at what level is it processed? Are sequences of words semantically analysed to extract sentential meaning? Or is the meaning of individual words processed without their integration? And what consequence does this semantic processing have for the focal task processing in the current thesis? In a comprehensive review, G. Underwood and Everatt (1996) propose that unattended information undergoes semantic analysis but only at the level of individual word meanings. More specifically, they argue there is no evidence for inter-word semantic processing: In other words there is little evidence that unattended sequences of words gain the integration necessary for recognition of their underlying meaning which requires a propositional analysis of an irrelevant sentence thought to require focal attention. More specifically, they argue that listeners do not appear to recognize the deep structure of an unattended sentence or recognize the common category of words in an unattended list. Based upon this conclusion, a reasonable hypothesis would be that individual meaningful irrelevant items interfere with the focal task processing of the individual meanings of TBR items (or the use of the meanings of those items for, say, semantic organization).

Indeed, consistent with this hypothesis, a small body of existing evidence suggests that the irrelevant sound produces disruption at the level of individual words. For example, Martin et al. (1988, Experiment 1) report that an irrelevant passage of coherent text produced no more disruption of comprehension than randomly arranged words that were taken from the text. This suggests that neither the continuity of speech (i.e., the

presence of co-articulatory cues) nor its inter-word semantic properties (i.e., semantic transitional probabilities) govern its disruption of reading comprehension. Some evidence also suggests that meaningful irrelevant sound produces disruption attributable to its lexical item, rather than supra-lexical, properties for the semantic category-clustering task used in Series 2 of the current thesis (Pope & Jones, 2002). This research shows that the order of approximation to English of irrelevant narrative has no effect on the degree to which it disrupts semantic-categorization (or category-clustering): Natural English narrative (first-order approximation) produces no more disruption than a high-order approximation to English (whereby every sixth word of a text is selected and randomly reinserted into the vacant positions) and a low-order approximation (whereby this procedure is performed with every second word). That these nonsense texts produce as much disruption as a coherent, meaningful text further supports the notion that irrelevant auditory-semantic material produces impairment at the lexical, rather than a sentential, level.

Further evidence that the inter-word properties of irrelevant sound do not produce disruption comes from a study manipulating the semantic-category homogeneity and heterogeneity of to-be-ignored sequences in a free recall task identical to that reported in Experiment 3 of Series 1 (M. Conway & Macken, 2002; see also Traub & Geffen, 1979). In this study, irrelevant sequences comprising ten items from ten different semantic-categories (category-heterogeneous sequences) were compared with two other types of to-be-ignored sequences; one type comprised ten items from a single semantic-category that was different to the TBR exemplars and the other type comprised exemplars that were drawn the same category as the TBR exemplars (category-homogenous sequences). The results were as follows: Between-sequence semantic similarity impaired free recall performance (category-homogenous sequences related to the TBR exemplars produced more disruption than unrelated sequences) but the unrelated category-homogenous and the category-heterogeneous sequences produced comparable disruption compared to a quiet control condition. Again this study suggests that the disruption produced by the semantic properties of irrelevant sound is at the level of the individual lexical items rather than at the level of the semantic relations between irrelevant words. Of course, even though these results suggest that the disruption is likely to be at the level of individual

word meanings (e.g., the recognition of the meaning of to-be-ignored words), the consequence of this conflict can be observed at a supra-word level; that is, manifest in the poorer semantic-integration (or clustering) of to-be-recalled words as shown in Experiments 6-8. Indeed, any impairment of the processing of the meaning of words will affect integration or clustering because the processes underpinning semantic-organization require the recognition of the associations between incoming stimuli and existing knowledge structures (G. Underwood & Everatt, 1996).

5.4.1.2 What is the nature of the “related nonword” effect?

Another finding, related to whether irrelevant sound is processed pre- or post-categorically, is that it was demonstrated in Series 1 and 3 (Experiments 1A, 1B, and 10) that irrelevant nonwords that had a phonetic resemblance to the real semantic-category-items from which they were constructed (e.g., “deg”, “togur” cf. “dog”, “tiger”) produced disruption when the TBR exemplars were from the same semantic-category. Rather than supposing this effect was acoustic or pre-categorical, it was argued that these ‘related nonwords’ were processed post-categorically (e.g., as words) thus giving rise to a semantic effect. That ‘related nonwords’ are processed lexically is consistent with a good deal of prior research showing that nonwords created in this manner can activate the real words from which they are derived (e.g., Wallace et al., 2000). However, in the context of the results of Experiments 1A, 1B, and 10 of the current thesis, one cannot be certain whether this phonetically-induced semantic effect is dependent on the ambiguity of the nonword. Is it possible then, that irrelevant *words* (e.g., “log”, “mat”, “now”, “coarse”, “bleep”, “note” cf. “dog”, “cat”, “cow”, “horse”, “sheep”, “goat”) that are phonologically, but not semantically, similar to to-be-recalled semantic-category words (e.g., “Animals”) produce a similar impairment in correct recall and elevation of false recall? A positive effect in this case must be attributable to semantic activation mediated (or primed) through phonology because the irrelevant words have distinct lexical-semantic entries. Prior research (e.g., Sommers & Lewis, 1999; Watson, Balota, & Roediger, 2003) suggests that this is possible. This work claims that activation can spread between phonological associates (“log” and “dog”) within a network of phonological associates (e.g., Collins & Loftus, 1975; Luce & Pisoni, 1998) such that a semantic associate (“dog”) can be activated and become vulnerable to source-monitoring error

(this suggestion that phonetically-induced semantic activation can arise is also generally consistent with the concepts of stimulus generalization and probability recognizers; see Dixon, 1981).

