REVISTA MEXICANA DE ANÁLISIS DE LA CONDUCTA 2014 NÚMERO 2 (SEPTIEMBRE)
MEXICAN JOURNAL OF BEHAVIOR ANALYSIS VOL. 40, 85-105 NUMBER 2 (SEPTEMBER)

PROMOTING INDEPENDENCE DURING COMPUTER ASSISTED READING INSTRUCTION FOR CHILDREN WITH AUTISM SPECTRUM DISORDERS

PROMOVER LA INDEPENDENCIA DURANTE LA INSTRUCCIÓN DE LECTURA ASISTIDA POR COMPUTADORA PARA NIÑOS CON TRASTORNOS DEL ESPECTRO AUTISTA

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Abstract

Headsprout® Early Reading (HER) is a web-based instructional program designed to teach nonreaders to read at a mid-second grade level within approximately one year of instruction. Though developed for the general population, recent research suggests children with autism spectrum disorders (ASD) may also benefit from using HER when one-to-one adult support is also provided (Grindle, Hughes, Saville, Huxley, & Hastings, 2013). Procedures to support independent interaction of children with ASD with HER may increase the usability of the program for this group. This study examined the impact of a behavior intervention package on the independent engagement and correct interactions per minute of 4 children with ASD with HER using a multiple baseline across participants design. Results showed that participants (1) required the behavior intervention to engage with the program and (2) demonstrated an increase in engagement and correct interactions per minute and a decrease in behavior that interfered with engagement when the behavior intervention was implemented.

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This study was supported by the College of Education at Michigan State University. The authors would like to thank the students and classroom teacher who participated in this research study. Correspondence concerning this article should be addressed to Joshua B. Plavnick, 341 Erickson Hall, Michigan State University, East Lansing, MI 48824. E-mail: plavnick@msu.edu

Keywords: autism spectrum disorders, computer assisted instruction, Headsprout® Early Reading

Resumen

Headsprout® Early Reading (HER) es un programa instruccional basado en la web diseñado para enseñar a niños que no pueden leer a leer a un nivel equivalente a la mitad del segundo grado con un año de instrucción aproximadamente. Aunque se desarrolló para la población en general, investigación reciente sugiere que niños diagnosticados con trastornos del espectro autista (ASD) pueden también beneficiarse con el uso de HER cuando existe apoyo individual por parte de un adulto (Grindle, Hughes, Saville, Huxley, & Hastings, 2013). Los procedimientos que faciliten la interacción independiente de niños con ASD con HER pueden incrementar el uso del programa por parte de este grupo. Este estudio examinó el impacto de un paquete de intervención conductual en la participación independiente y la correcta interacción por minuto de 4 niños con ASD con HER usando un diseño de línea base múltiple entre participantes. Los resultados muestran que los participantes (1) requirieron de la intervención conductual para involucrarse con el programa y (2) mostraron un incremento en la participación y correcta interacción por minuto y una disminución en la conducta que interfería con la participación cuando la intervención conductual fue implementada.

Palabras clave: trastornos del espectro autista, instrucción asistida por computadora, Headsprout® Early Reading

Reading is essential to academic, social, and economic success (Snow, Burns, & Griffin, 1998). Although most children learn to read at a level sufficient to support independence, children with moderate to severe disabilities are significantly, and often terminally, impacted by deficits in reading (Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Algozinne, 2006). Among this group, children with moderate to severe autism spectrum disorders (ASD) may be particularly difficult to teach to read based on the heterogeneity of children on the spectrum and a range of behaviors associated with the disorder that can interfere with learning (Ramdoss et al., 2011).

Effective reading instruction for children with moderate to severe ASD requires highly individualized and adaptive instructional programs that respond to each child's consistently changing needs across learning tasks (Browder, Ahlgrim-Delzell, Courtade, Gibbs, & Flowers, 2008). At the same time, many of these children also require behavior interventions to mitigate behaviors that interfere with sustained engagement with instructional programs (Grindle Hughes, Saville, Huxley, & Hastings, 2013). The combined expertise needed in behavior analysis, instructional design, and data-based decision making may surpass training that public educators receive in these areas (Watkins, Slocum, & Spencer, 2011).

The emergence of computer-assisted instruction (CAI) offers a potential solution to some of the challenges associated with teaching academic skills, including reading, to children with ASD (Pennington, 2010; Ramdoss, et al., 2011; Whalon, Al Otaiba, & Delano, 2009). CAI can provide engaging visual displays that highlight salient features of instructional content (Ramdoss et al., 2011), automated recording of student responding and customization of instructional content based on student learning outcomes (Heiman, Nelson, Tjus, & Gillberg, 1995), delivery of instructional content with a degree of fidelity that can be difficult to duplicate via teacher-delivered instruction, and the potential to free teachers' time to support the intervention in other important ways (e.g., administering behavior interventions and collecting data to refine instruction).

One internet-based CAI program that targets all areas of reading instruction (i.e., phonemic awareness, phonics, reading vocabulary, reading fluency, and comprehension) and may be beneficial for use with children with ASD is Headsprout® Early Reading (HER). HER consists of 80 web-based episodes (i.e., lessons) each lasting approximately 20 minutes. Episodes are individualized and adaptive in that content is altered based on a child's correct and incorrect responses to preceding instructional stimuli (Layng, Twyman, & Stikeleather, 2004a).

