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Comparing the Effects of Working Memory–Based Interventions for Children With Language Impairment

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Structured Abstract

Clinical Question: Do working memory–based interventions improve language, reading, and/or working memory skills in school-aged children with language impairment?

Method: Literature review of evidence-based practice (EBP) intervention comparisons

Sources: Google Scholar, ASHA journals database, Academic OneFile, Academic Search Complete, and ERIC

Search Terms: working memory intervention, language impairment

Number of Studies Included: 4

Primary Results: All four studies indicated that children with language impairment made improvements after memory-based interventions, although the improvements may not have been to language skills. Two separate studies reported generalization to untrained areas, namely word reading and expressive language. One study indicated that phonological awareness treatment in addition to language intervention may improve recall-based skills in children with language impairment. One study explored memory-based strategies that may be fruitful for children with language impairment.

Conclusions: There appear to be direct benefits from targeting working memory skills for children with language impairment. Incorporating phonological awareness and memory strategies into language-based interventions may improve working memory deficits in children with language impairment.

Comparing the Effects of Working Memory–Based Interventions for Children With Language Impairment

Kelly Farquharson and Chelsea E. Franzluebbers

Clinical Scenario

Katie is a school-based speech-language pathologist (SLP) in an elementary school that serves students in kindergarten through grade 6. She has a large and diverse caseload of children with speech and language impairments, although she predominantly works with children who have language impairment (LI) in the absence of other intellectual disabilities. Katie has noticed that many of these children struggle with reading processes, particularly in the area of decoding and comprehension. One child in particular, Marissa, has not been making progress in therapy, despite Katie's use of various language-based approaches. Marissa is in third grade and has received speech-language services for LI since kindergarten. Marissa's parents report that homework time is painful for everyone involved. Her teacher reports that Marissa has difficulty answering questions when she is called upon and appears frustrated during independent reading time. Specifically, she has a hard time decoding unknown words and also has difficulty answering comprehension-based questions. The classroom teacher has started to question whether Marissa's reading comprehension is limited by problems decoding text, understanding the text while reading, or recalling text information after reading. In this way, Marissa is behind many of her peers who are performing well in reading. In therapy sessions, Marissa performs poorly with sequencing, word recall, phonological awareness, following multi-step directions, and sometimes word finding. Although she believes that Marissa's primary deficit is language-based, Katie wonders if there is a working memory component to Marissa's LI.

Katie examines the research literature and finds that many children with LI have working memory deficits (Cain, Oakhill, & Bryant, 2004), and, conversely, that many children with working memory impairment have deficits in language (Archibald, Joanisse, & Edmunds, 2011). This discovery leads Katie to explore whether there are effective working memory–based interventions for children with LI and if there are specific techniques that she can incorporate into her therapy sessions with Marissa and other children on her caseload with similar memory concerns. She thus searches for research articles that examine working memory–based interventions for children with LI with potential impacts on language, reading, and/or working memory outcomes.

Background

In the absence of intellectual disabilities, such as autism and Down syndrome, children with LI characteristically struggle with the processing and production of spoken language. Some of the specific areas in which many of these children have difficulty are word finding, narrative retell and understanding, receptive and expressive vocabulary, grammatical understanding and expression, phonological processing, and working memory. Regarding the latter, working memory is a limited-capacity space that is used for the temporary storage of phonological or visual information before it is erased or stored in long-term memory. Cumulative evidence suggests that children with LI have difficulty with working memory tasks (e.g., Boudreau & Constanza-Smith, 2011; Edwards, Beckman, & Munson, 2004; Gathercole & Baddeley, 1990). Some specific examples of working memory tasks include following multiple-step directions, repeating nonwords, counting forward or backward by a set incremental amount (e.g., ± 3), transcribing a series of recently heard sentences verbatim, and following the actions of multiple characters over the course of a story (Boudreau & Constanza-Smith, 2011). Working memory has been found to be crucial for vocabulary and reading acquisition (Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1990) as well as phonological awareness (Oakhill & Kyle, 2000; Schuele & Boudreau, 2008). Working memory may be involved with reading comprehension tasks such as making inferences, recalling details within a passage, and understanding new vocabulary. Thus, if a child has a working memory deficit (in addition to LI or in isolation), it is likely that the child may exhibit weakness in reading comprehension abilities.

