

The Effects of Real-Life Scene Familiarity on Accuracy When Using Visual Scenes
Displays to Organize Vocabulary on Speech Generating Devices

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Abstract

Purpose: Evidence supports using dynamic visual scene displays (VSDs) for children as between 25-40 months old. This study explored vocabulary type and the number of scenes displayed concurrently in relation to navigation skills.

Method: Thirty-one children located 54 targeted items using a 2-page liked navigational page, on a dynamic VSD. Tests of mean accuracy were completed to examine participant performance selecting the scene across three opportunities. An analysis examining relationship between performance and chronological age and receptive language was also completed.

Results: Results indicated participants increased their scene selection by an average 14% across three opportunities, without instruction. However, not occur for target symbol selection as a result of a ceiling effect occurred for the selection of individual symbols on the second page of the dynamic display. . In addition, there was no relationship between either scene and and target symbol selection accuracy to either the age of the participant nor their receptive language in this study.

Conclusion: Young children can improve their navigation skills as a result of exposure in the absence of instruction. Chronological age appeared to have a relationship that approached significance with respect to the accuracy with which participants' selected the relevant scene depicting the target symbol, but did not appear to influence participants' accuracy in locating photographs depicting a target referent on the second page of a visual scene display.

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Over 2.5 million Americans experience speech disabilities that compromise speech intelligibility (Beukelman & Mirenda 2005). For most of these individuals, augmentative and alternative communication (AAC) systems represent an important tool to assist them in meeting their daily communicative opportunities and obligations. The American Speech Language and Hearing Association (ASHA) defined AAC as an area of clinical practice that attempts to compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders (i.e., the severely speech-language and writing impaired (American Speech-Language-Hearing Association 2002)). Disabilities requiring an AAC application may be the result of either developmental or acquired disabilities. AAC systems that have been demonstrated to be effective for this population include both aided and non-aided applications (Mirenda & Beukelman, 2005). Briefly each of these applications will be described.

Describing Unaided and Aided Communication

Unaided communication systems involve the use of bodily mechanisms. Speech, natural gestures, facial expressions, sign languages, sign systems, and fingerspelling represent examples of unaided communication. Aided communication applications require support from external means. Symbols used in aided communication applications include the use of graphic mode communication systems that utilize two and three dimensional symbols (e.g. orthography, pictures, photographs, line drawings, Blissymbols™). Output mechanisms for aided communication applications include synthesized and/ or digitized speech (Mirenda & Beukelman, 2005).

Most strategies to organize symbols in aided communication applications for children have been based on conceptual models of adults without disabilities. Consequently, they may not be compatible with how young children best learn to communicate (Drager, Light, Curran Speltz, Fallon, & Jefferies, 2003; Light, 1997; Light & Drager, 2002; Light & Lindsey, 1991). For young children optimal communication systems may require interventionists to consider designs other than the use of simple isolated symbols placed on a grid of symbol locations (Blackstone et al. 2007). There are two symbol display strategies commonly used in children's aided augmentative communication displays. These include Traditional Grid Displays and Visual Scene Displays.

Describing Traditional Grid and Visual Scene Displays

In a Traditional Grid Display isolated symbols are configured in rows and columns according to specific organizational strategies (*i.e.*, by category, by activity, alphabetically, or idiosyncratically). The grid display is decontextualized in that no background or other context is paired with the isolated symbol that is displayed.

Visual Scene Displays (VSDs) are “portraits” of events people, actions, objects and activities against the backgrounds or context in which they occur or exist (Blackstone 2004.) Visual scenes can be created using photographs, line drawings or pictures. Recent technological advances (*e.g.* miniaturization, storage capacities, processing speed, video, photo and voice capabilities, and page linking capabilities) allow a wide range of possibilities in designing generic or highly personalized VSDs (Blackstone 2005). A generic VSD utilizes common generic pictures of scenes that may capture using line

drawings or digitized photos. With generic scenes, the learner would have had no direct contact with the actual environment represented in the scene. Personalized scenes contain referents and contexts for those referents with which the learner has had personal experience. For example a photograph from a trip to Hawaii could be loaded into a speech generating device to serve as a main photo or topic setter. Parameters influencing the continuum of generic to personalized visual scene have been a recent area of consideration. Dietz et al. (2006) suggested four parameters of VSDs that, when considered, influence the personalization of a visual scene: “environmental context (setting, people, objects, activities as part of the symbol), interactional context (people performing a depicted action), personal relevancy (e.g. a photograph of a learner at his own birthday party), and clarity regarding elements key to the implied relationships.” A photograph that includes these parameters should maximize the personalization (and presumed meaningfulness) of the VSD because of its familiarity to the learner (Fallon Light, & Achenbach 2003). The importance of context in graphic symbol displays as part of an aided communication system is supported by the observations that children learn vocabulary through deeply embedded social contexts (Brown, Collins, & Duguid 1989).

In describing the advantages of VSDs, Drager and Light (2003) suggested that visual scenes “(a) represent familiar events or activities thereby maximizing the meaningfulness of the representations, (b) present language concepts in context thereby providing support for children’s understanding in the early stages of language learning; and (c) organize language schematically according to event experiences, a mapping that

is congruent with young children's organization of language concepts (cf., Fallon, Light, Achenbach, 2000)" (Drager & Light, 2007, p. 209).

Without that contextual support, it may be more difficult to generalize isolated symbols to meaningful messages (Beals, 1997; Tabors, 1995; Hart & Risley, 1995; Nelson, 1996; Weizman & Snow, 2001; Light et al. 2004). Because vocabulary items in visual scenes can be represented within context, they have been theorized to reduce metalinguistic demands and facilitate early language learning (Drager & Light, et al., 2003). Non-contextually rich symbols used in traditional grid displays require using separate isolated images to convey one message about who, what, and where an event took place. Proponents of VSDs argue that a symbol embedded in a visual scene could convey all of this information simultaneously. The meaning of individual symbol elements such as people, objects and actions and associations between these elements may be more integrally related in VSDs because they involve recognizing the gist of a depicted scene or event and evaluating it as a whole rather than as component parts (McKelvey et al., 2007, Wilkinson & Jagaroo 2007). For example, using the traditional grid format, a user could string together a picture of a boy, soccer ball, and trophy to initiate conversation about a grandson who won a soccer tournament. However, the same conversation could be initiated more easily using a VSD, if the user had a single picture of the grandson in his soccer uniform holding the championship trophy on the soccer field. Formulating messages with a collection of separate symbols with limited context may be limited by the cognitive demands memory, association, and reasoning (McKelvey 2007).

