

Working Memory and Interference Control in Children with Specific Language Impairment

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Abstract

Language and communication disorders are often associated with deficits in working memory (WM) and interference control. WM studies involving children with specific language impairment (SLI) have traditionally been framed using either resource theories or decay accounts, particularly Baddeley's model. Although significant interference problems in children with SLI are apparent in error analysis data from WM and language tasks, interference theories and paradigms have not been widely used in the SLI literature. A primary goal of the present paper is to provide an overview of interference deficits in children with SLI. Review of the extant literature on interference control shows deficits in this population; however, the source and the nature of the deficit remain unclear. Thus, a second key aim in our review is to demonstrate the need for theoretically driven experimental paradigms in order to better understand individual variations associated with interference weaknesses in children with SLI.

1. Introduction

In our review of interference control in children with specific language impairment (SLI), we first provide a brief summary of working memory (WM) models that preceded and led to current interference theories. One of our goals is to examine the extent to which conceptual and methodological advancements in experimental literature have been transferred to clinical research. We aim to demonstrate that theoretical models defining specific functions and processes are more useful than traditional models for analyzing individual differences. This advantage is particularly relevant to clinical research, as clinical populations, such as children with SLI, typically show large heterogeneity and present a great challenge to researchers. Following our review of WM theories, we discuss various interference paradigms that have been used successfully with children with SLI.

Children with SLI exhibit below average language performance in the absence of any sensory or intellectual deficits. Although IQ measures fall within the average range, these children show weaknesses in WM as well as in interference control (e.g., Marton and Schwartz 2003; Montgomery 2003). Based on our previous findings on resistance to interference in children with SLI (Marton, Campanelli, Eichorn, Scheuer, and Yoon 2014; Marton, Campanelli, Scheuer, Yoon, and Eichorn 2012) and studies examining the relationship between language processing and resistance to interference (Van Dyke, Johns, and Kukona 2014), we assume that the WM and interference problems observed in children with SLI do not only accompany the language disorder but represent an underlying cause that determines how the language impairment manifests itself.

Over the past two decades, research in WM has shown extensive growth, as evidenced by the large number of studies and development of more complex theoretical models. Significant conceptual and methodological changes in WM models are evident in the literature, with gradual movement away from theories that focus on the number of memory representations to accounts that emphasize the nature and integrity of representations and functions within WM. Interference control is a critical aspect of WM performance because different WM functions are linked to effective resistance to interference, as relevant and irrelevant items continually compete for the same limited WM capacity (Unsworth, Brewer, and Spillers 2013). Although the term inhibitory control is sometimes overextended and used interchangeably with interference control, most theorists differentiate the two processes (e.g., see Friedman and Miyake 2004; Mazuka, Jincho, and Oishi 2009; Wilson and Kipp 1998 for specific distinctions and taxonomies). Our review is based upon Friedman and Miyake's (2004) widely accepted model, which distinguishes between (1) inhibition of prepotent responses, in which automatic behavior is blocked in response to specific stimuli; (2) resistance to distractor interference, in which external, irrelevant stimuli such as competitors or distractors are suppressed while target stimuli are selected; and (3) resistance to proactive interference, in which previously relevant memory traces are suppressed based on currently relevant task goals.

In children, the relationship between WM and interference control becomes stronger with increased age. This change is related to the development of factors that determine WM efficiency, such as activation, intentional suppression, and strategic processes (Roncadin, Pascual-Leone, Rich, and Dennis 2007). Development of interference control also extends later into childhood than response inhibition. Whereas response inhibition develops during the preschool years, interference control continues to develop through sixth grade (Bjorklund and Kipp Harnishfeger, 1990). In this paper, we focus on interference control rather than on response inhibition because it is the ability to resist interference that plays a critical role in language processing in both children and adults (Martin-Rhee and Bialystok 2008; Van Dyke and Johns 2012).