5.4.1.3 Task-invariant or task-induced semantic processing of irrelevant sound?

An additional issue that requires addressing is whether the type of processing recruited by the sound is determined by the nature of the focal task (e.g., is task-induced) or occurs no matter what type of processing the primary task involves (e.g., is task-invariant). In other words, if a focal task requires semantic processing does one somehow become 'magnetized' to process the semantic properties of the irrelevant sound? Or does this semantic processing occur regardless of whether semantic processing takes place in the focal task? According to a task-invariant hypothesis, semantic processing of irrelevant sound may occur—and semantic properties be represented in memory—during tasks that require serial recall but evidence of this will not be manifest (i.e., disruption will not emerge) because only the serial representation of the sound will conflict with the serial ordered representation of TBR material (for similar discussion, see Jones, 1999). Alternatively, a task-induced hypothesis would suppose that the semantic characteristics of irrelevant sound will be represented only if the focal task requires semantic analysis.

The task-induced, versus task-invariant, hypotheses could be assessed in future research by the use of a mixture of instructional manipulation and priming techniques. For example, conceptual-implicit memory tests (e.g., Graf, Shimamura, & Squire, 1985; Mulligan & Stone, 1999; Rappold & Hashtroudi, 1991) could be used that capture whether or not the semantic properties of irrelevant material are processed during stimulus presentation. One conceptual-implicit test of memory, the category-exemplar production test, is usually presented as an incidental task after an experimental paradigm (e.g., free recall of relatively low dominance TBR exemplars; Mulligan, 2002; Mulligan & Stone, 1999). The test involves presenting participants with a category-name and asking them to generate the first n items that come-to-mind. Conceptual priming is assessed as the difference in proportion of the old category-exemplars studied and the new instances of categories produced. By tagging this category-exemplar production task on the end of the free recall tasks performed under different task-instruction (free versus serial recall; see Experiments 3 and 8 of the current thesis) the degree of semantic

processing of irrelevant items could be assessed by the extent to which the irrelevant items are conceptually-primed. Using the category-exemplar production task, the task-induced hypothesis would be supported if conceptual priming of irrelevant category-items only occurs with free, but not serial, recall instructions, whereas the task-invariant hypothesis would be corroborated if conceptual priming occurred to the same degree regardless of task-instruction.

Although there is this possibility of positive priming, other patterns of data could also feasibly emerge. For example, it may also be the case that the category-exemplar production task will reveal inhibition (or negative priming) of the irrelevant category-items presented during study; that is the irrelevant items will be less, rather than more likely, to be produced (e.g., Perfect, Moulin, M. A. Conway, & Perry, 2002). Moreover, if free recall, as compared with serial recall, instruction produces a conflict by semantic processes that inhibitory mechanisms must solve, then it is possible that with free recall instructions there may be negative priming of items on the category-exemplar production task whereas with serial recall instruction positive priming may emerge (see also section 5.2.2.4).

5.4.1.4 Are to-be-ignored events inhibited?

The use of the term inhibition in the present thesis is used in the “strong” sense (see Bjork, Bjork, & M. C. Anderson, 1997; M. C. Anderson & Bjork, 1994) to refer to the inhibition of active representations of irrelevant items under conditions of between-sequence semantic similarity (i.e., semantic representations of irrelevant items are thought to suffer a decrease in their activation). In this context, the use of term inhibition contrasts with its use in a weaker sense as a description of the retrieval blocks produced, for example, by passive changes in activation levels or cue-target strength as is assumed in structural accounts (e.g., J. R. Anderson, 1983; Mensink & Raaijmakers, 1988; Rundus, 1973) whereby special inhibitory mechanisms are considered unnecessary. Whilst it was considered that an inhibitory account afforded a better explanation of the between-sequence semantic similarity effects reported in Series 1-3 of the current thesis, the support for inhibition is indirect: in none of the experiments reported in this thesis was a direct experimental manipulation used to ‘capture’ inhibitory effects. Thus, it is possible that a mixture of non-inhibitory mechanisms may make a contribution to the

forgetting demonstrated in the experiments reported in this thesis. However, it is generally considered (see M. C. Anderson, 2003) that whilst structure-based theories are sometimes considered as having the virtue of parsimony, they play down ones ability to overcome interference between competing, distracting memories to retrieve a desired memory and the repercussions, if any, that such resolution of competition has for both the interfering traces and the information and target memories. Moreover, there are both functional and logical reasons why inhibition, as well as excitation (or activation), is required generally as well as in relation to the paradigms reported in this thesis.

At a general level, the capacity to stop retrieval of erroneous information and redirect action is crucial to everyday life. Without this elementary ability one would lose the essential flexibility to adapt behaviour according to changes in ones goals, or to changes in the environment itself: In short, one would be a slave to habit or reflex. However, it is generally accepted that one is kept from being automatically controlled by habitual actions through overriding the undesired habitual action by inhibitory processes. Moreover, inhibitory processes have other functional utilities: they can, for example, aid the suppression of outdated memories (Bjork, 1989). Thus, inhibition is important for ensuring context-sensitive, coherent, goal-directed and adaptive behaviour (M. C. Anderson, 2003).

It is also well accepted that an inhibitory process must exist to supplement an excitatory (activation) process to fulfil the role of suppressing interfering, competing information—that derived from analysis of distracting information—in order that an internal representation of target information can be differentiated from that of the distracting information (e.g., M. C. Anderson, 2003; Houghton and Tipper, 1994). Houghton and Tipper (1994), for example, outline two reasons as to why an inhibitory process must exist to supplement an excitatory process.

The first reason relates to the efficiency and speed at which target and distractor information can be separated: Excitation applied to target information coupled with inhibition applied to distracting information produces faster separation of the two sources than purely excitation of the target information. If excitation was the only means of separating target from distracting information, the speed of excitation and thus rate of separation, if grounded in biological (i.e., neural) hardware, must operate within a finite,

upper-bound limit (Houghton & Tipper, 1994). Furthermore, the biological plausibility of inhibition is evident since mechanisms such as lateral inhibition are ubiquitous in the neuronal system (Walley & Weiden, 1973; see M. C. Anderson & Bjork, 1994).

