Single Case Design Elements in Text Comprehension
Research for Students with Developmental Disabilities

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Abstract: Recently researchers have begun exploring the efficacy of interventions designed to improve text comprehension skills for students with developmental disabilities (DD). Text comprehension is essential for understanding academic content as students with disabilities make progress in the general education curriculum. This article focuses on single case design (SCD) studies of interventions and supports for improving text comprehension skills for students with DD. Specifically, the article examines elements essential for rigorous single case design research in this area. After reviewing the research, we provide recommendations for improving rigor of research in this area.

Within the past decade, an increased focus on academic achievement for all students has changed the approach to instruction for students with developmental disabilities (DD, including students with intellectual disability and autism spectrum disorders). Historically, curriculum for students with DD has emphasized life skills instruction (e.g., preparing meals) or prerequisite skill instruction (i.e., calling letters). While there is still debate over how to balance academic instruction with instruction on life skills (Ayres, 2012; Browder, 2012; Hunt, McDonnell, & Crockett, 2012), researchers have begun to explore effective methods for teaching academic content to this population. Results show that students can learn academic content in math (Browder et al., 2012), science (Hudson, Browder, & Jimenez, 2014; Knight, Spooner, Browder, Smith, & Wood, 2013), social studies (Schenning, Knight, & Spooner, 2013; Zakas, Browder, Ahlgrim-Delzell, & Heafner, 2013), and language arts (Mims, Lee, Browder, Zakas, & Flynn, 2012) when explicit and systematic procedures are implemented.

An increased emphasis on reading for all students can create greater opportunity to engage in the general curriculum and learn skills that are meaningful for all students. The National Reading Panel (NRP, 2000) identified the following core components for reading instruction: phonemic awareness, phonics instruction, fluency, vocabulary instruction, and text comprehension. While the NRP report evaluated reading practices for readers without disabilities, researchers have suggested that students with developmental disabilities also require intensive instruction in these five areas (Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Algozzine, 2006). However, traditionally reading instruction for students with DD has focused on sight word instruction. Despite research indicating that sight word instruction does not contribute to comprehension in advanced stages of reading, (e.g., when reading words in extended text; Erickson, Hatch, & Clendon, 2010), little emphasis was placed on other elements of reading instruction for students

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with DD, such as phonics instruction and comprehension (Knight, Browder, Agnello, & Lee, 2010).

Reading instruction for students with DD should systematically address all of the components recommended by the NRP. However, slow progress or lack of progress in one area, such as phonics instruction, should not impact whether or not students with DD receive instruction in text comprehension skills (Browder et al., 2009). Some researchers have emphasized that text comprehension is not just a by-product of successful decoding (Erickson et al., 2010; Nation, Clarke, Wright, & Williams, 2006) but is central to why we teach students to read.

Students who make slow progress towards fluently decoding text have other ways to engage text, allowing for instruction to focus on text comprehension. Assistive technologies such as E-text and text-to-speech can support struggling readers and can offer students an opportunity to interact with text without decoding it (Browder et al., 2009). Additionally, read alouds or shared story reading, where a proficient reader reads the text to the student while providing opportunities for the student to participate and respond within the story are low tech and inexpensive solutions for accessing text without the ability to decode (Hudson & Test, 2011). Providing access to written text, whether through E-text or read-alouds, will not be enough to guarantee comprehension. Students with DD still require intensive instruction to learn text comprehension skills (Erickson et al., 2010).

Text comprehension is crucial for students’ progress in the general education curriculum and their independence throughout a text rich society. In typical general education science, social studies, and language arts courses, a great deal of content is communicated through written text and subsequently full participation in those domains requires skilled text comprehension. Additional research is needed to determine the best instructional methods to increase comprehension of academic text. To accomplish this, researchers need to use methodologically sound and well-designed studies to yield precise information regarding effective and efficient methods for developing text comprehension skills.

This review evaluates how researchers have used single case research designs to analyze interventions, measure dependent variables, and control for threats to internal validity with respect to academic text comprehension skills of students in K-12 with DD. This review focuses on single case designs because they include some of the design methodologies used most frequently with lower incidence populations. Relative to reading, the review adopts the definition of text comprehension used by Knight and Sartini (2015), which included a student demonstrating his/her understanding of text-based content (e.g., answering questions, providing definitions, applying text content to novel situations), regardless of whether the student reads independently (i.e., reading comprehension) or accesses text via proficient readers or assistive technology (i.e., listening comprehension). While they may seem like different skills on a surface level, both are rooted in overall language ability. “It may be more correct to say that the potential for comprehending a written text is set by the ability to comprehend that same text when it is spoken,” (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001, p. 43). In this study, authors review the current state of the single case design literature on teaching comprehension across content areas to students with DD and make recommendations based on these findings.

Method

Identification of potential articles began with an electronic search using the following databases: ERIC, Proquest, PsycInfo, and Web of Science for the combinations of the terms: reading, reading comprehension, text comprehension, and literacy combined with other search terms to narrow the specific population, including: disability, intellectual disability, cognitive disability. The online search was conducted for years 1975–2015. To be included in this literature review, articles needed to meet several criteria. First, only articles using single case design methodology were included. The definition of single case design was adopted from the What Works Clearinghouse Single Case Design Technical Documentation (Kratochwill et al., 2010). Articles needed to be peer-reviewed and published in English. Second, the researchers had
to evaluate interventions where at least one dependent variable was text comprehension (i.e., either reading, listening, or supported), although the academic subject matter could vary (i.e., text comprehension of science content would be included). Third, comprehension had to be measured at the phrase level or higher. Studies measuring comprehension at the single word level were omitted. Fourth, participants had to be between 3–22 years of age in order to reflect the population of students who receive special education services under IDEA. Finally, students with developmental disabilities was defined as students who met at least one of the following disability related criteria: documentation of an intellectual disability (IQ below 70 and deficits in adaptive behavior or special education eligibility), or autism spectrum disorder with documented intellectual functioning below 70. Studies of students participating in the state’s alternate assessment were included when disability was not clear. As long as one participant in the study met the above criteria, the article was analyzed. Several journals were hand-searched from 2012–2015: Exceptional Children, Research and Practice for Persons with Severe Disabilities, The Journal of Special Education, Education and Training in Autism and Developmental Disabilities and Focus on Autism and Other Developmental Disabilities. These journals were searched to identify any articles not identified in the online searches and were selected because they contained many of the articles identified during the online search. Finally, an ancestral search was completed on all articles identified through the online and hand searches. A total of 26 single case design studies met the full inclusion criteria (see Table 1).

