Effects of a Story-Mapping Procedure Using the iPad on the Comprehension of Narrative Texts by Students With Autism Spectrum Disorder

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Abstract
This study investigated the effects of a modified system of least prompts and an electronic story-mapping intervention for elementary students with autism spectrum disorder. Participants were first taught to identify story element definitions using constant time delay. Participants then listened to age-appropriate narrative texts with a problem–solution structure, completed an electronic story map, and orally answered questions related to the story elements. If unable to complete the map or answer questions, a system of least prompts was used that redirected the students to use provided supports and provided rereads of portions of the text. A multiple probe across participants design was used to examine the effects of the intervention. Outcomes indicated the intervention was effective for teaching story element definitions, labeling of the story element map on an iPad, and comprehension of story element questions. The limitations of the study as well as implications for future research and practice are discussed.

Keywords
autism spectrum disorders, literacy, technology, prompts, graphic organizer

Text comprehension is the process of constructing meaning from text and is essential to becoming literate. Without text comprehension, students lack a critical skill for learning academic content or functioning in the future as independent adults. Students with autism spectrum disorder (ASD) often struggle with text comprehension even when they have decoding skills (Asperg, Kopp, Berg-Kelly, & Gillber, 2010; Nation, Clarke, Wright, & Williams, 2006). Despite this challenge, research on comprehension for students with ASD has been underemphasized (Chiang & Lin, 2007).

In a comprehensive review on reading for individuals with significant cognitive disabilities, Browder, Wakeman, Spooner, Ahlgrim-Delzell, and Algozine (2006) reported only 6% of participants in the identified studies had ASD, and only a few studies measured or reported comprehension. Most of these studies focused on sight word identification. Chiang and Lin (2007) conducted a comprehensive review of reading for students with ASD that was inclusive of both vocabulary (e.g., sight word) instruction and academic text comprehension at the sentence level or above. The reviewers only found 11 studies that addressed comprehension, and only 5 of these had an academic focus; the remaining studies examined functional use of sight words or matching words to pictures.

Noting the lack of an evidence base for teaching comprehension to students with ASD, Whalon, Al Otaiba, and Delano (2009) recommended applying strategies that have strong support with other disability groups and then determining what additional supports students with ASD may need. Story grammar is one such strategy for teaching comprehension of narrative texts given its extensive evidence base with students with learning disabilities (Boulineau, Fore, Hagan-Burke, & Burke, 2004; Wade, Boon, & Spencer, 2010). Story grammar describes a “character’s problem or conflict, a description of attempts to solve the problem, and an analysis of the chain of events that lead to a resolution” (Dimino, Gersten, Carnine, & Blake, 1990, p. 20). Think aloud procedures involve teachers giving students models for how they arrive at a conclusion. Through think aloud procedures, teachers can use story grammar as a framework for modeling complex metacognitive processes in a manner
that is concrete and discrete. Teaching story grammar emphasizes the common structure shared by texts of common genre and the relationship between the most salient aspects of those texts (Gardill & Jitendra, 1999).

Students often demonstrate their understanding of story grammar through story maps. Story maps are graphic organizers that visually display elements of story grammar. Presenting story maps to students prior to and during reading provides students a framework for organizing new knowledge, which allows students to attend to relevant features as they occur and to process visual and verbal information concurrently (Ozmen, 2011). Story maps may help students with ASD who have weaknesses in working memory. Graphic displays of information eliminate the need for students to suspend story elements in their memory while making connections between them and attempting to respond to comprehension questions (Stringfield, Luscre, & Gast, 2011). Visual supports have been shown to increase academic performance and information recall of students with ASD (Burton, Anderson, Prater, & Dyches, 2013; Cihak & Ayres, 2011; Prater, Carter, Hitchcock, & Dowrick, 2012). Specifically, graphic organizers have been used to teach academics to students with autism in other content areas such as science (Knight, Spooner, Browder, Smith, & Wood, 2013) and social studies (Schenning, Knight, & Spooner, 2013; Zakas, Browder, Ahlgrim-Delzell, & Heafner, 2013). For students with ASD, graphic organizers may serve the same function as a think aloud procedure used in traditional story grammar approaches. The use of visual supports may help by making the story structure explicit, displaying the story structure in a salient manner, and providing opportunities to demonstrate how conclusions can be drawn from the text visually.

Some support for using story mapping can be found in a study by Stringfield et al. (2011) who investigated the effects of a story map on the text comprehension of three male elementary students as measured by Accelerated Reader (AR) quizzes. Participants independently read AR books at their reading level and completed story maps that focused on six story elements. Only a brief and informal training period occurred for each participant on the first day of intervention for each of the story elements. After completion of the story map, participants were orally asked AR questions. No response options were provided, and a modified system of least prompts procedure was used to provide error correction during the AR quiz. Results of the study found a functional relation between story mapping and text comprehension.

