LSHSS

Tutorial

A New Memory Perspective on the Sentence Comprehension Deficits of School-Age Children With Developmental Language Disorder: Implications for Theory, Assessment, and Intervention

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Purpose: The nature of the relationship between memory and sentence comprehension in school-age children with developmental language disorder (DLD) has been unclear. We present a novel perspective that highlights the relational influences of fluid intelligence, controlled attention, working memory (WM), and long-term memory (LTM) on sentence comprehension in children with and without DLD. This perspective has new and important implications for theory, assessment, and intervention.
Method: We review a large-scale study of children with and without DLD that focused on the connections between cognition, memory, and sentence comprehension. We also summarize a new model of these relationships.
Results: Our new model suggests that WM serves as a conduit through which syntactic knowledge in LTM, controlled attention, and general pattern recognition indirectly influence sentence comprehension in both children with DLD and typically developing children. For typically developing children, language-based LTM and fluid intelligence indirectly influence sentence comprehension. However, for children with DLD, controlled attention plays a larger indirect role.
Conclusions: WM plays a key role in children's ability to apply their syntactic knowledge when comprehending canonical and noncanonical sentences. Our new model has important implications for the assessment of sentence comprehension and for the treatment of larger sentence comprehension deficits.

Children with developmental language disorder (DLD) show significant difficulties mastering spoken and written language yet have broadly normal-range nonverbal intelligence, normal hearing sensitivity, articulation, and no neurological impairment (Leonard, 2014). Syntactic deficits that interfere with sentence comprehension are a major feature of the language profile of school-age children with DLD (Dick et al., 2004; Friedmann & Novogrodsky, 2007; Leonard et al., 2013; Montgomery & Evans, 2009; Montgomery et al., 2009; Robertson & Joanisse, 2010; van der Lely & Stollwerck, 1997). These children also demonstrate a variety of memory deficits. Memory is a complex system comprising short-term memory (STM), working memory (WM), and long-term memory (LTM; Cowan, 2008). STM involves the very short-term retention of information. WM refers to the ability to temporarily store information while at the same time engaging in some kind of mental activity. LTM is the repository where all our language knowledge permanently resides (Atkinson & Shiffrin, 1968). Children with DLD show significant deficits, relative to their typically developing (TD) same-age peers, in verbal STM capacity (Archibald & Gathercole, 2007; R. Gillam et al., 1998), verbal WM capacity (Ellis Weismer et al., 1999; R. Gillam et al., 1995; Montgomery, 2000), and language LTM knowledge (Evans et al., 2009; Lum et al., 2014). They also exhibit poor attentional control, which is an important component of WM (Victorino & Schwartz, 2015). Though there is general consensus that the memory and comprehension deficits of children with DLD relate,

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there is disagreement about the nature of the relationship. In this tutorial, we describe a new, conceptually integrated and data-driven model of the nature of this relationship that focuses on verbal WM, language LTM, and sentence comprehension.

The Broad Character of DLD

Much is known about the language abilities of young children with DLD through the preschool and kindergarten years. Relative to their same-age TD mates, children with DLD have difficulty acquiring a vocabulary (Alt & Plante, 2006; Gray, 2003) and exhibit significant weaknesses in learning and using grammatical morphology, especially verb morphology related to tense marking (Leonard et al., 1997; Rice et al., 1995). It is their deficit in finite verb morphology that most reliably discriminates young children with DLD from their same-age peers (Rice et al., 1998), especially in combination with a phonological STM deficit indexed by poor nonword repetition (Conti-Ramsden, 2003). Both deficits represent clinical markers of DLD (Bishop, 2006).

The language and memory weaknesses of children with DLD persist through the elementary school–age and adolescent years (R. Gillam et al., 1998; Johnson et al., 2010). These individuals continue to have lexical deficits, both in terms of acquiring breadth and depth of vocabulary knowledge (Capone & McGregor, 2005; McGregor et al., 2013). Deficits in the use of grammatical morphology, however, no longer distinguish children with and without DLD after about 7 years of age, even though those with DLD continue to make errors (Moyle et al., 2011). Deficits in syntactic ability, instead, become more evident as demands for more complex academic language use increases (R. Gillam & Johnston, 1992; Nippold et al., 2008). Such increased demands take on major importance when you consider that the syntactic ability of TD children undergoes substantial change during these years (Nippold et al., 2005). Relative to their same-age peers, the sentences of those with DLD are significantly less complex in the spoken modality (R. Gillam & Johnston, 1992; Nippold et al., 2008) and written modality (R. Gillam & Johnston, 1992; Scott & Balthazar, 2013). The sentence comprehension abilities of these children are also markedly compromised, particularly for complex syntactic forms (Dick et al., 2004; Friedmann & Novogrodsky, 2007; Montgomery & Evans, 2009; van der Lely & Stollwerck, 1997). Interestingly, measures of preschool syntactic ability are relatively poor predictors of older children's ability (Scott & Stokes, 1995), suggesting, importantly, that the syntactic ability of older children is qualitatively different than that of younger children. Limitations in memory, including verbal STM, verbal WM, and LTM (declarative–procedural memory), persist in older school-age children and adolescents (see R. Gillam et al., 2017, for a review), as do deficits in controlled attention (Marton et al., 2014).

Why Sentence Comprehension and Syntax Are Important to Appreciate

There are a number of reasons for appreciating sentence comprehension and syntax in children with DLD. Children with receptive–expressive deficits are at greater risk for academic failure than those with just expressive deficits (Conti-Ramsden et al., 2009). The few treatments that have been designed to enhance syntactic knowledge and auditory sentence comprehension yield no clinical benefit for complex structures (Ebbels et al., 2014; Zwitserlood et al., 2015). Auditory sentence comprehension is a strong predictor of reading comprehension in TD children (Botting et al., 2006; Catts & Kamhi, 2012), and reading comprehension is a strong predictor of academic achievement (Keskin, 2013; National Institute of Child Health and Human Development, Report of the National Reading Panel, 2000). Students with DLD show poor reading comprehension through adolescence (Catts et al., 2008; Kelso et al., 2007; Scott & Balthazar, 2010, 2013) and beyond (Botting, 2020; Nippold & Schwarz, 2002). They also exhibit poor academic achievement (Conti-Ramsden et al., 2009; Simkin & Conti-Ramsden, 2006). Syntactic ability and sentence comprehension are important vehicles for reading comprehension (Scott, 2009). Students start encountering complex structures in about the fourth grade (Curran, 2020; Montag & MacDonald, 2015; Nippold, 2017; Scott & Balthazar, 2010). For example, the passive *The molecular state of oxygen changes by interacting with hydrogen* and object relative *The criminal that the judge sentenced to 20 years was upset by the ruling* express complex relationships between the main elements in the sentence. Poor syntactic ability hampers children's understanding of multiple-clause sentences that pervade written texts and, very likely, the learning of academic vocabulary. About 2.4 million public school students carry a diagnosis of learning disability (LD), and about 80% of them have a language-based LD (National Center for Learning Disabilities, 2014). Significantly, poor auditory sentence comprehension is a major factor in reading comprehension deficits (Spencer et al., 2014). Those with DLD who pass their high school curriculum varies widely (50%–90%; Conti-Ramsden et al., 2009; Whitehouse et al., 2009), and just 9% of students go on to attend college (Conti-Ramsden et al., 2018). The stakes for improving the sentence comprehension abilities of school-age children with DLD could not be higher.