The HER program teaches early reading skills via four core pedagogical approaches that have also been identified as effective for teaching children with ASD (Watkins, 2008; Watkins et al., 2011). These pedagogical approaches are outlined below and described in detail by Layng and colleagues (2004a). First, HER emphasizes *reduced errors* by providing explicit instruction at a child's current level of performance, slowly building on that initial level, and providing a variety of stimulus prompts that are gradually faded to ensure a high rate of accurate responding. Second, a *mastery criterion* is required for children to move from one learning segment to the next within an episode and a criterion of 80% accuracy is recommended for children to progress from one episode to another. Third, g*uided practice* is used to ensure students can accurately discriminate sounds, letters, and words with fluency requirements introduced as children demonstrate high levels of accurate responding. And fourth, *cumulative review and application* ensures skills are revisited and performed under a variety of instructional conditions to support stimulus and response generalization. Several studies have shown that nonreaders, with and without disabilities, who complete the 80 HER episodes learn to read at approximately a second grade level (e.g., Grindle et al., 2013; Huffstetter, King, Onwuegbuzie, Schneider, and Powell-Smith, 2010; Layng, Twyman, & Stikeleather, 2004b).

An advantage of HER for children with ASD is the potential to teach and measure early reading skills without requiring vocal speech, which can be a deficit for many children with ASD (Mirenda, 2008). Although HER encourages children speak out loud when instructed, children with limited verbal repertoires can still participate and learn by selecting from an array of stimuli across a range of learning tasks. For example, HER teaches reading skills by asking children to: (a) identify letter-sound correspondences by pointing to sounds in printed words as the narrator reads the sound

aloud; (b) point to words or pictures that correspond to a printed or spoken word; (c) respond to a question about a printed sentence, illustration, or story by selecting correct pictures; (d) find pictures that contain specific sounds in beginning, medial, or final position; and (e) say the sounds and then select a computer character who says the sounds "just like you did" (Layng, Twyman, & Stikeleather, 2004a).

Preliminary research has recently emerged offering empirical support of HER for children with ASD (Grindle et al., 2013; Whitcomb, Bass, & Luiselli, 2011). Whitcomb and colleagues (2011) first reported outcomes of HER applied to a child with ASD. In combination with one-to-one therapist support to provide prompts and error correction, HER was administered to a 9-year-old boy with ASD who demonstrated greater accuracy in word identification and accurate reading of HER stories following the completion of 23 episodes. This investigation provided initial evidence of HER teaching reading skills to a child with ASD.

A similar behavior intervention package was used by Grindle and colleagues (2013), who administered HER to four children with ASD, aged 4 to 6 years. Each student completed the program with a tutor who administered individualized reinforcement systems and prompts to attend to the computer screen and/or speak out loud when requested. In addition, students were provided with several instructional enhancements and adaptations to ensure their participation, including: (1) using discrete trial teaching to teach discriminations embedded within HER when students did not meet a 90% mastery criterion on repeated lessons, and (2) increasing students' reading fluency through modeling, flashcards, and graphing. On average, it took participants 14 weeks to complete 40 of 80 episodes, and 28 weeks to complete all 80 episodes in HER. These outcomes suggested HER could be completed by children with ASD in a timeframe that was similar to the 12-week period observed by the program developers when testing the first 40 episodes with typically developing children (Layng et al., 2004a). In addition to an increase in accurate responses over time, participants demonstrated gains in reading as indicated by scores on the First Grade Dynamic Indicators of Basic Early Literacy Skills (Good, Kaminski, & Dill, 2002) and the Word Recognition and Phonics Skills Test (Carver & Moseley, 1994).

Despite preliminary positive reading outcomes for children with ASD who complete HER episodes, extensive support has been provided to ensure they engage with HER (Grindle et al., 2013; Whitcomb et al., 2011). Such supports are often employed in behavior analytic research and practice when teaching academic skills to children with ASD, though long-term reliance on these supports limits the replicability of the intervention, particularly in public educational settings where resources to support one-to-one instruction are limited (Kasari & Smith, 2013). The purpose of the present investigation was therefore to conduct a preliminary evaluation of a procedure designed to teach children to engage and interact with HER and assess whether children could sustain interactions with HER as support was gradually faded. A second purpose was to assess whether supports to promote engagement with HER could also impact children's rate of correct responding.

Method

Participants

Four children, three boys and one girl, with ASD participated in the investigation. Children were selected for participation based on referral from a local school district's ASD consultant and then from their classroom teacher. In order to participate, children had to (a) have a prior medical or school-based diagnosis of ASD, (b) independently interact with an iPad (on any apps or programs) for a minimum of one minute, and (c) test into one of the HER entry points identified in the placement assessment manual (i.e., episode 69 or below; Mimio, 2012).

Sam was a 6 year, 9 month old male in first grade who, at the time the study started, received 50% of his instruction in the general education classroom with a one-to-one paraprofessional, and 50% in the self-contained ASD classroom. His diagnosis was completed by the school's multidisciplinary evaluation team and his score on the Gilliam Autism Rating Scale - Second Edition (GARS-2; Gilliam, 2006) was 87 suggesting a likely ASD. Sam emitted some vocal responding but did not speak in full sentences and frequently repeated words or phrases spoken by others. Sam engaged in several challenging behaviors including falling down on the floor, screaming, running away from instructors, and knocking items off of tables or desks. Most of these behaviors occurred when Sam was presented with a demand to complete a task. Sam could identify 15 of 34 sounds presented in a researcher-developed HER target sound assessment but did not identify any sounds within words in the first section of the HER placement assessment and therefore placed into the first episode of HER. When presented with an iPad, Sam independently searched YouTube to watch videos of preferred commercials.

Alex was an 8 year 10 month old male in third grade and received 50% of his instruction in the general education classroom with a one-to-one paraprofessional and 50% in the self-contained ASD classroom. His diagnosis was completed by the school's multidisciplinary evaluation team and his score on the GARS-2 was 81 suggesting a possible ASD. Alex had a standard score of 66 on the Peabody Picture Vocabulary Test - Fourth Edition (PPVT-4; Dunn & Dunn, 2007). He could communicate with others using two- to three-word phrases. Alex engaged in frequent aggression toward others, often occurring when a demand was placed on him or upon an unplanned change in routine. Alex identified 13 of 34 sounds on the HER target sound assessment, but did not identify sounds within words, read words or nonwords, and placed into the first episode of HER. Alex interacted independently with an iPad by taking pictures or searching the internet for videos of preferred songs.