The students in Stringfield et al. (2011) were working toward grade-level achievement and were described by the authors as having high-functioning autism. The need exists to see if story maps can be used as an effective support for students with ASD who are working on alternate achievement or who may be beginning at a more literal level of comprehension. Williamson, Carnahan, and Jacobs (2012) found that even students with “high-functioning” autism displayed three cognitive profiles in comprehension including imaginative, strategic, and text bound. Text-bound comprehenders have strength in answering literal comprehension questions. Strategic comprehenders are successful at answering comprehension questions regardless of text features or background knowledge and are able to make a variety of inferences. Imaginative comprehenders are the most visually oriented and successful in text that is supported by pictures. Given Williamson et al.’s findings, it is possible that the students who were able to use the story maps in Stringfield et al.’s work had at least strategic levels of comprehension. The question remains whether students with ASD, who have below average intelligence but are also learning to read, may benefit from a story-map intervention.

Some promise for the extension of story mapping to students with ASD and below average intelligence can be found in the study by Zakas et al. (2013). In this study, students with ASD who had IQs ranging from 61 to 76 used a story map to glean key details from informational text in social studies. The interventionist pretaught seven history story grammar terms before teaching participants to use the story map to demonstrate comprehension of an adapted grade-level social studies text using a modified system of least prompts. All three of the middle-school participants improved their comprehension skills with story maps.

While students in the studies by Stringfield et al. (2011) and Zakas et al. (2013) could read independently, story maps may also be useful for students who need assistance to access passages of text because of underdeveloped reading skills. Several studies have demonstrated that students with ASD can improve comprehension of passages of text through interactive read-alouds (Browder, Trela, & Jimenez, 2007; Mims, Hudson, & Browder, 2012). Students with ASD may also need support to write and organize the map through the use of computer-assisted instruction (CAI). CAI has a strong research base for students with ASD (Odom, 2013), including for use in teaching academics (Knight, McKissick, & Saunders, 2013; Pennington, 2010). Despite this strong evidence base, CAI has not been used with story mapping to teach students with ASD to comprehend narrative text.

Although the use of CAI is promising to teach academics to students with ASD, it is not yet an evidence-based practice (EBP). Technology is only a mode of delivering instruction; it should be carefully paired with established EBP for teaching academics to this population (Knight, McKissick, et al., 2013). Story element definitions in this study were systematically and explicitly taught through constant time delay, which is an EBP for teaching literacy to students with significant disabilities (Browder, Ahlgrim-Delzell, Spooner, Mims, & Baker, 2009). A system of least prompts was used
to teach students to label an electronic story map and use the completed story map to answer comprehension questions. The prompting hierarchy was developed based on previous research on teaching listening comprehension to students with developmental disabilities (Browder, Hudson, & Wood, 2013; Hudson, Browder, & Jimenez, 2014; Mims et al., 2012; Stringfield et al., 2011).

The purpose of this study was to evaluate the effects of an intervention that utilized systematic instruction and CAI, specifically an electronic touch-based story-mapping procedure delivered via an iPad, to teach comprehension skills related to story elements to students with autism. The treatment package incorporated four of the eight strategies the National Reading Panel (2000) named as effective for teaching comprehension: (a) graphic organizers, (b) story structure, (c) question answering, and (d) multiple strategy instruction. The research questions were as follows:

**Research Question 1:** What is the effect of constant time delay on the identification of story element word definitions for students with ASD?

**Research Question 2:** What is the effect of a modified system of least prompts on the labeling of an electronic story map for students with ASD?

**Research Question 3:** What is the effect of a self-completed electronic story map and a modified system of least prompts on the comprehension of story element questions for students with ASD?

### Method

#### Participants and Setting

Three students participated in the study. Students were eligible for participation based on the following inclusion criteria: (a) participation in a special education program under the Individuals With Disabilities Education Act (IDEA) eligibility category of autism, (b) participation in Alternate Assessments Based on Alternate Achievement Standards (AA-AAS) if enrolled Grades 3 through 5, (c) vocal language as their primary mode of communication, (d) parental consent and student assent, and (e) satisfactory score on a prescreening measure. The prescreening measure evaluated the participants’ fine motor abilities regarding manipulation of the iPad and preexisting knowledge of story elements. Two boys and one girl ages 8 to 10 years old participated in this study. Their demographic information is provided in Table 1.