What Is Sentence Comprehension?

Sentence comprehension represents a unique problem-solving space because listeners must understand what the speaker is saying while managing two fundamental challenges. The first is the immediacy of comprehension. Listeners must create structure and meaning in the moment. They may manage this problem by initiating comprehension from sentence onset (Marslen-Wilson & Zwitserlood, 1989) and incrementally building structure and meaning from all available cues in the input (phonological, morphological, syntactic, semantic). Listeners also use their developing sentence representation to anticipate upcoming language material at a general level (e.g., next word is a noun [N] or verb [V]) or even lexical level (i.e., specific word), depending on the availability and strength of semantic/real-world cues, that is, knowledge about who typically does what to whom (Altmann & Kamide, 1999; Ferretti et al., 2001). The second challenge involves listeners wrestling with a severely capacity-limited WM system that must hold in mind the products of processing earlier parts of a sentence while processing new, incoming material. The capacity of listeners' WM is only about three to four chunks of information. However, listeners may manage this limitation by creating just a few, integrated chunks (e.g., phrases, clauses) out of the stream of words and then combining the chunks into a single cohesive sentence (e.g., McCauley & Christiansen, 2015, 2017).

Take the complex object relative sentence *The criminal that the judge sentenced to 20 years was upset by the ruling*. Even though this sentence is not a high-frequency canonical/typical noun–verb–noun (NVN)/subject–verb–object (SVO) structure (e.g., *The judge sentenced the criminal to 20 years*), adults know that Noun Phrase 1 (NP1), *the criminal*, is the patient of the action (*sentenced*) and *the judge* (Noun Phrase 2 [NP2]) is the agent of the action. Adults understand such sentences with relative ease because they activate from LTM relevant language knowledge to quickly build structure and meaning. This process is facilitated by the use of semantic and real-world knowledge about who does what to whom (i.e., judges sentence criminals). Listeners are able to manage their memory limitations by chunking the input stream into a few intermediate units, such as noun phrases (NPs), verb phrases (VPs), and clauses (independent, dependent); storing these chunks in WM; and then combining the chunks into a single cohesive sentence. Chunking, of course, depends on the state of listeners' language LTM.

Individuals with good language knowledge are better able to manage the temporal and memory challenges of auditory sentence comprehension than those with weaker knowledge. However, what is meant by language knowledge? We adopt a view from the cognitive language sciences, one that allows us to think a bit differently about what language knowledge is and how this knowledge, as represented in LTM, interfaces with verbal WM to influence sentence comprehension. We believe this view has important implications for the field of speech-language pathology. Though the DLD literature certainly includes descriptions about the relationship between memory and sentence comprehension, these descriptions have fallen short because they have narrowly focused on the role of STM and/or WM. None of the descriptions have explicitly taken into account the potential influence of language LTM; the nature of the representations of syntactic knowledge in LTM; or the structural and functional relationship among LTM, WM, and sentence comprehension. The result is an absence of conceptually integrated and data-driven models of comprehension (Montgomery, Gillam, & Evans, 2016). The model we describe in this tutorial is the first such model. Theoretically, it can address the temporal and memory challenges of comprehension, offering us a glimpse into the differences in the structural/functional relationship between memory and comprehension between children with DLD and TD children. We also believe the model offers important implications for the assessment and treatment of comprehension deficits of children with DLD.

Sentence Comprehension Deficits of Children With DLD: Two Historical Perspectives

Snapshot of Deficits

Children and adolescents with DLD exhibit marked sentence comprehension deficits. Though noncanonical structures, such as passives (*The molecular state of oxygen changes by interacting with hydrogen*) and object relatives (*The criminal that the judge sentenced to 20 years was upset by the ruling*), are difficult even for TD children, they understand passives by the early school-age years and object relatives by early to mid-adolescence (Dick et al., 2004; Friedmann & Novogrodsky, 2007). For those with DLD, such structures pose major problems through adolescence (Dick et al., 2004; Friedmann & Novogrodsky, 2007). Relative to canonical/typical structures, passives and object relatives are hard because there is a mismatch between the typical mapping of agent to subject and patient to object. Instead, in passives and object relatives, NP1 still functions grammatically as the subject, but semantically as the patient, and NP2 still functions grammatically as the object, but semantically as the agent. Even though passives have an NVN surface form with the addition of a *by*-phrase (*The elephant was attacked by the tiger*), and object relatives have an obvious noncanonical NNV form, children must come to know that, in both cases, NP1 is the patient and NP2 is the agent. Historically, two broad theoretical perspectives have been advanced to help explain the sentence comprehension deficits of children with DLD.

Linguistic Perspective

Verbal *be* passives (*The lion was bitten by the monkey*) and object relatives (*The lion* [*that the monkey bit*] *was brown*) pose special problems for children with DLD (Dick et al., 2004; Montgomery & Evans, 2009; Montgomery et al., 2017; van der Lely & Stollwerck, 1997). van der Lely and colleagues were the first to offer a theoretical explanation of these children's sentence comprehension deficits. They proposed the computational grammatical complexity hypothesis (Marinis & van der Lely, 2007; Marshall et al., 2007) in which it is assumed that the children have trouble building grammatical structures requiring "syntactic movement." The account assumes that the representation/mechanism responsible for movement is not used obligatorily by children with DLD but is used in an optional manner.

However, children with DLD also have trouble with canonical structures requiring no syntactic movement. The children's difficulties become apparent as sentence length increases with the addition of NP-modifying adjectives that are critical to comprehension (*The yellow dog washes the white pig, The fat clown* [*that is hugging the skinny girl*] *is* *laughing*; Leonard et al., 2013; Montgomery et al., 2009; Robertson & Joanisse, 2010). Findings such as these suggest that nonsyntactic factors (e.g., memory capacity limitations, interference between NPs with critical modifying adjectives) also play a role in these children's comprehension difficulties.

Memory Perspective

The sentence comprehension deficits of DLD have also been described from a memory perspective. This perspective has mainly focused on the role of WM. However, a second perspective has begun to emerge, one suggesting the importance of LTM, specifically procedural memory.

WM. WM is the ability to hold a limited amount of information in mind while performing some kind of mental activity at the same time (Baddeley, 2012; Cowan, 2017). Investigators have examined the association between verbal WM and sentence comprehension in children with DLD, with the main assumption being that the reduced verbal WM capacity of these children hinders their comprehension because they have trouble remembering information they have already processed earlier in a sentence, as they process newly arriving information. Correlation results and pattern analyses from these studies have been taken to suggest that a capacity limitation hinders these children's comprehension of verbal *be* passives (Montgomery & Evans, 2009; Robertson & Joanisse, 2010) and lengthy SVOs (Montgomery, 2000; Montgomery et al., 2009; Robertson & Joanisse, 2010). These children also have difficulty deciding which NP is the agent in SVOs when both the agent and patient NPs include a modifying adjective (*The yellow dog washes the white pig*), suggesting that the children have trouble managing the memory interference created by the adjectives (Leonard et al., 2013).