The relationship between language processing and WM, as well as interference, has been widely studied in the literature from a theoretical point of view, and several review papers on this topic have previously been published in this journal (Mazuka *et al.* 2009; Van Dyke and Johns 2012). Therefore, the present paper focuses only on issues that help demonstrate specific phenomena in children with SLI. We present findings on the relationship among WM, interference control, and language in a population that exhibits deficits across these areas. Children with SLI provide unique insight into different error patterns and strategies observed in tasks measuring WM and interference control.

2. Working Memory Accounts

2.1. RESOURCE THEORIES

Working memory is traditionally viewed as a system with limited resources that must be shared between storage and processing operations (Just and Carpenter 1992; King and Just 1991). According to resource theories, WM tasks each require a certain amount of activation to perform storage and computations. Thus, individual differences in WM performance reflect differences in the amount of available activation. When demands of a particular task exceed an individual's total capacity, performance will suffer. More complex tasks are more demanding on WM capacity; WM performance therefore decreases as task complexity increases. Studies based on resource theories typically employ variations of complex span tasks. For example, verbal span tasks measure capacity limitations in processing complex linguistic information and require active maintenance and updating of items in WM. In these tasks, participants are presented with

increasingly long sets of sentences (e.g., set of 2 sentences, 3 sentences, etc.). They are then asked to remember all sentence-final words within each set and answer a question that targets the content of a sentence within the same set. Processing complex sentences requires more WM resources than processing simple sentences; thus, WM performance decreases as the syntactic complexity of the sentences increases (King and Just 1991). Evidence supporting resource theories is based on correlations between WM capacity, as measured by complex span tasks, and reading and language comprehension (Daneman and Carpenter 1980; Daneman and Carpenter 1983; MacDonald, Just and Carpenter, 1992), complex learning (Kyllonen and Stephens 1990; Shute 1991), and aging (Miyake, Carpenter, and Just 1994).

Resource theories have also been used to explain verbal WM deficits in children with SLI. It has been suggested that children with SLI have specific difficulty managing simultaneous storage and processing and as a result, show a breakdown in the storage of information when processing demands become too taxing (Montgomery 2003). Results across studies reveal a consistent pattern of weaker performance on complex verbal span tasks for children with SLI compared to typically developing (TD) peers, particularly as sentence complexity increases (Marton and Schwartz 2003; Montgomery 2000). The nature of this problem, however, is language specific. There is a clear interaction between language typology and the capacity demands of certain structures across languages. Thus, the vulnerability of specific linguistic structures in children with SLI differs across languages (Thorn and Gathercole 1999). For example, in English, increased syntactic complexity is associated with decreased WM performance (Marton and Schwartz 2003; Montgomery 2000), whereas in languages that are rich in morphology, such as Hungarian, it is increased morphological complexity that has a strong effect on verbal WM performance in children with SLI (Marton, Schwartz, Farkas, and Katsnelson 2006).

Notably, not all WM scholars agree that the results of complex span tasks reflect limitations in resources. A number of authors (e.g., Engle 2002; Lustig, May, and Hasher 2001) suggest that WM span performance is directly related to individual differences in ability to suppress information that is irrelevant to current task goals or contexts. In complex span tasks, participants must discriminate target words of the current set from words in previous sets, as well as other language items (e.g., words within sentences). It is reasonable to assume that the predictive power of complex span tasks can also be attributed to individual differences in the ability to resist proactive interference (see more details in section on interference below).

Others have criticized proponents of resource theories for being vague in their definitions of resource capacity (Hasher, Lustig, and Zacks 2007; Navon 1984). Some authors in the literature tend to use terms such as activation, resources, and capacity interchangeably, whereas others use these terms with different referents. Inconsistent use of these terms may contribute to some of the discrepancies in the literature. Interpretations of complex span outcomes also vary, in part, because of differences in task complexity and modality. Overall, as a result of conceptual and methodological differences, clinical studies that are based on resource theories often employ vague concepts and use complex methods that measure several functions simultaneously.