Isabelle was a 5 year 7 month old female in kindergarten who was in a general education classroom for almost the entire day, with the exception of 30 min in the resource room where she received reading instruction. Isabelle was diagnosed with ASD by the district multidisciplinary evaluation team. Isabelle did not emit any vocal

words and instead used pictures, gestures, or physically manipulated others (e.g., pulled teacher's arm to preferred object) to communicate. Her standard score on the PPVT-4 was 113, which placed her in the average range compared to similar aged peers. She engaged in crying, pinching, and dropping to the floor when her schedule changed or when preferred items were removed. The HER placement assessment was modified for Isabelle because she did not emit vocal verbal behavior. She was instead asked to discriminate target sounds from a three stimulus array and accurately discriminated all 34 sounds on the HER Target Sound Assessment. However she did not point to any sounds within words or discriminate nonwords and was therefore placed into the first episode of HER. When presented with an iPad, Isabelle independently entered a *PBS Kids* application to play preferred games.

Timothy was an 8 year 9 month old male in third grade and received 50% of his instruction in the general education classroom with a one-to-one paraprofessional and 50% in the self-contained ASD classroom. The school's multidisciplinary evaluation team administered the GARS-2; his score was 115, suggesting a very likely ASD. He frequently ran away from adults when given an instruction to complete a nonpreferred task. Timothy emitted full sentences, though often in the form of echolalia. He read words he had memorized, but did not sound out new words or read nonwords. He tested into the 47th episode of HER on the placement assessment. Timothy independently interacted with the iPad by typing two or three letters into the Safari address bar and sequentially looking at each website automatically generated from the browsers history.

Setting

The study was conducted in a suburban elementary school that served students between preschool and fourth grade. Researchers conducted preliminary observations to identify current behavioral practices used with participants. There were no observed instances of accurately implemented evidence-based practices for increasing desired academic skills. None of the children had prior experience with conditioned reinforcement systems including the token boards used in the present study. The teachers and paraprofessionals employed some visual supports in the form of showing pictures of desired behaviors (e.g., sit down, quiet) or preferred items and activities from which the child could select. Edible items were used as rewards for behaviors such as following directions and remaining in designated locations. However, teachers often made edible items available to children after a child refused to follow an instruction or relinquish a preferred item, or attempted to leave an instructional setting. For example, if a child attempted to leave an instructional area, the teacher might show the child a piece of candy and say "sit down, and then you can have a skittle." Error correction (with and without redirection) was the most common consequence-based tactic we observed.

Sam, Alex, and Timothy completed the HER teaching episodes in a designated ASD classroom during one-on-one teacher instruction. The other children in that

classroom remained in the room and worked with paraprofessionals at various learning centers. The classroom teacher was beginning her second year working with children with ASD. She held a Masters degree and teaching endorsement in the area of learning disabilities and had enrolled in her first two courses in a graduate program leading to an endorsement in ASD at the time this study started. Although students were in a self-contained classroom and had one-to-one paraprofessional support in the general education classroom when the study started, the school was actively working toward moving all students with ASD into full-time general education placements with no designated one-to-one support staff.

Isabelle completed the HER episodes during her 30 minutes of resource room support. Her sessions were completed with the resource room teacher in a quiet setting (e.g., school conference room, computer room, library). Isabelle's teacher had 30 years of special education teaching experience. She did not hold a teaching endorsement in ASD, but attended multiple years of professional development in this area that was provided by a state initiative to support teacher training in ASD.

Materials

Teachers used a MotivAider® (Behavioral Dynamics Inc., 2014) vibrating timer to prompt them to record data at the end of a 15-s interval and a researcher created data collection sheet and pencil to code responses. HER episodes were initially administered using an iPad 2 (Apple, 2014) and accessed through the Photon web browser, an application that translates Flash embedded content for display on an iPad. Episodes lagged and occasionally froze when displayed on the iPad 2; the Microsoft Surface Pro 2 tablet (Microsoft, 2014) was therefore also used to administer HER episodes. The Surface Pro 2 has a fourth generation Intel® Core™ i5 Processor and built in Flash Player (Microsoft, 2014) and displayed the HER episodes without lags or other disruptions. Token economy materials included a 12.5 cm X 30 cm laminated poster board with 2.5 cm X 2.5 cm pictures of rules for each student to follow and stars (i.e., tokens) students could periodically earn. All stimuli were fastened to the token board with Velcro™.

Measurement of the Dependent Variable

Three dependent variables assessed in this study including the percentage of intervals participants engaged with HER, the percentage of intervals participants engaged in behavior that interfered with completing HER (i.e., interfering behavior), and the participants' number of correct interactions within the HER program per minute. For an interval to be coded as an instance of engagement, the student had to (1) orient his or her head toward the computing device and not look away for more than two consecutive seconds and (2) interact with the HER program by touching the screen when instructed and in the manner instructed. If a participant navigated outside of HER dur-

ing an interval, the interval was coded as non-engaged. Similarly, if a participant used two fingers to repeatedly zoom in and out, the interval was coded as not engaged. Whole interval sampling was used to code engagement or non-engagement during 15-s intervals within a 5-min observation period that occurred at the beginning of the scheduled experimental session.

Interfering behavior was defined as aggression; self-injury; property damage; aggression toward objects without damage; yelling or screaming; getting out of seat and more than an arm's length away from the computing device; navigating out of the HER program; or refusing to begin a session or interact with the device. Interfering behavior was recorded using a partial interval sampling method during 15-s intervals during the same 5-min observation period identified above.