Using VSDs may not result in any advantage for some preschool aged learners. Relatively limited information is available regarding the 1) cognitive skills that are required to derive an advantage from a visual scene display, and 2) the influence that repeated exposure in real environments represented in a VSD may impact the usefulness of the display. DeLoache (1995) investigated young children's skills in corresponding pictures with scale models as representations of a real room. In this task children were shown miniature objects that were hidden objects placed to in a model room that represents the real referent. They were told that a bigger toy was hiding in the same place in a larger room. Subsequently they were asked to locate the toy in the larger room. Three year olds were successful; however younger children were unsuccessful even though they were able to return to the model and retrieve the small toy which controlled for children's ability to recall the item for which they were searching. DeLoache and Burns (1993; 1994) reported similar findings using pictures of rooms. In this task, the experimenter pointed to the hiding place in the picture of the entire room. Twenty-seven month olds used photographs as well as line drawing to guide their search in a room. Results suggested that photos were more successful than line drawings as organization aids in searching. DeLoache (1991) DeLoach and Burns (1993) reported that two year old children could name objects in a room and in a picture scene. Subsequently, they were successful in retrieving an actual toy located in a room when given a verbal instruction – but– they were not successful in locating hidden objects using photos or line drawings. Even when they observed the photo being taken of the real object in the actual room where the item was placed the children were unsuccessful. Troseth, Casey, Lawver, Walker and Cole (2007) reported that two year olds who saw themselves engaging in a

retrieval task while watching themselves on videotape subsequently were successful in locating an object in the actual setting. However, when still photos were used they were less successful. The preceding evidence suggests that the representational advantages purported for VSDs with very young children are not as straightforward as often purported.

Displaying Traditional Grid and Visual Scene Displays on Fixed and Dynamic Displays.

VSDs can be used on either fixed or dynamic displays. In a fixed display, symbols are simultaneously visible to the user. Symbols on one page do not electronically link to other symbols nor lead to a new array of symbols. In a dynamic display not all of the symbols in the communication array are simultaneously displayed. The selection of a symbol on one page can result in triggering the selection of a different but related set of symbols on another page. A potential advantage of dynamic displays is that they allow access to a greater range of symbols while allowing for a smaller number of symbols per page. However, a learner must be able to navigate, which requires the ability to understand that graphic symbols are available in the system by accessing other pages of symbols that may not be directly visible.

Some dynamic displays require that a learner be able to match a superordinate symbol to a subordinate symbol. For example, a display of a child's bedroom may include a closet and toy chest among other commonly found bedroom objects. When selected, the toy chest may open to reveal the child's favorite toys, likewise when

selected the closet may open to the child's clothing. The toys and clothes in this example open to a new page in which individual items may be selected. In this application, a learner needs to match the correct symbol selection that will link them to a page containing a related symbol (Reichle, Dettling, Drager, & Leiter, 2000). This navigational skill may be particularly difficult for young children because they must hold in mind a conceptual model of the hidden pages of the system (Drager & Reichle, 2010). Additionally, they must understand the relationship between the representations used on page 1 and page 2 (which is not visibly displayed at the onset of a communicative opportunity [Light & Drager, 2007]). Other dynamic displays simply represent an enlargement of a portion of a scene. For example, in a main page a dollhouse with a wall cut away may display each room of a house with its content. If the learner wished to communicate about an item located in the refrigerator, he could select the kitchen. Upon doing so, an enlarged kitchen page would appear with enlarged features that were depicted in a much smaller in the original scene. This application may reduce cognitive load on the learner when compared to the former example in which the learner linked from a symbol on one page to a functionally related but perceptually different symbol on the second page of the display.

Examining the Efficacy of Visual Scene Displays

Several researchers have examined the efficacy of VSD with young children between one and four years of age. Variables included typically developing children and children with developmental disabilities, chronological age, vocabulary selection, navigation, and exposure with feedback.

Drager et al. (2003) and Drager et al. (2004) examined the use of two and half and three year old children to determine accuracy in locating prestored vocabulary in speech generating device technology. Symbols displays included a 2x2 grid layout of symbols on dynamic display organized taxonomically, symbols in a 5x5 grid layout on a dynamic display organized schematically, and symbols in four integrated contextual scene layout on a dynamic display organized schematically. Across exposure opportunities, the investigators monitored the children's performance on concrete vs. abstract words, and whether they were able to generalize their learning to novel vocabulary displayed in scenes. Participants were randomly assigned to one of three page layouts described above. The instructional cues initiated opportunities. For example, "Bobby wants to talk to say [targeted vocabulary word]. Please show him how to say [targeted vocabulary word] (Drager et al., 2003 p.302)," was used to direct the children to help a stuffed bear (Bobby) to communicate at a party depicted in visual scenes on a SGD.

The investigators reported that two and half and three year old children had difficulty locating targeted vocabulary in all three conditions in dynamic display settings. Performance was significantly better with the schematically organized integrated scene, compared to taxonomic and schematically organized grid displays. Drager et al. (2004) speculated that with the two traditional grid organizations children had to rely on higher order symbol relationship to understand the single symbol denoted an entire page of language concepts. They further speculated that with the contextual scene design, children had smaller representations of the actual pages of vocabulary. One possible reason that participants had difficulty locating targeted symbols may have been due to the

inability to match a superordinate symbol to a subordinate symbol. During the first learning session two and half year olds, on average, located less than one item and three year olds performed barely above chance. The children increased their performance accuracy significantly by the second learning opportunity with the contextual visual scene display. Across all four learning sessions, 12 vocabulary items were probed per session. Among the 12 available symbols, two year olds gained an average of 1.6 vocabulary words when organized in the taxonomic grid display, 1.9 vocabulary words with the schematic grid display and 4.1 words in the schematic scene display. Three year olds gained an average of 3.4 vocabulary words with the taxonomic grid display, 5.5 vocabulary words organized in the schematic grid display, and 7.0 words with the contextual scene display across the learning opportunities. From this investigation it is reasonable to suggest that two year olds have more difficulty than three year olds locating vocabulary in dynamic symbol displays when they are required to match superordinate symbol to a subordinate symbol.

Light et al. (2004) examined symbol searching accuracy with 40 typically developing four and five year olds. Page layouts that included a grid layout on dynamic display organized taxonomically, a grid layout on a dynamic display organized schematically, and an integrated contextual scene layout on a dynamic display organized schematically. A second independent variable included vocabulary type (concrete vs. abstract). Additionally, investigators examined generalization to novel symbols. They found that the four year olds and five year olds performance did not significantly differ between the three language organization system across mean accuracies (51% taxonomic

grid condition, 45% schematic grid condition, 52% schematic scene condition for four year olds and 62% taxonomic grid condition, 64% schematic grid condition, 59% schematic scene for five year old children), but five year olds were more accurate and learned more vocabulary items. They had more success selecting concrete vocabulary items compared to the abstract vocabulary.

Collectively, studies reviewed here suggest that younger children, between two and half and three years of age had significantly more difficulty locating stored vocabulary on a dynamic AAC device when it was organized in a grid layout organized taxonomically and when it was organized in a grid layout organized schematically. Comparatively, when the stored vocabulary was organized in an integrated contextual scene layout the youngest children marginally improved. Participants aged four and five year-old performed similarly using all displays.

Light and Drager (2005) examined the impact of AAC intervention (using VSDs) on the language development of ten young children (ages 15-40 months) with significant developmental disabilities (including cerebral palsy and Down syndrome). They concluded that all of the children “(a) used the visual scene displays to participate in social interactions, during the first session (one use of a visual scene display was modeled), (b) demonstrated significant increases in turn taking immediately upon introduction of the AAC technologies utilizing visual scenes; (c) sustained these gains in turn taking; and (d) learned to use other display types including traditional grid displays and hybrid displays (i.e., displays that utilized visual scenes but had some concepts displayed in a traditional grid layout)” (Light et al., 2005, p. 76). Drager et al. (2006)

found similar results in a study with four-year-old preschoolers with autism. She examined the effect of Aided Language Modeling (ALM) with two preschool children with autism aged four and four and half participated in three experimental conditions baseline, intervention, and maintenance sessions. Investigators concluded that the ALM training resulted in (1) an increase comprehension of new symbols and (2) modest and variable increases in the ability to label objects.