A second reason concerns the fact that, within a biological information processing system, target information and distracting information must have a limited dynamic range: In other words, a maximum and minimum excitatory value. To illustrate this point, Houghton and Tipper (1994) suppose the existence of an arbitrary scale (0, 1) whereby 0 represents no excitation, and 1 represents maximum activation. Exposure to this system of two signals—representative of target (T) and distracting (D) information—each at high levels (both 0.9) would require excitation of the target information ($T = 1.0$, $D = 0.9$) but this excitation would mean that the *unchanged* excitation level of distracting information is still enough to substantially impair performance. In cases such as these, Houghton and Tipper (1994) argue that a mechanism must exist to suppress the excitation of distracting information to a significant extent.

Logically, the argument for a functional, inhibitory mechanism can be used against the passive, activation-blocking (e.g., resource-diffusion) or occlusion accounts (e.g., J. R. Anderson, 1983; McGeoch, 1942; Mensink & Raaijmakers, 1988; Rundus, 1973). To recap, according to occlusion accounts activation spreads from a category retrieval cue to category-exemplars at a rate proportional to the strength of the category-exemplar-category retrieval cue association. An exemplar that exceeds a certain activation threshold fastest seizes control of a limited capacity response production mechanism until the activation level diminishes, allowing other exemplars to be retrieved. In this case of between-sequence semantic similarity it could be argued that activated high-dominance irrelevant items will be persistently retrieved (e.g., the responses persevere) at the expense of to-be-recalled exemplars, even though list-exemplars can remain highly active. Clearly, however, to not have a mechanism that is capable of disengaging response production (output) from stronger items (e.g., irrelevant items) would mean that retrieval is slave to passive events (e.g., automatic activation of irrelevant items) and not in any way under the control of functional, executive retrieval mechanisms. Moreover, if one has no mechanism to deal with this occlusion of target responses by irrelevant responses then how does one ever break out of the cycle of response perseveration? In

short, there must be a mechanism that affords the capacity to stop perseveration, to redirect action and override automatic habitual responses as without this basic ability retrieval would be slave to response habits (e.g., high-dominance items would be persistently retrieved because of the strong association with the category represented by the a list or mnemonic cue). It is noted, however, that the phenomenological experience of occlusion can arise but that this can be produced by inhibition: the retrieval of irrelevant events cannot only inhibit TBR exemplars but can increase the accessibility, and thus repeated retrieval, of those events. Thus, an inhibitory view does not ascribe occlusion any role as a mechanism of retrieval failure independent of inhibition (see M. C. Anderson & J. H. Neely, 1996).

Supposing that an inhibitory mechanism does exist and is at work in the experiments reported in this thesis, of what character may it comprise? One possibility is that the mechanism may be one of lateral inhibition (e.g., Walley & Weiden, 1973) whereby response competition can be resolved by providing feedback to enhance activation differences across exemplars. Such an inhibitory mechanism can work as follows: Given a slight activation advantage of a relevant exemplar over an irrelevant item, inhibition can automatically spread more from the relevant exemplar to the irrelevant item than the other way around letting activation of the relevant exemplar reach threshold and thus enabling its production as a response. Lateral inhibition is thus an automatic mechanism that relies upon the assumption that competition derives from the structure of memory—namely amongst similarity relations—in the form of inhibitory connections that link incompatible items (M. C. Anderson & Bjork, 1994). However, although lateral inhibition mechanisms are computationally plausible they are rather inflexible with regard to the goal-directed character of a focal task: lateral inhibition is not flexible enough to allow inhibition of any object that interferes with the performance of a primary task. A more general inhibitory mechanism is more desirable, one that can, according to the goals of the task, be directed to different types of information processing such as during semantic processing or response production (Tipper, 1992).

The requirement for a more general inhibitory mechanism is reinforced by the findings that lateral inhibition accounts cannot explain why irrelevant items that are semantically-unrelated to a TBR category produce disruption as is found in the empirical

chapters of the current thesis. One possibility is that these unrelated irrelevant items are also subject to inhibition and thus performance impairment reflects a cost of the use of inhibition. This appears entirely plausible as M. C. Anderson and Bjork (1994, pp. 306) state: “If a flexible directed inhibitory mechanism causes retrieval inhibition, then any item interfering with the production of a memory target ought to be subject to inhibition, regardless of whether the interfering item is similar or shares a common retrieval cue with the target”.

A final reason to suspect that irrelevant events are inhibited in the paradigms reported in the empirical chapters of this thesis—particularly those that investigate between-sequence semantic similarity—is that they appear to represent quintessential tasks that M. C. Anderson and colleagues (e.g., M. C. Anderson, 2003; M. C. Anderson & J. H. Neely, 1996) would argue to trigger inhibitory control processes: The tasks are both ones of selective attention and semantic competition (M. C. Anderson & J. H. Neely, 1996) and thus fulfil the criterion for inducing inhibitory mechanisms to achieve selective attention.

Despite these persuasive logical and functional reasons why inhibitory processes are involved in the paradigms reported in this thesis, a few methodological variations to the paradigms reported in this thesis may serve to reveal more direct evidence of inhibitory mechanisms. This avenue of research is currently being traversed by way of using a negative priming approach (e.g., Banks, Roberts, & Ciranni, 1995; DeSchepper & Treisman, 1996; Hughes & Jones, 2003a; Tipper & Driver, 1988). Using this approach, irrelevant category items that are presented on trial n are presented as TBR exemplars on trial $n + 1$. Support for the inhibitory construct could be gained if free recall performance on trial $n + 1$, whereby recently to-be-ignored items become to-be-recalled events, is poorer when compared to a control condition whereby there is no relation between the to-be-ignored and relevant items on consecutive trials. Using a similar paradigm to this, Banks et al. (1995) have shown that if a word that has just been presented to the unattended ear is subsequently presented to the attended ear, the response to the word is delayed: a result they suggested was evidence for an inhibitory process.