Correct interactions per minute (CIPM) was defined as the number of accurate responses (i.e., touching the correct stimuli on the computing screen) when presented with HER stimuli divided by the total minutes of engagement in the HER session. The HER protocol collects total interactions, percentage of correct interactions, and total minutes in the program. From these data, the researchers multiplied total interactions by the percentage of correct interactions and divided by the total number of minutes in the session to compute the CIPM.

Interobserver agreement (IOA) was obtained for engagement and interfering behavior by having two observers independently record the dependent measures for a minimum of 30% of all sessions for each participant, evenly distributed across experimental conditions. Observers were trained to a criterion of 90% agreement with the first author prior to conducting independent observation sessions. To calculate agreement, each interval was scored as an agreement or disagreement. Total agreements were then divided by the sum of agreements plus disagreements and multiplied by 100 to obtain a percentage. During baseline, mean IOA was 87% (range, 74% to 100%) and 91% (range 90% to 100%) for engagement and interfering behavior, respectively. During intervention, mean IOA was 94% (range, 85% to 100%) and 99% (range, 96% to 100%) for engagement and interfering behavior, respectively.

Experimental Design

A multiple baseline across participants design was used to examine the effects of adding a behavior intervention package to HER sessions on the dependent variables. Performance of all participants was simultaneously assessed under baseline conditions and until responding was stable for at least one participant. At that time, the intervention was administered to the first participant and then sequentially to remaining participants. All participants remained in the baseline phase until stable responding was observed.

The behavior intervention package consisted of differential reinforcement of incompatible behavior and response interruption and redirection, and was applied by the teacher to increase engagement with HER. Because Sam and Alex consistently

demonstrated almost no engagement with HER during baseline, they received the intervention prior to Timothy and Isabelle. The criterion to shift a participant from baseline to intervention was two or more consecutive sessions below 60% engagement and a clear change in level of engagement when the intervention was applied to the preceding participant.

Procedures

All participants completed the HER placement assessment prior to beginning baseline. All participants started with episode one, except Timothy who started with episode 47. Also prior to beginning the baseline condition, all participants were required to complete a set of introductory tutorials entitled "Mousing Around". These tutorials are part of HER and are used to introduce the computer-based interaction, navigation, and some of the language used in HER sessions. This preliminary program was completed with the assistance of the classroom teacher or a member of the research team who provided prompts to complete the training tasks and offered encouragement and praise to students for completing the sessions. Following completion of Mousing Around, participants started HER sessions under baseline conditions. Only the classroom teacher and researchers had access to the login information for administering HER sessions. The teacher was asked to only administer sessions once per day as part of the research study and there was no evidence to suggest students accessed additional sessions.

Baseline. The purpose of the baseline condition was to assess participant interaction and engagement with HER when presented with no additional instruction or support from the teacher. To begin a baseline session, all participants were instructed to sit at a table with a teacher; no other students were at the table. The teacher placed an iPad 2 tablet with the student's HER session loaded and delivered the instruction "time to do your reading." At this time, the teacher started a timer to record engagement and interfering behavior data during the first 5 minutes of the baseline session. The teacher provided no additional instruction, prompts, or reinforcers to the student. The student was free to interact with the HER program, navigate out of the HER program, or enter into other applications on the tablet. If the student got up from the table, the teacher redirected the student by saying "you are not done with your reading, come back to the table" up to three times, but did not provide any additional prompts to return to the instructional area. Baseline sessions were terminated when the student stopped interacting with HER for 5 min or when the student finished an episode; the latter never occurred.

During baseline sessions, the researcher and teacher recorded behaviors that interfered with participants engaging with HER. The two most common interfering behaviors for each participant are listed and defined in Table 1. These behaviors were used to inform the selection of incompatible behaviors for each participant that could be reinforced during the intervention condition (see below).

Table 1

Individual student rules during intervention sessions

Student	Interfering Behaviors	Rules	
Sam	1. Exited program by pressing home button 2. Touched screen before instruction was given	Stay in reading: the reading program needed to continue running on the screen of the tablet (i.e., could not click/swipe out of program or turn off tablet)	Wait to answer: leave hands on table until the program delivered a complete instruction, then select response
Alex	1. Exited program by pressing home button 2. Left instructional area	Stay in reading (see above)	Stay in chair: remain in the chair at the table while completing intervention sessions
Isabelle	1. Restarted segments 2. Left instructional area	Follow the program: after completing a segment, let the program run and do not reset to view previous content	Stay in chair (see above)
Timothy	1. Zoomed in and out of program 2. Touched screen before instruction was given	Use one hand: touch the screen with one hand at a time (to eliminate zooming in)	Wait to answer (see above)

Intervention. The behavior intervention package consisted of differential reinforcement of incompatible behavior (DRI) and response interruption and redirection (RIRD). These components were selected based on observations conducted by the first author in the classroom prior to the current study, as well as when children completed Mousing Around and baseline sessions. During these observations, participants intermittently followed directions and performed a number of conditional discriminations (e.g., matching spoken word to object or picture of object). However, the children did not reliably follow basic instructions or engage in academic tasks, presumably due to a lack of reinforcement delivered by educators for doing so. DRI was therefore used to reinforce rule-following behaviors, which were incompatible with the interfering behaviors identified during baseline and depicted in Table 1. For example, if a participant was observed to press the 'home' button on the iPad during HER, the rule for that participant was "stay in reading" and reinforcement was administered contingent

on the student independently staying in the HER program for a designated period of time. RIRD was used to lightly block and physically redirect attempts to engage in the interfering response. For a participant who clicked the 'home' button during reading instruction, RIRD involved physically stopping the child's hand from contacting the 'home' button and guiding his or her hand to a location in front of the screen, though prompts to touch the screen were not administered.