Olin, Reichle, Johnson, & Monn (2009) investigated the learning demands children between the ages of 24-27 and 33-36 months experienced while using a dynamic device with VSDs. They designed a main page with four visual scenes displayed concurrently depicting an integrated whole seen. The four visual scenes were approximately twenty- five percent the size of their embedded counterpart. On the embedded pages, which was an enlarged display of the selected visual scene, targeted vocabulary items were created by forming a 1.5 inch x 1.0 inch hot spot. Each targeted vocabulary item was placed approximately 2.0 inches from one another. Accuracy and response latency were recorded to evaluate children's ability to locate nine concrete vocabulary items across sessions until a master criterion of 75% was achieved. Children who were 33-36 months old met criterion faster and more accurately than the 24-27 age group. However, but mean accuracy was relatively high for all participants (82.14% for 24-27 months old and 90.97% for 33-36 month olds.)

Comparatively, there were several differences in design that separated Drager et al. (2003) and Drager et al. (2004) with the Olin et al. (2009) study. Both had a colored, whole integrated scene depicted on Page 1 (house) which was divided into four visual

scenes (four rooms in a house). However, Drager et al. (2003) and Drager et al. (2004) utilized line drawn scenes while Olin et al. (2009) used photographs. These photographs were proportionately larger than the line drawings creating larger targets for children to access. In addition to larger symbols, Olin et al. (2009) organized theirs without any foreground/background, with a 12 symbols and with overall less visual complexity. This allowed for images to be of higher resolution and eased the load of visual processing. Drager et al. (2003) and Drager et al. (2004) four visual scenes contained 61 vocabulary items that were used as probes, instruction and for a generalization. This arrangement decreased each symbols size and increased the complexity and arrangement of symbols. In addition, Drager et al. (2003) and Drager et al. (2004) included a modest foreground and background.

The two studies also chose different vocabulary types. Drager et al. (2003) and Drager et al. (2004) had 30 concrete vocabulary items and 30 abstract vocabulary items, whereas Olin et al. (2009) chose 12 concrete vocabulary items. Vocabulary items were divided up evenly between the four visual scene displays with three vocabulary items per VSDs in Olin et al. (2009) and 15 per VSD in Drager et al. (2003) and Drager et al. (2004).

Navigation between Page 1 and Page 2 were similar in the previously mentioned studies. When a room of the house was selected on Page 1, a blow-up representation of that room was available on Page 2. Essentially, the link symbols were smaller, but identical pictures to the vocabulary pages.

The performances of two- and three-year olds between the Olin et al. (2009) and Drager (et al. 2004) investigations differed greatly. Preschoolers in the Olin et al. (2009) had accuracies over 80% whereas the preschoolers' accuracies for Drager, Light and colleagues substantially lower. It is unclear if these differences are related directly to number of symbols presented, symbol size, visual complexity, vocabulary type, spacing of vocabulary selections, or the organization of language on the display.

Examining the Number of Symbols Concurrently Introduced on Dynamic Displays

Mizuko, Reichle, Ratcliff & Esser (1994) found that having fewer symbols per page from which to choose in a fixed display resulted in increased accuracy of symbol selection for young children. Drager (et al. 2003), Drager (et al. 2004) and Light (et al. 2004) concurrently introduced 12 training items with two and half- to three and half-year old children. In this latter investigation, children had extremely poor accuracy, achieving an average of 41% in four sessions. As discussed earlier, Olin et al. (2009) investigated the learning demands of visual scene dynamic display systems with children 24-27 and 33-36 months of age using nine vocabulary items. The children aged 24-27 months achieved a mean accuracy of 69.44% and the children aged 33-36 achieved a mean accuracy of 86.57%. The younger group of children reached a criterion approximating 85% correct identification with no more than seven teaching opportunities.

In relatively few and short treatment sessions young children demonstrate high competence navigating a two page linked system when language is organized into VSDs.

Certain factors may increase the rate and accuracy of targeted vocabulary selection, however it remain somewhat unclear what the most contributing variables are.

Summary and Research Question

A critical variable that appears to require further scrutiny with visual scene displays is the influence that the number of scenes and symbols within a scene has on the performance of very young children. The current investigation examined the performance with a number of symbols that fell between the number utilized in Olin et.al (2009) 12 symbols and Drager et.al (2003;2004) 60 symbols. Consequently, one purpose of this investigation was to use a nine dynamic visual scene displays with each scene containing six contextually embedded symbols to examine: (1) initial performance and performance after 3 exposure sessions among children between 25 and 40 months of age in locating scenes compared to locating individual vocabulary symbols within scenes.. A secondary objective was an examination of the correlation between performance accuracy and chronological age.

Method

Participants

Thirty-one typically developing toddlers between 25-40 months of age participated. Each participant had written consent from a parent or legal guardian that acknowledged his or her participation. Although typically developing toddlers would not likely be the population to benefit from speech generating devices, they were chosen for this study for several reasons. First, typically developing toddlers can provide information regarding basic learning strategies and/or difficulties associated with the

technology. There also is little empirical data to support using speech generating devices (SGDs) with visual scene displays (VSDs) with toddlers. Thus research with typically developing children can provide preliminary insight into the cognitive processing demands associated with different technologies and changes in performance with children across key developmental stages free from the confounding effects of motor, sensory, perceptual and other impairments. Using typical communicators as participants may (1) better facilitate the understanding of the cognitive processes that underpin the development of symbol competence, and (2) provide group level data on basic learning challenges associated with parameters of AAC systems. Finally, utilizing typically developing participants addresses the ethical concerns of spending time teaching young children with disabilities AAC technologies such as visual-scene displays that may not be the best fit for the individual's needs" (Light et al., 2004).

Setting

All sessions took place in a small, quiet room or hallway to eliminate distractions in the child's home or daycare. Participants sat next to the investigator, either on the floor or on chairs at a table. Parents or legal guardians were given the choice of observing. At times, an adult who was familiar to the child was present and/or a second investigator (in order to obtain procedural fidelity and response reliability).

Procedural Overview and Design

Children participated in a screening session and three exposure sessions within a 14 day interval. They utilized a speech generating Visual Scene Dynamic Display-Dynavox VMax™ (Series 5) and selected fifty-four vocabulary items from nine

concurrently displayed scenes respectively. Participant accuracy selecting target symbols was examined for scenes symbols and for individual item symbols. Additionally, performance in each of the two display types on the first session and third session were compared to examine practice effect.

Equipment Used to Display Visual Scenes

The Dynavox VMax™ (Series 5) speech generating device displayed experimental stimuli. It was placed on the floor or on a child-sized table.

Screening Procedures

Vocabulary comprehension, vision, fine motor, hearing, cognition and previous experience using a SGD were all screened to determine a participant's eligibility to participate in the study. A summary of participant performance on all screening measures is displayed in Table 1.