Given the strong relationship between working memory and language difficulties, it is important to explore whether working memory should be a direct focus during intervention for children with LI. In fact, working memory is specifically listed as an area in which SLPs have the knowledge and skills necessary to provide assessment and intervention [American Speech-Language-Hearing Association (ASHA), 2002]. Specifically, ASHA has suggested that working memory is among the many cognitive processes necessary for reading and writing, and thus targeting it within intervention is well within the scope of practice for SLPs. However, it is important to note that working memory–based interventions have received mixed support in the literature. For instance, some research has indicated that working memory intervention programs are successful in improving reading skills in typically developing children (Loosli, Buschkuehl, Perrig, & Jaeggi, 2012) and in children with attention-deficit/hyperactivity disorder (ADHD; Holmes, Gathercole, Place, Dunning, & Hilton, 2010). However, other interventions have had no positive impacts for children with working memory impairment (Elliott, Gathercole, Alloway, Holmes, & Kirkwood, 2010). Thus, it is difficult to determine whether working memory–based interventions would be helpful for children with LI who also have difficulties with working memory.

Clinical Question

Katie used the PICO (population, intervention, comparison, and outcome) framework to specify her clinical question:

P – school-aged children with language impairment

I – working memory–based interventions

C – alternative or no intervention

O – improvements in language, reading, or working memory

Thus, her clinical question is: Do working memory–based interventions improve language, reading, and/or working memory skills in school-aged children with LI?

Search for Evidence

Katie began her search using the online articles available to her as an ASHA member and also used her local university library. Using Google Scholar, the ASHA website, Academic OneFile, Academic Search Complete, and ERIC, Katie identified a total of 68 articles that met her search terms of working memory intervention and language impairment. Katie used the following inclusion/exclusion criteria to narrow down the list of 68 articles, including only those studies that

a) featured an experimental, quasi-experimental, or single-subject experimental design;

b) involved school-aged children diagnosed with language impairment in the absence of significant intellectual disabilities (children with comorbid memory impairment, dyslexia, or ADHD were not excluded);

c) featured primary analysis of a working memory–based intervention program (i.e., was not a meta-analysis or qualitative review); and

d) included pre- and post-intervention language, reading, and/or memory measures.

Using these criteria, Katie eliminated 33 articles that were not experimental in nature and 31 articles that did not meet the sample criteria. Katie reviewed the four remaining articles, the details of which are summarized in Table 1.

Evaluating the Evidence

Katie reviewed the four articles, which were published between 2009 and 2014, in chronological order. She also analyzed the results of each study by considering threats to validity and overall quality based on an evidence-based framework set forth by Dollaghan (2004) and the levels of evidence outlined in Gillam and Gillam (2006).

Across the four studies, there were a total of 65 school-aged children observed, all of whom had language and/or working memory impairment. The first study, Ebert and Kohnert (2009), provided processing-speed and auditory memory treatment to two children with LI within a staggered-baseline, single-case design. The two children received sixteen 90-minute treatment sessions over the course of four weeks. Sessions included four treatment activities focused on processing speed and auditory memory, each targeted for 20 minutes. Processing-speed activities involved visual scanning (colors, shapes, etc.), rapid decision making, and visual problem solving using software designed for this

purpose. Auditory memory activities involved memory for sequence of auditory stimuli and discrimination of repeated phonemes, again using specialized software. Treatment outcomes were based on measures of choice visual detection and rapid automatic naming (processing-speed tasks), auditory pattern matching and nonword repetition (auditory memory tasks), as well as standardized measures of language. In general, the children showed improved performance on standardized language testing after treatment, particularly for expressive language. One participant exhibited gains in nonword repetition, and both participants showed improvements in rapid automatic naming. The authors attribute these gains to improved access to stored lexical information and perhaps to improved attention.

Katie considered the quality of this study per recommendations for engaging in evidence-based practice (Dollaghan, 2004; Gillam & Gillam, 2006). Katie felt that the organization and clarity of methodology for this Level 4 (single-case) study was straightforward and helpful. She also liked that the researchers designed the intervention using commercially available software, which made the results much more applicable to her clinical practice. However, in analyzing the results from this study, Katie found five main concerns. First, the children in the study were permitted to select the order of treatment activities in each session. While this may provide a randomized order, it could also cause order effects. Second, the small *n* of the single-case design made generalization of any improvements difficult. Third, the second participant missed two sessions. Again, considering the small *n,* this could greatly influence the results. Fourth, the standardized testing was given twice within a 6-week window, which could result in practice effects. Similarly, there was no follow-up testing for any measures, thus long-term effects of these interventions are unknown. Last, it was unclear if these children were receiving any other services for LI.

