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The Effect of High-tech AAC System Position on the Joint Attention of Infants without Disabilities

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Joint attention is critical for language development in children. Children with complex communication needs have additional challenges in managing their joint attention, and there is minimal information on how to reduce these demands. Sixteen infants without disabilities and their caregivers participated in a within-subjects design with two storybook reading interactions. In reading, the researcher either held a high-tech AAC system directly in front of herself (aligned with eye-gaze) or to the side (divided from eye-gaze). The frequency and duration of coordinated and passive joint attention episodes were analyzed. The aligned condition resulted in significantly greater frequency and duration of coordinated joint attention than passive joint attention in episodes involving the AAC system. Age was significantly related to frequency and duration of joint attention only in the aligned condition. Future directions and clinical implications are discussed.

Keywords: Joint Attention; Augmentative and Alternative Communication

INTRODUCTION

Although early intervention in AAC has previously focused on unaided and simple digitized system intervention, high-tech AAC strategies have been implemented with young children with complex communication needs (Light & Drager, 2007). When aided AAC strategies are considered, it is crucial to evaluate the attentional demands of the context and technologies used (Light & Drager, 2007). In particular, simultaneously engaging in communicative interactions to serve a variety of functions while also attending to multiple foci poses a challenge (i.e., partner, aided AAC system, and shared activity) (Cress, 2002; Light, Parsons, & Drager, 2002). Minimizing the demands presented by aided AAC systems is essential because further advances in cognitive, social, and literacy skills are rooted in children's early speech and language development (Light, 1997; Light & Drager, 2007). A system that facilitates language expression can help children to transition from single-word to multi-word utterances, use language in a variety of contexts with a variety of partners, and build metalinguistic skills (Paul, 1997).

An important index of children's ability to shift among multiple foci is joint attention (JA; Bakeman & Adamson, 1984); that is shifting one's attention between an adult and object or other person. JA emerges reliably in children without developmental disabilities between 9–15 months of age (Bakeman & Adamson, 1984; Carpenter, Nagell, & Tomasello, 1998) and has been linked to early vocabulary and conversational skills (Markus, Mundy, Morales, Delgado, & Yale, 2000; Tomasello & Farrar, 1986; Tomasello & Todd, 1983). Social communication milestones achieved during this timeframe include following adults' eye gaze, social referencing, and imitating adults' actions on objects. These skills emerge in close developmental synchrony and represent the early stages of human social cognition and cultural learning (Tomasello, 1999). JA skills, including sharing, following, and directing attention, emerge predictably during the first 2 years. Infants begin to check adult attention at 9–12 months, follow attention at 11–14 months, and

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direct attention in an imperative fashion at 13–15 months (Carpenter et al., 1998).

Typical JA interactions are triadic in nature and involve the child, the communication partner, and the target object of interest. The complexity of the communication increases when introducing an aided AAC system into the interaction (Cress, 2002): joint attention episodes involving AAC are quadratic rather than triadic in nature because they involve the child, the communication partner, the AAC system, and the target object, such as a toy or book.

One strategy for reducing the JA demands of implementing aided AAC with beginning communicators involves manipulating the positioning of the AAC system during an interaction. Work by Butterworth and Cochran (1980) found that infants between the ages of 6–18 months of age are much more likely to engage in joint visual attention if the target is within their visual field: they consistently located targets within 40° of their midline to either side, but inconsistently located targets at the maximum distance of 75° from midline. Infants followed adult eye gaze, but fixated on a target only if it was within their visual field when using peripheral vision.

According to Clibbins (Clibbens & Powell, 2003) using a visually based modality for language places greater emphasis on JA abilities. Visual communication, such as signing or using a graphic symbol communication board, is most effective when it is in the direct line of sight of the individual (Clibbins & Powell). However, individuals using aided AAC devices must share their visual attention with the AAC system in order to generate a message, which increases the demands beyond those of using speech.

Recommendations for reducing the attention demands of early AAC users have been made (cf. Clibbens & Powell, 2003; Light & Drager, 2007). Parents participating in parent-child dyads using sign as a modality for communication, actually sign in the child's line of sight or use the child's body as the prop for the signs (e.g., use the child's face instead of the adult's face when signing CAT). For aided AAC systems, the presentation of a toy and book could be in close line of regard, symbols could be infused into a play activity, or the actual content of a book or scene could be presented within an AAC system. Another option is to pair the adult's eye gaze and the AAC system. This coupling may also lessen the quadratic demands of the interaction (Light, 2007).