WM not only involves storage but also controlled attention, which is important to information storage (Baddeley, 2012; Engle et al., 1999) and entails different abilities such as allocating attention, sustaining attention, and switching attention (Baddeley, 2012; Engle et al., 1999). Some research has examined the potential influence of controlled attention on the sentence comprehension of children with DLD, but it is limited. These studies have focused on the role of sustained attention and attentional resource allocation, testing the assumption that the poor comprehension of children with DLD relates to difficulties allocating sufficient attentional resources during comprehension and maintaining attention over the course of a sentence (Leclercq et al., 2013; Montgomery, 2008, Montgomery et al., 2009). Results of these studies suggest that the comprehension of even simple grammar by children with DLD is not yet automatic.

LTM. One especially relevant LTM framework that has the potential to help us understand the broad range of language learning difficulties in DLD is the declarative/procedural memory model of Ullman and colleagues (Hamrick et al., 2018; Hedenius et al. 2011; Ullman, 2004). Ullman (2004, 2016) proposes that these LTM systems underpin language learning. Procedural memory relates to the unconscious (implicit) learning of patterns (Squire et al., 1993; Ullman, 2004). Implicit learning involves learners tracking the distributional regularities in the input. These regularities in syntax correspond to different word order patterns such as SVO/NVN, passive (NVN with a *by*-phrase), and object relative (NNV) structures. TD children unconsciously use input regularities to learn different syntactic patterns, including passives and object relatives (Gómez & Gerken, 1999; Kidd, 2012; Kidd & Arciuli, 2016; Savage et al., 2003). An implicit learning–syntax learning connection comes from findings showing that performance on implicit learning tasks predicts TD children's syntactic learning, indicating that implicit learning may support syntactic learning (Conti-Ramsden et al., 2015; Kidd, 2012; Kidd & Arciuli, 2016).

Declarative memory is primarily an explicit (conscious) system that supports the learning, storage, and retrieval of factual information (Squire, 2004; Ullman, 2004; Ullman & Pierpont, 2005). Related to language, the system supports the learning, storage, and retrieval of words. Declarative memory is thought to be responsible for establishing the relationship between form and meaning, that is, binding the conceptual, phonological, and semantic features of words into unified representations. Declarative memory may also be important to syntactic learning, however, especially early in life, by supporting the learning of linguistic chunks larger than the word (Hamrick et al., 2018; Ullman, 2016).

Compared with TD children, children with DLD show poor implicit learning across the nonverbal and verbal domains (Evans et al., 2009; Hedenius et al., 2011; Karuza et al., 2013; Lum et al., 2014), suggesting that the children have an implicit learning deficit (Garraffa et al., 2018; Lum & Conti-Ramsden, 2013). A DLD implicit learning deficit was first proposed by Ullman and Pierpont (2005) in their procedural deficit hypothesis to explain the children's language deficit. Recent studies support the hypothesis. For example, performance on implicit learning tasks do not predict sentence comprehension in these children (Conti-Ramsden et al., 2015), suggesting that these children's syntactic learning is not supported by implicit learning. Children with DLD who have syntactic deficits exhibit significant difficulty with long-term retention of newly learned visual sequences (Hedenius et al., 2011). Together, such findings suggest that the implicit and syntactic learning difficulties of the children are intertwined. Finally, these children tend to show stronger declarative memory, indexed by lexical knowledge, than procedural memory (Conti-Ramsden et al., 2015). It is unknown whether the declarative memory and syntactic learning abilities of these children are related. Ullman and Pierpont suggest that this system may play a critical compensatory role in learning grammar when the procedural system is impaired.

A New Model of Sentence Comprehension

While memory limitations are implicated in the sentence comprehension deficits of children with DLD, the nature of the relationship has been unclear. The lack of clarity owes to the absence of an integrated model, one that specifies the structural/functional relationship between memory (WM, language LTM) and comprehension. What we mean by a structural/functional relationship is how different mental abilities such as WM and LTM influence children's sentence comprehension. It could be that each ability has its own direct influence on comprehension, or it may be that one ability directly influences comprehension while the other ability indirectly supports comprehension via its relationship with the other mental ability. An integrated model would advance our understanding of the structural relationship between memory and comprehension and provide new and important clinical implications for the assessment and treatment of sentence comprehension deficits. We propose such a model in the present tutorial, one we refer to as the GEM (Gillam–Evans–Montgomery) model (see Figure 1).

Our model is a first pass at characterizing the structural/functional relationship between memory and sentence comprehension. As such, the model focuses on children's use of a specific syntactic cue, word order, to guide their comprehension. We felt it was prudent to build a model from the ground up, to figure out first how children use word order to build structure given the importance of this cue in English (Bates & MacWhinney, 1989) and the importance of syntax to comprehension (Kaan & Swaab, 2002). We must first understand the structural relationship between memory and syntactic processing before we can understand the interaction effects of multiple linguistic cues and memory. Our model borrows heavily from the chunk-and-pass model of sentence comprehension developed by Christiansen and colleagues (McCauley & Christiansen, 2014, 2015, 2017) in which structure building is a foundation to comprehension.

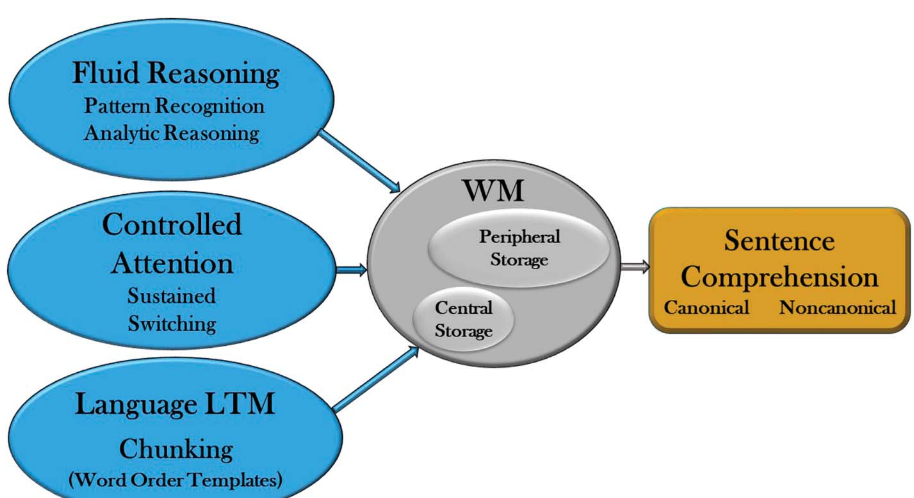
Components and Motivation of the Model

The model includes four mechanisms: fluid reasoning, controlled attention, WM, and language knowledge in LTM. Selection of the mechanisms was motivated by their relevance to comprehension based on findings in the DLD, TD, and adult comprehension literatures. We emphasize the structural relationship between WM (including controlled attention), LTM, and comprehension, but we also mention the role of fluid reasoning.