Study Analysis

Analysis and synthesis of the research is organized around key elements typically found in the method section of a research study. The review focuses on potential issues that may threaten internal validity by summarizing: participants, research design, independent and dependent variables, and data analysis. The review then provides recommendations for future research based on the synthesis. Some of these validity issues may be unavoidable while others, given sufficient resources, may be more amenable to change for future studies. Adopting the most rigorous research methodology will generate instructional strategies that we can be sure are effective when implemented in classrooms. In order to improve focus within this narrative, results are presented for each component area (e.g. participants) and then immediately followed by a discussion and recommendations. While this combination of results and discussion is unconventional, this presentation reduces the need to repeat elements of the results within the discussion.

Results and Recommendations for Future Research

Participants

Results. The term developmental disability encompasses individuals with a wide range of abilities. Typically, researchers described their inclusion criteria relative to students by IQ scores, medical diagnoses, school eligibility category, and/or whether students participated in alternate assessments based on alternate achievement. While these descriptors use terms that are familiar to many researchers, they do little to explain the heterogeneity within this population of students relative to the topic of interest. Some studies included in this review selected participants based on students’ behaviors or learning needs. For example, Browder, Trela, and Jimenez (2007) selected students based on current reading skills by including students who could read less than 20 sight words.

Some studies described their participants’ skills beyond those required for inclusion in the study. One particular study described the student’s English language ability, pre-academic skills, and ability to follow a picture schedule with prompts (Spooner, Rivera, Browder, Baker, & Salas, 2009). Information about students’ challenging behaviors that impacted academic instruction was reported (e.g., Browder, Lee, & Mims, 2011; Mims, Hudson, & Browder, 2012). One study included information about the students’ participation with their general education peers and reading levels (Shurr & Taber-Doughty, 2012).

Student communication skills were frequently reported (e.g. Browder et al., 2007; Mims, Browder, Baker, Lee, & Spooner, 2009; Shurr & Taber-Doughty, 2012). One study in-
### TABLE 1