The intervention sessions started in the same manner as baseline with the student and teacher alone at a table. During intervention sessions, students were immediately presented with a menu of two or three pictures representing preferred items and instructed to select the picture of the item they wanted to earn. Preferred stimuli were identified by the teacher's observations of items available in the classroom and that each child often engaged in problem behavior to obtain. Once a child selected a picture, the teacher instructed the child to place it on an empty space on a token board, which had picture icons displaying the child's rules to follow and space for up to 10 tokens.

Tokens were conditioned as reinforcers during the first intervention session. The session began with one token removed from the board. Participants earned the token contingent upon independently following designated rules (Table 1) while completing one independent interaction with the HER program; tokens were delivered for rule-following behavior, regardless of correct or incorrect discriminations of stimuli presented via the HER program. An independent interaction was defined as the child touching a stimulus on the screen when instructed, as opposed to attempting to press the 'home' button, the off button, or leaving his or her seat. If the child broke a rule (e.g., attempted to exit HER), the teacher redirected the child to engage with HER and the child did not earn a token. Another opportunity was immediately presented, and the child could earn a token contingent on independent rule-following behavior. Once the child engaged in an independent HER interaction, the teacher delivered a token and behavior specific praise for rule-following, and then prompted the child to trade in his or her tokens for the pre-selected preferred item. The child was then given time to consume the item, if edible, or approximately 30 s to interact with preferred stimuli (e.g., crayons and paper). The process was replicated until a child independently engaged in one interaction with the HER program across three consecutive opportunities.

After a participant reliably performed a single independent interaction, token reinforcement was delivered on a fixed interval (FI) 15-s schedule. Participants were required to independently follow rules after being presented with HER on the iPad 2 for 15 s in order to obtain the token and trade in for a preferred item. If a participant broke or attempted to break a rule during a session, the teacher interrupted and redirected the interfering response and did not provide a token at the end of the interval. When a child demonstrated independent rule following for 15 s across two consecutive opportunities, an additional token was removed prior to the next administration of the token board, thus requiring children to demonstrate independent rule-following for two 15-s intervals in order to trade in for a preferred item. Each time a participant

acquired all tokens with no instances of interfering behavior or non-engagement across two consecutive administrations of the token board, an additional token was removed prior to the next administration, until all 10 tokens were removed from the token board. The terminal schedule of reinforcement was thereby thinned while a FI 15-s schedule for delivering token reinforcement was sustained. A HER intervention session continued as long as the child independently selected a preferred item or activity from the picture array prior to starting a token board administration. Mean session length was 5 min, 48 s (range, 33 s to 18 min, 16 s). All children progressed to full token economy implementation (i.e., 10 tokens were removed from their token boards) by the end of the fifth intervention session.

Once participants progressed to earning 10 tokens prior to trading in for a preferred item, the duration of the interval was gradually increased to a maximum of 1 min, thereby requiring 10 min of independent rule following to obtain the preferred item. In addition, the teacher moved approximately two to three m away from the participant to observe HER interaction from a distance. The teacher approached the child at the conclusion of each interval to deliver a token contingent on the child following rules for the entire interval.

The study was scheduled to continue in order to determine whether participants could sustain engagement with HER and whether additional educator support would be necessary to progress through certain episodes. However, the classroom teacher left in the middle of the school year to accept a position in another district. Despite our request to continue the study with a new teacher, the district replaced the teacher with a temporary substitute and asked the researchers to terminate research activities in that classroom.

Procedural Integrity

A trained observer measured the accurate implementation of the behavior intervention using a categorical checklist (available from first author) during a minimum of 20% of all intervention sessions across participants. Checklist components included accurate use of materials, choice of preferred items, interruption and redirection, presentation of tokens, praise, and trade in procedures. Mean percentage of procedural integrity during sessions for Sam, Alex, Isabelle, and Timothy was 88% (range, 64%-100%), 100%, 90% (range, 75%-100%), and 80% (range, 77%-83%), respectively.

Results

Effects of the behavior intervention package on levels of engagement and interfering behavior for each participant during baseline and intervention conditions are presented in Figure 1. During baseline, Sam's mean percentage of intervals with engagement in HER was 1% (range, 0% to 5%), and interfering behavior was 98% (range, 95% to 100%). He demonstrated an immediate increase in engagement and