Although broad measures of joint attention can serve to illustrate the relative effectiveness of strategies to minimize demands of interactions for young children, it is necessary to consider more specific aspects of attention and attention demands in interactions. In terms of the nature of the interactions to be studied, Cress, Arens, and Zajicek (2007) tracked engagement behaviors of children with developmental disabilities in structured and unstructured play. Their results suggest that embedding opportunities within more structured play tasks, such as communication temptations or elicitations of a specific behavior, led to higher levels of engagement and more complex joint attention behaviors.

Another useful framework for analyzing interactions is consideration of the components of joint attention. There are two primary types of JA engagement: passive and coordinated (Bakeman & Adamson, 1984). Passive joint attention (PJA) is the ability to attend to an object at the same time another individual is attending to the object, but without attempts to interact or evidence of awareness that the other person is also engaged. Coordinated joint attention (CJA) is characterized by shifts in attention between an object of common interest and another individual who is also attending to that object. Awareness of the other person's presence is shown by alternating eye gaze between the other person and the object, or by talking about the object or event of joint interest. PJA is the less demanding than CJA and clearly emerges earlier (Bakeman & Adamson). An understanding of both of these components (passive and coordinated) is critical in understanding joint attention demands and functions in AAC interactions.

THE CURRENT STUDY

The objective of the current investigation was to determine the effects of the alignment of a high-tech AAC system with adult gaze on the frequency and duration of JA of infants without disabilities during structured storybook reading interactions. Specifically, the researcher held the high-tech AAC system either directly in front of herself (aligned with eye-gaze) or to the side (divided from eye-gaze). To evaluate the effect of the experimental conditions, the participants were infants without disabilities. Including participants without disabilities allowed for isolation of joint attention as a variable independent of competing physical demands. Higginbotham (1995) also suggested participants without disabilities were viable choices to aid in participant recruitment and to minimize exploitation of participants with disabilities' time and energy as the important dimensions for future study are obtained. This strategy has been used in previous studies in order to define important variables of interest (see Light, Drager, McCarthy, Mellot, Parrish, Parsons, et al., 2004; McCarthy, Light, Drager, McNaughton, Grodzicki, Jones, et al., 2006; Wagner & Jackson, 2006). The current investigation was part of a larger study by the authors examining the factors associated with parents' and children's joint engagement with aided AAC in different interactions.

The research questions were the following: (a) What is the effect of high-tech AAC system position (aligned or divided from the adult's eye gaze) on the infants' frequency and duration of joint attention involving any combination of elements in the interaction (person, book, AAC system)? (b) Within each condition (aligned and divided) are there differences in frequency and duration of coordinated and passive joint attention in episodes involving only combinations with the AAC system? (c) How is age associated with joint attention episodes across conditions? It was hypothesized that the frequency and duration of PJA and CJA episodes would significantly increase when an AAC system was aligned with adult gaze compared to when the AAC system was divided from an adult's gaze. Furthermore, it was anticipated that the frequency and duration of CJA episodes would be significantly greater than PJA episodes in the aligned condition only. Age was expected to correlate with the frequency and duration of joint attention.

METHOD

Research Design

A within-subjects experimental research design was used. The independent variable was the position of an AAC system (aligned with or divided from adult eye gaze). The dependent variables were frequency and duration of children's passive and coordinated JA episodes when interacting with the AAC system, book, and the researcher.

Participants

Sixteen infant-parent dyads participated in the study. The infants (10 males and 6 females) ranged from 9–14 months of age ($M = 10.56$, $SD = 1.55$). Participants were recruited through advertising at local childcare centers and university-based bulletin boards and electronic advertisements. The infants were chosen for the study because they were beginning communicators who were able to participate in JA routines with their parents or caregivers. They met the following inclusion criteria: (a) identified as a beginning communicator by their parent as indicated by their responses to six target items from the Communication and Symbolic Behavior Scales-Developmental Profile (CSBS-DP): Infant Toddler Checklist (Wetherby & Prizant, 2002) indexing the ability to follow and initiate joint attention; (b) responded to at least two adult-directed bids for JA (to control for a single response by chance) during administration of the Early Social Communication Scales (ESCS; Mundy et al., 2003); (c) scored within typical limits on the CSBS-DP Caregiver Questionnaire (Wetherby & Prizant); and (d) were learning English as their primary language. Children were excluded if they (a) scored as an ‘‘initiator’’ of JA, as evidenced by a ratio of greater than 20% of higher level initiations (e.g., pointing, showing) compared to the total initiations, including lower level behaviors (e.g., eye contact, alternating), on the *ESCS* (Mundy et al., 2003); (b) used words to communicate, per parent report; or (c) had known developmental, visual, or hearing impairments. The abridged version of the ESCS (Mundy et al., 2003), as described below, ensured that the infant did not regularly initiate JA routines, because that would indicate a level of communication that was too advanced for the purposes of the study. Parent reports of word use, general development, vision, and hearing were accepted for eligibility purposes. One family discontinued participation due to scheduling conflicts.