5.4.1.5 The role of source monitoring

It was discussed in Series 1 that the source-monitoring process becomes fallible in the presence of between-stream semantic similarity but this is only one factor that can

attenuate source-monitoring. To provide further support for the role of source-monitoring in the tasks used in Series 1 it would be useful to manipulate other aspects of the similarity between the TBR and irrelevant sources such as their sensory and perceptual characteristics as well as their semantic detail (e.g., Mather, Henkel, & M. K. Johnson, 1997). Sensory, perceptual and semantic characteristics are used to discriminate (and attribute) the source of memories (Johnson, Foley, & Leach, 1988; Henkel & Franklin, 1998; Lindsay, M. K. Johnson, & Kwon, 1991) and thus TBR and irrelevant material that is similar on all, or several, of these dimensions should be harder to discriminate than when they differ on just one dimension. Current research (J. E. Marsh, Hodgetts, & Jones, 2006) is investigating this hypothesis further by manipulating perceptual, as well as semantic, factors along with other factors that are known to affect false memory formation. For example, this novel research—that was initiated in Series 1 of the present thesis—is continuing to show that factors such as the modality of list presentation (auditory or visual) and type of output (written or oral recall) that are associated with increasing the difficulty of the source-monitoring process also affects the degree of false recall of irrelevant items.

To illustrate the importance of modality factors in determining false recall: auditory presentation typically leads to the formation of more false memories (internal generation of non-presented critical items) than visual presentation (Cleary & Greene, 2002; Gallo, McDermott, Percer, & Roediger, 2001; Kellogg, 2001; R. E. Smith & Hunt, 1998; but see Maylor & Mo, 1999). This is arguably because auditory presentation, as compared with visual presentation, is perceptually more similar to inner speech (E. J. Marsh & Bower, 2004) and/or that visual presentation lends itself more to item-specific processing or the use of orthographic information that can aid the discrimination between TBR and internally-generated events during retrieval (Kellogg, 2001; R. E. Smith, Lozito, & Bayen, 2005; but see Schacter, Israel, & Racine, 1999). In support of the suggestion made in Series 1 of the current thesis, that between-sequence semantic similarity makes the source-monitoring process more fallible than usual, J. E. Marsh et al. (2006) have demonstrated that when TBR and irrelevant items are both perceptually and semantically similar (i.e., when they are presented in the same modality (auditory or visual, distinguishable by male and female voice, or colour respectively) and from the same

semantic-category) false recall of the irrelevant items is greater compared with when the two sources of items are perceptually distinct but semantically similar (i.e., when they are presented in different modalities but from the same semantic-category). With reference to the source-monitoring framework (M. K. Johnson et al., 1993), these results reflect the fact that source judgments that heavily weight semantic information are fallible (prone to source misattribution) when there is some semantic similarity between sources of TBR and irrelevant items and that this is exacerbated when there is also perceptual similarity between the sources (cf. Henkel & Franklin, 1998). Interestingly, perceptual similarity has no effect on the number of items recalled in between-sequence semantic similarity conditions which further supports the suggestion outlined in Series 1 of the present thesis, that false recall and forgetting may be underpinned by different mechanisms.

Another finding from this current research (J. E. Marsh et al., 2006) that bears resemblance to the findings reported with false memory paradigms is that changing the response mode from written to oral recall dramatically increases the degree to which irrelevant items are falsely recalled following visual, but not auditory, presentation. In fact, the modality effect for false recall of irrelevant items disappears when the response mode is oral report. This is consistent with previous findings that have shown that incidence of false memory is greater following auditory, as compared with visual, presentation when the response mode is written recall, but that this modality effect disappears when the response mode requires oral responding (Kellogg, 2001). Generally, these findings are compatible with the suggestion that written recall relies on the access of orthographic information (essentially discriminating perceptual detail) to aid retrieval and since irrelevant items have no associated orthographic information, a modality effect arises for written but not oral output (Kellogg, 2001).

This area of research is also exploring the subjective, phenomenal characteristics that falsely recalled irrelevant items have. The phenomenological qualities of these memories for falsely recalled exemplars are being assessed by way of remember/know judgements (e.g., Gardiner & Java, 1993; Tulving, 1985a). On this distinction remember judgments are vivid, recollective and conscious experiences (e.g., of hearing or seeing the word), whereas know judgments are for confident memories of items that do not have associated specific detail. To report thus far, falsely recalled items are, overall, more likely to be

“know”, as compared with, “remember” responses. However, when the TBR and irrelevant items are both presented in the auditory modality the related intrusions produced from the speech were more likely to be remember responses, whilst when the presentation modalities are mixed the same intrusions are more likely to be know responses (J. E. Marsh et al., 2006). Such findings suggest that falsely recalled irrelevant speech items are phenomenally different to falsely recalled critical items (which tend to be remember judgements, e.g., Roediger & McDermott, 1995) but they are nonetheless consistent with the idea that elevated similarity in perceptual information between source of to-be-recalled and irrelevant items can substantially impair source-monitoring judgements by giving rise to recollection of perceptual detail.

One outstanding, but intriguing question, with regard to the results reported in Series 1 of the present thesis is why, and indeed how, irrelevant sound affects meta-memory for correctly recalled items. In Series 1 irrelevant sound, regardless of between-sequence semantic similarity, reduced the confidence with which participants rated that the exemplars they had recalled correctly were presented during the experiment. It was speculated in that series that this effect may be one attributable to the semantic properties of irrelevant sound which could interfere with meta-memory decisions by impairing the semantic processing of TBR exemplars. But how might semantic irrelevant sound impair meta-memory decisions? One possibility is that semantic activation of irrelevant items may reduce source memory for correct items by impairing the process of binding features (e.g., semantic properties) into a complex mental event (see Chalfonte & M. K. Johnson, 1997; Hicks & Hancock, 2002). Another possibility, which does not necessarily conflict with the first, is that irrelevant sound exerts its effects by affecting the processes underpinning recollection and familiarity (e.g., Jacoby, 1991). These two processes, that of recollection and familiarity, can purportedly be assessed using remember-know judgements. Factors such as semantic processing increase reports of remembering but not knowing (Gardiner, 1988; Rajaram, 1993) and as such, if semantic processing of list items is impaired by semantic irrelevant sound (regardless of its relatedness to the to-be-recalled material) there should be a distinct outcome: reports of correct remembering should decrease along with false recollection (cf. Dewhurst et al., 2006).