2.2. DECAY THEORIES

2.2.1. Traditional Decay Theories

Decay theories are the oldest models for explaining individual differences in WM. The primary assumption of these theories is that memory representations decay with the passage of time in the absence of a reactivation process, such as rehearsal (Thorndike 1913). Temporary storage of information thus depends on the trade-off between rehearsal and decay.

The most widely used model incorporating the concept of decay is Baddeley's (2003) account, which describes a multicomponent, limited capacity system. Various presentations of this model are provided in the literature; we focus our review only on those components and processes that are relevant to verbal WM and interference in children with SLI. One of the modality-specific components in this model is the phonological loop, which is responsible for temporary storage of verbal material. Maintenance of phonological items within the short-term store of the phonological loop is supported by verbal rehearsal. Based on this view, individuals with better rehearsal rates are able to keep more items in an active state than persons with lower rehearsal rates. Thus, this model attributes the word-length effect (in which lists of shorter words are recalled more accurately than lists of longer words) to the rehearsal process. This is in contrast to other views that attribute the word-length effect to interference (e.g., Oberauer 2009).

Baddeley's model became very popular in the SLI literature, in part, because the phonological loop plays a critical role in reading and vocabulary acquisition, areas in which children with SLI show deficits (Gathercole 2006; Gathercole and Baddeley 1993). A substantial number of studies examined phonological short-term and WM based on Baddeley's model by using variations of word and non-word repetition tasks. Researchers from different laboratories and countries have consistently found that children with SLI perform more poorly than TD children on non-word repetition (e.g., Bishop, North, and Donlan 1996; Dollaghan and Campbell 1998; Graf Estes, Evans, and Else-Quest 2007), and poor non-word repetition, as a result, has become a behavioral marker for specific language impairment (Bishop *et al.* 1996; Conti-Ramsden 2003). Although children with SLI show a rehearsal rate that is comparable to TD children on word retrieval tasks (Gathercole and Baddeley, 1990; van der Lely and Howard 1993), their non-word repetition performance shows a more drastic decline than their peers' as stimulus length increases (i.e., word-length effect; Balthazar 2003; Gathercole 2006; Marton and Schwartz 2003). Based on Baddeley's model, these results reveal that children with SLI are more strongly affected by an increase in word length than their peers, presumably because they have more difficulty keeping phonological codes active. The magnitude of this deficit seems to be related to various factors, particularly to the nature of the non-words (i.e., syllable structure, length, similarity to real words, etc.).

In earlier studies, verbal rehearsal deficits have been suspected to underlie non-word repetition difficulties in children with SLI because slower verbal rehearsal may account for poor non-word repetition. Yet, the verbal rehearsal rate of children with SLI does not differ from their peers in word retrieval tasks (Gathercole and Baddeley, 1990; Gillam, Cowan, and Day 1995; van der Lely and Howard 1993). Even their rate of articulation, which is assumed to reflect verbal rehearsal rate, is similar to that of typically developing children (Montgomery 1995). Poor non-word repetition in children with SLI has also been attributed to poor auditory discrimination, but the data in the literature are not consistent, with different outcomes reported by authors using different discrimination tasks. Montgomery (1995) found significant differences in the discrimination accuracy of typically developing children and children with SLI on non-word pairs differing by a single phoneme, but only with four-syllable non-words. Other authors, however, found that children with SLI demonstrated accurate discrimination of non-words and real words that varied in word length (Gathercole and Baddeley, 1990; Marton and Schwartz, 2003). Results reported by Edwards and Lahey (1998) also did not support auditory discrimination problems as the underlying cause of non-word repetition deficits in children with SLI. These authors examined the percentage of errors made on unstressed syllables and stop consonants (presumed to be among the most challenging signals for children with SLI to discriminate) but found similar performance for children with SLI and TD peers on both classes of errors. One possible explanation for the lack of consistency between these studies and Montgomery's (1995) findings is related to interference. Montgomery presented each

non-word pair twice successively. This dual presentation may have caused item interference. For example, the second presentation of Word 1 might have interfered with the preceding presentation of Word 2 (e.g., 1. zopanishful–topanishful, 2. zopanishful–topanishful; see more details in Marton and Schwartz 2003). Further evidence for interference problems in non-word repetition have been provided by results of error analyses. Marton (2006) reported that 80–90% of non-word repetition errors produced by children with SLI across different studies consisted of segment substitutions with no change in syllable structures. The majority of segment substitutions were assimilation errors in which production of one part of the non-word influenced production of another part (e.g., dofushid became dodushid).