The second study, Wener and Archibald (2011), used an *n*-of-1 design to examine treatment effects for three groups of children: children with LI ($n = 3$), children with working memory impairment ($n = 2$), and children with comorbid language and working memory impairment ($n = 4$). The nine children participated in two 4-week intervention periods, one focusing on verbal strategies and one focusing on visual strategies. The strategies were taught in a counter-balanced fashion across the two treatments to control for order effects. Treatment sessions consisted of 15 minutes of probe testing and 45 minutes of strategy training. Verbal strategies included modeling the process of connecting ideas with target words, using subvocal rehearsal to recall target words within sentences, and verbal rehearsal to update mental lists within memory. Visual memory strategies included stimulated mental picture creation and drawing physical pictures of objects to prompt later recall. Results revealed group differences such that children with LI (in isolation or comorbidly with memory impairment) improved with verbal strategies more so than with visual strategies. Domain-specific improvements were also seen; there were significant improvements in verbal recall after the verbal strategies were taught but not after the visual strategies were taught. Similarly, there were significant improvements in the geometric puzzle task after the visual strategies were taught but not after the verbal strategies. At 4-month follow-up, the children with LI had improved on standard measures of grammatical skills but had not maintained generalization of trained strategies. The children with working memory impairment displayed generalization of trained strategies.

In analyzing the results of this study, Katie felt that it was a well-done pilot study (also Level 4). However, she felt that there were two primary concerns. First, assignment to the treatment group was only partially randomized due to geographical constraints. While this may be more realistic in clinical practice (i.e., many SLPs have to travel to multiple buildings and may need to determine order of treatment and treatment groups based on proximity rather than need), it certainly calls to question the generalizability of the results. In particular, because there was not true randomization, it is unclear if the children in the treatment group made gains as a result of the intervention or if there were other school-level or environmental-level factors that contributed to their growth. Second, the small *n* of the study provided interesting initial results but may make generalization of these results difficult. Of bigger concern were the unequal group sizes across the disorders.

The third study, Bragard, Schelstraete, Snyers, and James (2012), also employed a single-case design with four French-speaking children with LI and word-finding difficulties. Pre- and post-testing included a receptive (pointing) and expressive (naming) picture identification task. Over a 2-week period, each child received six

treatment sessions focusing on phonological skills (e.g., phoneme segmentation, recall of initial phoneme) for 15 minutes and semantic skills (e.g., associations, definitions) for 15 minutes. The authors chose the phonological-based tasks, as they are most closely tied to memory skills, whereas the semantic-based tasks are tied to improving vocabulary and reading comprehension. Specifically, phoneme segmentation required the child to pair each phoneme in a word with a visual token; the initial phoneme recall required the child to randomly select a picture and try to recall the first phoneme. The semantic association task required participants to explain how two pictures were associated. Cues and models were provided as needed. The word-definition task required participants to describe a selected card to the experimenter, providing enough details such that the experimenter could guess it. Results indicated that all children improved on phoneme segmentation but not phonological recall. Three of the four children improved semantic associations, and all improved in defining words. Improvements with word finding were maintained at a 6-month follow-up for the words that had been trained, but there was no carryover for untrained words.

Katie's appraisal of this third Level 4 study raised two important concerns. First, the children in this study were native French speakers, which raises concerns in translating the results to her English-speaking caseload. Second, the authors focused on children with LI and word-finding difficulties, and the treatment was geared toward improving word-finding difficulties. Although Katie can certainly see the connections between children with word-finding difficulties and what she sees in children on her caseload, she was unsure of the direct relationship between the results of this study and her need for an intervention for Marissa.

The fourth study, by Park, Ritter, Lombardino, Wiseheart, and Sherman (2014), provided phonological awareness intervention to children with LI. The work was influenced by previous studies (Gillam & van Kleeck, 1996; van Kleek, Gillam, & Hoffman, 2006) showing significant improvements in memory skills after training for phonological awareness. Park et al. (2014) examined 50 children with LI and comorbid reading deficits, and assigned them to two conditions. All 50 children received four 1-hour language-intervention sessions each week for four weeks, with 25 children receiving an extra 20 minutes of phonological awareness intervention during each session. The phonological awareness intervention was based on the Baddeley Working Memory model, arguably the most well-known model of working memory functions (Baddeley, 1986). The authors argued that this approach would improve the underlying phonological representations that are necessary for success with phonological awareness as well as working memory tasks. The phonological awareness intervention was systematically designed to move from developmentally easy tasks (e.g., identification of phonemes) to more difficult tasks (e.g., phoneme deletion) upon achieving 80% accuracy for 20 stimuli within a level. The experimental group performed significantly better on all post-test measures of word reading and all verbal working memory measures; the strongest improvements were in the areas of digit and word recall. The authors concluded that training phonological awareness did, in fact, improve phonological representations as well as verbal memory capacity.

Katie was excited by the results of this study, which was the only Level 2 (nonrandomized) study included in her corpus. Phonological awareness treatment was provided within a theoretical framework that directly related to her concerns for Marissa's memory abilities. The larger sample size made generalization of results seem tenable. She did, however, identify one main limitation to this study, in that the intervention sessions were very long. Katie is on a limited time schedule given her large caseload within the public schools. Although she would like to be able to provide such intensive treatment to Marissa and other children like her, Katie knows that this is not feasible.