Fluid Reasoning

Fluid reasoning is the ability to apply logical and analytical reasoning, independent of prior experience or knowledge, to solve novel problems, for example, recognizing and interpreting novel patterns (Cattell, 1963). The influence of fluid reasoning on auditory sentence comprehension of children is unknown. However, there is research in the adult sentence comprehension literature relevant to our thinking. Some investigators (Andrews et al., 2017) have argued that fluid reasoning and comprehension are similar in that both involve recognizing and interpreting patterns in the input. These authors have shown that, relative to adults with weak fluid reasoning, those with stronger abilities are better at determining the agent–patient relationship in complex sentences containing weak semantic/real-world cues (*The woman that the man helped sang well*). In this object relative, neither NP (*the woman*, *the man*) is semantically favored as the agent, which renders the sentence more difficult than an object relative with strong semantic cues (*The criminal that the judge sentenced was unhappy*). Results of this study suggest that those with stronger general pattern recognition abilities are better able to determine agency and thus the agent–patient relationship using syntactic structure. In

Figure 1. Simplified structural model of sentence comprehension reflecting the relationship between cognitive processing and sentence comprehension. The model represents the indirect (mediated) influences of fluid reasoning (pattern recognition), controlled attention (sustained attention, attention switching), language long-term memory (LTM; chunking of input, use of word order templates), and the mediating influence of working memory (WM; central storage component, peripheral storage component) on the comprehension of simple and complex structures.



school-age TD children, fluid reasoning and reading comprehension have also been shown to be significantly correlated (Motallebzadeh & Yazdi, 2016).

Controlled Attention

Sustaining attention over the course of a sentence should allow children to attend to the incoming words of a sentence, thus promoting their chunking of the input into linguistic units. Attention switching may be important in allowing children to toggle their attention between storing linguistic chunks in WM that have already created (keeping them in an active state) and language LTM, which generates new chunks from incoming input (Finney et al., 2014).

Language LTM

Language knowledge resides in LTM. Consistent with the chunk-and-pass model of language processing developed by Christiansen and colleagues (Chater et al., 2016; McCauley & Christiansen, 2015, 2017), our GEM model assumes a connectionist (Christiansen & MacDonald, 1999; MacDonald & Christiansen, 2002; McCauley & Christiansen, 2015) and usage-based (Abbot-Smith & Tomasello, 2006; Lieven et al., 2009) perspective of language learning and processing. A key processing principle of the chunk-and-pass model is immediate chunking of the input and passing chunks created at lower levels (e.g., phonological, lexical) to higher levels (e.g., multiword units, syntactic). Chunking the input into multiword units allows listeners to create intermediate structures such as NPs, VPs, and clauses. Chunking occurs repeatedly over the course of the input until all necessary structures are realized, at which point they are combined into a single, cohesive representation. As structures are realized, listeners use available semantic/real-world cues to assign meaning to the words and phrases. In keeping with the pass-and-chunk model, we believe that knowledge of syntactic structure emerges as a natural byproduct of language processing experiences, with children creating multiword memory templates corresponding to different syntactic structures such as SVOs, subject relatives, passives, and object relatives. Input chunking improves with age as the language system gains more language processing experience, which leads to more robust and stable multiword traces, which, in turn, leads to further gains in processing efficiency (Thiessen, 2017).

Multiword chunks are important building blocks for syntactic development and are used for comprehension and production (Arnon & Clark, 2011; Bannard & Lieven, 2012; Cornish et al., 2017). Repeated language processing experiences provide children crucial input about the distributional patterns across words, allowing them to create multiword chunks and the opportunity to reuse different components (nouns, verbs) within these chunks to acquire new multiword chunks (Cornish et al., 2017; Theakston & Lieven, 2017).

The importance of learning and using multiword chunks cannot be overstated. As mentioned, listeners face two fundamental challenges during comprehension. First, comprehension takes place in the moment, requiring listeners to make immediate sense of what is being said. Second, listeners must store in memory earlier parts of a sentence while processing downstream material. Reliance on multiword chunk templates can greatly minimize both challenges. Activation of multiword representations allows listeners to efficiently chunk a stream of incoming words into fewer, more cohesive structural units. Doing so also allows listeners to anticipate upcoming words. Activation of multiword templates thus not only speeds up comprehension but also conserves memory space.

WM

WM is the ability to hold information in an active state while performing some kind of mental activity (Baddeley, 2012; Cowan, 2017). Sentence comprehension is all about concurrent processing and storage. To understand a sentence, listeners must store the products of earlier processing (phrases, partial or complete clauses) while processing new, incoming information. Viewing the WM–comprehension link in this way leads us to adopt the embedded processes model of Cowan and associates (Adams et al., 2018; Cowan et al., 2012, 2014).

A central tenet of Cowan's model is that WM is nested within LTM, a view that is empirically supported (Engle et al., 1999; Loaiza & Camos, 2018; Nee & Jonides, 2013). In the context of comprehension, the basic idea is that incoming words are activated in LTM and become the momentary objects of WM. According to Cowan, the capacity of WM, which is limited to about three to four chunks of information, includes chunks in the focus of attention at any given moment (central storage) and other chunks that lie just outside the focus of attention (peripheral storage). Chunks in WM may be of variable size, depending on how the input has been chunked. As we have suggested, clauses (independent or dependent) are very efficient chunks because they contain NPs and VPs that hang together in a cohesive way, thereby maximizing memory space. This view of chunking corresponds nicely with the chunk-and-pass model of language comprehension and provides strong motivation for why we have adopted Cowan's WM perspective as part of our comprehension model.

The conduit function of WM. We mentioned that WM should serve as a conduit for fluid reasoning, controlled attention, and language LTM to influence children's sentence comprehension. What do we mean by this? It simply means that these other mechanisms operate through WM to indirectly influence comprehension. Two assumptions motivate our reasoning. First, we assume that it is WM that is most proximal to comprehension because it is the mechanism that coordinates concurrent verbal processing and storage. Second, each of the other mechanisms relates positively to WM, which leads us to elevate WM to a conduit function.

What is the relationship between these other mechanisms and WM? In terms of fluid reasoning, novel problem solving appears to involve both information processing and storage. Evidence shows a moderate-to-strong relationship between WM and fluid reasoning in adults (Burgess et al., 2011; Fukuda et al., 2010; Kane et al., 2004) and TD children (Engel de Abreu et al., 2010). The link between WM and controlled attention is inherent in processing, as controlled attention is part of the WM system (Baddeley, 2012; Cowan et al., 2012; Engle et al., 1999). Controlled attention enables participants to toggle their attention between processing incoming information and previously stored information. The link between WM and language LTM plays out in two important ways. First, WM corresponds to the temporary storage of those items that have been activated in language LTM. Another way to think about this relationship is that those items activated in LTM are the very same ones that become the temporary objects of WM. The second and related link between WM and LTM is that WM functions as the conduit for language LTM during comprehension. It is language LTM that allows chunking to occur, and once it does, it is WM that stores the products of that chunking while the listener processes new material.