Despite the large number of non-word repetition studies in children with SLI, the nature of the deficit is still not well understood because non-word repetition is not only a measure of phonological WM but also a measure of language processing. It is difficult to disentangle phonological processes and memory processes; however, moving beyond accuracy and reaction time (RT) measures and examining error patterns and strategy use in children with SLI may advance our understanding of the nature of the non-word repetition deficit.

2.2.2. Time-based Resource-Sharing Theories

An alternative account to the traditional decay theories is the time-based resource-sharing model (Barrouillet and Camos 2001). The authors' goal was to account for the cognitive demands of tasks and control for the passage of time in a single model that integrated resource and time constraints. It has been suggested that retrieval of memory contents depends not only on the number and complexity of items retrieved but also on the time allowed to perform the retrieval process. During complex WM span tasks, attention needs to be frequently switched from processing to reactivating decaying memory traces. Towse and colleagues argued that WM span depends on the duration of processing time (Towse, Hitch, and Hutton, 1998). The authors studied the performance of 6- to 11-year old typically developing children on different span tasks (counting, operation, and reading). Their findings showed that even when processing difficulty was held constant, children exhibited a decline in performance as the retention interval of items increased. Thus, the longer participants had to maintain certain memory contents, the more poorly they remembered those items.

Although the time-based resource-sharing theory has been supported by a series of experiments in the developmental literature, this model has rarely been used by researchers focusing on SLI. In one application of this framework, Montgomery and Evans (2009) found that complex sentence comprehension in children with SLI was highly correlated with attentional resource capacity/allocation, as measured by the competing language processing task (CLPT; Gaulin and Campbell 1994).

In sum, although the original decay theory has been criticized by a number of researchers, a modified version, the time-based resource-sharing account is still being tested in the experimental literature and may elucidate the role of interference control in WM performance. Baddeley's model, which incorporates the concept of decay, is widely used in the SLI literature. Certain WM effects, such as the word-length effect, are generally interpreted based on decay theory in this literature, but may be better understood based on the interference account (see next section).

2.3. INTERFERENCE THEORIES

According to interference theories, WM limitations are related to interference between memory representations. Interference may occur in two directions (Underwood 1957), with

either new information affecting older material (retroactive interference) or previous memory traces affecting new information (proactive interference). Several classic paradigms have been developed to demonstrate the critical role of interference control in effective WM performance, but the locus of interference is still debated.

To support the notion of interference over decay, Lewandowsky and Oberauer developed a series of experiments in which they demonstrated that passage of time did not play a significant role in WM performance (Lewandowsky, Geiger, and Oberauer 2008; Lewandowsky, Oberauer, and Brown 2009; Oberauer 2009). The authors tested several concepts of the ‘Serial Order in a Box’ model and on the basis of their findings, suggested that encoding is novelty sensitive. Thus, the extent to which new items are encoded depends upon the extent to which they differ from previously encoded items. Closer similarity among items increases the chance of interference. The authors’ results showed that recall performance was associated with the novelty of distractor items but not with the number of repetitions or mere passage of time.

To follow up on Lewandowski and Oberauer’s experiments, Berman, Jonides, and Lewis (2009) designed the recent negative task (first developed by Monsell 1978), an experimental paradigm in which rehearsal was not prevented via a secondary task but was made counterproductive. Participants were presented with four target words followed by a probe and were asked to decide whether the probe word was one of the original items. In this task, decisions were made almost immediately and no previous sets had to be recalled; thus, there was no need for rehearsal. Certain probe words, however, were intrusion items from previous trials. The authors also manipulated inter-trial intervals. Results revealed that time manipulation had essentially no effect on performance but the degree of interference was significant. Thus, the findings provided further evidence in support of interference theories.