All of the participants used vocal language to communicate although they all received speech language therapy in school to address communication deficits related to ASD. Stuart’s first language was Spanish, and teachers reported that he spoke Spanish at home. Although Stuart received English as a Second Language (ESL) services, he did not have difficulty expressing his thoughts, opinions, and preferences in English in the school environment. Stuart spoke in long sentences, often without giving his communicative partner a chance to speak. In addition, he displayed more disfluency in his speech when he was excited or in a hurry. Aaron was capable of speaking in four- to five-word sentences or phrases although he preferred to use as few words as possible or nonverbal means of communication in the classroom environment. When he became excited or wanted access to a preferred item, Aaron would repeat a word or phrase as a request. When he did not want to engage in an activity or was upset, he also would protest verbally by repeating either what he wanted to do or did not want to do in a low tone. Karen was able to speak in complex sentences when she was motivated. She could adequately express her ideas and feelings to adults and peers within the classroom. She often showed concern for classmates by commenting to herself or an adult near her about her perception of a peer, such as “He is sad,” or “He wants to play on the computer instead.” Karen frequently repeated several similar phrases related to taking care of an infant, such as “She wants her mommy,” “Waah, Waah, she’s crying,” or “Shh . . . Shh . . . It’s alright.” These vocalizations often interfered with her social and academic progress within the classroom.

All of the participants had some beginning reading and writing abilities. According to teacher reports, Stuart was able to identify and write many sight words and would attempt to sound out any he did not know. He had difficulty decoding and spelling, and he did not yet know all of his sounds. His teacher reported he was able to answer some literal comprehension questions but struggled to understand the meaning of some words due to his limited English proficiency and communication deficits. Aaron and Karen were both able to decode and encode words on a beginning second-grade level according to teacher reports. Aaron had difficulty understanding the emotions or motivations of characters, which affected his ability to understand the plot.

#### Table 1. Participant Demographics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Stuart</th>
<th>Aaron</th>
<th>Karen</th>
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<tr>
<td>Age (in years)</td>
<td>8</td>
<td>9</td>
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</tr>
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<td>ASD</td>
<td>ASD</td>
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<tr>
<td>IQ/instrument</td>
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<td>70&lt;sup&gt;b&lt;/sup&gt;</td>
<td>64&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Adaptive behavior</td>
<td>88&lt;sup&gt;c&lt;/sup&gt;</td>
<td>77&lt;sup&gt;d&lt;/sup&gt;</td>
<td>70&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Participates in</td>
<td>N/A (too young)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>alternate assessment</td>
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<sup>a</sup>Wechsler Individual Achievement Test—Third Edition (WIAT-3).  
<sup>b</sup>Developmental Assessment of Young Children (DAYC).  
<sup>c</sup>Adaptive Behavior Assessment System—Second Edition (ABAS-2).  
of stories that he read. Karen struggled with sequencing events in a story and maintaining topic in her response, which made it difficult to gauge her understanding of texts.

Aaron and Karen had some behaviors that affected their progress in academics, including reading. Aaron had difficulty attending to tasks for longer than 10 min prior to the study according to teacher report. He often refused to follow the classroom schedule and had a behavior intervention plan in place for aggressive escape-maintained behavior. Karen became anxious with tasks she perceived as long or difficult and would yell or refuse to complete the tasks. Karen also was very routine oriented and used a self-monitoring system to work through her day. This reduced some of her anxiety about any minor changes in schedule, although she still only attended to tasks for a span of 10 to 15 min.

The study took place in a self-contained classroom in a suburban public elementary school in the southeastern United States. The classroom had eight students with autism, one teacher, and two paraprofessionals. The primary interventionist was a doctoral student in special education who had 4 years of experience teaching students with autism. Sessions took place in a one-on-one setting within the participants’ classroom during daily literacy rotations for approximately 20 to 30 min a day between the hours of 9:15 a.m. and 10:30 a.m. In addition, students participated in other literacy stations during that time period. These activities included independent phonics or spelling tasks (e.g., find pictures that begin with /s/ sound), direct instruction in early literacy or phonics skills with the teacher (e.g., first sound in words), or content area sight word instruction with a paraeducator. Although their other literacy activities sometimes involved comprehension (e.g., point to picture in a storybook), they did not address story elements, completing graphic organizers, or answering comprehension questions without a response board.

Materials

Each story used in the study had a problem–solution structure. A bank of stories for the intervention was chosen from elementary qualitative reading inventories and elementary basal readers. Stories were adapted to follow the guidelines established in the story-mapping literature for the clear presentation of targeted story elements in every story (Gardill & Jitendra, 1999). Each story was adapted to be between 100 and 120 words and to have a decoding and comprehension level of second to third grade according to the Lexile Framework for Reading: Lexile Analyzer (MetaMetrics, 2011). For some stories, this involved reducing text complexity and shortening the text. However, the five story elements targeted in the study, which are key to problem–solution stories (character, setting, problem, solution, and outcome), remained intact. Stories were presented on an 8.5” × 11” paper in Times New Roman size 18 font. They did not include any pictures to control for the effects they could have on comprehension. Two stories were randomly chosen for each session. No stories were repeated for a participant; once a story was used, either in baseline or intervention, it was removed from the list of potential stories for future sessions for that participant.