Current research is also evaluating what effect between-sequence semantic similarity has on remember/know decisions for correctly recalled items (J. E. Marsh et al., 2006). Note that in Series 1 of the current thesis, between-sequence semantic similarity had no additional effect on the confidence ratings which were disrupted when to-be-recalled items had been presented or retained, in the presence of irrelevant sound. This later research using remember/know decision data, however, has shown a distinct pattern of results. In a recent study (J. Marsh et al., 2006) it has been shown that in conditions of between-sequence semantic dissimilarity, as compared with between-sequence semantic similarity, remember, as compared with know, responses are more common for correctly recalled items. However, know responses are more common for the between-sequence semantic similarity, as compared with dissimilarity condition. Tentatively, this suggests that between-sequence semantic similarity enhances feelings of familiarity (thought to give rise to know experiences; e.g., Kelley & Jacoby, 1998) at the expense of recollection. Further experiments are also planned to investigate whether between-sequence semantic similarity during study also influences recognition memory using old-new and remember-know judgements (cf. Roediger & McDermott, 1995). In this scenario source-monitoring confusion could be manifest in false alarms for auditory presented items whereby participants respond "old" to a related item when it was in fact presented as irrelevant speech. Such a finding would be consistent with the idea that residual semantic activation produced by the irrelevant items could boost familiarity and lead to false recognition (J. R. Anderson & Bower, 1973).

In sum, application of the source-monitoring approach to selective attention paradigms, as promoted by the current thesis, has had the advantage of offering a framework in which to understand how false recall of irrelevant items can arise. As outlined in Series 1 an explanation for how irrelevant items are recalled with confidence as belonging to the TBR list is lacking in extant theories of auditory-semantic distraction. For example, the role of source-monitoring decision processes is not outlined in the Working Memory model (Baddeley, 1986) where it is unclear how irrelevant items that enter the phonological store are prevented from entering the phonological loop and/or being produced. The demonstration that source-monitoring processes can breakdown under conditions of between-sequence semantic similarity suggests that these processes

do play a role and are given more credence in the future. Moreover, consideration of the source-monitoring process also has the promise of shedding new light on old data: particularly that derived from manipulations of between-sequence semantic similarity. For example, M. C. Smith and Groen (1974; see also Traub & Geffen, 1979) presented participants with short dichotic lists whereby participants attended to the words presented in one ear only. Testing involved presenting a probe word which required participants to respond with whether or not this word had been in the attended list. Participants made slower response times and higher error rates to negative probes that were not on the attended list, but on the unattended list, compared to when negative probes had not been on the unattended list. In line with the source-monitoring approach, this occurred only when words in the unattended list were members of the same semantic category as the attended words

5.4.1.6 Are there other cases of interference-by-process?

The current thesis has provided evidence that the interference-by-process construct works in the case of semantic focal tasks, but the general construct of interference-by-process suggests that other interference-by-processes can be expected to occur. The possibility of finding other interference-by-processes is currently being explored by manipulating between-sequence phonological similarity using free recall experiments (J. E. Marsh & Jones, 2006). To report thus far, the phonological similarity between TBR and irrelevant items has a pronounced disruptive effect on free recall performance: Irrelevant words (e.g., “black”, “mack”, “block”, “blank”, “lack”, “sack”) that are phonologically similar to to-be-recalled words (e.g., “smack”, “track”, “pack”, “snack”, “rack”, “flack”, “slack”, “bleak”, “back”, “hack”, “plaque”) produce more disruption than phonologically dissimilar words (e.g., “hand”, “land”, “sand”, “hound”, “panned”, “stand”). This suggests that processing and generation of phonologically similar exemplars is disrupted by the processing of phonological similarity in the unattended material. Interestingly, neither the Feature model (Neath, 2000), nor the Working Memory model (Baddeley, 1986), as compared with the interference-by-process account, predict this between-sequence phonological similarity effect.

Several additional experiments that make use of the category-clustering paradigm used in Series 2 of the current thesis can also be envisaged to extend this quest to uncover

other interference-by-processes. In category-clustering experiments, phonological, as well as semantic, similarity can be used as an organizational aid. For example, words that rhyme with each other are often clustered together at test regardless of being separated during presentation (Forrester, 1973; Forrester & King, 1971). On the interference-by-process account, one might expect that because clustering in this task involves processing the words phonologically, as opposed to semantically, the clustering of the list-exemplars at test will be less, if at all, vulnerable to disruption via the semantic properties of irrelevant sound. Nevertheless, it is possible that this task will be disrupted by irrelevant sounds that are amenable to a similar, phonological analysis such as would be the case with between-sequence phonological similarity (e.g., J. E. Marsh & Jones, 2006), or when the irrelevant items are all drawn from a rhyme-category (see the General Discussion of Chapter 4 for further elaboration).

5.5 CONCLUSIONS: STRUCTURES OR PROCESSES?

One of the most fundamental issues in past- and present-day psychology is the division between structural approaches (e.g., Wundt; Titchener, as cited in Roediger et al., 2002) and process or action-based approaches to the mind (W. James, 1890; Leont'ev, 1959, 1975, as cited in Wertch, 1979; see Boring, 1950). The structural approach supposes that perceptual or mental experience is to be understood by identifying the *contents* of the mind: Structuralists attempt to capture central aspects of mental life often through the development of cognitive models that comprise hypothetical stores (Atkinson & Shiffrin, 1968; Baddeley, 1986; Broadbent, 1958) and systems (Broadbent, 1958; Tulving, 1985b, 1999) with different hypothetical properties (e.g., stores for phonemic or semantic content). As a product of assuming the existence of static structures (stores, systems, and memory traces), the structuralist approach assumes that memory phenomena, including forgetting, are the result of passive as compared with dynamic processes.