While these previous studies examined interference effects in association with memory functions, more recent findings also suggest a strong relationship between interference effects and language comprehension (see Van Dyke and Johns 2012 for a review). Items that share linguistic features may interfere with each other at any stage of encoding or storage, but particularly during retrieval. If the retrieval cues are not sufficient to distinguish between target and distracting items, then interference will occur (Van Dyke and McElree 2006). This model has not been tested with children with language impairment but has been successfully used with poor readers, therefore this warrants further investigation with children with SLI.

2.3.1. Interference Control in Children with SLI: Evidence from Error Analysis Data

Before researchers adopted interference paradigms in the SLI literature, error analysis data from WM span tasks already indicated that children with SLI have more difficulty resisting interference than their typically developing peers. It has been reported, for example, that errors produced by children with SLI on complex verbal span tasks tend to consist of sentence-final words from previous sets or words from the questions and/or answers related to the given set (Marton, Kelmenson, and Pinkhasova 2007; Weismer, Evans, and Hesketh 1999). In an analysis of the types of interference errors produced by children with SLI, Marton and colleagues (2007) found that most errors consisted of items from the current set and were either previously recalled target items (perseveration) or words from the sentence context that were not sentence-final words (contextual distraction). A significantly smaller percentage of errors were target items from previous memory sets. Interference errors increased as a result of increased set length, and interference error rates of children with SLI were significantly larger at each set length than that of both age- and language-matched (younger) children.

To further explore this problem, Marton and Eichorn (2014) examined children’s interference errors in a modified linguistic span task. Children were first presented with incomplete

sentences that they completed with their own words. The completed sentences were then presented to the children as a verbal span task. The purpose of this task modification was to ensure word familiarity and to facilitate retrieval of target words from long-term memory prior to the span task. Error analysis data revealed twice as many interference errors in children with SLI compared to TD children, with the majority of errors consisting of target items from previous trials (perseverations). A possible explanation for the interference errors was that children with SLI may have produced a limited set of words (because of their restricted vocabulary) when completing the sentences of the modified span task and that more frequent use of the same words increased the likelihood of interference errors. Analysis of the number of different words produced by the groups (SLI, age- and language-matched controls), however, showed no group difference. Thus, the large number of interference errors in children with SLI was not associated with more limited vocabulary use. Children with SLI maintained items from previous trials that interfered with current sets. An alternative explanation may be that children with SLI had difficulty differentiating between relevant and irrelevant information at retrieval. Lillenthal and her colleagues reported in a recent study that low-span individuals differed from high-span participants not in the level of activation of memory items but in their ability to discriminate between relevant and irrelevant memory content (Lillenthal, Rose, Tamez, Myerson and Hale, 2015).

Interference weaknesses in children with SLI are further evident in data from list recall tasks (a simple task in which participants are presented with a list of items and are asked to repeat as many items as possible). One indicator of interference in list recall tasks is the suffix effect. The addition of a final, not-to-be-recalled item (i.e., suffix) to word lists in a recall task causes recency effects to be diminished (Greenberg and Engle 1983) due to interference of the suffix with list-final items. Gillam and colleagues examined the suffix effect in children with SLI and found that these children show larger suffix effects (more interference) than their TD peers (Gillam *et al.* 1995). The authors noted that children with SLI had particular difficulty maintaining the serial order and position of memory items and that the suffix interfered with the serial position information to a greater extent in children with SLI than in controls.

In sum, although the WM literature provides evidence for weak interference control in children with SLI, the methods employed in these studies have not been optimal for testing more specific questions about potential underlying problems, such as the source of interference. Thus, there is a critical need for researchers to adopt more experimental theories and tasks when studying interference control in children with SLI. In the next section, we present different interference paradigms that have been used in children with SLI and that more closely resemble classic tasks used in the experimental literature.