A Test of the Model

We conducted a large-scale project with 117 children with DLD and 117 TD children propensity-matched for age (7–11 years), gender, mother's education, and family income. Supplemental Material S1 displays the demographics of each participant group, and Supplemental Material S2 presents the entrance test scores of each group (also see Montgomery et al., 2017). The two overarching aims of the project were to (a) build a model describing the structural/functional relationship between cognition and children's syntactic sentence comprehension and (b) determine whether the model was applicable to both children with DLD and TD children. The children completed a comprehension task and a variety of cognitive tasks over three testing sessions during a week's period, with each session lasting about 2 hr. The tasks were administered in a prescribed random order across all children (see Montgomery et al., 2018, for details).

Sentence Comprehension Task

We used a "whatdunit" agent selection task (Montgomery, Evans, et al., 2016), which is a variant of the "who did what to whom" paradigm (Dick et al., 2004). Understanding who did what to whom is fundamental to sentence comprehension (Ferretti et al., 2001), as listeners create an agent–patient relationship between the two most relevant NPs. Given our interest in children's ability to use word order cues to guide their comprehension, our sentences had no semantic/real-world cues, thus making them implausible and forcing the children to rely just on their word order knowledge. Implausibility was created by using inanimate nouns to represent the agent and patient of each sentence. We recognize that semantic cues are important to comprehension (Bates et al., 1984; Dick et al., 2004), and the lack of them made our task unusual. However, we consider the task to be a comprehension measure because children still had to assign proper semantic roles to NPs to understand who did what whom. Because our task was unusual by putting pressure on syntactic knowledge and WM, we expected the children to perform more poorly than children in other comprehension studies that included a full complement of cues (e.g., Dick et al., 2004).

The children listened to two canonical structures: SVOs (*The square had changed the bed under the very new dry key*) and subject relatives (*The watch that had hugged the truck behind the kite was bright*). They also listened to two noncanonical structures: verbal *be* passives (*The watch was bumped by the wheel near the very bright clock*) and object relatives (*The chair that the bread had splashed under the square was new*). The SVO and passive sentences included a single clause, while the subject and object relative sentences included two clauses (main, relative). All sentences contained a prepositional phrase near the end of the sentence, but it was not critical to comprehension. After hearing a sentence, the children saw three images on the screen, one corresponding to the agent, one to the patient, and a third to the noun in the prepositional phrase. The children were asked to choose the agent image.

Sentence comprehension performance. As expected, both groups showed significantly better comprehension of canonical structures than noncanonical structures. The children with DLD were significantly outperformed by their mates across all sentence types. The more interesting findings related to group differences in developmental changes in comprehension. Each group was divided into a younger cohort (Age_{Mean} = 8 years 1 month) and an older cohort (Age_{Mean} = 10 years 8 months) of about equal size (see Supplemental Material S3 for details about the groups). The groups were split in this fashion given the absence of developmental data to guide us as to what children's *syntactic* sentence comprehension abilities are as assessed in this project. TD children showed developmental improvement for both structures. The children with DLD showed improvement only for the canonical structures. More interesting, the older children with DLD were significantly outperformed even by the younger TD children on both the passives and object relatives (see Supplemental Material S3 for scores). These findings align very well with recent studies showing that TD children's syntactic knowledge only gradually emerges to guide comprehension (Skeide et al., 2014; Wu et al., 2016). Our findings also suggest that DLD children's knowledge of structure emerges even more slowly, especially noncanonical knowledge.

Alternatively, the children may have had trouble with the sentences not for syntactic reasons but because they had to suppress the typical inanimate meaning of the nouns and instead attribute agent and patient hood to the nouns. Children with DLD exhibit trouble with inhibition on verbal WM tasks (Mainela-Arnold et al., 2010; Marton et al., 2014). Had inhibition been a significant problem, though, its effect likely would have been comparable across sentence types. However, the children showed significantly poorer noncanonical sentence comprehension than canonical sentence comprehension, just like the TD children.

Cognitive Measures

Each of the cognitive mechanisms was indexed by two or three measures. Fluid reasoning was indexed by performance on the Figure Ground, Sequential Order, and Repeated Patterns subtests of the Leiter International Performance Scale–Revised (Roid & Miller, 1997). Controlled attention was represented by performance on an experimental sustained attention task and an experimental attention switching task. Language LTM was indexed by performance on the receptive–expressive portions of the Test of Narrative Language (R. Gillam & Pearson, 2004), which included holistic measures of lexical, sentential, and event knowledge in comprehension and production tasks. According to Bower (2008), these measures effectively assess narrative chunk ability (chunk size and chunk access). Finally, WM was indexed by performance on two tasks involving concurrent processing and storage of words and digits or high and low tones. Across all tasks, the children with DLD performed significantly worse than their TD peers. A description of the cognitive measures can be found in Supplemental Material S4, and scores on the measures are presented in Supplemental Material S5.

The Sentence Comprehension Modeling Process

A multistep modeling process was used to describe the structural relationship between cognition and sentence comprehension (see Supplemental Material S6 for a description of the modeling process and results of both the confirmatory factor analysis and structural equation modeling). The aims of modeling were to (a) describe the relationship among WM, language LTM, and sentence comprehension; (b) determine whether the relationship was similar or different for the DLD and TD groups; and (c) determine whether the relationship was similar or different for canonical and noncanonical sentence comprehension. In the first step, each cognitive construct was created by combining their respective tasks into a composite measure. Results of a confirmatory factor analysis verified the validity of each construct for the groups combined and separately. Second, structural equation modeling was done to test which of five models was the best in describing the structural/functional relationship among the cognitive mechanisms and comprehension.

The first model tested was a direct model to determine whether one or more of the cognitive mechanisms had its own *direct* influence on sentence comprehension (see Supplemental Material S7 for model fit statistics for the path analysis model predicting sentence comprehension). This model proved statistically inadequate, indicating that no mechanism influenced comprehension in a direct way (see Supplemental Material S6 for criteria defining adequate model statistics). We then tested four *indirect* models to determine whether any of the cognitive mechanisms mediated (served as the conduit for) the other mechanisms to indirectly influence comprehension. Only the model with WM as the conduit (GEM model) proved to be statistically adequate (see Supplemental Material S8 for the actual Structural Equation Modeling-derived WM-conduit model). Not only was the model adequate for all the children together, it was adequate for each group separately (see Supplemental Material S9 for standardized model results for direct and indirect paths of the WM-conduit model of comprehension for each group). The model thus confirmed our hunch that it *is* WM that functions as a conduit through which each of the other mechanisms indirectly influences comprehension in children with DLD and TD children.