In contrast, the process-based approach, as advocated in the present thesis, denies that the mind/brain system can be usefully explained by assuming the existence of static structures in the mind. Instead, the functionalist approach subscribes to the view of an activity- or action-based approach to the study of mental life. As in the current thesis, the

crux of the functionalist approach is that stimuli cannot be considered in the absence of goals (acts and intentions) that underpin the processing of those stimuli. According to the process-based approach, memory phenomena, including forgetting, are the result of active, dynamic processes that need to be considered with regard to the goals of an activity (as a function of task demands, instructions, and retrieval cues) and the particular operations deployed in the service of the overarching goal (e.g., M. C. Anderson, 2003; Humphreys et al., 1989; Kolers & Roediger, 1984; Wertsch, 1979; Toth & Hunt, 1999). In other words: “Memory is treated as an integral part of certain cognitive processes and not a separate mechanism” (M. K. Johnson & Hirst, 1991, pp. 197).

5.5.1 Why is the cognitive system selective?

The selectivity of the cognitive system is traditionally thought to arise because of an inherent structural limitation on the mind/brain’s capacity to process information. One approach considers that selective attention is necessary by way of an inherent *processing* limitation on the part of the mind/brain system (e.g., Broadbent, 1958, 1971; Eriksen & St. James, 1986; Treisman, 1960). Selection, according to one view embedded in this approach, is required to filter the massive inflow of perceptual information at a reasonably early stage in a linear series of processing stages from stimulus to response in order to protect capacity-limited cognitive systems from overload. By this view, there is a putative processing ‘bottleneck’ that explains why humans find it difficult to engage in concurrent tasks/suffer interference from task irrelevant stimuli (Allport, 1989; O. Neumann, 1984, 1996). The structuralist, bottleneck theories (e.g., Broadbent, 1958; Treisman, 1960) assume the existence of filters or a series of filters responsible for selecting information on the basis of various pre- or post-categorical cues yielded by sensory information.

Typically, these selective filters controlled propagation of information to a limited capacity stage of processing (where identification or categorization takes place) allowing pre-categorical, physical properties of sensory information (e.g., pitch, intensity, gender of voice and spatial location) to pass through, but prevented, or attenuated, the entry of post-categorical, semantic properties (Broadbent, 1958, 1971; Treisman, 1964, 1969). Because these theories suppose that the selective filter operates at an early stage of

physical analysis, they are termed 'early selection' theories. Alternatively, 'late selection' theories suppose that the bottleneck exists at a later stage of processing after post-categorical, semantic analysis (Deutsch & Deutsch, 1963; Duncan, 1980; Norman, 1976).

There are numerous criticisms, however, of this structural, bottleneck approach, not least that pertaining to a logical flaw in the theorizing by which it is undergirded (Allport, 1989; O. Neumann, 1996; Van der Heijden, 1992). Specifically, the notion of limited capacity rests upon dual inferences, the first of which subsumes the latter. The first inference is that a) evidence of unattended information failing to interfere with focal task performance indicates that b) this unattended information must be blocked from being processed and therefore c) there is evidence of the bottleneck, or rather a stage of capacity-limited processing. Logically, however, this argument is incorrect and is a fallacy of 'affirming the consequence' (Popper, 1959; Van der Heijden, 1992). The notion of 'selective processing therefore limited capacity' does not legitimately follow from 'limited capacity therefore selective processing' because limited capacity is an a-priori theoretical assumption and selective processing is what is observed.

Subsumed by, and also fated by, the same logical error as the first inference is a second, more specific interference. This second inference concerns the notion that because certain aspects of stimuli do not interfere with a given mental task (for example, the findings showing that the semantic content of unattended sound does not impair shadowing performance in a dichotic listening task; Cherry, 1953), this not only indicates limited capacity but also serves to pinpoint where, along a discrete series of processing stages, capacity is limited (in the case of Cherry's dichotic listening studies, at a pre-categorical stage of analysis based on physical features, see Broadbent, 1958, 1971). This inference is another instance of the 'fallacy of affirming the consequence': "...from 'is not represented and can therefore not serve as the basis for selection' it does not follow 'cannot serve as the basis for selection and is therefore not represented' (Van der Heijden, 1992, p. 162; see also Duncan, 1984). In this case what is observed is differential effectiveness of selection (e.g., based on different cues); that some information is not represented is, as in the first example, just the a-priori notion of limited-capacity. In conclusion, that the empirical support for the bottleneck, including

that which concerns early selection, is underlain by erroneous logic seriously weakens its standing as an explanative construct of any real worth.

Another structural approach, formulated in response to a growing number of failures to locate a central bottleneck, supposed that rather than being due to the structure of the information processing system per se (and passage of information through a single channel, filters, or sequential stages), the bottleneck was reflective of a single processing capacity, or pool of processing resources, that could be distributed between multiple tasks or allocated to a single task according to task priorities or demands (Kahneman, 1973; Wickens, 1992). On one of these approaches, human performance suffers interference from irrelevant information in selective, and divided, attention tasks because the finite resource labeled 'attention' becomes saturated when an nonspecific demand on processing is too great. According to a derivative of this approach, unattended stimuli usurp any remaining processing capacity after capacity has been allocated (Lavie, 2000).

One major problem for the notion of capacity as a general purpose or single resource is that interference between two tasks is critically dependent on the type of processing demanded by each task (e.g., Posner & Boies, 1971; see O. Neumann, 1996). Attempts to reconcile this problem of task-specific interference witnessed the advent of more specific, multiple-capacity sharing approaches, whereby overall processing capacity could be portioned into a multi-dimensional taxonomy of finite, 'attentional' resources (e.g., one set of resources for auditory, one for visual presentation and one for spatial) and the extent to which human performance was limited corresponded with the degree to which two tasks draw upon the same finite pool of resources and mode of operation (Wickens, 1992). This approach was soon met by problems, however, because the growing number of patterns of specific interference meant that it was soon difficult to come up with a limited, and therefore parsimonious, taxonomy of resources that could accommodate all the task-specific interference data (O. Neumann, 1996).

A more central problem for the single- and multiple-capacity sharing approaches is that they are underpinned by theorizing that is inherently circular. The observation that irrelevant information or dual tasking results in interference is used as evidence for the existence of a resource (or resources) whereby, in reality, this is just an a-priori theoretical assumption. In sum, single- or multiple-capacity sharing theories do little

more than offer a redescription of the data they were designed to explain. Surprisingly, however, capacity theories have still remained in situ as explanations for why processing is selective and human performance limited (Buchner et al., 2004; Duncan, 2006; Lavie, 1995, 2000).