The participants' responses to tasks on the ESCS (Mundy et al., 2003) are indicated in Table 1. The Initiating Joint Attention (IJA) behaviors are categorized as lower level (eye contact with the tester or alternating looking between an object and the tester) or higher level (pointing to an active toy or other object in the room or showing a toy by raising it upward toward the tester). Responding to Joint Attention (RJA) behaviors included following proximal point and line of regard.

Materials

The abridged version of the Early Social Communication Scales (ESCS; Mundy et al., 2003)[1] contains 25 semi-structured interactions used to elicit target behaviors; takes approximately 15–25 min to administer, depending on the child's responses and cooperation; and measures three categories of early social-communication behaviors: JA behaviors, behavioral requests, and social interaction behaviors. Behaviors initiated or responded to by the child are assessed. Behaviors are further classified as high or low level, yielding a more complete description of the infant's actual early social-communicative skills. The validity and reliability

TABLE 1 Gender and Age of Participants, and Scores on Inclusion Criteria Measures.

		CSBS-DP CQ	ESCS RJA	ESCS IJA	
Sex	Age (mos)	Standard score	Responses	Lower level	Higher level
F	9	107	2	13	0
M	9[a]	111	3	15	0
F	9	113	7	15	2
M	9	113	2	12	0
F	9	115	8	11	0
M	10	87	4	10	0
M	10	93	4	14	0
M	10	104	6	12	0
F	10	106	8	14	1
M	11	78	7	10	0
F	11	92	10	14	1
M	11	111	9	12	3
M	12	87	6	19	2
M	12	102	8	11	2
M	13	99	11	17	3
F	14	81	8	15	3
Mean	10.56	99.94	6	13.38	1.06

Note. CSBS-DP CQ = Communication and Symbolic Behavior Scales-Developmental Profile Caregiver Questionnaire. ESCS RJA = Early Social Communication Scales Responding to Adult Directed Bids for Joint Attention. ESCS IJA = Early Social Communication Scales Initiating Joint Attention.

[a]Age adjusted for prematurity.

of the abbreviated version of the ESCS (Mundy et al., 2003) has been demonstrated in several studies (Markus, Mundy, Morales, Delgado, & Yale, 2000; Mundy & Gomes, 1997; Mundy, Kasari, Sigman, & Ruskin, 1995; Mundy, Sigman, & Kasari, 1994; Mundy, Sigman, Kasari, & Yirmiya, 1988).

The Communication and Symbolic Behavior Scales-Developmental Profile (CSBS-DP; Wetherby & Prizant, 2002) is a norm-referenced evaluation tool for measuring children's communicative competence that has evidence-based validity and reliability for screening and evaluating children with developmental delays (Wetherby, Allen, Cleary, Kublin, & Goldstein, 2002). Two of the three subtests or tools within the CSBS-DP were used for the present study, including the Infant Toddler Checklist and the Caregiver Questionnaire. The Checklist was used as an initial telephone screening measure of children's social, speech, and symbolic skills. The Caregiver Questionnaire was used to assess children's emotion eye gaze, communication, gestures, sounds, words, understanding, and object use.

Stimuli

The stimuli for both conditions were developed using Boardmaker with Speaking Dynamically Pro™.[2] The stimulus pages were presented on a Sahara TufTab i310XT[3] touch screen tablet PC with a 12.1 in viewable screen and resolution set to 1280 × 800.

Two books were used in the study: *Brown Bear, Brown Bear, What Do You See?* (Martin, 1995) and *Polar Bear, Polar Bear, What Do You Hear?* (Martin, 1991), written by Bill Martin Jr. and illustrated by Eric Carle. Parents of all participants reported at least one exposure to at least one of these books. Only one parent reported these books to be "favorites" for her child. Each page of each book was scanned onto the touch screen PC.

The pages appeared on the screen as in the book; however, three additional active buttons were placed on each page. The main button activated "wav" files of actual animal sounds (e.g., there was a "roar" sound for the bear) and was embedded under the illustration of each animal. A red outline of the animal appeared when the animal was pressed and the sound was activated. The two other buttons allowed the experimenter to advance the screen forward or move backward within the book; however, these buttons were not visible on the display.