Vocabulary comprehension. The experimenter implemented the *Receptive One-Word Picture Vocabulary Test 2000 edition (ROW-PVT[Brownell, 2000])* with each participant prior to the first testing session. Participants who performed within one deviation of the test's mean performance for the chronological age of the participant passed the language screening. Participants' standard score are listed in Table 1.

Vision and fine motor. Vision and fine motor skills related to task participation were assessed in a match to sample task. Participants were to match at least eight out of nine line drawings from the *Child's Recognition and Near Point Test (Allen, 1957)*. Nine line drawings choices were scanned and displayed in a traditional three by three grid display on the Dynavox VMax™ (Series 5) display. Each line drawing was 1.5 x 1.0 inches in size and placed about two inches apart as displayed in Figure 1.

Participants were verbally introduced to the task and the nine drawing by the experimenter demonstrating how to point with the index finger to the line drawings. The children imitated “finger pointing,” and subsequently, were encouraged to point to every line drawing at least one time. When a participant made a selection on the Dynavox VMax™ (Series 5) display, the name of the item was spoken using. The AT&T Natural lab voice, Paul was the speech output and remained the speech output for the entirety of this study. The experimenter reinforced participation and the use of correct pointing techniques. If a toddler pointed with an open hand or otherwise incorrect, they were shown a model again and continued practice. Reinforcement was not contingent on learner performance.

Duplicates of the nine line drawings were scanned and printed onto index cards, with each drawing on a separate index card. Initially, the index card was placed beside the participant and the participant was shown one card at a time and asked to match or point to the corresponding picture on the Dynavox VMax™ (Series 5).

To screen vision acuity, the researcher moved and stood fifteen feet away from the participant holding up each of the cards, one at a time. The participant was to point to the line drawing on the Dynavox VMax™ (Series 5) display that corresponded to the picture being held up. The investigator provided the spoken instruction “Point to this picture” while holding up one of the index cards. The research never referred to the line drawing by name. This avoided giving a participant a verbal cue as to which line drawing to select. If a child responded correctly, as noted by the speech output of the device that corresponded to the line drawing displayed, the next index card was shown accompanied by the same spoken instruction. If a child did not respond to a spoken instruction after ten

seconds a second instruction was given. If a child still did not respond after the second verbal prompt, the card was placed in the back of the remaining cards to be prompted once more. Incorrect scores were only recorded after a participant was given two non-consecutive opportunities to match line drawing from the index card to the line drawing on the Dynavox VMax™ (Series 5) display. If a child responded incorrectly (i.e. the speech output did not match the line drawing held by the investigator), that index card was placed in the back of the remaining cards to be presented a second and final time. Participants were verbally encouraged throughout the vision screening for participation but not contingent on accuracy. To be eligible for the study, participants needed to correctly match at least eight out of the nine drawings from fifteen feet away after no more than two opportunities.

Parent questionnaire. Parents/legal guardians were provided with a questionnaire and asked to answer yes or no to six questions that included: 1.) Does your child speak English at home?, 2.) Does your child have any known or suspected hearing loss?, 3.) Does your child have any known or suspected uncorrected vision loss?, 4.) Does your child have any known cognitive, emotional or physical delays or disorders?, 5.) Does your child have any known or suspected language comprehension deficits?, and 6.) Does your child have experience using touch screen computers or any augmentative communication devices? Parents/legal guardians were also given space to list any additional comments they had on the form. This information was used to determine eligibility of a participant.

Any participant that did not speak English in their home, had a hearing, vision, language or otherwise delay/disorder was not eligible. In addition, any participant with

experience using touch screen computers and/or augmentative communication devices was also excluded from the study.

Independent Variable

Performance on (scene selection) compared to performance on (vocabulary item selection), and the effect of repeated exposure with feedback served as independent variables. Additionally performance as a function of repeated exposure was examined.

Dependent Variable

The dependent variable measured was accuracy. On the linked (second page of the display) accuracy was defined as correctly selecting the specific symbol representing the targeted vocabulary item. A correct response was scored if the speech output by the device matched the experimenter's spoken model at the outset of an opportunity. Accuracy for selecting a scene was scored correct if the scene selected contained the targeted symbol, incorrect if the scene selected did not contain the targeted symbol and incorrect if no scene was selected within ten seconds of the verbal prompt. An incorrect response was scored when the speech output of the device did not match the experimenter's spoken prompt, or if no symbol was selected within ten seconds after the spoken prompt.

If a participant correctly identified the scene, but not the specific symbol associated with a vocabulary item researchers recorded a correct response for scene selection and an incorrect response for vocabulary selection. However, if the participant did not correctly identify the scene, an incorrect response was recorded for scene selection and specific vocabulary selection. For example, following the prompt "Can you show me the ice cream?" a participant could score one of three ways. Accuracy was

judged correct if the child first selected the dining room and then the ice cream. Accuracy was half correct if the child first selected the dining room (correct) and anything but the ice cream (incorrect.) Accuracy was incorrect if the participant selected any scene that was not the dining room.

Experimental Stimuli

Visual screen displays. A dynamic symbol display was utilized in the experimental task. Nine visual scenes organized in a 3 row by 3 column display with fifty-four target vocabulary items embedded on 7x9.5 inch screen. First, nine colored scenes included included a: (1) Bathroom Scene, (2) Bedroom Scene, (3) Dining Room/Birthday Scene, (4) Family Room Scene, (5) Front Entry Scene, (6) Kitchen Scene, (7) Animal/ Barnyard Scene, (8) Playground/Toy Scene, and a (9) Transportation Scene. Each scene was 1 $\frac{3}{4}$ x 2 $\frac{3}{4}$ inches and linked to a second scene containing a larger, 7 x 9.5 inches, representation of that scene with the other eight scenes removed from the display.

Each scene housed six targeted symbols consisting of colored digital photos that matched the scene thematically. The photos also included other items that provide context for the scene, but are not targeted vocabulary items. Each of the six-targeted symbols within a scene were created into hotspots. The hotspots containing each symbol differed slightly in size and shape, and were designed to match the size and shape of targeted symbol in the context of the visual scene in which it was displayed. For example, the hotspot for the bottle was smaller in size than the hotspot for the train to maintain relative size integrity of the items depicted.

All photographs of scenes were created using a Casio Exilim™ 7.2 mega pixel digital camera. Several target vocabulary items were digitally cut and inserted into the scene, or modified using *Adobe® Photoshop® CS4*. Each of the scenes is provided in Appendix A. All digital photos were downloaded into a Dynavox VMax™ (Series 5) speech-generating device in a schematic scene organization. The AT&T voice (Paul) was selected as the speech output voice.

Vocabulary items. Fifty-four target vocabulary items were selected from a composite list of initial object names that 65% of 24 months olds comprehend according to the MacArthur Communication Development Inventories (MCDI). The fifty-four vocabulary items were grouped into the nine scenes described in the previous section. All vocabulary items chosen were developmentally appropriate for toddlers and represented object names. Each vocabulary item, including the MCDI percentage of children 24 months of age that understand the target item are displayed along with percentage of 24 month olds who comprehended the item in Table 2.

Examining Symbol Goodness of Fit with the Scene in Which It Was Placed.