The functional view advocated in the current thesis supposes that attention is not some entity that can be moved, diffused, or is capacity-limited. Instead, the adopted 'selection-for-action' view (see Allport, 1989, 1993; O. Neumann, 1987, 1996) is that the attentional selectivity of the cognitive system is not due to a limitation in information processing. On this approach, the structuralist assertion that 'selection is required due to limited capacity' is turned on its head: Limited capacity is viewed as a functionally *healthy* result of a variety of selective mechanisms whose evolved function it has been to ensure that only task-relevant information assumes control of action and coherent behaviour. This view is adopted upon reflection of the fact that selectivity can arise '...independently of any a-priori limitation of central processing, from the concrete requirement of univocal control of action...' (Allport, 1989, p. 649).

The selection-for-action view dismisses the invocation of a serious capacity-limited stage among a sequential-monotonic stream of discrete processing stages and ill fated appeals to the notion of finite processing resource to explain why and how the cognitive system is selective (Allport, 1993). Instead, the selection-for-action perspective emphasizes the constraints in preparation and control of action: limited capacity arises due to the limitations of effector systems to carry out multiple actions concurrently (Allport, 1987, 1990; O. Neumann, 1987, 1989).

The main idea behind the selection-for-action perspective is that integrated actions require the selection of particular aspects or attributes from the environment that are relevant to the action at hand. At the same time, the information irrelevant to the action should be ignored. Impairment, or limitations, in focal task performance can emerge because the action-parameters of the category of action of the generic skills that are co-opted to perform a particular focal task are underspecified: More specifically, human performance can be compromised by irrelevant information that is compatible with the skill adopted for the primary task at a general level but is incompatible at a more specific level. The limitation in human performance, however, occurs as a cost of avoiding an

ensuing behavioural chaos, by the operation of selection processes that prevent irrelevant information from simultaneously controlling an effector or skill involved in a focal task (O. Neumann, 1987). In short, the selection-for-action view refutes the widely held view that there is some hypothetical limited attentional capacity or resource that imposes the need for selection as a solution. Rather than being the solution, selection is the problem in need to solution: limitations in human performance are the adaptive consequences associated with the resolution of the selection problem (for extensive discussion, see Allport, 1993; O. Neumann, 1996).

5.5.2 A broad framework for understanding auditory distraction:

The competition-for-action approach

Considering the effects of auditory distraction in terms of the selection-for-action view is an attempt to view auditory distraction as a less marginalized or unique phenomenon than it is typically considered (Cowan, 1995; Neath, 2000; Page & Norris, 2003). Moreover, the selection-for-action approach is already well established and applies generally to several areas where there is a close interaction between conscious processing and motor behaviour (Gibson, 1979; Hommel, Müsseler, Aschersleben, & Prinz, 2001; Rizzolatti & Craighero, 1998). A relatively novel approach that is allied to the selection-for-action view of selective attention regards auditory-distraction as the result of mechanisms responsible for solving a ‘competition-for-action’ between TBR and irrelevant sources of information (Hughes & Jones, 2005). The competition-for-action approach aims to provide a coherent framework within which the numerous and varied effects of auditory distraction can be understood by alluding to a general set of principles and constructs (e.g., overspecification, inhibition) that are relevant to a diverse number of cognitive tasks.

The competition-for-action framework holds that in the case of the serial recall, the classical ISE is the residual cost of preventing (possibly through attentional processes such as inhibition; see Hughes & Jones, 2003a) a competing irrelevant source of serial order information (that derived from the obligatory, preattentive processing of irrelevant sound)—that is a plausible candidate for the skill-based action of serial rehearsal—from actually assuming the control of that action at the expense of the relevant source of order

information (created by deliberate focal task processing; Hughes & Jones, 2005; for a similar suggestion in relation to shadowing tasks, see Allport, 1980). Thus, the classical ISE is viewed as an adaptive consequence associated with the resolution of a selection problem (cf. Allport, 1993; O. Neumann, 1996, see also Hughes & Jones, 2003b). This competition-for-action approach is a slightly more specified version of the interference-by-process approach (Jones & Tremblay, 2000). To elaborate, whereas the interference-by-process account supposes that it is similar, concurrent processes per se that produce the classical ISE, the competition-for-action framework supposes that it is the products of the serial order processing of the irrelevant sound trying to encroach into action that inevitably triggers selection mechanisms such as inhibition that ultimately give rise to disruption. Of course, this competition-for-action framework explains why neither the meaningfulness of irrelevant speech or between-stream semantic similarity plays a role in the disruption when serial recall is instructed or spontaneously adopted (e.g., Buchner et al., 1996; see also Experiments 3 and 8 of the current thesis): In this case it is the information that the irrelevant sound yields about serial order, not its meaning, that is broadly compatible with the action (or process) of serial rehearsal.

As regards to the current thesis, the competition-for-action approach also explains why auditory-semantic distraction occurs to the performance of free recall tasks *only* when semantic processing or semantic-categorization is an obvious or instructed strategy: When the primary task involves semantic-categorization or semantic retrieval—unlike the case with serial recall—the irrelevant semantic information extracted from the speech produces competition for semantic retrieval processes. Impairment can thus be understood in terms of a relative difficulty in selecting the correct source of semantic information as both to-be-recalled and irrelevant sources compete for the category of action being called for in the semantic recall task. Other auditory-semantic effects such as the picture-word interference and cross-modal Stroop tasks (see sections 1.2.6.3.5 and 1.2.6.3.6, respectively) are also readily explained within the competition-for-action framework. For example, cross-modal Stroop interference can be thought to arise because the irrelevant sound source contains response-appropriate information that specifies a global category of action (the verbal production of a colour-name) and a specific category of action (naming a colour) but is incompatible with the specific response required

(naming the specific colour of the ink) and thus the interference is a product of the selection system preventing the irrelevant information from being coupled to the generic skills involved in the naming response (cf. O. Neumann, 1987; for a similar explanation, see Finkbeiner & Caramazza, 2006).