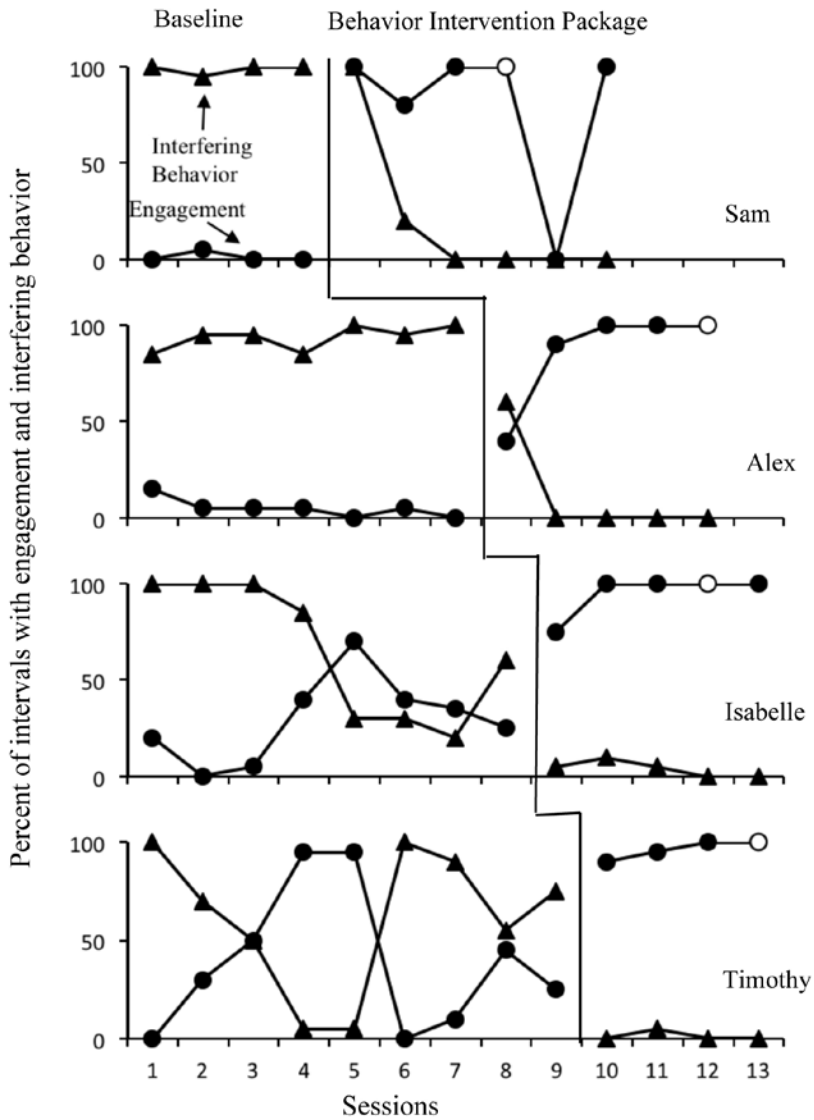

Figure 1. Percentage of intervals participants were engaged in reading (circles) and engaged in an instance of interfering behavior (triangles) during the first five minutes of a Headsprout® Early Reading session. Open circles indicate the session during which token economy reached full implementation (i.e., all 10 tokens removed).

relatively rapid decrease in interfering behavior once the intervention was implemented. Mean engagement increased to 80% (range, 0% to 100%) of intervals during the intervention, while interfering behavior decreased to a mean of 20% (range, 0% to 100%) of intervals.

Alex demonstrated a pattern similar to Sam with mean baseline levels of engagement at 5% (range, 0% to 15%) of intervals and interfering behavior at 93% (range, 85% to 100%) of intervals. Alex's levels of engagement and interfering behavior changed immediately when the intervention was implemented. Mean percentage of intervals engaged during intervention was 86% (range, 40% to 100%) while interfering behavior decreased to 12% (range, 0% to 60%).

Isabelle demonstrated some variability in engagement during baseline with a mean of 29% (range, 0% to 70%) of intervals engaged. During intervention, this stabilized and increased to 96% (range, 75% to 100%). Her interfering behavior was also variable during baseline with a mean of 65% (range, 20% to 100%) of intervals. This decreased and stabilized to near-zero levels during intervention with a mean of 4% (range, 0% to 10%) of intervals with interfering behavior.

Similar to Isabelle, Timothy demonstrated variable levels of engagement and interfering behavior during baseline. Mean percentage of intervals engaged with HER and engaging in interfering behavior was 39% (range, 0% to 95%) and 55% (range, 5% to 100%), respectively. Responding changed immediately when the behavior intervention package was applied; Timothy engaged with HER for a mean of 96% (range, 90% to 100%) of intervals and demonstrated interfering behavior at a mean of 1% of intervals (range, 0% to 5%) during the intervention condition.

Results of the behavior intervention package on participants' CIPM with the HER program are depicted in Figure 2. Overall, participants engaged in relatively low levels of responding during baseline and demonstrated an immediate increase in CIPM once the intervention was implemented. Sam and Alex engaged in zero interactions per min during baseline, as they essentially clicked out of the HER program as soon as the tablet was handed to them. They spent the 5-min session engaged with other activities on the tablet. Sam and Alex both demonstrated an immediate change in responding when the intervention was applied. Mean CIPM during intervention on the iPad 2 for Sam and Alex was 5.2 (range, 0 to 15) and 6.4 (range, 3.5 to 8), respectively. When the tablet was changed from an iPad 2 to a Surface Pro 2, Sam immediately demonstrated greater consistency in performance and an upward trend in responding across sessions ($M = 10.3$). Alex also demonstrated improved responding when the Surface Pro 2 was introduced with a mean CIPM of 13.1 (range, 5.4 to 22.5).

Isabelle and Timothy each demonstrated slight variability during baseline, with bursts of interactions followed by a return to zero interactions per min. Unlike Sam and Alex, they engaged with the HER program during some baseline sessions, but once they demonstrated errors and the program subsequently administered error correction sequences, Isabelle and Timothy exited HER and interacted with other applications on the tablet. Isabelle's mean CIPM during baseline was 1.85 (range, 0 to 8.8) and Timo-