To examine the validity between each targeted vocabulary item and the scene in which it appeared, each targeted symbol was rated by a group of fifteen graduate students enrolled in speech-language pathology and audiology and practicing speech language pathologists with respect to the goodness of fit with the scene in which it was placed. Each rater randomly viewed one scene at a time, on the Dynavox VMax™ (Series 5), and rated each vocabulary item on a 5-point Likert scale. Each item on the scale was anchored with respect to its goodness of fit with the scene in which it was placed as follows: (1) poor representation, (2) “ok” representation, (3) acceptable representation, (4) good

representation and (5) excellent representation. Any symbol with an average rating that was less than a 3.5 was deleted from the scene and a new item was selected. Any scene that averaged less than a four rating was not used. Anytime a change was made to a vocabulary item, the scene was re-rated again by another group of fifteen adults. Table 3 displays each vocabulary word's scored average, with values closest to five indicating a well matched vocabulary item to a scene.

Speech comprehension of the experimental stimuli. Each of the fifty-four targeted vocabulary items used in the VSDs was screened prior to the testing sessions. This information was gathered to verify participants' prior receptive knowledge of the selected vocabulary items. Each vocabulary item was represented using color, obtained from Google™ Images, and approximated digital photographs used in the experimental tasks. Representations were approximately 2x3 inches in area. Four representations were placed on one page. A fourteen page binder housed the target symbols. Participants were given a spoken instruction, such as “point to the ___” (targeted vocabulary item)”. Since vocabulary items were represented four to a page, the experimenter prompted one vocabulary item per page and then proceeded to the following page. This decreased the possibility of a child responding by process of elimination. Once the last page of the binder was reached, the investigator returned to the beginning of the binder and prompted a second and different vocabulary item on that page. This cycle continued until every vocabulary item had been prompted. The vocabulary items were presented in a random order. Participants were reinforced for participation during the screening and experimental portion of this study using verbal praise, stickers, small trinkets and/or

candy for participation and motivational purposes. They were not reinforced contingent on correct responses and were not corrected for incorrect responses

Experimental Tasks

Following screening, each child participated in three sessions that were completed 2-5 days apart. Each testing session was approximately 20-30 minutes. During each session the participants were asked to locate all fifty-four vocabulary items from one of three counterbalanced scene orders.

Each testing session began by inviting the participant to play with a computer. Children were introduced to his/her own sticker chart and stickers. Stickers served as incentives throughout the task. Stickers were never given based on accuracy of performance, but only to increase or maintain participation. Once the participants agreed to play, the computer the task was introduced.

The investigator spoke the following narrative to the participants “This is a special computer that can talk. It has pictures that you can touch. There are many things that I need help finding in the pictures. Can you help me find them?” Once the participant agreed the investigator then used instructional prompts such as “Find the ___,” “Show me the ___”, “Where is the ___,” and “Point to the ___” followed by one thirty-six targeted vocabulary items. As an example, the investigator said “I need help finding the ice cream. Can you show me the ice cream?” The last word in the instructional prompt served as (1) a cue for the researcher to touch the white screen of the device which allowed screen to be shown to the child and (2) a cue for the child to find the vocabulary item. The

participant proceeded by selecting the scene which the ice cream was located in and then selected the ice cream.

Participants were not given opportunities to correctly select the vocabulary item if they incorrectly selected the scene display. Researchers did not correct participants' incorrect responses. When a vocabulary item was selected voice output naming the object occurred simultaneously as the screen went to a white screen. The researcher recorded the participants' accuracy, then white screen was touched which displayed the scene options and the next item was presented. Contingent on no child response, instructional prompts were repeated up to three times.

Across intervention opportunities, the order of in which targeted scenes and symbols were presented was counterbalanced from three randomly determined orders. Participants did not receive the same order for any two sessions.

Data Analysis

Procedural and response reliability. An independent observer was trained in the implementation of all procedures by first practicing with the primary researcher. Subsequently, this individual observed the primary researcher. This individual independently scored procedural fidelity and response reliability for 16% of participants. For both procedural fidelity and response reliability item by item agreement was computed using the formula $\frac{\text{agreements}}{\text{agreements} + \text{disagreements}} \times 100$.

Statistical Analysis.

Data analysis involved displaying performance accuracy from first to third session for selection of scene and selection of individual targeted symbols. To test the hypothesis that differences in scene-selection scores between sessions were significant, the data were analyzed using a repeated measures ANOVA with “session” as the within-subjects variable. The linear contrast, a measure that may be interpreted as an estimate of a linear trend or “learning effect” was applied. To examine the relationship between vocabulary and scene selection scores and the age of the participants and their receptive language score was examined using linear regression. Session 3 was chosen for this analysis to maximize the performance observed, especially on scene selection. Linear regression models were calculated for Session 3, with both score types (vocabulary and scene selection) regressed on both participant age (in months) and normalized receptive language score. Results were corrected for the number of regressions performed using a Bonferroni correction ($\alpha/4 = 0.0125$).

Results

Results will first be described for accuracy in scene selection followed by target symbols selection accuracy. A subsequent analysis examining the relationship between performance and chronological age and receptive language competence will be addressed.

Examining Accuracy in Selecting Visual Scenes

Results for the 9-scene condition are shown in Table 4 Participants accuracy selecting scenes in Session 1 ($M = 54.75\%$, $SD = 11.59\%$), Session 2 ($M = 60.66\%$, SD

= 12.28%) and Session 3 (M = 68.46%, SD = 13.84%). The mean percent correct for scene selection increased by nearly 6% from Session 1 to Session 2 and by nearly 8% from Session 2 to Session 3. Together this yielded a 14% improvement across the three sessions) with no feedback provided contingent on correct or incorrect responses.

To test the hypothesis scene-selection accuracy differed significantly between sessions, a repeated measures ANOVA with “session” as the within-subjects variable was completed. Performance across the three sessions differed significantly ($F(2, 60) = 44.21$, $p < 0.001$). The effect size, partial η^2 , was 0.596 (the proportion of the variance accounted for by the “session” variable). The linear contrast, a measure that may be interpreted as an estimate of a “learning effect,” also yielded a significant effect across sessions ($F(1,30) = 70.81$, $p < 0.001$; , partial $\eta^2 = 0.70$).

Examining Accuracy in Selecting Target Symbols

For individual symbols depicting specific vocabulary items there was a ceiling effect. An effort was made at the outset of the investigation to demonstrate that learners comprehended all individual vocabulary used. It is likely that comprehension informed production which contributed to the ceiling effect. This was necessary to control for the learners’ vocabulary skills to enable an uninfluenced examination of navigational skills. Care was taken to ensure that language skills were not an influence on learner performance. In spite of the ceiling effect, there was some growth from Session 1 to Session 3. Participants mean accuracy for selecting vocabulary in Session 1 (M = 90.8765%, SD = 6.84088), Session 2 (M = 94.1965, SD = 5.72862) and Session 3 (M = 94.1223, SD = 7.35168)

Examining the Relationship between Chronological Age and Receptive Vocabulary Competence on Selection Accuracy

The relationship between scene and target symbol selection accuracy and 1) the age of the participants, and 2) their receptive language score was examined using linear regression (Neter, Kutner, Nachtsheim, and Wasserman, 1996). We focused on scene selection Session 3 to maximize the potential influence of these two variables on the performance observed. Linear regression models were calculated for Session 3, with both score types (vocabulary and scene selection) regressed on both participant age (in months) and normalized receptive language score. Scatterplots for these results are shown in Figures 3 and 4. Results were corrected for the number of regressions performed using a Bonferroni correction ($\alpha/4 = 0.0125$).