The board books were also present in each experimental condition, in order to help understand the addition of the aided AAC system as a fourth variable to the interaction. The AAC system is intended as a tool for communication, not as the toy. This knowledge is necessary in order to understand the effect on the joint attention abilities of a child of adding the AAC system within play interactions with other objects, such as dolls or blocks that cannot be scanned into the system then removed from the interaction.

Procedure

Pre-screening

The researcher conducted a preliminary phone interview, that lasted approximately 10–15 min, with all interested parents. During the phone interview, the researcher asked select questions from the CSBS-DP Infant-Toddler Checklist (Wetherby & Prizant, 2002). The selected questions addressed the most basic inclusionary and exclusionary criteria for participants. After determining preliminary eligibility, interested parents were given a choice to complete the sessions within their home ($n = 3$) or in a University research laboratory ($n = 13$). Variables, such as noise, sibling presence, and other distractions, were controlled as much as possible across the home and clinic settings.

Session 1

All interactions in Session 1 were videotaped. The camera was set at an angle to allow a view of the child's face and a profile of the adult's face (experimenter). The parent and child engaged in a 10-min free play interaction with a standard set of toys to allow the child to familiarize himself or herself with the setting. Next, the researcher and child participated in a 5-min free play interaction, with toys similar to those used in the parent interaction, to increase the child's comfort level with the unfamiliar communication partner. The parent completed the CSBS-DP Caregiver Questionnaire (Wetherby & Prizant, 2002) during this time. Lastly, the researcher completed the ESCS (Mundy et al., 2003) protocol, as the child sat in his or her parent's lap at a collapsible table at eye level with the researcher. The administration of the ESCS took approximately 15 min. Parents received $10 at the end of the session for their participation. After scoring the CSBS-DP Caregiver Questionnaire (Wetherby & Prizant, 2002) and the *ESCS* (Mundy et al., 2003) protocol, an eligibility determination was made.

Session 2

Session 2 occurred approximately one week after Session 1 ($M = 7.1$ days; $SD = 2.0$ days). The second session was videotaped with two cameras, allowing for a full view of the infant's face and a partial view of the researcher and a side view of the interaction. The high-tech AAC system was introduced in two experimental conditions, aligned and divided. The order of book and condition combinations was counterbalanced. Prior to each of the interaction sessions, the touch screen tablet PC was cleaned and calibrated to increase instrumental reliability.

In both the aligned and divided conditions, the researcher read the book with the AAC system (with the physical board book present) while sitting on a blanket on the floor. The length of the book-reading interactions was similar across participants (M length = 282.03 s; $SD = 31.68$ s; range = 242–384 s). Parents were allowed to bring a familiar comfort object for the child to manipulate during the interactions, but no parents chose to include another object in the interaction.

Similar to the administration protocol of the ESCS (Mundy et al., 2003), the infant sat in a parent's lap; however, the interaction took place on the floor instead of at a table. The parent was instructed to remain neutral, quiet, and seemingly uninvolved during the interaction, similar to the instructions given to parents during the administration of the *ESCS* (Mundy et al., 2003). The parents were asked to sit still and only smile if their infant turned to look at them during the interaction. They were also instructed to allow their child to get up if the child attempted to do so.

The procedures for the activity were similar to those used by Light (2007). The verbal script followed the text of the storybooks, with only two additions of *This is the* ____ (title) *story* at the beginning and *All done* at the end. During each reading of the story, the researcher accessed the AAC system through direct selection to activate the sound of the animal on the page, and then read the page. The researcher then turned to the next page of the book, waited 5 s, and then accessed the sound for the animal represented on that page via the AAC system. The researcher modeled direct selection on the AAC system for each page of the story when the animal was first viewable, before reading the page. There were 10 models provided during each book-reading interaction; (i.e., the number of open pages highlighting a specific animal or person in the books). The last page of the book (consisting of all animals from the story on a single page) was not included in data analyses. Brief breaks were provided between condition interactions to switch books and files on the AAC system, and as needed by the infant.

If a child became upset during an interaction, he or she was allowed a 5-min break consisting of free play with one of the toys introduced during the caregiver-child free play interactions. During these breaks, the infant could play with the parent, the researcher, or alone. The interrupted interaction was then resumed at the page following the page where it had been discontinued, thus ensuring that each page was presented only once. One of the participants required two breaks during an interaction; however, the other 15 infants took only one or no breaks during each story-reading interaction.