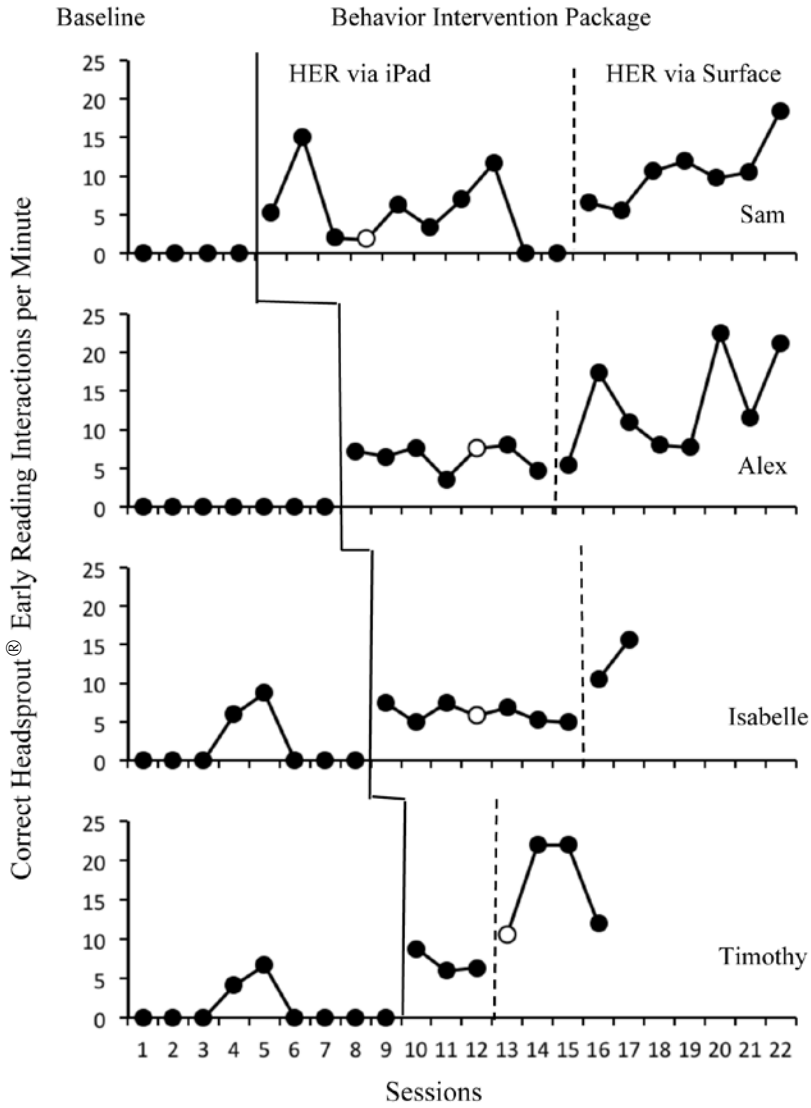

Figure 2. Rate per minute of correct interactions during Headsprout® Early Reading episodes across participants. Dashed line indicates change in tablet from iPad-2 to Surface Pro 2 for each participant. Open circles indicate session during which token economy reached full implementation (i.e., all 10 tokens removed).

Table 2

Summary of Headsprout® Early Reading program progress

	Total episodes completed	Mean sessions per episode	Mean percent correct
Sam	4	4.25	81
Alex	5	3	86
Isabelle	4	3	88
Timothy	2	3.5	90

thy's was 1.2 (range, 0 to 6.8). Isabelle and Timothy both demonstrated an immediate change in the consistency of responding when the behavior intervention package was introduced. Isabelle had a mean CIPM of 6.1 (range, 4.9 to 7.5) when using the iPad 2 and 13.1 (range 10.5 to 15.7) when using HER on the Surface Pro 2. Timothy had a mean CIPM of 7.0 when using the iPad 2 (range, 6.0 to 8.8) and 16.6 (range, 10.5 to 22) when using the Surface Pro 2. Neither Timothy nor Isabelle returned to zero-rate responding, as observed during baseline sessions, during the intervention condition.

Table 2 depicts HER episode completion data for each participant. Children completed only a handful of episodes due to the emphasis on training independent engagement with HER and to the premature termination of the study. All children completed episodes with greater than 80% accuracy, speaking to the potential of the initial HER episodes to teach correct responding to children with ASD.

Discussion

The primary objective of the present investigation was to assess whether a behavior intervention package increased independent engagement of children with ASD with HER. Participants demonstrated an increase in engagement and decrease in interfering behavior each time the intervention was applied and sustained engagement as educator support was faded, indicating they did learn to independently interact with HER. A second objective was to evaluate whether children with ASD progress through HER once a behavior intervention is implemented to address behaviors that interfere with engagement. All children did demonstrate an increase in CIPM when the intervention was applied. And although two of the children had some CIPM for two sessions during baseline, interactions could not be sustained once children engaged in errors in responding. Upon introduction of the behavior intervention, children persisted with HER despite making errors. Once the Surface Pro 2 was identified and used to deliver HER, all children had more than 10 CIPM, showing preliminary potential for children with moderate to severe ASD to independently progress through the HER program.

Inter-participant variability in responding was observed when children were presented with the technology in isolation during the baseline sessions. Sam and Alex immediately exited the HER program and entered other apps on the tablet. Isabelle and Timothy both interacted with the HER program to some extent during baseline, but not in the manner intended. Isabelle learned she could press the back button and exit the HER program, log in to her account, and restart a previous segment or watch a post-segment cartoon with no demands to actively respond. This behavior allowed for an isolated interval scored as not engaged (when she logged out), but the subsequent interval(s), during which she completed the same segment she had just finished, was scored as engaged. Therefore, although she was engaged in HER, she was not actually progressing until the rule "follow the program" was implemented as part of her intervention and attempts to exit the program after completing a segment were redirected (i.e., teacher gently guided her hands to rest on table). Timothy often manipulated the screen size by zooming in and out with his two index fingers while HER was running instead of selecting responses as instructed by the program. The rule "use one hand" was therefore selected for his intervention. Zooming behaviors stopped at that time and he demonstrated increased engagement with HER.

The observed levels of engagement during both baseline and intervention conditions support assumptions of Grindle et al. (2013) and Whitcomb et al. (2011) that individualized behavior interventions are needed, at least initially, to ensure engagement and limit interfering behavior for some children with ASD during HER instruction. The need for behavior interventions to support engagement was highlighted by the baseline data in the present investigation wherein the presentation of a tablet computer and the instruction to "do your reading" generally lead to low or variable engagement with HER and low CIPM with many sessions at or very close to zero across all four children. The experimental confirmation of the need for supplemental behavior intervention is important because it speaks to the absence of results based on technology alone and offers some guidance on minimal supplementation needed from intervention agents when using HER.