Neither regression reached a level of statistical significance. The regression slope for scene selection on age in months was not significant after the Bonferroni correction was applied ($F(1,29) = 8.148, p = 0.0079, \text{adjusted } R^2 = 0.1924$). Additionally, the regression slope for scene selection on receptive language score did not yield a statistically significant difference ($F(1,29) = 1.655, p = 0.2085$).

Discussion

This study examined accuracy during 3 exposure sessions in locating target visual scenes and specific symbols within an array of 9 concurrently displayed visual scenes. Subsequent analyses examined the improvement in accuracy in selecting scenes and specific targeted symbols without feedback during each of three opportunities with each vocabulary item. Additionally, the correlation between accuracy variables that included chronological age and receptive vocabulary skills were examined. Across three exposure

opportunities, participants improved from a mean correct response percentage of 55% correct in selecting the correct visual scene to a mean correct response percentage of 68% which represented a significant improvement. Individual vocabulary selection accuracy was very high during the first exposure opportunity creating a ceiling effect. During the initial exposure opportunity, participants mean accuracy in selecting individual symbols within a scene in was 90%. By the third exposure opportunity participants' mean accuracy was 94% which suggested a modest improvement. It is important to point out that even though there was no feedback provided to the learners there was significant improvement in performance. This suggests that young children are capable of improving their visual scene navigation skills as a result of exposure in the absence of organized instruction.

It was somewhat surprising that performance in the accurate selection of visual scenes was inferior to the selection of actual vocabulary in that the target photo was also displayed in the original scene. It seems reasonable to speculate that the 9 scenes as well as other potential symbols within each scene served as a greater distracter than occurred during the selection of individual vocabulary on a linked page. This may be further indirect evidence that the greater the number of symbols in a display, the more challenging the discrimination task even for typically developing children. It seems reasonable to hypothesize that children with developmental disabilities may find the selection of scenes even more challenging. The scenes constructed for the current investigation displayed the target symbol within the scene. It seems reasonable to hypothesize that constructing VSD's in which the main page scenes do not contain the

target symbol may represent a substantially more challenging task for learners. To date no investigations have made this comparison.

The ceiling effect demonstrated by learners with respect to performance on the selection of individual symbols (once a scene had been successfully made) was somewhat of a necessity. Symbols representing vocabulary items for which the learners had a high probability of correctly selecting were purposely chosen to better ensure an examination of navigational skills rather than vocabulary comprehension skills. The original selection of vocabulary also may explain, in part, why there was a lack of correlation between comprehension skills and performance. Additionally, participants in the current investigation all demonstrated typical comprehension skills. It is unclear whether the outcome may have been different with participants who displayed a greater range of vocabulary comprehension skills. Initial interest in comprehension was spurred by numerous studies reporting relationships between comprehension skills and numerous aspects of communicative acquisition (Clark 1981; Mizuko 1987; Sevcik, Ronski, & Wilkinson 1991; Sevcik & Ronski 2002; Sevcik 2006; 2004; Namy 2001; Namy, Campbell, & Tomasello.)

Given the results reported by Olin et.al (2009) and Drager et.al (2003; 2004) it is plausible that chronological age could have influenced learner performance.

Chronological age appeared to have a relationship that approached significance with respect to the accuracy with which participants' selected the relevant scene depicting the target symbol, but did not appear to influence participants' accuracy in locating photographs depicting a target referent on the second page of a visual scene display. It is possible that with a larger sample of participants displaying the same range in ages that

was present in the current investigation may have resulted in a significant effect of age. This may represent an important variable requiring additional investigation providing greater clarity regarding the rate at which learners master the navigational skills required in the navigational task examined in this investigation. It seems plausible that the ability to classify objects into scenes is a skill that one would expect to be closely related to the selection of the correct scene. Unfortunately, in this investigation classification skills were not examined. Typically children are beginning to display evidence of this skill between 2.5 and 4 years of age even though it continues to develop into the elementary years. Classification skills represent an important variable that have not been directly examined in VSD investigations with typically or atypically developing populations to date.

Limitation of Current Investigation

One must be careful in applying the outcomes of the current investigation to children with developmental disabilities who may be candidates for speech generating devices. Limitations involving cognitive, existing communication skills and/or attention skills may have influences on performance in the tasks that were the focus of the current investigation that differ substantially from the typically developing children's performance. Additionally, the experimental task used had limited external validity in that it did not represent a natural communicative exchange. Finally, the sample of children in this investigation was relatively small which may have made significant outcomes more challenging to obtain.

Implications for Future Investigations

An area requiring further exploration is the influence that the number of different scenes and number of different symbols within a scene may have on learner performance. Often, interventionists working with children who use speech generating devices concurrently display as many as 36 symbols so that they can model the symbol use in the natural environment. Thirty-six symbols could be arranged in a number of different scene configurations, (2 scenes each depicting 18 vocabulary, 3 scenes each depicting 12 vocabulary, 4 scenes each depicting 9 vocabulary, and so on). Current evidence suggests that the greater number of scenes in a display may increase learner's navigational challenge, so if we reduce the number scenes but maintain the number of vocabulary how will learner's fair. And, how would varying levels of chronological age, comprehension, and classification skills affect learner accuracy.

Further investigation should examine chronological age and its relationship to developing navigation skills. Separate studies could set criterion of achievement and record rate of learning by age. Difficulty of navigation could be measure in terms of increased by number of displays, complexity of display, etc. This study may help interventionist to begin introductions of SGDs at an appropriate developmental level (e.g. 12 symbols or 36 symbols. As we

With respect to main-page scenes, there has been a propensity to display the target symbol as part of the initial scene that the child must select in order to navigate to a second page that allows the actual target symbol (as was the case in the current investigation). Future research should compare this method of displaying a visual scene dynamically with a display option in which the original scene displayed does not contain

the target symbol that is the target symbol (for example, an individual might select a store front of movie rental store. This scene selection would link to a page containing a number of movies with titles clearly displayed on a shelf of the store. We hypothesize that this display method would be more challenging than the first in that it places a greater premium on being able to classify items for which the learner might shop with the appropriate store front. To date, both to the two dynamic VSD display strategies have been implemented with no clear evidentiary base supporting a particular strategy.

An additional variable to further examine is the size of main page representations. Since portability is contributing factor when selecting an appropriate AAC device, and more sophisticated devices are becoming “pocket sized,” it is worth discerning the optimal size of main page representations that adequately lead preschool aged children to embedded pages. Results would indicate a degree of iconicity necessary for navigation between the main page and embedded pages on smaller, more portable devices. In the current investigation, vision acuity was screened. However, as the size of scene symbols decrease it may become increasingly more likely that learners overlook the target symbol in the scene display. This, in turn, may influence the performance of learners who may rely on target symbol redundancy between page 1 and page 2 to make correct choices.

With very young children, future investigators may wish to examine the influence of first teaching learners search paths in actual environments prior to teaching them to follow a search path using digitized photos. Learners younger than three have demonstrated consistent inability to understand representational intent of line drawings, photographs, and miniature objects (DeLoache 1991, 1995; DeLoach & Burns 1993, 1994; and Troseth, Casey, Lawyer, Walker & Cole 2007.) However, young learners

demonstrated increased success when learning was paired with verbal instruction, real objects and videography.. In one condition real scene search path intervention would precede introducing the same search path via digital photo. A second group of participants would receive a condition in which they would search for a target by using only digital symbols. Total opportunities to reach a mastery criterion would be compared across the two groups of participants.