The electronic touch-based story map was researcher developed using the SMART notebook© application. An example of the story map displayed on the application can be seen in Figure 1. The SMART notebook application allowed for multiple ways for the students to record their answer. Students were able to press the microphone button and use the speech-to-text feature, write their answer using the drawing tool, or type their answer using the on-screen keyboard. Participants were able to either type into the provided boxes or use the drawing tool to produce their answers. The story element definitions were also presented on an iPad 3 using the SMART notebook application.

Research Design

A single case, multiple probe across participants design was used (Tawney & Gast, 1984). All three participants entered baseline at the same time and were probed every day. Once a stable trend with at least five data points was obtained, the first participant entered the intervention phase. The remaining participants continued in baseline with intermittent probes occurring at a minimum of every eight probes and concurrently as each participant entered intervention (Gast & Ledford, 2010). Once the first participant demonstrated a stable, accelerating trend of three data points in both independent labeling of story elements on the story map and independent correct answers to comprehension questions about story elements, the second participant entered intervention. This systematic introduction of participants to the intervention continued until all participants were introduced to the intervention (Gast & Ledford, 2010). The mastery criterion for story element definitions was three consecutive
sessions with at least 11 out of 12 independent correct answers. Mastery criterion for labeling the story map and answering comprehension questions was above 80% accuracy for 3 consecutive days on both measures. Once participants reached criterion for mastery, maintenance probes were conducted until all participants completed the intervention and had maintenance collected at least once.

Dependent Variable and Data Collection

Procedures

Three dependent variables were measured in each probe. The first dependent variable was the independent number of correct pairings of story element words to definitions (e.g., problem/what causes trouble). Responses were scored as independent correct if the participant touched the correct answer within 4 s. Six story elements were taught: (a) character (the people in the story), (b) setting (where and when the story takes place), (c) problem (what causes trouble), (d) solution (how the problem is fixed), (e) outcome (the ending of the story), and (f) main idea (what the story is all about). Each of the 6 story elements was presented twice in each session for a total of 12 story elements per probe. The second dependent variable was the labeling of the electronic touch-based story map, as measured by independent labels of 5 story elements per story map, for a total of 10 story elements per probe. Main idea was not included on the story map. Responses were scored as independent correct if the participant initiated the correct response within 10 s. The third dependent variable was the number of comprehension questions answered independently and correctly. The questions were about story elements from the story and map. Responses were scored as independent correct if the participant orally responded with a correct answer within 10 s. There were 6 questions asked for each story, 1 matching each of the story elements for a total of 12 questions per probe. For all dependent measures, only independent correct responses were counted as correct; any responses requiring a prompt, incorrect responses, or nonresponses were not graphed.

Procedures

Prescreening. Following parental consent and student assent but prior to baseline, a prescreening was conducted. The purpose of the prescreening was to obtain specific information regarding the participants’ ability to identify story elements, to ensure that appropriate story elements and definitions were chosen, and to assess the participants’ ability to access and manipulate the electronic touch-based technology. In addition, the prescreening ensured all participants had not already acquired the skills needed to identify story elements and were appropriate participants for this study. Participants were interviewed and asked to describe or identify the definitions of story elements and asked to match story elements to their definitions after they were read aloud to them. One adapted short story was then read, similar to those that were used throughout the remaining portions of the study. After reading the book, participants were asked if they could orally identify the story elements from the text. None of the participants were able to identify story elements during this prescreening.

General procedures. Each probe consisted of four general activities: (a) identification of story element definitions, (b) listening to an adapted short story read by the interventionist, (c) completion of story map of story elements from adapted short story, and (d) answering comprehension questions about story elements. Although the students had some emergent reading skills, the passages were read aloud to focus on comprehension of fluently read text. The students were encouraged to look at each line of text or text point as it was read aloud to them. At different points, participants would read along with the interventionist when high frequency or known words were presented or when they recognized the name of the character.

Following completion of the story element questions, participants were always provided individual reinforcement in the form of 2 min of self-selected school and age-appropriate games on the iPad (e.g., go cart racing or pet salon). The reinforcement was only contingent on completing the first story and accompanying map and questions, not on performance. This contingency remained constant throughout phases. A second story was read and procedures were repeated to complete one probe session in one session if participants were able to sustain attention to the task. If participants needed a break or were unable to continue with a second story, the session was completed another day.

Baseline. During baseline, the students were assessed on the three dependent variables: (a) identification of story element definitions, (b) labeling of story map, and (c) comprehension of story elements. During the baseline, stories were randomly selected from the sets to be used during instruction. Students received no instructive feedback.