**Articles included in Review**

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Research Design</th>
<th>Independent Variables</th>
<th>Dependent Variable Related to Comprehension</th>
<th>Text</th>
<th>Participant Response Mode</th>
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<tbody>
<tr>
<td>Bethune &amp; Wood (2013)</td>
<td>n=3, aged 8–10 years Mild ID/ASD</td>
<td>Multiple baseline across participants</td>
<td>Graphic organizer to organize text topics by why-questions</td>
<td>Independent correct answers</td>
<td>Excerpts from published reading curriculum, 2–4 pages long</td>
<td>Vocal</td>
</tr>
<tr>
<td>Browder, Hudson, &amp; Wood (2013)</td>
<td>n=3, aged 11–13 years Moderate ID</td>
<td>Multiple probe across students</td>
<td>Graphic organizer to teach definitions of why-questions, system of least prompts &amp; constant time delay</td>
<td>Correctly matching why-questions to definitions, and independent correct answering comprehension questions</td>
<td>Books adapted from grade level text (reduced reading level to 1st–2nd grade, divided into small chapters, comprehension questions embedded into sections)</td>
<td>Vocal or touching correct answer in text</td>
</tr>
<tr>
<td>Browder, Lee, &amp; Mims (2011)</td>
<td>n=3, aged 6–9 years Severe ID and physical or sensory impairment</td>
<td>Multiple probe across response modalities</td>
<td>Scripted task analytic lessons with systematic prompting</td>
<td>Independent, correct answers</td>
<td>Books adapted from age appropriate text (laminated, real objects inserted, embedded repeated story line)</td>
<td>Eye gaze, select object, or touch correct object</td>
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<tr>
<td>Browder, Mims, Spooner, Ahlgrim-Delzell, &amp; Lee (2008)</td>
<td>n=3, aged 7–10 years, profound ID with physical disabilities and intense medical needs</td>
<td>Multiple probe across participants</td>
<td>Task analyzed lessons built based on Universal Design for Learning, system of least prompts</td>
<td>Independent correct student responses to comprehension questions from choice of 2 objects or answers</td>
<td>Books adapted from age appropriate text (character’s name changed to child’s name, insertion of repeated story line, real objects used as comprehension aids)</td>
<td>Eye gaze, reach towards object, touch object</td>
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<tr>
<td>Browder, D., Trela, K., &amp; Jimenez, B. (2007)</td>
<td>n=6 students, aged 12–14 years Moderate ID</td>
<td>Multiple probe across teachers</td>
<td>Read alouds, adapted books, task analysis for teachers to teach reading skills to emergent readers</td>
<td>Correct student responses on certain steps of task analysis, one step was correct student response to a comprehension question</td>
<td>Adapted text (e.g., text was simplified to 2nd-3rd grade reading level, picture symbols inserted for important vocabulary, embedded definitions of new words, repeated story lines, summaries at end of chapters)</td>
<td>Vocal or by touching symbol</td>
</tr>
<tr>
<td>Evmenova, Behrmann, Mastropieri, Baker, &amp; Graff (2011)</td>
<td>n=5, aged 19–24 years One 19 year old participant with moderate ID</td>
<td>Multiple baseline across participants with alternating treatments</td>
<td>Adapted video instruction (captions, highlighted text)</td>
<td>Independent correct responses to 3 factual questions</td>
<td>Video clips from Discovery Channel United Streaming</td>
<td>Vocal</td>
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<tr>
<td>Study</td>
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<td>Dependent Variable Related to Comprehension</td>
<td>Text</td>
<td>Participant Response Mode</td>
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<td>Evmenova &amp; Behrmann (2014)</td>
<td>n=6, aged all MOID or MID enrolled in a secondary program. Only 4 were under 22. GE reading level for those 4 are grades K-8</td>
<td>Multiple baseline across students</td>
<td>Video clips with alternate narration at reduced reading level, alternate narration with verbatim captions, with symbols, or with text highlighted in yellow as it was read. Video searching option presented at end of video</td>
<td>Correct answers to inferential and factual comprehension questions</td>
<td>In adapted narration condition, the text difficulty was reduced and all passive voice sentences were removed</td>
<td>Vocal</td>
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<tr>
<td>Flores &amp; Ganz (2009)</td>
<td>n=4, aged 10–14 years. Three participants with mild and moderate ID/ASD</td>
<td>Multiple probe across behaviors</td>
<td>Use of scripted published reading program utilizing Direct Instruction (DI)</td>
<td>Correct responses on 3 DI comprehension tasks</td>
<td>Text from DI reading program</td>
<td>Vocal</td>
</tr>
<tr>
<td>Flores &amp; Ganz (2007)</td>
<td>n=4 aged 10–14 years. One participant with Moderate ID</td>
<td>Multiple probe across behaviors</td>
<td>Use of scripted published reading program utilizing Direct Instruction (DI)</td>
<td>Correct responses on 3 DI comprehension tasks</td>
<td>Text from DI reading program</td>
<td>Vocal</td>
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<tr>
<td>Fritschmann, Deshler, &amp; Schumaker (2007)</td>
<td>n=8, aged 15 years old. Three participants with mild or moderate ID</td>
<td>Multiple probe across students</td>
<td>Instruction in multi-step inference strategy</td>
<td>Independent correct answers of factual and inferential comprehension questions, participants correct usage of strategy</td>
<td>Text passages from published reading curriculum, grades 4-9</td>
<td>Unknown</td>
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<td>Hua, Hendrickson, Therrien, Woods-Groves, Ries, &amp; Shaw (2012) Focus</td>
<td>n=3, aged 21 years Mild ID/ASD</td>
<td>Multiple baseline across participants</td>
<td>Repeated readings with error correction, comprehension prompting before reading passage, systematic prompting to answer comprehension questions after reading passage</td>
<td>Correct answers on inferential and factual comprehension questions</td>
<td>Text passages adapted from 3rd and 6th grade materials (shortened to be completed within 90 seconds)</td>
<td>Vocal</td>
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<tr>
<td>Hua, Therrien, Hendrickson, Woods-Groves, Ries, &amp; Shaw (2012)</td>
<td>n=3, aged 19–21 years, 2 with Mild ID</td>
<td>Multiple baseline across participants</td>
<td>Repeated readings with error correction, question generation prompts (cue cards) before reading passage, systematic prompts</td>
<td>Independent correct answers on factual and inferential comprehension questions</td>
<td>Text passages adapted from 1st, 2nd, and 6th grade materials (e.g., shortened to be completed within 90 seconds)</td>
<td>Vocal</td>
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<td>Hudson &amp; Browder (2014)</td>
<td>n=3, aged 9–11 years Moderate ID</td>
<td>Multiple probe across students</td>
<td>Peer tutoring, peer read-alouds with scripted directions for providing system of least prompts, pre-teaching wh-concepts, response boards</td>
<td>Independent correct answers and prompted correct answers</td>
<td>Books adapted from grade level text (reduced reading level, definitions inserted, enlarged text, laminated page protectors. Response boards - each contained the wh-rule, a place to indicate need for help, and possible answers on the board (see p. 8)</td>
<td>Point to correct answer on response board with up to 9 possible choices</td>