With the exception of Sam during his fifth intervention session, all participants demonstrated a very high level of engagement across all intervention sessions. During Sam's fifth session, the instructor starting fading her proximity to Sam, who continuously turned around in his chair to look at his teacher. Because he had looked away from the tablet for several seconds, the intervals were coded as not engaged, though Sam would ultimately turn back around and continue engaging with HER for a brief period of time. A plan was developed to adjust procedures should turning around continue to be an issue during the next intervention session, but future instances of turning around were not observed.

The present study offers an extension to previous research in that a systematic protocol for fading the behavior intervention package over time was demonstrated. The potential to gradually fade aspects of the intervention might facilitate broader use of the HER program for children with ASD in settings where sustained one-to-one

support is not possible. It is important to note that children were able to progress in the HER program and show an increase in CIPM without the discrete trial instructional strategies employed by Grindle et al. (2013). One explanation for this is that children did not progress far enough in the HER program where difficulties with the response requirement could arise (e.g., discriminating "is" and "is not"). It is also possible that the four core pedagogical approaches used in HER, *reduced errors, mastery criterion*, *guided practice, and cumulative review and application,* can be effective in teaching the reading content to some children with ASD. Our hypothesis is that the form and amount of teacher-administered instruction will likely vary across children with ASD and within an individual child as he progresses through the HER program. Research that elucidates a decision making process for practitioners to use when administering HER to children with ASD could help guide resource allocation to maximize efficient administration of HER to this group of children.

An important distinction between the technology used in the present investigation and previous studies was delivery of HER via tablet as opposed to desktop computers. Touch screen tablet computers have a number of advantages over desktop and laptop computers including: (1) simplified interaction for children who may struggle to operate a mouse or track-pad (e.g., Shimizu, Yoon, & McDonough, 2010), (2) potential preference for touch screen devices among children with ASD (Hourcade, Bullock-Rest, & Hansen, 2012), and (3) enhanced mobility of tablets. In addition, the smaller tablet devices are much easier for districts to store and distribute to groups of students. However, similar to participants in the present investigation, children can easily navigate out of the designated instructional program with tablet computers or interact with the device in other ways that interfere with learning (e.g., Timothy zooming in and out on the screen). Although it is possible to "lock" the device in a particular application, we instead opted to reinforce sustained engagement in the program to simultaneously address other interfering behaviors, such as leaving one's seat, that could arise.

Another important consideration in using a tablet computer for instructional purposes is the amount of access to technological devices children have. The participants in the present investigation had a strong preference for leisure activities on the iPad and we sometimes allowed access to those activities contingent on earning all tokens. Separate from the research study, participants were able to spend extensive unregulated time on tablet computers within the classroom. We assume that children's history with the tablets increased the likelihood that they exited HER during baseline and intervention sessions and suggest practitioners limit the amount of unregulated time on computers for children with ASD and simultaneously consider methods to help children discriminate between "free time" and "work time" on computing devices. A simple solution might be to use different covers or colored cases for leisure and work devices with the hope that children learn to associate a particular color with the expected activity.

There are several limitations to the present study that could be addressed with future research. First, early termination of the study limited participants' overall progression through HER episodes. Although participants did learn to interact independently

with HER, the extent to which this would translate to reliable completion of episodes is unknown. Replications of the behavior intervention followed by a longer term assessment, including follow-up measures of children's progression through HER could address this limitation. Second, the 5-min observation period did not account for behaviors occurring after the designated observation session. The observation duration was selected based on the minimum length of a baseline session should a child immediately exit the HER program. However, as some intervention sessions lasted much longer than 5 min, it would be important to objectively assess participant engagement during longer HER sessions to determine whether there is an optimal session duration for a child as she progresses through HER episodes. As children progress to a point where they complete an episode in a single session, the intervention may need to be supplemented or replaced by other behavioral interventions, such as the use of a break card or a visual activity schedule.

Third, the multi-component intervention package limited the conclusions we are able to draw about the necessity of each component. Empirically, the effects of RIRD subcomponents (i.e., blocking and redirection) cannot be teased apart from DRI subcomponents (i.e., contingent reinforcement, extinction, visual stimuli signaling rules and consequences). From a practical standpoint, multi-component intervention packages are often difficult for practitioners to implement, particularly if they do not receive the same level of coaching provided to the intervention agents for the present investigation. Future research could address this limitation with a careful component analysis, perhaps starting with the least intrusive procedure and sequentially adding intervention components as needed. Such research may elucidate the necessary components for replicating results and provide a trouble-shooting framework for practitioners who want to implement HER with children with ASD.

Finally, participants were not required to say sounds and words out loud when instructed by the HER program. Previous research used prompts to ensure children said the sounds and words out loud, and clearly, speaking sounds and words upon presentation of textual stimuli is an important skill for reading. Procedures to evoke saying sounds and words out loud during HER, particularly for children whose speech and language is delayed, and an evaluation of how saying the sounds and words out loud impacts reading for these children will be important for future research.

In conclusion, the present study demonstrated children with ASD can learn to interact independently with HER and, once they are able to interact, they might begin to learn the reading skills taught within the HER program. The behavior analytic strategies within HER, including explicit and systematic presentation of stimuli, reduced errors and error correction sequences, mastery criteria, and practice to fluency, align with instructional practices known to be effective for children with ASD (Watkins, 2008). Individualized interventions that bring the behavior of children with moderate to severe ASD under the instructional control of HER therefore have potential to promote early literacy among these children, which has to date been a challenging task for researchers and practitioners.

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