Working With Working Memory

Singer, B., & Bashir, A. (2018). Wait…what??? Guiding intervention principles for students with verbal working memory limitations, *Language, Speech, and Hearing Services in Schools, 49*, 449–462.

Summarized by Carol Westby

Working memory is a core cognitive process essential for executive functions such as planning and problem-solving. Students with specific language impairment (SLI) are known to have working memory deficits. Because complex tasks require simultaneous storage and active processing, they require working memory. But performance on such tasks is influenced by more than working memory capacity; performance is also affected by attention, cognitive load of the processing tasks, the use of strategies for remembering, and familiarity of the language being processed. Singer and Bashir state that "we are still in the process of understanding the nature verbal working memory, its development, and how working memory limitations affect language and learning" (2018, p. 451). There is very little information available on interventions for working memory deficits. The purpose of this article was to present five guiding principles to frame the development of interventions for working memory.

Principle 1: The underlying neurodevelopmental status and the absolute capacity of working memory cannot be directly manipulated to improve contextualized language processing.

A number of commercial products claim to increase working memory capacity by having users practice a variety of working memory games (e.g., CogMed [Pearson Education]; Jungle Memory [Memosyne Ltd.]) as a way to improve working memory through computerized practice activities. The concept behind these programs is that repeated practice with activities will, over time, increase working memory capacity. Numerous reviews of these activities and programs, however, don't show any objectively measured real world outcomes. Some studies have shown greater working memory performance on novel tasks of working memory following the use of computer training programs (Holmes et al., 2010); however, no studies have demonstrated clear transfer to other, more academically relevant reasoning or to real-time language processing abilities (Melby-Lervåg & Hulme, 2013).

Singer and Bashir maintain that SLPs must use more dynamic intervention approaches that involve the integration of listening, speaking, reading, mathematics, writing, problem solving, and social interaction demands that children with SLI face across their school day.

Principle 2: Increasing efficiency and automaticity with language frees up resources in working memory; in turn, this functionally improves working memory capacity.

Children with SLI have difficulty acquiring the patterns of language simply through exposure to adults who use language fluently. Understanding and formulating language requires attention, storage, coordination, and problem-solving processes. Listening and speaking place a load on working memory (Gillam, Montgomery, Gillam, & Evans, 2017). There is no evidence in the literature that the absolute capacity of verbal working memory can be altered. Gillam and colleagues maintain that the challenge children with SLI face with working memory tasks is not one of capacity alone. They argue that memory capacity results from a dynamic interaction between language knowledge, prior language-learning history, and the ability in any given moment to selectively attend to and process incoming information. Working memory is not a fixed capacity; it varies with:

- the knowledge, processing skills, and abilities a person has at any given time;
- the type and familiarity of information the student must remember;
- the processing demands of the task;
- the concomitant demands for inhibition, attention, and emotional regulation; and
- the characteristics of the learning environment.

The goal of intervention is not to increase working memory but to increase knowledge and automaticity of language patterns so as to "free up" resources for active processing. For example, for struggling readers, intervention goals focused on improving phonological and phonemic awareness serve to facilitate decoding

ability, and in turn, automaticity of decoding facilitates fluent reading (National Reading Panel, 2000). As fundamental reading processes are automatized, the mental effort and attentional resources required for word recognition lessen, thereby allowing the reader to devote cognitive resources to comprehension monitoring, which demands working memory.

This same idea can be extended to other levels and features of language as well. Children with SLI have deficits not only with working memory but also with syntax (Gillam & Johnston, 1992; Scott, 2009), which plays a central role in both listening and reading comprehension (Brimo, Apel, & Fountain, 2017). Complex syntax places demands on verbal working memory because it requires that information be held in mind until it can be coordinated with propositions that appear much later in the sentence. When students lack syntactic knowledge, they must devote cognitive resources to comprehending. Interventions that target morphology, syntax, and vocabulary to improve automaticity free up working memory to attend to comprehension. Children with SLI who have stored knowledge about these aspects of language recognize linguistic patterns more readily, thereby alleviating executive working memory demands for language processing.

Principle 3: Storage and effective processing of verbal information in working memory can be supported through the use of visual anchors that serve to make language stand still.

Rehearsal and Visualization

Interventions that employ visual imagery in support of verbal working memory have been shown to be effective. Gill, Klecan-Aker, Roberts, and Fredenburg (2003) compared three different interventions. Experimental groups were taught to use either a rehearsal strategy or a rehearsal/visualization strategy. A control group received the same amount of traditional language therapy that targeted relevant semantic and syntactic structures through direct instruction, modeling, and practice. After 5 weeks of intervention, both groups receiving strategy instruction showed significant improvement relative to the control group in following complex directions. Long term, however, the group using only the rehearsal strategy did not maintain their significant advantage over the control group; only the group taught to use the rehearsal/visualization strategy retained improved performance. This study provides

support for the use of strategic instruction pairing rehearsal with visualization to enhance students' ability to hold increasingly complex verbal directions in working memory long enough to execute them in a classroom setting. Intervention strategies such as these should not be taught for the sake of working on working memory. Rather, intervention should introduce strategies that maximize students' ability to use language to participate successfully in authentic learning experiences that tax working memory.