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<td>Study</td>
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<td>Hudson, Browder, &amp; Jimenez (2014)</td>
<td>n=3 upper elementary Moderate and severe ID</td>
<td>Multiple baseline across participants</td>
<td>Peer tutoring, adapted science lessons (e.g., read aloud with scripted directions for how to administer system of least prompts)</td>
<td>Independent correct answers and prompted correct answers on 6 comp questions (2 inferential and 4 literal)</td>
<td>Adapted grade level science (e.g., lesson summaries developed at 400-600 Lexile to capture main ideas, vocabulary definitions inserted)</td>
<td>Point to correct answer on response board from 6 possible choices</td>
</tr>
<tr>
<td>Knight, Spooner, Browder, Smith, &amp; Wood (2013)</td>
<td>n=3, aged 13–14 years Moderate ID and ASD</td>
<td>Multiple probe across students</td>
<td>Constant time delay, multiple exemplars of a graphic organizer, teach examples and non-examples, teaching loosely</td>
<td>Independent correct completion of steps of a task analysis demonstrating student knowledge on a science topic (e.g., convection)</td>
<td>Science concepts and vocabulary related</td>
<td>Points to, touches, or vocalizes correct answer. Also placing answers in correct location on graphic organizer</td>
</tr>
<tr>
<td>Knight, Wood, Spooner, Browder, &amp; O’Brien (2015)</td>
<td>n=4, aged 11–14 years Mild and moderate ID/ASD</td>
<td>Multiple probe across participants</td>
<td>Supported e-text (Book Builder) with explicit instruction (Model-Lead-Test)</td>
<td>Independent correct answers from a field of 4 possible answers on digital quiz with vocabulary, factual, and application questions</td>
<td>Grade level science lessons adapted for use with Book Builder (vocabulary definitions, examples and illustrations, simplified text, etc.)</td>
<td>Select by clicking correct answer</td>
</tr>
<tr>
<td>Mims, Browder, Baker, Lee, &amp; Spooner (2009)</td>
<td>n=2, aged 6–9 years Severe ID and visual impairments</td>
<td>Multiple probe across books</td>
<td>System of least prompts, comprehension questions asked within the text, adapted text</td>
<td>Independent correct answers to factual comprehension questions</td>
<td>Adapted age-appropriate books (e.g., real objects inserted in book, repeated storylines added)</td>
<td>Select by touching real object from field of 2</td>
</tr>
<tr>
<td>Mims, Hudson, Browder (2012)</td>
<td>n=4, aged 12–14 years Severe ID and autism</td>
<td>Multiple probe across participant</td>
<td>Read alouds, systems of least prompts to use graphic organizer to answering questions and sequence story events</td>
<td>Independent, correct answers to multiple choice questions</td>
<td>Books adapted from grade level mathematics (text summarization, controlled vocabulary, words paired with symbols, books printed &amp; laminated inside binders)</td>
<td>Select picture answer from field of 4</td>
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<tr>
<td>Mucchetti (2013)</td>
<td>n=4, aged 6–8 years Moderate ID and ASD</td>
<td>Multiple baseline across participants with modified alternating treatment design probe</td>
<td>Shared reading, teacher task analysis to engage students in lesson (e.g., system of least prompts)</td>
<td>Correct responses to literal comprehension questions (e.g., who, what, where)</td>
<td>Adapted books (e.g., tactile objects inserted, picture symbols, simplified text)</td>
<td>Vocal, pointing or touching correct response from field of 4</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Research Design</td>
<td>Independent Variables</td>
<td>Dependent Variable Related to Comprehension</td>
<td>Textual Interventions</td>
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<tr>
<td>Roberts &amp; Leko (2013)</td>
<td>n=3, 6th grade students (ages not specified). Only one participant (mild ID and ASD) had comprehension as a dependent variable.</td>
<td>Multiple baseline across participants</td>
<td>Individualized lesson plans and adapted books, targeted to address student's IEP goals and academic content, teacher task analysis to teach content.</td>
<td>For the one participant, correct responses to yes/no comprehension and vocabulary questions.</td>
<td>Adapted books (e.g., split books into sections and inserted 2–3 comprehension questions in each section, inserted symbols, reduced text complexity).</td>
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<tr>
<td>Schenning, Knights, &amp; Spooner (2013)</td>
<td>n=3, aged 11–13 years, Moderate ID</td>
<td>Multiple probe across participants</td>
<td>Structured inquiry process, teacher task analysis and script for presenting lessons, adapted text, and graphic organizer.</td>
<td>Independent correct student responses to placement and placement of answer on graphic organizer.</td>
<td>Adapted social studies text (e.g., picture cues, reduced text complexity to 2nd–3rd grade reading level).</td>
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<tr>
<td>Shurr &amp; Taber-Doughty (2012)</td>
<td>n=4, aged 12–15 years, Moderate ID</td>
<td>Multiple probe across participants</td>
<td>5 picture cues (representing a text feature such as character) presented with discussion about the pictures before, during, and after the read aloud.</td>
<td>Correct answers to factual multiple choice questions.</td>
<td>Text from age-appropriate published reading series.</td>
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<tr>
<td>Spooner, Ahlgrim-Delzell, Kemp-Inman, &amp; Wood (2014)</td>
<td>n=4, aged 8–12 years, Mild and moderate ID</td>
<td>Multiple probe across students</td>
<td>Shared stories delivered via iPad, systematic instruction (constant time delay and modified system of least prompts).</td>
<td>Independent correct answers to factual and inferential comprehension questions from a field of 4 answers.</td>
<td>Adapted grade level passages (e.g., reduced text complexity, picture symbols, all passages rewritten to follow same story structure).</td>
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</tr>
<tr>
<td>Spooner, Rivera, Browder, Baker, &amp; Salas (2009)</td>
<td>n=1, aged 6 years, Moderate ID and ASD</td>
<td>Multiple probe across skill set</td>
<td>Culturally relevant adapted books, forward chaining of literacy tasks</td>
<td>Independent correct responses across three literacy-related skill sets (one was comprehension).</td>
<td>Adapted children’s books (e.g., repeated story line, highlighted vocabulary words, pages separated for easy turning).</td>
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<tr>
<td>Zakas, Browder, Ahlgrim-Delzell, &amp; Heafner (2013)</td>
<td>n=3, aged 11–13 years, Two participants with mild ID and ASD</td>
<td>Multiple probe across students</td>
<td>Modified graphic organizer with scripted prompts, pre-teaching social studies vocabulary.</td>
<td>Independent correct answers across three literacy-related skill sets (one was comprehension).</td>
<td>Adapted graphic organizer questions with multiple choice options.</td>
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</table>
cluded information about the student’s listening comprehension skills, such as the ability to follow verbal directions (Mims, Hudson, et al., 2012). If students did not communicate using words, information about other communication modalities (such as facial expressions, reaching, and eye movement) were reported in several studies (e.g., Browder et al., 2011; Browder, Mims, Spooner, Ahlgrim-Delzell, & Lee, 2008; Mims et al., 2009).