2.3.2. Interference Control in Children with SLI: Evidence from Interference Paradigms

2.3.2.1. Conflict Paradigm

Using a conflict paradigm, Marton and colleagues examined resistance to proactive interference in children with SLI (Marton *et al.* 2014). The method consisted of a simple categorization task with target and distractor stimuli. Conflict was created by presenting certain items as targets in one category and distractors in a subsequent category (e.g., the stimulus 'soccer' was a target in the 'sports' category but a distractor in the 'colors' category; see Figure 1). Half of the distractors consisted of previous targets; the other half were new items.

Children with SLI performed as well as TD peers in baseline conditions where all distractors were new items, but showed weaker resistance to interference in the conflict condition. Although all children exhibited a decrease in performance accuracy in the interference condition compared to the baseline, the decrement in performance was significantly greater for children with SLI than for their peers.

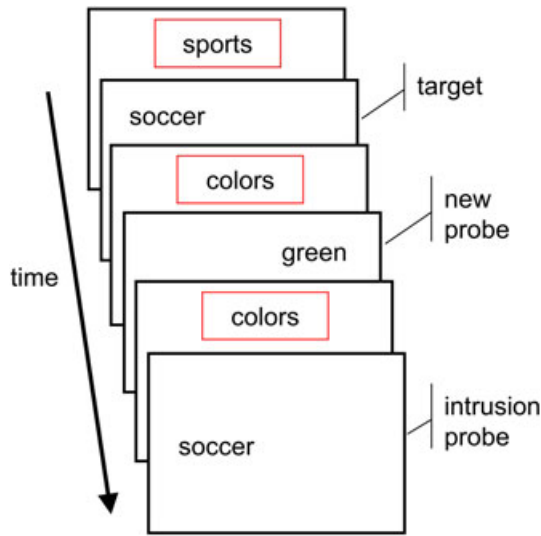


Fig. 1. Conflict paradigm: categorization task.

Results from experiments using directed forgetting provide further information about the interference problems in children with SLI. In these experiments, children are first presented with lists of items that they need to memorize, followed by a cue indicating which items need to be forgotten and which need to be remembered (see Figure 2). Following the memorization phase, a probe is presented that is either a target or an interference item. Participants are asked whether the probe is part of the to-be-remembered list. Interference items may be members of the to-be-forgotten list or members of previous to-be-remembered lists.

Preliminary results from a recent study using a directed forgetting experiment revealed that children with SLI are more susceptible to interference than their TD peers (Scheuer, Campanelli, and Marton 2015). Children with SLI produced more interference errors than

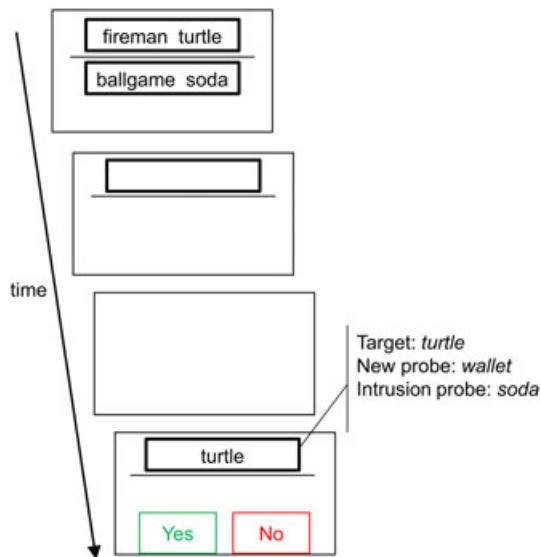


Fig. 2. Task of directed forgetting.

typically developing children. When provided with retrieval cues, children with SLI were able to improve their speed of processing, but showed difficulty removing old items from WM. Both typically developing children and children with SLI benefited from longer cue-stimulus intervals (CSI) when responding to interference items. Unexpectedly, however, children with SLI showed an increase in processing speed with longer CSIs when responding to target items. This pattern was not present in TD children. Performance of children with SLI reflected an ‘all or nothing’ strategy. Unlike TD participants, children with SLI either kept previous items active in WM, even when it was not beneficial, or removed all information including target items.