Advance Organizers

Visual–spatial strategies that present concepts in graphical form have also been shown to reduce demands on working memory and, in turn, support language processing. This may occur because the visual schema represents both the key vocabulary and the organization of the discourse. In this way it provides a visual framework that has the potential to support listening.

Graphic Organizers

Graphic organizers (GOs) differ from advance organizers by visually portraying not only key concepts but also the relationships between those concepts, which may or may not be hierarchical in nature. GOs' visual representations of linguistic information enable students to hold language externally so they can manipulate the information conveyed before it decays from working memory. Singer and Bashir (2000) developed a set of six graphics called Brain Frames.

Each of the six graphics visually represents the underlying pattern (or schema) of a specific propositional discourse (e.g., sequencing, showing causes/effects, comparing/contrasting, showing relationships, categorizing, and telling). However, rather than fill in predrawn boxes or bubbles on premade GOs, students construct their own Brain Frames by hand. The use of GOs with children with SLI has the potential to influence effectiveness of language processing by way of increasing metalinguistic awareness of discourse patterns.

Principle 4: The verbal working memory demands of real-time language processing can be supported by heightening linguistic structure and salience.

External Language Factors That Influence Verbal Working Memory

The manner in which people speak and write can influence working memory and affect comprehension

and learning. Educators and SLPs need to monitor and adjust such things as their:

- rate of speech,
- use of emphatic stress to highlight key words,
- utterance length,
- semantic and syntactic complexity,
- use of sentence parsing with micropauses to highlight
- functional grammatical elements, and
- use of gestures to visually emphasize and anchor meaning.

By adjusting the way in which speech pathologists and teachers talk to students, they may minimize breakdowns in language processing that are rooted in verbal working memory deficits.

Internal Language Factors That Influence Verbal Working Memory

Students must maintain ideas in mind while they formulate sentences and connected discourse (e.g., monologues and narratives). They have to keep track of what they have said and what they intend to say Thus, conversation and spoken monologues tax verbal working memory considerably. Discourse monitoring and updating in working memory is particularly difficult for children with SLI. Interventions that incorporate visual anchors to support students with constructing schemas for discourse (e.g., story grammar icons) have been shown to support students with language formulation beyond the single sentence level (Gillam & Gillam, 2016; Singer & Bashir, 1999).

Principle 5: Professional collaboration should seek to identify factors that influence student performance and, in turn, accommodate students' verbal working memory limitations across different language and learning contexts.

External Factors That Influence Verbal Working Memory

When designing interventions, SLPs must consider the ways in which external factors (e.g., environmental context, task) influence students' processing and classroom performance. Consider:

- *How classroom interruptions may break concentration, causing students to lose track of what they are*

holding in mind and what they are doing. For students with SLI, intrusions may vie for attentional resources and disrupt the ability to hold and maintain information in verbal working memory. Classroom-based intervention may be required to address this interfering factor.
- *Background noise can tax verbal working memory*. Multiple learning groups talking and working simultaneously can contribute to a busy and noisy learning environment. Students with low working memory capacity are particularly sensitive to noise interference when performing more complex language comprehension tasks (Sullivan, Osman, & Schafer, 2015). Teachers and SLPs should work together to minimize the negative effects of noise on students' language processing. Also, they should consider where to provide intervention for those students who are highly sensitive to background noise.
- *Processing burden of a task*. Elements such as task familiarity and the presence or absence of pressure on students for rapid and/or accurate responses can increase the mental load of a task. Mental load and mental effort comprise what is termed *cognitive load*. Tasks that have high cognitive load are inherently complex. Consideration of task complexity and cognitive load is important when designing intervention for verbal working memory in all settings. SLPs should consider the cognitive load imposed by the spoken and written language that students encounter across the various settings of a school day. More time and mental effort is required to understand spoken and written sentences that (a) are composed of a high number of propositions or embeddings, (b) have elements that are not in the expected subject–verb–object order, or (c) have crucial elements that are far apart (King & Just, 1991; Thompson & Shapiro, 2007). SLPs should collaborate with educators to modify curriculum materials for students with SLI who lack the language knowledge needed to access them. The goal is to decrease the linguistic complexity of tasks and, in turn, lighten the load on verbal working memory so that students can manage the language of school.

Internal Factors That Influence Verbal Working Memory

Intervention must consider the ways in which internal factors (e.g., emotions, motivation, engagement) influence students' language processing and

school performance. Anxiety has a negative influence on verbal working memory. Children with SLI develop an increasing awareness of their language limitations through childhood and, especially, by the middle school years. This awareness can lead to social anxiety (Beitchman et al., 2001; Cantwell & Baker, 1991). Students know their language limits, and when verbal working memory, language processing, and language formulation demands of a given academic task or social interaction exceed their abilities, they become anxious. Comprehensive intervention for children with SLI, then, requires a collaboration between the SLP, students' classroom teachers, school psychologists, and, as needed, other mental health professionals.

A Framework for Intervention

The five principles that are discussed in this article form a framework to guide the development of intervention approaches for students with working memory limitations. Whether working with factors that are internal or external to the child, the ultimate goals of intervention for students with verbal working memory limitations are to:

- identify the underlying factors that constrain the students' performance,
- teach students evidence-based tactics and strategies for meeting working memory and task demands,
- implement appropriate classroom accommodations, and
- modify instruction and task demands to diminish factors that are constraining verbal working memory.

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