Some researchers assessed students’ skills after teacher nomination, but before the beginning of the study. For example, Shurr and Taber-Doughty (2012) assessed whether participants could answer basic multiple-choice questions, the same response topography measured in the study. Other researchers assessed students’ skills using standardized measures like the Peabody Picture Vocabulary Test (Mucchetti, 2013), curriculum-based measures like the Dynamic Indicators of Basic Early Literacy Skills (DIBELS, e.g., Allor, Gifford, Al Otaiba, Miller, & Cheatham, 2013; Hua, Hendrickson, et al., 2012).

Recommendations. Since students with DD have a wide range of abilities and needs, researchers should provide as detailed behavioral descriptions about participants as page limits allow. With respect to text comprehension specifically, researchers should describe the participant’s communication abilities (e.g., orally, using AAC, sign language), academic strengths (e.g., decoding and comprehension abilities), and academic deficits. This comprehensive description assists in assessing the potential generality of the findings to specific learners. In addition, detailed participant descriptions may aid in future replications.

Researchers should consider assessing students’ skills to establish baseline equivalence between participants as well as to determine if participants demonstrate sufficient prerequisite skills (e.g., attending to materials, responding to attentional cues) to meaningfully participate and benefit from the intervention. Screening students’ skills may help researchers determine if prerequisite skills need to be taught before the start of the intervention study. Establishing baseline equivalence will enable researchers to make comparisons between each participant’s response to intervention.

Research Designs

Results. Almost all SCD studies included in this review used multiple baseline or multiple probe designs (e.g., Bethune & Wood, 2013; Evmenova & Behrmann, 2014; Flores & Ganz, 2007; Fritschmann, Deshler, & Schumaker, 2007; Hua, Hendrickson, et al., 2012; Hudson et al., 2014; Mims et al., 2009; Spooner et al., 2009), likely because these designs are ideal for academic skills that cannot be reversed (Gast, Lloyd, & Ledford, 2014). Most multiple baseline studies in this review measured changes across participants (e.g., Bethune & Wood, 2013; Hua, Hendrickson et al., 2012; Hua, Therrien, et al., 2012; Hudson et al., 2014; Roberts & Leko, 2013). One study used a multiple baseline across participants design in combination with an alternating treatments design (Evmenova, Behrmann, Mastropieri, Baker, & Graff, 2011). In this study, the authors evaluated a functional relation between the intervention package and improved text comprehension with a multiple baseline, and used an alternating treatment design during the intervention phase to evaluate components of the intervention package.

Multiple probe designs have been used across students to improve skills (e.g., reading, comprehension, pre-literacy; Bethune & Wood, 2013; Browder, Mims, et al., 2008; Shurr & Taber-Doughty, 2012), conditions (e.g., books, student response modes; Browder et al., 2011; Flores & Ganz, 2009; Mims et al., 2009), and across student response modalities (e.g., signing, pointing, Browder et al., 2011).

Recommendations. Multiple probe and multiple baseline across participant designs are the most widely utilized SCD in this line of research. These variations are fundamentally different from SCDs that measure the dependent variable across conditions or across behaviors, and have some limitations researchers should consider and address in their studies. First, because the independent variable is introduced across various individuals but not systematically replicated with any one individual, multiple baseline designs across participants rest “solely on inter-subject replication” (Wolery, Gast, & Ledford, 2014, p. 313). Future research should consider combining across participants designs with other single
subject research designs to improve rigor (e.g., Evmenova et al., 2011).

Researchers may wish to consider utilizing multiple probe over multiple baseline designs. Multiple probe designs offer a distinct advantage because baseline behaviors are measured intermittently rather than continuously, requiring fewer exposures to pre-intervention conditions. This is ethically prudent because researchers have already made an a priori assumption that the intervention is better than what is occurring in baseline conditions. Not only is less exposure to the less effective condition preferable, but students are unlikely to increase text comprehension skills from repeated testing alone (Gast, Lloyd, & Ledford, 2014). As research continues to identify successful text comprehension interventions, researchers may wish to consider employing comparative designs (e.g., adapted alternating treatment) to study intervention components and/or refine intervention packages (Wolery et al., 2014).

**Independent Variables**

**Results.** In some studies, the independent variable consisted of one intervention rather than a package of multiple interventions (e.g., a published reading program). The majority of studies, however, utilized treatment packages with multiple intervention components.

*Published reading programs.* Two studies used a Direct Instruction reading intervention series (Corrective Reading Thinking Basics) to improve text comprehension (Flores & Ganz, 2007, 2009). In both studies, researchers implemented the Direct Instruction program exactly as recommended by the publisher.

*Comprehension-enhancing supports.* In many studies, comprehension-enhancing supports, such as paper-based materials and technology applications were created or adapted for use in the treatment package. A few studies created graphic organizers to enhance text comprehension (e.g., Bethune & Wood, 2013; Browder, Hudson, & Wood, 2013; Knight et al., 2013; Schenning et al., 2013; Zakas et al., 2013). Some studies utilized technology applications to aid text comprehension, including supported eText (Knight, Wood, Spooner, Browder, & O’Brien, 2015) and adapted video instruction (Evmenova et al., 2011).

*Adapted text.* While some studies used original text as intervention materials, many researchers created adapted books or reading passages to increase student understanding. Typical adaptations included inserting repeated story lines (e.g., Browder et al., 2011; Browder, Mims, et al., 2008; Browder et al., 2007) and symbols to augment text (e.g., Mims, Hudson, et al., 2012; Roberts & Leko, 2013). Word count was often reduced in order to effectively communicate the most essential components of the passage (e.g., Evmenova et al., 2011; Mims et al., 2009). Grammatical changes were made, such as removing passive voice statements in favor of declarative statements (Evmenova et al., 2011). In one study, all of the social studies passages were adapted so that content was presented in the same order (i.e., first the event, then place, then people; Zakas et al., 2013).

Some studies inserted real objects referenced in the story (e.g., shoelaces, pens, candy) within the book for students with sensory or visual impairments or to provide context for students who benefit from using real objects over pictures (e.g., Browder et al., 2011; Mims et al., 2009; Mucchetti, 2013). Portions of the book were often enlarged for emphasis or to increase access for students with visual impairments (e.g., Spooner et al., 2009). In a study conducted with students who had profound multiple disabilities, researchers addressed individual student needs through added accommodations, such as low light adaptations, illuminated reading materials on a light box, and a flashlight to call attention to the features of the book (Browder, Mims, et al., 2008).

*Instructional procedures.* Instructional procedures were often included as components of larger treatment packages. Both studies by Hua and colleagues (2012) utilized repeated reading, where the text is presented multiple times to increase comprehension. Additionally, many studies evaluated the use of teacher task analyses to improve fidelity of instruction in respect to text comprehension (e.g., Browder, Flowers, & Wakeman, 2008; Browder et al., 2011; Browder et al., 2007). Read-alouds or shared story reading was frequently included in treatment packages.
aimed at increasing comprehension (e.g., Browder, Flowers, et al., 2008; Browder et al., 2007; Mims, Hudson, et al., 2012; Mucchetti, 2013; Shurr & Taber-Doughty, 2012; Spooner et al., 2009).