Overall, although the pattern of deficit is consistent across studies using conflict paradigms, more experimental studies are needed to clarify the cause of these children’s high susceptibility to interfering items. We next review the literature on picture-word interference paradigms in order to further explore how the performance of children with SLI differs from that of typically developing children on different types of interference tasks.

2.3.2.2. Picture-Word Interference Paradigms

The picture-word interference paradigm has been used to evaluate the time course of phonological and semantic processing during lexical access in different populations (de de Hoog, Langereis, van Weerdenburg, Knoors and Verhoeven, 2015; Jerger, Martin, and Damian 2002). This task has several variations, but in most studies, participants view a picture that they must name while interfering words (presented auditorily or in print) or pictures are presented (see Figure 3). Distractor items are either phonologically or semantically similar to the target or are unrelated, neutral words. Time is manipulated between presentation of the target item and distractor (stimulus onset asynchrony or SOA). The interference effect is measured as the difference between response times to related and unrelated items.

Data from typically developing children and adults indicate that semantic information is retrieved prior to phonological information during lexical access. Adults exhibit slower RTs when semantically related words are presented relative to unrelated words, but show faster RT when phonologically related distractors are presented relative to unrelated items (de Hoog et al. 2015; Schwartz 2009). Thus, semantically related words show interference, whereas phonologically related words show a facilitative effect. Data from typically developing children indicate a less consistent pattern, with some authors reporting early phonological facilitation and early semantic interference (Jerger, Martin, and Damian 2002), while others show early phonological interference (Brooks and MacWhinney 2000).

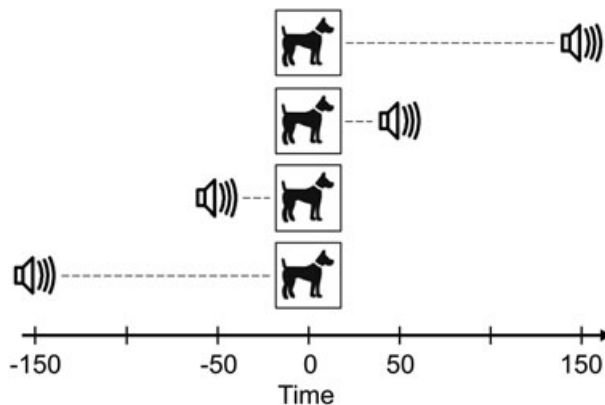


Fig. 3. Picture-word interference paradigm.

Studies of children with SLI show evidence of early semantic interference, early phonological interference, late phonological facilitation, and late semantic interference (Seiger-Gardner and Brooks 2008; Seiger-Gardner and Schwartz 2008). Children with SLI produced more errors and responded more slowly than children with cochlear implants, children with hearing impairment, and typically developing controls across all three experimental conditions (phonological, semantic, unrelated), independent of the time course of distractor item presentation (de Hoog et al 2015). The authors concluded that children with SLI have more poorly specified phonological and lexical representations, which lead to slower and less accurate naming. An alternative explanation is that these children have more difficulty selecting and suppressing items when there are competing stimuli in phonological and semantic conditions.

The late phonological facilitation effect suggests that children with SLI use phonological primes to support lexical access (Seiger-Gardner and Schwartz 2008). The late semantic interference effect can be interpreted in at least two ways. The effect may reflect either a slow decay rate of semantic alternatives or inefficient suppression of competitor items. If activation of previous items is not suppressed in a timely manner, these items can potentially interfere with new lexical items. Future studies are needed to address this question in more detail.

The last line of research reviewed in the next section relates to verbal fluency in children with SLI, as deficits in verbal fluency have also been associated with item competition and interference.

2.3.3. Verbal Fluency

Verbal fluency tasks have been popular in the clinical literature, although researchers are not in agreement about the functions and underlying mechanisms measured by these tasks. In verbal fluency tasks, individuals are asked to list exemplars of a given semantic category within a specified time limit (typically 60 seconds), without repeating the same items. Errors in the task include words from other categories and repeated items. Typically developing children and adults tend to produce semantic clusters (subcategories) when listing words of a given category. Good cognitive control is required when switching between clusters, in order to prevent interference (Hirshorn and Thompson-Schill 2006).