Even though the WM-conduit model was applicable to each group, there were some very important and interesting group differences in the magnitude of the indirect influences of fluid reasoning, controlled attention, and language LTM on comprehension (see Supplemental Material S9 for standardized model results for direct and indirect paths of the WM-conduit model of comprehension for each group). For the children with DLD, the indirect influence of fluid reasoning was very small and nonsignificant on canonical and noncanonical sentence comprehension. For the TD children, the influence was significant for each sentence type. The influence of controlled attention was a different situation. Controlled attention had a significant indirect influence on the comprehension of both canonical and noncanonical structures for the children with DLD, but not the TD children. The role of language LTM on each group's comprehension was most interesting. LTM had a significant indirect influence on canonical sentence comprehension in both groups; its strength was about the same for each group. However, its influence on noncanonical sentence comprehension was very different for each group. For the TD group, LTM had a moderate and significant influence, but for the children with DLD, it had no effect. Strikingly, the indirect influence of LTM was 191% greater for the TD children than the children with DLD.

The New Perspective: Putting Things Together

As we expected, WM played a vital role in the comprehension of the children with DLD, which was consistent with the previous literature (e.g., Conti-Ramsden et al., 2015; Montgomery & Evans, 2009). However, compared with other findings, our findings paint a more nuanced picture of WM. The typical interpretation has been that children with DLD have insufficient storage capacity to support sentence comprehension. However, this interpretation assumes a false binary choice between sufficient and insufficient. The dichotomy ignores the role of language knowledge in LTM and the chunking function of LTM in determining the functional sufficiency of storage capacity. Our results suggest that children with DLD, like TD children, have sufficient WM capacity to support comprehension under certain circumstances. This conclusion derives from the fact that (a) all of our sentences included just one or two clauses and (b) the children with DLD had a 2.5-chunk WM span (TD children had a 3.5-chunk span) based on their performance on the Woodcock-Johnson III Tests of Cognitive Abilities Auditory WM subtest (Schrank et al., 2001), plenty to support comprehension. The important takeaway here is that sentence comprehension derives from the structural relationship between language LTM knowledge, which either facilitates or hinders effective chunking of input and the ability to store these units in WM.

Even though the GEM model (see Figure 1) is a good description of the sentence comprehension of both groups, two striking differences between the groups were evident. We focus on the role of language LTM and controlled attention. Whereas syntactic knowledge in LTM indirectly influenced both canonical and noncanonical sentence comprehension in the TD children, its influence in the children with DLD was restricted to canonical structures. That LTM influences the comprehension of canonical sentences of the children with DLD is important because it suggests that these children, like TD children, (a) have multiword templates in LTM corresponding to NVN structures, (b) can use these templates to chunk input into relevant linguistic chunks (phrases, clauses), and (c) can combine chunks into a cohesive canonical structure. These findings and interpretation are in keeping with those of Borovsky et al. (2012), who showed that adolescents with DLD use NVN templates to facilitate real-time sentence processing. However, despite the relatively good comprehension of our children, we would argue that their canonical multiword templates are less robust than those of their TD mates.

Regarding the comprehension of noncanonical sentences, the role of language LTM was quite different for each group. For the DLD group, language knowledge in LTM exerted no significant influence on comprehension. We take these results to mean that children with DLD possess severely weak, if not nonexistent, noncanonical word order templates. The especially poor learning of these patterns is, in part, likely due to their being lower frequency than canonical structures (Wells et al., 2009). Children simply do not hear them as often as canonical structures. It is important to point out, though, that the TD children in our study were also significantly poorer in comprehending the noncanonical structures relative to the canonical structures, suggesting that even they had not yet established strong noncanonical word order templates. We thus interpret the overall DLD comprehension pattern to be consistent with the view that these children have a significant implicit learning deficit that affects syntactic learning generally but disproportionately affects the learning of noncanonical structures (Montgomery et al., 2018, 2017).

The second striking difference was that both canonical and noncanonical sentence comprehension was mentally effortful (i.e., use of controlled attention) for the children with DLD, suggesting that comprehension was not automatic for these children. Because we argue that these children have NVN templates in LTM, it may seem counterintuitive to say that high-frequency canonical structures require mental effort. However, if these children's NVN templates are weak or unstable, it seems reasonable to assume that the children have yet to acquire any automaticity (Lum et al., 2017; Montgomery, 2000; Montgomery & Evans, 2009; Montgomery et al., 2009). For noncanonical structures, the situation was different. Language knowledge in LTM had no influence on the children's comprehension, implying they have very weak or nonexistent word order knowledge of these structures to aid chunking and comprehension. It is no surprise, then, that the children relied on the only mechanism available to them—controlled attention. With weak or no noncanonical multiword templates, the children were forced to process what they heard in a word-by-word manner. Such inefficient processing would necessarily lead to severe difficulty managing the dual temporal and memory constraints of comprehension, leading to a complete swamping of WM storage.

Future Research Directions

The model we have presented here focuses on sentence comprehension guided by word order cues. Of course, listeners take advantage of all available cues, including semantic/real-world cues and context. Researchers may wish to explore children's learning of different multiword patterns as a function of the availability of other cues and cue combinations. If it can be shown that the availability of semantic/real-world cues in noncanonical structures leads to reliably better comprehension in children with DLD, such findings would yield new and important theoretical and clinical implications about the grammar learning abilities of these children and the conditions that promote stable learning/retention of such word order patterns. An important related issue would be to determine whether such learning translates to more automatic chunking of input, and if so, whether greater automaticity leads to a different relationship between memory and comprehension. Whether declarative memory supports the creation of multiword syntactic templates is an important issue to investigate, too, a possibility raised by Hamrick et al. (2018). A more complete model of comprehension would characterize the structural/functional relationship between declarative LTM, procedural LTM, and sentence comprehension.

Another obvious question is whether the relationship we have demonstrated here holds for younger and older children, both children with DLD and TD children. Do early school-age children present the same structural/functional relationships as the children we studied (7- to 11-year-olds) or is the relationship different? Also, does this relationship hold in older children than those studied here? Would adolescents with DLD with more language processing experience be expected to acquire stronger multiword canonical and noncanonical word order templates? If so, we might expect language LTM to play an even stronger role in these children's comprehension than it does during the school-age years, leading to more automatic and accurate linguistic chunking of the input.

Theoretical and Clinical Implications of the New Perspective

Theoretical

This new integrated perspective shows that the relationship between memory and sentence comprehension is more complex and nuanced than previous research has suggested. It suggests that sentence comprehension in children with DLD occurs primarily through the confluence of controlled attention and WM, making comprehension effortful.

Comprehension of noncanonical structures is especially effortful because the children likely have nonexistent multiword templates to activate from LTM to help them chunk what they hear, leaving them to process the input in an inefficient word-by-word way, which, in turn, swamps their WM storage. The comprehension of canonical structures is likewise effortful because of less robust or stable NVN templates represented in LTM. Critically, this new perspective advances our understanding of the relationship between WM and LTM and their influence on these children's sentence comprehension. The model urges us to stop viewing WM capacity in simple binary terms, that children have sufficient or insufficient capacity to support comprehension. Rather, sufficiency of WM storage *should be* viewed relative to the linguistic–memory demands of the listening task, as sentences vary widely with respect to the number of chunks they contain.

Clinical

R. Gillam et al. (2019) noted that the new perspective described here has both assessment and intervention implications for understanding the relationship between memory and language. In that article, we offered some broad-based implications. In the present tutorial, we focus on the relationship of WM, language LTM, and sentence comprehension. Our assessment suggestions center on making reasonable estimates about the memory requirements of sentence comprehension. The intervention suggestions focus squarely on improving the syntactic knowledge of children with DLD to improve their comprehension.