Identification of story element definitions. The interventionist placed the iPad on the table in front of the participant and presented the verbal direction, “Match the story elements with their definitions.” The story elements appeared one at a time in the center of the screen in a green box. Along each side of the screen were three gray boxes containing answer choices to the six definitions. All words were read aloud to the participants. Participants indicated their answer either by saying the word aloud or touching the iPad. No prompting, feedback, or error correction other than verbal reinforcement for on-task behavior was provided. Each story element was presented two times for a total of 12 trials at
the beginning of every day’s session. The identification of story element definitions was the first task each day, regardless of whether the participant would complete one story that day or two.

**Labeling of story map.** Participants were presented with the electronic touch-based story map on the iPad, as seen in Figure 1. They were presented with the verbal direction, “Fill in the character from the story.” If a participant said an answer aloud and was struggling to spell it, the spelling was provided letter by letter by the interventionist, but without any acknowledgment of the accuracy of the answer. If directly asked how to spell a word, it was supplied. If the interventionist was unsure of what was typed, the participant was asked. No prompting, feedback, or error correction other than reinforcement for on-task behavior was provided. Participants were encouraged to fill out the entire story map; however, if they indicated they were finished without all of the elements completed, the interventionist moved on to the next task.

**Comprehension of story elements.** The interventionist orally asked the participants comprehension questions following completion of the story map. Each question aligned with one of the story elements. For example, “How did Mr. Wolf warm up?” would align with the solution story element. Participants had access to the story map on the iPad and the story. The students did not have a response board to answer these questions; a vocal response was required. No prompting, feedback, or error correction other than reinforcement for on-task behavior was provided. It should be noted that the wording of the questions required the student to do more than match the question to the story element. For example, for the question, “How did Mr. Wolf warm up?” the words “warm up” would not appear on the story element for solution. The map would simply say “fire.” The student needed to comprehend that the question was asking for the solution (to Mr. Wolf’s problem of being cold) as well as using the map to recall the specific answer.

Following completion of the story element comprehension questions for the first story, a second story was read, and the story map and comprehension procedures were repeated for a total of two stories read in each probe. If participants needed a break or were unable to read a second story, the probe was continued the next session.

**Intervention.** Each day during intervention, the instructor began with instruction on the story element definitions. Once the student matched the elements to their definitions with prompting as needed, the instructor read the story and taught story mapping. The students were then prompted to use their map to answer the comprehension questions. Each of these lesson components will now be described.

**Teaching story element definitions using constant time delay.** Following procedures established in baseline, the iPad was placed on the table in front of the participant by the interventionist. The interventionist gave the student the instructional cue to “match the story elements to their definitions.” The appearance, format, and randomized presentation of the elements and definitions remained the same in intervention as it was in baseline. In the first trial, the interventionist used 0-s constant time delay to systematically teach the story element definitions to the students. To model in 0-s trials, the interventionist read the story element and touched the correct answer while reading it aloud, then asked the student to do the same. In the next two trials, 4 s was inserted between the presentation of the story element and the model prompt. If participants were unable to make an independent correct response, the interventionist provided a model prompt, as was provided in the 0-s trial, and then asked the student to touch the correct definition. Each probe included two sets of 4-s time delay trials, with all six story elements presented in each set for a total of 12 data points each probe. Only independent correct responses from 4-s delay trials were graphed.

**Teaching story-map labeling using a modified system of least prompts.** On the first session of story-map instruction, participants received training on using the electronic touch-based story map. The interventionist modeled how to use the features of the SMART notebook© application, including the read-aloud features, the multiple ways to input an answer (e.g., speaking, writing with drawing tool, or typing), zooming in and out, and scrolling around the page. The read-aloud feature available in intervention provided cues for the definition for each story element. If participants touched the speaker icon next to each story element word, the word would be read aloud and the definition would be provided. For example, if the participant touched the speaker icon next to setting, they would hear “Setting, where and when the story took place.” This was a repetition of the exact definition they were taught in the previous story element definition task. Independent activation of this feature did not count against independent correct responses. Once the training period was over, participants were encouraged to apply what they learned about the electronic touch-based graphic organizer to the story they just read.

The interventionist gave the participants the direction, “Fill in the character from our story.” If participants tried to go out of order, they were told to fill out the story map in the order it was presented. This feedback was not scored as a prompt as it did not provide information on the correct answer. All participants chose to use the on-screen keyboard to type their answers in every session, just as they had in baseline. If the participant did not respond within 10 s or responded incorrectly, the interventionist delivered the following hierarchy of prompts as needed: (a) prompted the
student to activate the read-aloud of the story element definition on the story map and reviewed completed story map, (b) reread portion of the text (two to three sentences) that contained the answer, (c) reread the sentence or phrase from the story that contained the answer, and (d) read the answer and had the participant fill it in on his or her story map. The same procedures for assisting with spelling and comprehending the participants’ written response were used in intervention as baseline. The participants completed one story map for each story read. Each story map contained a maximum of five correct responses, one for each story element, and two story maps were completed each probe, for a total of 10 possible correct responses per probe. Only independent correct labeling of story elements was scored as correct.