In clinical populations, poor verbal fluency performance has been associated with impairments in semantic search and semantic memory (Chertkow and Bub 1990), weakness in WM (Daneman 1991), slower processing speed (van Beilen et al. 2004), and poor interference control, specifically poor resolution of conflicts (Novick, Trueswell, and Thompson-Schill 2005). Interpretations of what this task measures vary; however, as in the WM literature, these interpretations have generally moved from a more quantitative perspective that focuses on the amount of information activated in semantic memory to a more function-based approach that considers the role of interference in word retrieval. Researchers have also examined performance based on different measures, such as the amount of verbal material, accuracy of retrieval, and clustering and switching patterns (Weckerly, Wulfeck, and Reilly 2001).

Children with SLI have been shown to generate fewer words and produce a smaller proportion of correct responses compared to their TD peers (Henry, Messer, and Nash 2012; Weckerly et al. 2001). The pattern of clustering and switching in children with SLI, however, did not differ from that of the controls. Based on this finding, Weckerly and colleagues concluded that verbal fluency problems in children with SLI are more linguistic in nature. From the perspective of interference theories, however, one might argue that poor resistance to interference affects the number of words generated as well as the number of correct items when there is competition among members of a given semantic category. Although authors of the above studies did not report error types, perseveration is a common error in this population. Children

with SLI in our studies showed increased rates of perseveration on verbal fluency measures as well as verbal sequencing tasks, in which they listened to increasingly long lists of items (2–6 items) within a given semantic category (e.g., toys), then reordered and repeated the items on the basis of a given criterion (e.g., increasing size; Marton et al. 2014). Relative to typically developing peers, children with SLI more frequently repeated previously named items. These perseverative errors may reflect poor resistance to proactive interference.

In summary, verbal fluency tasks involve sustained activation, selection, and creation of novel responses, as well as resolution of conflicts between competing response options (Novick, Trueswell, and Thompson-Schill 2005; Novick et al. 2009). Providing participants with retrieval cues, such as the name of a subcategory, may limit item competition and facilitate generation of appropriate words. A comparison of performance in cued and uncued conditions may help us examine and clarify the root of interference in verbal fluency tasks. If children with SLI generate more words but produce fewer perseverative errors under cued conditions, outcomes could provide further evidence for an interference problem in this population.

4. Conclusions

The present review focused on WM and interference in children with SLI. Our aim was to demonstrate that interference and language problems are frequently associated. Review of the literature provides considerable evidence of deficits in both WM and interference control in children with SLI; however, the source and nature of the interference weakness are not well understood.

Another key aim of this review was to emphasize the need for tasks employing experimental manipulations that can provide more specific data about the interference problems in children with SLI. Although theoreticians have developed testable models of WM and interference control, these theoretical frameworks and methodologies have generally not been transferred to the clinical literature, resulting in an unfortunate gap between the experimental and clinical literature. The use of more theoretically driven experimental tasks in future clinical studies may help us better understand WM and interference weaknesses in children with SLI and clarify the relationship between these weaknesses and language deficits. For example, cue-based retrieval models may help us better understand the nature of memory interference problems. Retrieval cues are used to reduce interference from distractor items; however, the usefulness of such cues for children with SLI is an open question. Whether these children would benefit from different cues associated with targets in a manner similar to typically developing children is not known. Examining effects of different cues on the retrieval process may help identify the source of interference problems in children with SLI.

A more nuanced perspective on these weaknesses would also be invaluable for the development of sound intervention strategies designed to address problems in interference control. Potential educational applications of interference research are considered by Dempster and Corkill (1999); however, conducting careful empirical studies of the effectiveness of specific therapeutic techniques for specific clinical populations is a critical and open avenue for future research on this topic.

Note

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