Assessment

Making a determination about children's sentence comprehension abilities is important to any language assessment. At the heart of this determination is a judgment about children's language knowledge (language LTM). At the same time, we must recognize WM's potential influence on comprehension, especially storage. Because WM and LTM are interconnected, reasonable inferences could be made about children's ability to chunk what they hear into linguistic units. Recall that input chunking is driven by language LTM knowledge and that efficient chunking of input into fewer coherent units leads to the conservation of WM space.

Language LTM. We would argue that sentence repetition tasks are the best way to assess children's language knowledge. Our model focuses on syntactic knowledge, but we know that semantic/real-world cues are important in guiding comprehension, and for that reason, performance on standardized assessments of comprehension will automatically reflect the broader range of children's linguistic knowledge. Sentence repetition tasks are a sensitive measure of children's linguistic knowledge. Recent studies with TD children support this view by showing that sentence repetition loads onto a unitary language knowledge/ability factor (Klem et al., 2014; Moll et al., 2015). Sentence repetition has also proved to be a sensitive discriminator of children with and without DLD (Archibald & Joanisse, 2009; Conti-Ramsden et al., 2001), including those who speak nonmainstream dialects of English (Oetting et al., 2016). Collectively, these findings (a) support the idea that sentence repetition is a good representative index of children's language knowledge and (b) reveal why sentence repetition discriminates children with and without DLD so well. Finally, examining children's sentence repetition may yield insights into the number and size of chunks children are able to manage and reproduce, providing insights into the WM–LTM connection of children (Gilchrist et al., 2009).

Sentence repetition tasks appear on several standardized tests, including the Clinical Evaluation of Language Fundamentals–Fifth Edition (Wiig et al., 2013), Woodcock-Johnson IV Tests of Oral Language (Schrank et al., 2014), and the Detroit Tests of Learning Ability–Fifth Edition (Hammill et al., 2018). Children listen to sentences varying in structure and length and repeat each one as faithfully as possible. Scoring is typically graded, with full points awarded for perfect repetition and partial points if there are errors. A total raw score is converted to a scaled score and then interpreted relative to the norms. In addition to the scaled score, the speech-language pathologist (SLP) may wish to perform an informal structural analysis of all the sentences to determine the number of linguistic chunks and size of each chunk contained in each sentence.

Gilchrist et al. (2009) describe a method on how to estimate number and size of chunks within sentences. A chunk is a multiword unit (i.e., dependent clause, independent clause, prepositional phrase), and chunk size is the number of content words (e.g., nouns, main verbs) within each chunk. The Gilchrist et al. study is relevant to us because it was a developmental study in which the number and size of chunks produced during sentence repetition were compared across young children (7-year-olds), older children (12-year-olds), and young adults. All of the sentences were SVO-like (e.g., *Thieves took the painting. Our neighbor sells vegetables but he also makes fruit juice*). The first key finding was that young children recalled two to three chunks, whereas older children (9–10 years old) recalled four chunks, as did the adults. The second finding was that, across age groups, there was no difference in chunk size. These findings indicate that it is the number of to-be-remembered chunks that distinguishes young children and adults, not the amount of information within chunks.

We can illustrate the relevance of chunk number and size with the sentences below taken from the Clinical Evaluation of Language Fundamentals–Fifth Edition Sentence Repetition subtest. Sentence 1 is a one-chunk SVO with eight content words (*librarian, twelve, new, eighth-grade, science, books, reserved, us*). Sentence 2 is a two-chunk SVO (main clause, dependent clause), with Chunk 1 containing five content words (*boy, bought, book, his, friend*) and Chunk 2 containing four content words (*who, likes, short, stories*). Sentence 3 is also an SVO but has three clauses (main clause, two dependent clauses). Sentence 4 is a two-chunk nonreversible passive containing considerable lexical detail (*before, students, dismissed, told, teacher, turn in, assignments*).

1. (*The librarian has twelve new eighth-grade science books reserved for us*)
2. (*The boy bought a book for his friend*) (*who likes short stories*)
3. (*When the students finished studying*) (*they decided to get something to eat*) (*before going home*)
4. (*Before the students were dismissed for lunch*) (*they were told by the teacher to turn in their assignments*)

Using such a coding scheme could offer SLPs important insights into the number and size of chunks children with DLD may be able to handle in the service of sentence repetition. For example, these children likely would have trouble faithfully repeating Sentence 1 even though it is an SVO containing just one chunk. The reason is that the sentence contains considerable lexical detail related to *books,* which would likely tax storage. By contrast, Sentence 2, also an SVO but with two chunks (main clause, attached dependent clause), may not be as difficult as Sentence 1, because the words in each chunk form a more coherent and memorable unit. Sentence 3, containing three chunks, would likely pose marked difficulty for children with DLD because the number of chunks would bump up against or even exceed the bounds of the children's storage capacity. Sentence 4 should be the most difficult for children with DLD, not because it is a passive (as it is a nonreversible passive), but because it contains considerable lexical detail in each clause.

Sentence comprehension. A variety of standardized tests are available to assess school-age children's sentence comprehension. Some of these tests include the Test for Auditory Comprehension of Language–Fourth Edition (Carrow-Woolfolk, 2014), the Comprehensive Assessment of Spoken Language–Second Edition (Carrow-Woolfolk, 2017), the Test of Integrated Language and Literacy (Nelson et al., 2016), and the Test for Reception of Grammar Version 2 (Bishop, 2003). Each of these tests includes a range of syntactic structures. Children listen to individual sentences and point to a picture that matches the sentence, or they provide a short response to questions about each sentence.

The SLP may wish to perform a structural analysis on the test items as described above. It would be important to look for similarities in the child's recall and comprehension and to make reasonable inferences about (a) the child's word order knowledge and (b) the number and size of verbal chunks the child can manage.

Intervention

It may be tempting to direct intervention efforts to improve the WM deficit of children with DLD given that it serves such an important conduit function in comprehension. However, we do not take this position based on our model findings and the WM training literature. Over the past 10 years or so, much research has examined whether improving WM, specifically WM capacity, leads to the enhancement of more real-world cognitive abilities. Results of several systematic and meta-analytic reviews of numerous studies indicate that WM training can lead to immediate gains in performance on other WM tasks but does not lead to improved cognitive skills such as verbal and nonverbal reasoning, reading decoding, or math (see S. Gillam et al., 2018; Melby-Lervåg & Hulme, 2013; Melby-Lervåg et al., 2016, for reviews).

Instead, we argue for intensive language-based intervention designed to enhance these children's language LTM (syntactic knowledge) and sentence comprehension abilities. Two broad intervention approaches exist within the field of speech-language pathology, one implicit and the other explicit. Unfortunately, the field has no evidence-based treatments specific to sentence comprehension. Importantly, though, based on our reading of the implicit learning and explicit language training literatures, we believe we can offer some thoughts on what may be reasonable intervention approaches for children ages 8 years and older.