The Evidence-Based Decision

After reviewing the literature, Katie is cautious to broadly conclude that incorporating working memory–based techniques into her language intervention sessions with Marissa will translate into improved performance in language skills. Primarily, her hesitation reflects the overall dearth of evidence available, as well as the fact that three of the four studies were Level 4. However, Katie also knows that she needs to move forward with Marissa based on the information that she does have, in light of Marissa's ongoing difficulties with language as well as reading. Katie also concludes that in most cases, children with LI in the studies she examined did improve in trained areas. That is, when verbal recall was targeted, verbal recall improved. When visual recall, phonological awareness, or

grammar was targeted, those individual areas improved. Katie finds it encouraging that there were direct benefits from the given treatments, although she also recognizes that there were no consistent generalization effects seen in the studies (i.e., impacts on untreated areas) when examined. Perhaps this lack of generalization occurred because the children's skills were within normal limits to begin with, or perhaps they were unable to improve in untreated areas without direct intervention.

Katie is most intrigued by the results of the study by Park and colleagues (2014), which suggested that phonological awareness training could improve children's word reading skills as well as verbal working memory abilities. That study is the most causally interpretable of those in the corpus, with a large sample and assignment to comparable treatments. Katie thus decides to begin phonological awareness training and use some verbal strategies described in Wener and Archibald (2011; e.g., verbal retell, subvocal rehearsal, modeling) with Marissa, and she plans to closely document Marissa's progress in the areas of word reading, comprehension, phonological awareness, and overall language. In addition, Katie will involve the school psychologist, so as to consider use of cognitive testing for Marissa, specifically in the area of working memory. At this time, Katie only has a confirmed diagnosis of LI and would like to ensure that she is moving in the right direction with Marissa's treatment. Working memory testing will help establish a solid baseline for treatment as well as confirm or refute her suspicion of a memory-based deficit. Finally, Katie plans to discuss her intervention plan with Marissa's classroom teacher and parents in the hopes of developing a team approach toward improving Marissa's memory, language, and reading-comprehension skills in and out of the classroom.

Author Note

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Table 1. Article Reviews

Reference	Design	Population	Intervention Design	Memory Strategies Used	Results
Ebert & Kohnert (2009)	multiple single-case design	Two children with primary language impairment	Sixteen 90-minute sessions over 4 weeks. Four activities for 20 minutes each. Baseline, processing-speed tasks: choice visual detection and rapid automatic naming. Baseline, auditory memory tasks: auditory pattern matching and nonword repetition.	Specialized computer software	Improved performance on expressive language tests following treatment. Slight improvements in nonword repetition and rapid automatic naming.
Wener & Archibald (2011)	multiple single-case design	Nine 7- to 9-year-old children [3 language impairment (LI), 2 working memory impairment (WMI), 4 LI and WMI]	Two 4-week intervention periods with focus on verbal or visual strategies. Three probe tasks: picture recall, sentence formulation, and geometric puzzle completion. Pre- and post-language and WM testing, and 4 months post.	Verbal/linguistic: Connecting ideas with linking words, subvocal rehearsal, modeling, verbal rehearsal. Visuospatial/ memory: mental pictures, drawing pictures to review before retell.	Verbally focused treatment improved performance on picture recall. Visual focus improved geometric puzzle. Children with WMI improved on WM measures. Children with LI improved on grammatical measures.
Bragard, Schelstraete, Snyers, & James (2012)	multiple single-case design	Four Belgian, French-speaking children, ages 9:6–13:9 with specific language impairment (SLI) and word-finding difficulties (WFD)	Received 6 individual sessions over the course of 2 weeks with 15 minutes of phonological intervention (Phase 1: phoneme segmentation and Phase 2: recall of first phoneme in the words) and 15 minutes of semantic intervention (Phase 1: semantic association and Phase 2: definitions).	Providing visual support to help make associations with phonemes in a word; self-cueing; supplying the grapheme to stimulate recall of a phoneme; providing semantic clues.	All participants improved on phoneme segmentation but not in recall of first phoneme. Improvements in associations and defining words. Three of the 4 children exhibited reduction in WFDs. Results were maintained in 6 months follow-up for the treated words. No generalization occurred for untrained words.
Park, Ritter, Lombardino, Wiseheart, & Sherman (2014)	group design	50 school-aged children with SLI and word-reading deficits; 25 experimental, 25 control group	Both groups received four 1-hour language intervention sessions. Experimental group received an extra 20 minutes of PA intervention every day.	Teaching phonological awareness within the contexts of meaningful text; working in a developmental order on easy to difficult tasks; breaking up tasks into identification and then production.	Experimental group outperformed control on all verbal working memory measures. Strongest effects on digit recall and word list recall.