One problem in applying the competition-for-action approach to the findings reported in this thesis is that the view of selective attention on which it is based—selection-for-action—supposes that the limitation in human performance is thought to reside in the action system (e.g., due to the scarcity of effectors). Whilst this works well as an explanation for auditory distraction effects on naming and serial recall tasks that appear to call upon the action system (e.g., the gestural system, or sensorimotor apparatus), the approach needs further elaboration as an explanation of auditory-semantic distraction in tasks that may not, at least conceivably, recruit the action system. However, despite this, it is already well accepted that there are clear functional parallels between the control of motor behaviour and action and the control of memory retrieval, or internal actions (for a discussion, see M. C. Anderson, 2003; Shimamura, 1995). Moreover, likening retrieval to the selection-for-action view, M. C. Anderson (2003) supposes that in the context of semantic tasks self-generated and externally presented category-cues (e.g., “Fruit”) that are typically used to guide search of long-term memory, are relatively underspecified as a retrieval cue for a target memory—by virtue of the fact that they will be associated with other exemplars as well—and, as a consequence will activate related exemplars that are more strongly associated to the cue than the target item thus increasing competition for the actions underpinning retrieval. Furthermore, to resolve such retrieval competition—which could perpetually divert one from retrieving a target item—inhibitory control is exerted that enables one to accomplish flexible, context-sensitive and goal-driven behaviour. The cost of this requirement of inhibition, however, is that the inhibited, irrelevant material is more difficult to retrieve when it later becomes relevant. Forgetting of this material, therefore, is a cost of the functional mechanisms, or processes, that enable us to direct cognition to the TBR material (M. C. Anderson & J. H. Neely, 1996; see Chapter 1).

The competition-for-action framework is similar to M. C. Anderson and colleagues’ approach (e.g., M. C. Anderson, 2003; M. C. Anderson & J. H. Neely, 1996), but goes

one step further in supposing that competition-for-action also arises when the irrelevant material comprises English narrative, or words drawn from a category unrelated to the TBR exemplars. On this account, it is assumed any irrelevant source of semantic information will offer competition for the category of action involved in the focal task but that the competition-for-action is fiercer in conditions of between-sequence semantic similarity because irrelevant items in this case specify highly compatible, but ultimately response-inappropriate, information in the context of the semantic free recall task and thus are likely to require greater inhibition.

The competition-for-action approach also supposes that different auditory-semantic distraction effects will emerge depending on the nature of the semantic focal task and thus the type of response required. For example, as described in the foregoing paragraph, for the cross-modal Stroop task irrelevant information interferes with the processes underpinning the naming response. However, for tasks that require integration of exemplars related by semantic-category—or category clustering (see Series 2 of the current thesis)—the category of action logically differs. In this case, it may be that any activated irrelevant lexical items will be a candidate for the action or process of integrating to-be-recalled exemplars into clusters based on long-term semantic knowledge. For clustering tasks, therefore, the triggering of the selection mechanism that prevents irrelevant items from being integrated, results in deficits in recall performance. This explanation accounts for why the disruptive impact of irrelevant semantic material occurs not at the inter-word level but at the level of individual irrelevant lexical items on clustering tasks (Pope & Jones, 2002, see also Conway & Macken, 2002; see section 5.4.2.1).

It should also be pointed out here, however, that for semantic focal tasks, as compared with serial recall tasks, there is a relative difficulty in outlining the nature of the interfering concurrent processes (see the General Discussion of Series 2). More specifically, whereas in serial recall it is reasonably well accepted that the conflicting processes are ones of seriation (Jones et al., 1996), for semantic tasks one cannot, at least of the basis of the empirical work conducted in this thesis, define as clearly and with the same degree of specificity, what the conflicting semantic processes that take place on the unattended and TBR material are. On the competition-for-action framework, this issue of

delineating the nature of the interfering processes can be avoided because it assumes that it is the products of the semantic processing (e.g., activated lexical representations) that can produce a selection problem and disrupt focal task performance through triggering inhibitory processes and compromising the source-monitoring process. Thus, unlike serial recall where the representation of individual items, as compared with sequences of items, is considered unimportant, representations of items are clearly important for the competition-for-action framework for interpreting auditory-semantic distraction but it is inevitably an interference-*with*-process (source monitoring and/or inhibition) which determines the degree of disruption from irrelevant material.

In sum, the competition-for-action approach proposes that similar selection processes (e.g., inhibition) may be at work in serial recall and in semantic focal tasks but that the empirical manifestations of these selection processes are distinctly different. Moreover, the commonality in each case is that impairment in focal task performance in the presence of irrelevant auditory-semantic material is functional and process-based, rather than due to the structure or content of competing representations (although as acknowledged in the foregoing paragraph, the content of the TBR and irrelevant material may drive the nature of the interfering process/es). More specifically, on the competition-for-action view, impairment in focal task performance reflects the cost of selective attention mechanisms that operate to avoid 'cross talk' from information appropriate to actions or skills involved in, but inappropriate to the specific demands of, performing a given mental task.

5.6 SUMMARY AND CONCLUSIONS

The present thesis has shed much needed light on the phenomenon of auditory-semantic distraction. In the process, the empirical work has yielded support for the general applicability of the functional, interference-by-process construct to auditory-semantic distraction whilst questioning the veracity of structural accounts based upon interference-by-content or attentional resources. Moreover, the current thesis has outlined the important contribution that processes such as source-monitoring and possibly inhibition play in producing patterns of results associated with auditory-semantic

distraction. It is hoped that the empirical results reported in this thesis have highlighted how auditory distraction phenomena that appear quite disparate (e.g., in the context of serial recall and semantic free recall tasks) might be accommodated, with very few assumptions, within a process-oriented framework for understanding auditory distraction—that of competition-for-action—which is based upon an established account of selective attention. In so doing, the results provide convergent evidence against the structuralist position that the cognitive system is selective because of a structurally-imposed limited processing capacity. Indeed, on this approach hypothetical limited attentional resources or limited capacity short-term, or long-term storage modules are superfluous when accounting for the nature of auditory distraction phenomena.

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