Recommendations. One challenge in analyzing the current research on text comprehension revolves around the inability to parse effects of different components in a treatment package. For example, many studies reported in this review included adapted text as part of a larger treatment package. More research needs to be done to determine if adapted text is effective on its own, because adapting text with pictures, symbols, and real objects can be costly and time consuming for classroom teachers. Conversely, graphic organizers are generally inexpensive and easy to create. There is some evidence that graphic organizers may be effective comprehension support tools, but research generally evaluates their effectiveness within larger intervention packages. Adapted text and graphic organizers may not be effective without systematic instruction in text comprehension or how to use those aids to comprehend text. Some researchers have begun to examine the effectiveness of adapted text/graphic organizers when paired with systematic instruction (e.g., Knight et al., 2013; Mims, Hudson, et al., 2012). More research needs to be done to explore this relationship across content areas and grade levels.

Researchers should continue to evaluate the effectiveness of commercially-available reading programs. First, many of these programs provide a more comprehensive approach to reading instruction, including skills beyond text comprehension. It may be more logical to target comprehension alongside of other reading skills rather than in isolation. Targeting multiple reading skills through comprehensive instruction may help students draw connections between the individual reading skills and how to apply those skills when encountering text (Allor, Mathes, Champlin, & Cheatham, 2009). There is some early evidence that reading programs validated for use with students with high incidence disabilities may also work for developing readers with DD (Allor et al., 2009). If a school’s existing reading curriculum can be used effectively with students with DD (with adaptations and differentiated instructional strategies), then this may reduce school expenditures and time spent by teachers to create new or adapted reading materials for students with DD. Exposing students with DD to the same instructional materials used by general education peers may be in alignment with the law but doing so without evidentiary support is not.

More research needs to examine generalization of reading strategies across academic content areas. Different kinds of text (e.g., expository and narrative) may require different text comprehension strategies. Different text comprehension strategies may need to be taught differently to students with DD.

Selection and Presentation of Text Materials Across Phases

Results. The amount of instructional materials varied significantly across studies. Most studies included fewer than five different reading samples that were presented multiple times within the baseline and intervention phases (e.g., Browder et al., 2011; Browder, Mims, et al., 2008; Mims et al., 2009; Mucchetti, 2013). Two studies by the same research group used 27 reading passages to minimize student exposure to the same texts. Authors stated that the purpose of the large number of reading passages was so that participants did not encounter the same passage twice within the study (Hua, Hendrickson et al., 2012; Hua, Therrien, et al., 2012). One study used different reading passages for each data point in a tier, as well as one passage used in baseline and intervention (Knight et al., 2015).

The manner in which researchers selected reading passages varied. Mucchetti (2013) selected books with concrete (rather than abstract) storylines about concepts familiar to young urban students. Mims, Hudson et al. (2012) selected five biographies because participants’ general education peers would likely read those same biographies. In several studies, content experts advised the research team regarding the appropriateness of the materials (e.g., Browder et al., 2011, Mims et al., 2012; Zakas et al., 2013), and whether the adapted materials reflected the essence of the original materials (Mims, Hudson, et al.,
2012). In another study, a social studies content expert reviewed the adapted text for content validity (Zakas et al., 2013).

Many researchers selected reading materials based on level of difficulty. Some researchers modified text to achieve a particular level of difficulty. Bethune and Wood (2013) selected all reading passages from the same reading level in a particular reading curriculum. Mucchetti (2013) only used passages with a Scholastic grade level of 1.6–1.9. Hua, Hendrickson and colleagues (2012) computed Flesch-Kinkaid reading levels for research materials to ensure that materials matched known student reading levels. Additionally, they shortened reading passages to match participants’ assessed reading fluency rates. All passages were designed so that participants could read the passage within 90 seconds. Additionally, each passage used in the study introduced the same number of science concepts, regardless of topic. Another study assessed adapted reading passages to obtain a Lexile number (Hudson et al., 2014).

The manner in which materials are presented to the student(s) is important for controlling for practice effects. Bethune and Wood (2013) presented each reading passage only once during the study. In other studies, researchers randomly assigned passages to intervention sessions. (Hua, Hendrickson et al., 2012; Hua, Therrien et al., 2012; Mims, et al., 2012). Mucchetti (2013) utilized only three books, two adapted with picture symbols and one unadapted. Comprehension responses for the un-adapted book were continuously assessed in relation to responses for the two adapted books.

Mims and colleagues (2012) used five adapted biographies. In baseline, each biography was presented once in alternating fashion. Prior to intervention, each biography was probed once, then assessed 3–4 times in the intervention phase. Authors suggest that repeated exposure may have benefitted the student’s comprehension but highlighted this concern as a potential confound. Hudson et al. (2014) presented seven adapted science lessons in random order across participants to control for order effects.

Recommendations. When intervention materials are limited in number, repeated exposure to the same content can lead to practice effects and threaten internal validity. If repeated exposure is an intervention of interest, or if repeated exposure can’t be avoided, researchers may wish to measure repeated readings or materials in baseline to ensure that repeated exposure alone is not responsible for the change in the target behavior. If used, stability or contratherapeutic trends replicated across multiple students would indicate repeated readings alone had no effect on the target behavior.

On the other hand, if repeated readings are not a variable of interest or could be a potential confound, researchers may wish to create different passages for each data point so that students are never exposed to the same text/narrative twice. The researcher should ensure that reading passages were functionally equivalent in complexity, content, word count, and number of sentences, and/or paragraphs. Research has found minimal agreement among the various methods for determining passage difficulty (Ardoin, Suldo, Witt, Aldrich, & McDonald, 2005), so researchers should take care to employ the method with the strongest empirical support. If passages are not similarly difficult, comprehension will be confounded. Presenting the reading materials in different order across participants will also help to control for order effects (Mims, Hudson et al., 2012). Addressing these concerns during the planning stages of the project will help to establish the future case for a strong causal inference between the independent variable and the text comprehension skill upon visual inspection.