Conclusion

This exploration with typically developing preschool aged children demonstrated that with only exposure, children were fairly accurate locating appropriate visual scene displays to access targeted vocabulary items. Chronological age, vocabulary type, the number of symbols represented and the organizational of language on displays need full consideration for each individual to maximize symbol identification. Display design is not limited to these factors, but also includes variables such as animation, color, foreground/backgrounds, and overall visual processing. As we uncover design strategies for representing, organizing, and presenting vocabulary that are appropriate for preschool learners this can be adapted into everyday practice and alleviate clinicians from have to rely on their design intuition.

In addition to design, research also needs to consider potential disadvantages and advantages with respect to individual differences in learning strategies, including but not limited to performance with initial exposure and performance over repeated practice. Chronological and developmental methods are desired to increase rate of learning, increase accuracy and efficiency of selection, and overall communicative effectiveness

through all stages of learning. Identifying optimal learning strategies will also alleviate the trial and error effort clinicians and learners must tolerate during the initial learning stages with aided communication systems.

Further research is needed to identify navigation strategies for those with developmental challenges, whether limitations be in motor movement, visual processing, language and cognition, behavior, sensory, motivation or any combination. It is vital that AAC devices support and accommodate individual skill, minimize the effect of impairment and maximize communication ability in multiple settings.

Table 1

Participant results in screening protocols

Participant	Receptive Language	Vision & Fine Motor
1	91	9
2	110	8
3	104	8
4	92	8
5	102	9
6	107	9
7	116	9
8	98	8
9	104	9
10	116	8
11	95	9
12	101	9
13	91	9
14	124	9
15	113	9
16	106	9
17	114	9
18	100	9
19	126	9
20	99	8
21	101	9
22	111	9
23	121	9
24	121	9
25	105	8
26	108	9
27	129	9
28	114	8
29	111	9
30	108	9
31	99	8

Table 2

24-month old word comprehension averages according to MCDI. Range: 68.1-99.1

Scene	Vocab. 1	Vocab. 2	Vocab. 3	Vocab. 4	Vocab. 5	Vocab. 6
Bathroom 78.8	Bath 81.3	Duck 87.9	Potty 76.6	Soap 73.8	Toothbrush 72	Water 81.3
Bedroom 78.2	Bed 77.6	Bug 73.8	Light 74.8	Pants 70.1	Shoes 90.7	Socks 82.2
Dining Room 78.8	Balloon 86	Bubble 84.1	Cake 72.9	Chair 77.6	Cup 79.4	Ice cream 72.9
Family Room 85.8	Baby 90.7	Bottle 81.3	Kitty 86	Diaper 79.4	Foot 78.5	Mommy 99.1
Front Entry 75.1	Door 76.6	Hat 77.6	Key 83.2	Pizza 68.2	Phone 70.1	TV 74.8
Kitchen 79.9	Apple 84.1	Banana 75.7	Cracker 77.6	Cheese 84.1	Milk 81.3	Spoon 76.6
Animals 84.5	Bird 98.7	Cow 78.5	Horse 82.2	Flower 77.6	Pig 78.5	Dog 91.6
Playground 81.9	Ball 91.6	Bear 75.7	Book 89.7	Boat 82.2	Bunny 77.6	Doll 74.8
Transportation 76.2	Airplane 77.6	Bike 71	Bus 69.2	Car 84.1	Train 72	Truck 83.2

Table 3

Goodness to fit with the scene in which was placed at rated by group of adults on a 5-point Likert scale. Scale's anchor was (1) poor representation, (2) "ok" representation, (3) acceptable representation, (4) good representation and (5) excellent representation.

Scene	Vocab. 1	Vocab. 2	Vocab. 3	Vocab. 4	Vocab. 5	Vocab. 6
Bathroom 4.31	Bath 3.8	Duck 4.6	Potty 4.6	Soap 4.1	Toothbrush 4.6	Water 4.2
Bedroom 4.18	Bed 4.9	Bug 3.9	Light 4.0	Pants 3.8	Shoes 4.4	Socks 4.1
Dining Rm. 4.3	Balloon 3.5	Bubble 4.3	Cake 4.0	Chair 4.9	Cup 4.3	Ice cream 4.5
Family Rm. 4.42	Baby 4.6	Bottle 4.4	Cat 4.6	Diaper 4.5	Foot 3.9	Mommy 4.5
Front Entry 4.33	Door 4.1	Hat 4.2	Keys 3.8	Pizza 4.8	Telephone 4.6	TV 4.5
Kitchen 4.53	Apple 4.3	Banana 4.9	Cracker 4.7	Cheese 4.1	Milk 5	Spoon 4.2
Animal 4.53	Bird 3.8	Cow 4.2	Horse 4.8	Flower 4.7	Pig 5	Puppy 4.7
Playground 4.25	Ball 4.2	Bear 4.5	Book 4.5	Boat 4.0	Bunny 3.9	Doll 4.4
Transportation 4.58	Airplane 4.6	Bike 4.7	Bus 4.4	Car 4.9	Train 4.7	Truck 4.2

Table 4

Mean percentage correct and standard deviation for scene selection and vocabulary identifications across session.

Score Type	Statistic	Session 1	Session 2	Session 3
Scene Selection	Mean % correct	54.75	60.66	68.46
(% correct)	Std. Dev.	11.59	12.28	13.84
Vocabulary ID	Mean % correct	90.8765	94.1965	94.1223
(% correct)	Std. Dev.	6.84088	5.72862	7.35168



Figure 1. Child's Recognition and Near Point Test (Allen, 1957) as scanned in Dynavox.