**Teaching comprehension of story elements using electronic touch-based story map and system of least prompts.** Upon completion of the story map, the interventionist orally asked story element comprehension questions. Just as in baseline, each question aligned with one of the story elements on the map, except main idea. Participants had access to their self-completed story map with correct answers displayed on the iPad. If participants answered correctly and independently, the interventionist responded with verbal praise and moved on to the next question. If participants answered incorrectly or did not respond within 10 s, the interventionist used the following system of least prompts hierarchy: (a) prompted participant to use story map and story for help, (b) reread portion of the text (two to three sentences) that contained the answer, (c) reread the sentence or phrase that contained the answer, and (d) stated the answer and had the participant restate the answer.

**Maintenance.** Participants moved into maintenance for story element definitions once they received 100% mastery on three consecutive sessions or had met criteria for the story-map labeling and comprehension questions condition. In maintenance, participants were probed a minimum of every five sessions, and 0-s time delay trials were discontinued. Participants moved into maintenance when they demonstrated 80% independent correct responses on both story-map labeling and story element questions for three consecutive probes. Once participants reached mastery, maintenance on story mapping and story element comprehension data were collected every five probes until all participants complete the intervention and all participants had maintenance data collected at least twice.

**Reliability**

To ensure reliability and fidelity, a second observer trained by the primary interventionist calculated interobserver agreement and procedural fidelity. Both in vivo and permanent product (video) observations were used.

**Interobserver agreement.** Interobserver agreement measured reliability of the three dependent measures using the same data sheet for each of the dependent variables that the interventionist used during the intervention session. Interobserver agreement was conducted for 30% of the baseline and intervention sessions. Interobserver agreement was calculated by dividing the total interval agreements by the total intervals observed (Kazdin, 1982). Agreement of 90% or greater was considered acceptable.

**Procedural fidelity.** To ensure fidelity of the intervention, a second observer checked procedural fidelity. A procedural fidelity checklist was used that monitored whether or not the intervention, specifically the modified system of least prompts and delivery of constant time delay, was implemented as intended. Procedural fidelity was calculated for a minimum of 30% of the intervention sessions. Procedural fidelity data were calculated by dividing the number of steps correctly implemented by the total number of procedural steps and multiplying the quotient by 100 (Billingsley, White, & Munson, 1980). Fidelity of 90% or greater was considered acceptable.

**Results**

Figure 2 shows the number of independent correct identifications of story element definitions for Stuart, Anthony, and Karen. The x-axis represents probes and the y-axis represents the number of independent correct responses during each probe. Each of the participants demonstrated an immediate jump in level after instruction on the definition of the story elements began using constant time delay. (Note that in figures where Anthony and Karen’s data points are not connected, it took 2 days to complete the two stories.)

During baseline, Stuart’s average independent correct response to story element definitions was 1.2, and in intervention, it was 10. Stuart was able to reach mastery of story element definitions in eight sessions, as well as demonstrate maintenance of skills after three and eight sessions. Aaron’s average independent correct response to story element definitions in baseline was 1.7. Aaron was able to reach mastery of story element definitions in six sessions with an average performance of 9 independent correct responses and maintained the skill as demonstrated by retention of 11 and 12 correct responses in four and five sessions postintervention. Finally, Karen’s average performance in baseline was 1.4 independent correct responses with a jump in intervention to an average of 10.4. She was able to reach mastery of story element definitions in six sessions and maintained an average of 12 independent correct responses five and six sessions postintervention.

Figure 3 displays the number of independent correct labels of story elements on the story map for Stuart, Anthony, and Karen. The x-axis represents probes and the
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The $y$-axis represents the number of independent correct responses during each probe. A jump in level was demonstrated by each of the participants after instruction in labeling the story map using a system of least prompts began.

Stuart was able to consistently label the story map with 20% accuracy during baseline. Once intervention began, his accuracy increased to an average of 71.6%. He was able to reach criterion after 12 sessions and maintain performance five sessions later with a score of 90% accuracy. The graph of Aaron's performance during baseline demonstrated variability, with an average of 20% accuracy. However, after six intervention sessions, Aaron was able to reach mastery with an average performance of 68%. His performance not only showed an increase in level but also showed a decrease in variability. Aaron demonstrated maintenance of labeling the story map four sessions later with 90% accuracy. Karen also demonstrated variability in baseline, with increased initial performance and an overall average of 7% accuracy. After six sessions, Karen was able to reach mastery with average performance during intervention of 80% accuracy in labeling the story map.

Figure 4 displays the number of independent correct responses to story element questions for Stuart, Aaron, and Karen. The $x$-axis represents probes and the $y$-axis represents the number of independent correct answers in that probe. Visual analysis demonstrates an immediate jump in level for each of the three participants, which did not occur until the onset of intervention.