Dependent Variables

Results. Almost all studies included in this review measured students’ correct, independent responses to comprehension questions (e.g., Browder et al., 2013; Browder, Mims, et al., 2008; Browder et al., 2007; Evmenova et al., 2011; Evmenova & Behrmann, 2014; Fritschmann et al., 2007; Hua, Hendrickson et al., 2012; Hua, Therrien et al., 2012; Hudson & Browder, 2014; Hudson et al., 2014; Knight et al., 2013; Mims et al., 2009; Mims, Hudson, et al., 2012; Mucchetti, 2013; Shurr & Taberdoughty, 2012; Spooner, Ahlgrim-Delzell, Kemp-Inman, & Wood, 2014; Spooner et al., 2009). Evmenova and Berhmann (2014) also
measured students’ correct responses following review of the material after an initially incorrect response. Students were presented comprehension questions after viewing a video with captioning. If the student answered incorrectly, the student was permitted to use a video search feature to find the answer to questions within the video text (Evmenova & Behrmann, 2014).

Several studies used only literal recall comprehension questions, where the answer to the question is explicitly stated in the text (e.g., Bethune & Wood, 2013; Evmenova et al., 2011; Mims, Hudson, et al., 2012; Shurr & Taber-Doughty, 2012). Shurr and Taber-Doughty (2012) asked five literal recall questions, all using a wh-question format. Many more studies assessed students’ answers to both literal and inferential questions, where the reader has to draw meaning from different parts of text in order to answer the question (e.g., Fritschmann et al., 2007; Hua, Hendrickson et al., 2012; Hudson & Browder, 2014; Hudson et al., 2014; Spooner et al., 2014).

Development of questions varied across studies. Some studies utilized specific recommendations for developing comprehension questions. Shurr and Taber-Doughty (2012) followed Piontek’s (2008) criteria for developing valid and reliable multiple choice questions. In the same study, Flesch-Kinkaid reading levels were determined for the questions to be sure they were not more or less difficult than the actual text. In two studies, researchers wrote factual and inferential questions according to a definition authored by Davey and McBride (1986). According to this definition, the answers to factual questions can be found in the text without requiring the student to incorporate information from multiple sentences. The answer to inferential questions cannot be found directly in the text or require the student to incorporate information from multiple sentences (Hua, Hendrickson et al., 2012; Hua, Therrien et al., 2012).

In the majority of studies, comprehension questions were presented orally rather than in written form (e.g., Browder et al., 2011; Browder, Mims, et al., 2008; Evmenova et al., 2011; Hua, Hendrickson et al., 2012; Hua, Therrien et al., 2012). Timing of question presentation varied among studies. In one study, comprehension questions were presented at the end of the book (Browder, Mims, et al., 2008). Other studies presented the comprehension questions at the end of a short reading passages or short chapters (Bethune & Wood, 2013; Browder et al., 2013; Fritschmann et al., 2007; Hua, Hendrickson et al., 2012; Hua, Therrien et al., 2012; Roberts & Leko, 2013; Shurr & Taber-Doughty, 2012). Roberts and Leko (2013) subdivided one long book into smaller chapters, with 2–3 comprehension questions appearing at the end of the chapter. In many studies, comprehension questions were asked throughout the lesson, book, or reading passage (e.g., Browder et al., 2011; Hudson & Browder, 2014; Hudson et al., 2014; Mims et al., 2009; Spooner et al., 2009). One study allowed the teacher to select when to ask the comprehension questions, either during the story or at the end of the story (Browder et al., 2007).

In one study, researchers embedded comprehension questions on the page in the adapted text where students could locate the answers. Four possible answers were presented with words and symbols. All of the possible answers were plausible distractors, meaning that if the question was a “who” question, all of the possible answers would be people. Additionally, all four symbols depicted in the possible answers appeared on the corresponding page in the adapted text. This prevented students from choosing an answer because it was the only symbol from the possible answers that appeared on that page in the text (Mims, Hudson, et al., 2012).

Many studies required an oral response to comprehension questions (e.g., Evmenova et al., 2011; Flores & Ganz, 2007; Hua, Hendrickson et al., 2012; Hua, Therrien et al., 2012). Some researchers permitted students to respond using other response modalities, such as selecting the correct response from a field of pictures or items (e.g., Browder et al., 2007; Mims et al., 2009; Spooner et al., 2014). Answers were commonly provided in the form of yes/no or multiple choice questions ranging from a field of two (Browder et al., 2011; Browder, Mims, et al., 2008) to four answers (Mucchetti, 2013). Some studies allowed students to respond in a variety of ways depending on the student’s needs (e.g., eye gaze, point; e.g., Browder et al., 2011; Browder,
Mims, et al., 2008; Spooner et al., 2009). Browder and colleagues presented two real objects from the story. Students were asked to select the item that represented what the story was about. Students could respond using eye gaze, by touching the correct object, or by reaching towards the correct object (Browder, Mims, et al., 2008). Mucchetti (2013) provided response boards including four possible answers to support answering questions. Each possible answer included a word, symbol, and real object. Students could say the correct answer, point to the correct answer, or select the correct answer by pulling it off the board.

**Recommendations.** The manner in which text materials are selected and presented may impact researchers’ abilities to establish functional relations between the independent and dependent variables. Most of these studies measured comprehension as correct answers to questions (e.g., yes/no, multiple choice). Future research needs to ensure that questions are similarly difficult (i.e., written at similar reading levels). Yes/No questions are likely easier to answer correctly than multiple choice questions with more than two choices. Regardless, in baseline, researchers need to monitor student response patterns. Straight zero level correct responding with Yes/No or multiple choice questions in baseline would be a statistical anomaly and point to potential over-selectivity or possibly student naivété regarding how to respond to the questions.