Implicit intervention approach. An implicit approach would focus on helping children acquire knowledge of word order patterns via their natural tendency to track the distributional regularities in the input, an approach that should promote the development of stable long-term representations of these patterns (Abbot-Smith & Tomasello, 2006; McCauley & Christiansen, 2017) and their activation when needed. The approach should also promote (a) more automatic input chunking, (b) more efficient WM functioning, and (c) greater overall automatic language processing.

Plante and Gómez (2018) offer interventionists a language learning approach that is guided by five principles of implicit learning. We focus on four of them. The *first principle* concerns the regularity of input and the idea that children look for consistent patterns in the input. Accordingly, the to-be-learned targets should appear with (a) high frequency and high density (i.e., high-dose exposures) in short training bursts and (b) consistency across multiple examples of the target. It has been shown that as few as 24 training trials over a 15-min period yield a strong effect in children's morphological learning and use (Plante et al., 2019). *Principle 2* focuses on the variability of the nontarget material relative to the target in the sentence (Gómez & Maye, 2005). The idea here is that learning should occur more easily when the target appears with consistency and saliency relative to the surrounding nontarget material (Grunow et al., 2006; Torkildsen et al., 2013). *Principle 3* relates to providing children as few counterexamples of the target as possible (Gómez & Lakustra, 2004). If the target is the object relative structure (*The baby that the woman fed was hungry*), the clinician should avoid providing SVOs (*The woman fed the baby*), because it is a very different word order. *Principle 4* relates to the idea that input alone can lead to language learning, with learning occurring even when there is no requirement to produce the target (e.g., Bock et al., 2007; Plante et al., 2010).

One implicit approach that may be useful in facilitating children's learning of syntactic forms is structural priming. Structural priming refers to the tendency to repeat the same structure that was just heard (Bock & Loebell, 1990;

Pickering & Ferreira, 2008). Priming occurs presumably because listeners must have some representation of a structure in LTM for the input sentence to prime the same structure using different words. Some investigators view structural priming as a window into learners' implicit language learning (Bock & Griffin, 2000; Ferreira & Bock, 2006), an idea with important intervention implications for children with DLD.

Though there are not yet any structural priming intervention paradigms, a few studies have used structural priming to reveal the knowledge/sensitivity of SVO and subject relative structures in children with DLD (Coco et al., 2012; Foltz et al., 2015; Miller & Deevy, 2006). These studies asked children to (a) listen to prime sentences spoken by the examiner that described a picture (*The prince is throwing the ball*), (b) repeat the prime sentence, and then (c) describe the action in a second (target) picture (e.g., *The horse is eating the hay*). Leonard (2011) has argued that the structural priming technique could be fashioned into treatment activities to foster the grammatical learning of children with DLD. Like Leonard, we, too, believe structural priming has promise as a therapeutic method. We envision therapy to go something like below.

Children would be told by the clinician they will see some pictures in which a person or animal is doing an action to another person or animal. The clinician would then display a picture and describe what is happening in the picture (e.g., *The baby was washed by the woman, The girl was hugged by the boy*). Then the clinician would display a second picture (e.g., tiger chasing lion) and ask the children to describe what is happening in the picture. The expectation is that children would use the same structure spoken by the clinician (e.g., *The lion was chased by the tiger*). Immediately following the children's sentence, the clinician would produce the target sentence (*The lion was chased by the tiger*), regardless of whether the children produced the intended target sentence correctly or not. The intent of this step is to offer children another example of the target structure, without providing specific feedback about their production. This approach, of course, awaits experimental verification.

Explicit intervention approach. In this approach, learners are encouraged to use metacognitive abilities to aid the learning of new language forms (Finestack, 2014, 2018; Finestack & Fey, 2009) and to focus attention on the patterns of interest. The DLD literature includes two similar approaches to enhancing sentence comprehension, the shape coding approach and the MetaTaal approach. Each approach incorporates three training principles: (a) metalinguistic instruction (description/explanation about syntactic structures, feedback focused on structures, and manipulation of structures), (b) organization of training items, and (c) multimodal delivery of items (Balthazar et al., 2020).

The shape-coding method involves first assigning different parts of speech (noun, verb, adjective) a color and shape (Bolderson et al., 2011; Ebbels et al., 2014). The shapes are then grouped together in different ways to designate different kinds of phrases (noun, verb) and their position in the sentence. Children receive explanations about each part of speech, how the different parts are grouped into bigger units, and how the units relate to each other to form a sentence structure and overall meaning. Children complete numerous trials over many training sessions during which they combine the different shapes into the target structure(s). Following training, sentence comprehension is assessed. These approaches, unfortunately, yield little to no clinical improvement in sentence comprehension, particularly of complex structures.

We envision an explicit training method that is cognitively much simpler and more transparent, one that focuses on improving these children's learning of complex syntactic structures (passive, object relative) by focusing their attention squarely on the linkage between semantic role (agent, patient) and noun position in the sentence. The clinician would begin by telling the child they will be learning about passive (or object relative) sentences. Training would begin by providing the children an explanation (likely a reminder at this age) that a complete sentence contains one or more nouns and a verb. The interventionist would show the children a picture (dog chasing mouse) and tell them they could describe the picture using an active sentence (*The dog chased the mouse*). The clinician would explain that, in an active sentence, the first noun always does the action and the second noun always gets the action done to it. Next, the clinician would tell the children that a passive sentence could also be used to describe the same picture, that a passive sentence contains a special word "*by*" just before the second noun (*The mouse was chased by the dog*), and that it is this special word that makes the passive different from an SVO. Children would be told that, in a passive sentence, it is always the second noun, the one right after the special word "*by*," that does the action and the first noun always gets the action done to it. Children would then be administered a high density of training items comprising an action picture (lion scratching tiger), along with a sentence (*The tiger was scratched by the lion*). Following the sentence, the clinician would ask the children two questions. The first question (*Who was Ving*?) focuses on the agent of the sentence. Children would say either lion or tiger. If the child is correct, the interventionist would say, "Yes, the lion was scratching and we know because it came right after the word by." If the child is incorrect, the interventionist would say, "No, the lion was scratching, and we know because it came right after the word by." The second question (*Who was Ved?*) centers on the patient of the sentence. Children would say either tiger or lion. If the child is correct, the interventionist would say, "Yes, the tiger was scratched, and we know because it was the first noun." If the child is incorrect, the clinician would say, "No, the tiger was scratched, because it was the first noun." This implicit approach, too, awaits experimental verification.

Concluding Remarks

The relationship between memory and sentence comprehension in school-age children with and without DLD is complex and nuanced. The structural relationship between WM and language knowledge in LTM is especially important to children's comprehension. WM plays a vital conduit role, enabling children to remember what they have already heard while processing new incoming information. Language knowledge in LTM plays a crucial role in the function of WM, that is, more and better syntactic knowledge in LTM leads to better chunking of input and the conservation of memory space. To improve the sentence comprehension abilities of children with DLD, we advocate for an intensive language-based therapy approach that focuses on enhancing these children's discovery/learning, long-term retention, and activation of difficult sentence patterns.

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