Stuart had a variable baseline with an average performance of 36% independent correct answers. This increased during intervention to an average of 83% after 12 sessions when he met mastery. Stuart was able to maintain high performance after 1 week with a score of 91%. Aaron had a consistently low baseline with an average performance of 6.4% independent correct answers to story element questions that increased to an average of 85% after six intervention sessions when he met mastery. After five sessions, his maintenance of the skill was demonstrated by 100% correct responses to story element questions.
Karen’s baseline performance continued to be variable in the question answering condition with an average of 20% accuracy that increased immediately to an average of 87.3% independent correct answers in intervention. Karen was able to reach mastery of story element questions after six probes.

Discussion
This study demonstrates that the use of story mapping may be effective for teaching students with ASD with below average intelligence to comprehend passages of narrative text that are read aloud. Participants were able to acquire mastery of the story element definitions and a functional relation was demonstrated between constant time delay and identifying story element definitions. In addition, a functional relation was found between a modified system of least prompts and labeling of an electronic story map and between student-completed electronic story maps combined with system of least prompts and comprehension of questions related to story elements. Maintenance data show all participants were able to maintain high levels of performance on all three measures.

Once completed correctly, the story map became a support for answering story element questions. The descriptive statistics for each participant support this finding. During baseline, the participants were provided with the story map; however, it did not have the story element definition read-aloud feature. In addition, the participants were only told to fill in the story map; no error correction or feedback was provided. However, once they were given self-directed auditory story element definition cues and systematic instruction in how to fill out the story maps, they did not proceed to the comprehension question task until the graphic organizer had been filled out correctly. Data for each participant showed that the average percentage of correct responses to story element comprehension questions was higher than labeling the story map. Descriptive statistics for maintenance data also demonstrated that the story element map was a support tool as the average independent correct responses were higher for Stuart and Aaron for answering questions than labeling the map, and equal for

Figure 3. Graph of percentage of independent correct labels of story elements on electronic story map.
Karen. The systematic instruction of the story element definitions allowed the participants to identify the elements in the story and label them on their map. This labeling process and creating a support tool then enabled them to answer comprehension questions, which they were not able to do prior to the intervention.

Although story mapping has been used with students with learning disabilities (Boulineau et al., 2004; Gardill & Jitendra, 1999; Wade et al., 2010), applications with students with ASD are emerging (Stringfield et al., 2011; Zakas et al., 2013). This study is the first to teach students who are emergent readers and participate in alternate assessments to complete a story map and use it to answer comprehension questions. The story-mapping intervention was augmented with explicit instruction on story elements, CAI, and a read-aloud. How these features build on prior research and contribute to the literature on story mapping will now be discussed.

Investigations into the effectiveness of story mapping with students with ASD have not included explicit vocabulary instruction on story elements (Stringfield et al., 2011; Wade et al., 2010). Similarly, in studies with students with learning disabilities, the instructor often simply explains the story elements (e.g., Gardill & Jitendra, 1999). In contrast, in both the current study and Zakas et al. (2013), the instructor taught the story elements vocabulary to students using a time delay prompting and fading procedure until they mastered each definition (e.g., character is a person in the story). Constant time delay is an EBP for teaching vocabulary instruction to students with developmental disabilities (Browder, Ahlgrim-Delzell, Spooner, Mims, & Baker, 2009). Students will not benefit from interventions on story maps if they do not comprehend the terminology for story grammar, so providing this definition training is essential pretraining. The specific elements to be taught may vary depending on the type of text selected. For example, Zakas et al. (2013) taught comprehension of expository text. Resultingly, the relevant story elements were people, event, sequence, time, location, details, and outcome. In the

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**Figure 4.** Graph of percentage of independent correct answers to story element comprehension questions.
current study, the elements related to narrative text (e.g., setting, outcome). These elements are similar to those recommended by Carnine, Silbert, and Kame’enui (1997) as a narrative comprehension strategy.

A second way story-mapping instruction may be augmented for students with ASD is through the use of CAI like the tablet application developed in the current study. In their review of technology-based interventions to teach academics to students with autism, Knight, McKissick, et al. (2013) recommended higher quality studies be conducted that incorporate new technology, such as iPads. In his review of CAI to teach academics to students with autism, Pennington (2010) found that most interventions that taught literacy skills focused on simple match-to-sample activities, rather than literacy tasks targeting expressive skills such as those taught in this investigation. The current study contributes to the literature on using CAI to teach academics to students with ASD by demonstrating the use of an iPad to teach the more complex literacy skills of story mapping. One of the advantages of this technology is that students could review the story element definitions while working on the story map and answering comprehension questions by simply pressing the word. For example, pressing “character” resulted in a voiced definition: “People in the story.” Then when completing the map or answering a question, participants could self-check the accuracy of their understanding of the story element. The technology also helped the students manage the text in finding answers for their story map. For example, to find the outcome, the student could scan to the bottom of the story.