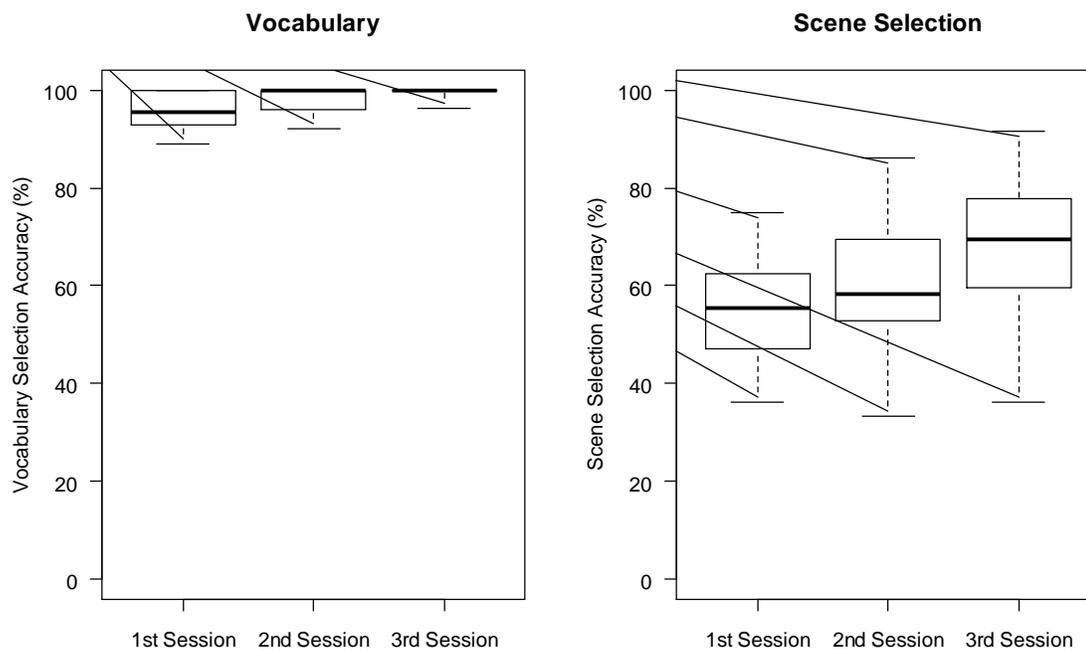


Figure 2. Box plots of vocabulary score and scene selection score (% correct) by session. The dark line represents the median the rectangle represents the extent of the interquartile range (25%-75%) and the ends of the “whiskers” represent the extreme data values.

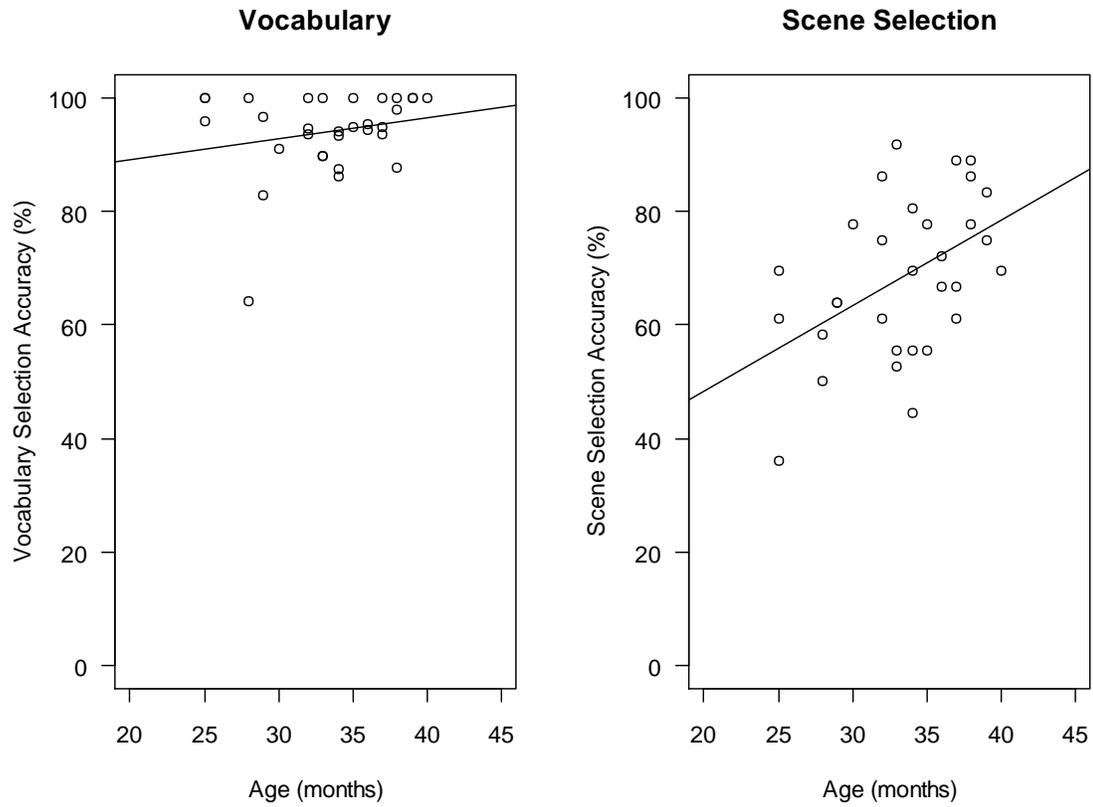


Figure 3. Scatterplots of age x vocabulary score and by scene-selection score (% correct) for Session 3. Superimposed is the linear regression line calculated for that session.

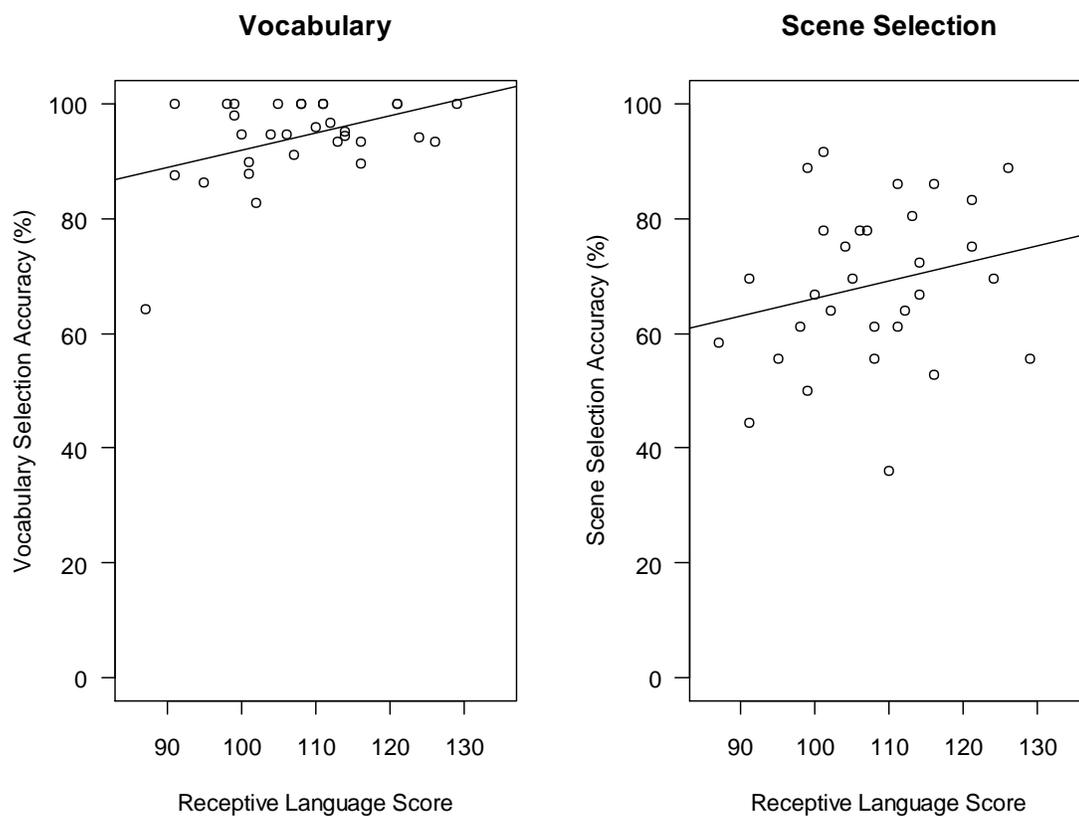


Figure 4. Scatterplots of receptive language score x vocabulary score and by scene-selection score (% correct) for Session 3. Superimposed is the linear regression line calculated for that session.

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