Future research needs to focus on the distractors in multiple-choice questions. Multiple choice questions with plausible distractors (items also in the passage, or items in a similar class as the target answer) may be more rigorous than distractors that are topically irrelevant. Some studies with other populations also measure if students can find the correct answer when given an opportunity to review the passage again after initially answering incorrectly. This is interesting from an experimental factor, and also is an important and practical skill for students to master.

Future research should continue to explore the impact of reading interventions on responding to factual and inferential questions as well as higher order thinking questions (i.e., Bloom’s Taxonomy). Answering factual questions correctly may be the foundation skill in reading comprehension, but it is not the end point. Additionally, because some interventions have differential effects on student responding to different question types, expanding the range of dependent measures is important. Story retell and question generation (where readers create questions about the story) are considered to be preferential methods for measuring comprehension (Salvia, Ysseldyke, & Bolt, 2013; Whalon, Al Otaiba, & Delano, 2009). Future research should explore if retell or other types of comprehension indicators are possible and/or preferable to the current measures for students who are able.

Students with DD might not always be able to respond orally to academic tasks. Students may demonstrate their understanding using other modalities, including signing, gesturing, vocalizations, other motor responses such as eye gaze, and/or assistive and augmentative communication devices (AAC; Browder et al., 2006). Defining other response modes is critical when the response behaviors might require a trained eye or some familiarity with the individual student in order to identify correct responding.

While infrequent in this literature, pre- and post-test assessments may be another way to quantify students’ response to intervention while simultaneously collecting ongoing data using single case design methodology (Whalon et al., 2009). Norm-referenced assessments may not be ideal due to inappropriate norm samples and strict standardization requirements. Some students with DD may not have much experience with the format and type of tasks common to these assessments, which may also limit student performance and may require accommodations that negate the norming standards. However, there are a variety of criterion-referenced assessments and curriculum-based measurements (CBMs, such oral reading fluency measures) that can be easily adapted so that students with DD can access the content of the assessment. Some of these assessments can be given as frequently as needed (Salvia et al., 2013). Furthermore, these types of assessments may be more sensitive to small but meaningful changes in performance that may be more typical for students with DD.
Visual Analysis and Reporting of Results

Results. Researchers used line graphs to display the single case data in these text comprehension studies. With visual analysis of multiple baseline and multiple probe designs (the most commonly used in text comprehension research), the visual analyst looks for an increase in level and/or therapeutic trend direction immediately after the independent variable is manipulated or introduced. Additionally, they look to make sure no changes occurred in the other tiers that had not been exposed to the intervention yet. Visual analysis is argued to be a more conservative method for evaluating intervention effects and making decisions about data (Parsonson & Baer, 1978).

For studies where the data changed following introduction of the independent variable, those changes were more commonly characterized by a change in therapeutic trend rather than an absolute level increase. For example, Mims and colleagues (Mims, Hudson, et al., 2012) documented an immediate increase for the first data point in the intervention phase for most participants. The following data points continued to indicate an increasing trend. In a different study by Knight and colleagues (2013), a similar trajectory was observed in the intervention phase data. In both of these studies, some participant data collected during the intervention phase continued to trend upwards until the participant reached mastery on the item (100%).

Some studies show much more variability in the intervention phase data, despite the upward trend observed after the intervention was introduced to the tier. Variability in data is not unusual for students with DD (Allor, et al., 2010; Whalon et al., 2009), but this does not simplify visual analysis of the data. Sometimes the data in the intervention phase overlaps some of the data points in the baseline phase (Browder et al., 2011; Browder et al., 2007; Mims et al., 2009; Shurr & Taber-Doughty, 2012). This data overlap may weaken conclusions regarding a functional relation between the independent and dependent variables. In some cases this may be the student’s first exposure to the type of intervention used, which may result in an overlap due to acquisition to the instructional procedure versus acquisition of the skill. There may be more overlapping data points in the first tier than in the remaining tiers as the student acclimates to the instructional procedure.

Recommendations. Visual analysis remains the most appropriate way to analyze results in single case designs (Gast & Ledford, 2014). When completing visual analysis, researchers should attend to stability prior to introduction of intervention and in the case of multiple probe or multiple baseline designs, continued stability in those tiers not yet exposed to treatment. Given the likelihood that the most prominent data feature change between baseline and intervention will be trend, researchers should avoid common overlap metrics (like percentage of non-overlapping data; PND) given the inappropriateness of this these statistics for single case design research (Haardörfer & Gagné, 2010; Wolery, Busick, Reichow, & Barton, 2010). Newer, true effect sizes are being developed and reported in the literature and researchers may consider using statistics like Tau-U which can account for trending data paths (e.g., Parker, Vannest, Davis, & Sauber, 2011).

Conclusion

Academic instruction for students with developmental disabilities is a recent phenomenon due to changes in legislative policy and subsequent changes in curricular focus. In addition, reading has been historically underemphasized for students with developmental disabilities (Browder et al., 2009; Katims, 2000). Considering these factors, the growing number of studies investigating text comprehension of academic materials for students with DD is promising. Excellent work has been conducted in this area, and the recommendations are not meant to diminish the importance of the previous research. Rather, the recommendations are offered via this synthesis as a means of helping to improve future research and build upon the foundation that past researchers have set.

Evaluating text comprehension for students with DD is a relatively new line of research and concerns related to methodological rigor are to be expected. Groundbreaking research will often have confounds, gaps, and flaws. Re-
searchers look to these bold trailblazers to guide their own work, leading to future improvements over time. Research teams build future projects based upon lessons learned directly from their own projects, reporting these limitations in discussion sections. Since this field is changing so quickly, researchers should support one another while advancing the field towards higher expectations of research rigor, including applying previous methodological strengths and recommendations to their own future research designs.

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