The third way the story-mapping intervention was augmented was through a read-aloud of the text passage. The text passages used were from literature that was matched to the students’ chronological age and grade but above their independent reading levels. For students to keep pace with general curriculum content, even when working toward alternate achievement, they need strategies for comprehending grade-aligned text. While the participants in this study continued to receive instruction in decoding from their classroom teachers, this intervention was designed to enhance their text comprehension skills. In prior studies using read-alouds with school-age students with ASD (Browder et al., 2007; Hudson et al., 2014; Mims et al., 2012), the goal has also been to promote comprehension of passages of text. Similar to Hudson et al. (2014), when a student could not answer a question, the instructor used a system of least prompts procedure through repeated rereading of progressively smaller portions of text containing the answer until the student gave the correct answer. However, the first-level prompt in the current study was a reference to the electronic story map, which was the target stimulus. In the current study, students began to use their emergent reading skills to scan the text for themselves, as well as using their story maps, to generate their answers. Browder et al. (2013) found that emergent readers with moderate intellectual disability (ID) could follow a similar prompting sequence to improve comprehension of simple passages they read for themselves. It might be feasible for students like those in the current study to use the same story-mapping intervention to improve comprehension of first-grade-level passages of text they read for themselves in addition to the read-alouds of chronologically age-appropriate text from their grade level.

Limitations and Future Research

As with any single case research design, the generalizability of results is limited due to the small number of participants. This study included only three participants with autism, ages 8 to 10, who reside in the southeastern United States. This was the first investigation into the effectiveness of story mapping with CAI and a system of least prompts to teach comprehension of narrative texts to students with autism and, as such, requires replication with a variety of researchers and participants in different settings before it is considered an evidence-based intervention.

A second limitation stems from the difference in implementation schedule for the participants. Stuart was able to complete two story maps and their corresponding questions to complete one probe in each session. However, due to limitations in their ability to attend to tasks, Aaron and Karen were only able to complete one story and set of questions per session. This gave them more exposure to teaching of the story elements in intervention as each session began with review of story element definitions.

A third limitation was the lack of social validity measures. Although students participated readily in the intervention, a formal measure of their preference for the intervention could have been conducted through an interview or by allowing them to select this format compared with an alternative (e.g., interactive read-aloud without story map and technology). In future research, the classroom teacher might also be asked to evaluate both the importance of the outcomes achieved and feasibility of use of the intervention in the future.

Future research should investigate the effectiveness of story-mapping interventions in small or whole group settings. Similar touch-based technology such as SMARTboards or Promethean boards could be used to display story maps to a group of students. The feasibility of implementation of this intervention by a classroom teacher would increase if it were delivered in a small group format. In addition, students would benefit from observational learning. This intervention might also be replicable in a general education setting in which the entire class is working on comprehension. The story mapping might be used with the entire class with the student with ASD receiving preteaching on the definitions of the story elements and the opportunity for a read-aloud of the grade-level text.
The process of preteaching vocabulary through constant time delay, using a story map as a graphic organizer to display information learned from a text, and asking comprehension questions based on information gathered from the graphic organizer is a process that might also be generalized to other content areas and other comprehension skills.

Implications for Practice

The results of this study continue to support the efficacy of constant time delay to teach vocabulary to students with developmental disabilities, including ASD. In general, practitioners should consider the vocabulary knowledge required of students during an academic lesson and pre-teach those concepts to promote understanding. When teaching story grammar, it will be especially important to preteach students the definitions of the story elements to be applied before using them as a bridge to comprehension.

The modified system of least prompts hierarchy that was used in this study to teach students to fill out the story map could be used to teach students to use other graphic organizers as comprehension support tools. For example, a graphic organizer depicting the sequence of events within a biography or other expository text could be displayed on a graphic organizer, and a prompting hierarchy that fits a student’s support needs could be implemented. Comprehending narrative and expository text is a standard that spans content areas and grade levels and could be taught using graphic organizers, possibly with CAI, and a modified system of least prompts.

Conclusion

The purpose of this study was to evaluate the effects of an intervention that utilized systematic instruction and CAI, specifically an electronic story-mapping procedure delivered via an iPad, to teach comprehension skills related to story elements to students with autism. Despite the importance of text comprehension across content areas and environments, there is a paucity of research on how to teach this vital skill to individuals with ASD (Browder et al., 2006; Chiang & Lin, 2007). Story mapping is one method by which students can demonstrate their understanding of story grammar. This study has shown that story mapping may be effective for students who have both ASD and below average intelligence when additional supports are put into place, such as explicitly teaching vocabulary, embedded student-directed technology supports, providing a read-aloud of the passage if needed, and allowing the completed story map to be used as a comprehension support tool.

Authors’ Note

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