Experimental Conditions

In the aligned condition, the child was seated across from the researcher at eye level in his or her parent's lap. The researcher held the AAC system with the pages of the book scanned into it immediately under her face. The AAC system was aligned with the researcher's eye gaze. The board book was also present to the side of the interaction, on the floor, below the level of the AAC system. In the divided condition, the child was seated across from the researcher at eye level, in his or her parent's lap. The AAC system with the pages of the book scanned into it was placed on the floor. The board book was also present in the interaction, on the floor, on the opposite side of the experimenter (see Figure 1).

The presentation of the books and conditions were counterbalanced, resulting in four possible combinations that were each presented to four participants. The first author conducted all data collection sessions.

Figure 1. Participants and researcher in aligned condition (top) and divided condition (bottom).

Coding

Data coding procedures were adapted from Bakeman and Adamson's (1984) scheme. Transcripts of the story-reading interactions were developed and indicated where the infant was looking in relation to the time stamp of the recording for each second of the interaction. The camera angle showing the front of the infant's face was used to generate the transcripts, except during times when the view of the child was obstructed, in which case the side camera angle was examined.

Each interaction transcript was linearly coded for coordinated and passive joint attention episodes. Attention episodes or engagement states that lasted at least 3 s were coded (Bakeman & Adamson, 1984). The 3-s duration could be a single event or the combination of events, as applicable within each code.

Episodes were terminated in one of two ways: (a) 5 consecutive seconds of engagement with (objects or persons) outside of the given code occurred; or (b) four consecutive events occurred and did not contain each of the objects/persons within that code. Therefore, codes were not applied when the infants were scanning all around the room without any indication of attention to an object or person. The specific coding categories and their descriptions are as follows:

Coordinated joint attention

Episodes of CJA were coded when infants were actively visually referencing and coordinating their attention between an object and the researcher. The infants were required to coordinate their attention between the researcher and the specific object by shifting their eye gaze back and forth from the AAC system or book to the adult, indicating that they were aware of the adult's joint focus. For example, CJA was coded when infants looked at the AAC system and then shifted to the researcher and back to the AAC system. All CJA episodes contained three events that included an object and the researcher. At least two of the events were the same object or person encompassing the other target item. Back-to-back shifts between object/person or person/object initiated a CJA episode if the infant returned to the initial object/person within 5 s.

Passive joint attention

Episodes of PJA were coded when the infants were engaged with an object (either the book or the AAC system) but did not make any attempts to interact with the researcher. During PJA episodes, infants did not provide any evidence they were aware the researcher was also engaged. PJA episodes were only required to contain one event including an object, but could contain multiple events if infants were primarily interested in the object but shifted to an outside event (e.g., the camera, the wall) very briefly (less than 5 s). An object engagement event, lasting at least 3 s in duration, not meeting the criteria of a CJA, initiated a PJA episode. PJA codes were differentiated depending on the object of interest. Therefore, frequency and duration of PJA with the AAC system and PJA with the book were tallied separately.

Reliability

Coding reliability

Two phases of coding reliability were implemented. An independent coder first verified the accuracy of the transcripts used for later coding. The coder was instructed to create a transcript using the time stamp on the DVDs to indicate where the infant was looking throughout the interactions. The coder had access to both camera angles from Session 2 and independently created transcripts for 15% (3 participants/six books) of the story reading interactions. Point-by-point comparisons of event shifts revealed 92.2% agreement between the transcripts. These results were interpreted as sufficient to ensure the transcripts were reliable for continuation of coding.

The independent coder was then trained by the primary researcher on the categories of codes described previously to calculate frequency and duration of CJA and PJA. Interjudge agreement for the story reading interactions was 89.5% for frequency and 86.2% for the duration of JA episodes. These scores are comparable to coding reliability scores (85% average) from Bakeman and Adamson (1984). Following their example, an agreement was tallied only for exact agreements second by second. Disagreements were primarily variations in the transcripts fluctuating by one or two seconds. These discrepancies rarely resulted in a disagreement about frequency of occurrence (e.g., the primary researcher coded a PJA episode of 3 s but the independent coder's transcript only indicated 2 s of the object engagement and therefore did not apply the PJA code). More commonly, the discrepancies resulted in a 1-s duration difference (e.g., primary researcher coded a CJA episode lasting 12 s and the independent coder indicated the CJA episode lasted 13 s). Only exact matches were noted as an agreement. Overall, the disagreements are not believed to have an impact on the data analyses.

Procedural reliability for ESCS

Procedural reliability was calculated by an independent coder for 10% (two) of the ESCS administrations, by viewing the DVDs from Session 1. The second coder used a copy of the ESCS procedures to verify that all procedures were followed accurately. The results revealed 95.9% procedural reliability for the ESCS administrations.

Procedural reliability for story reading interactions

Procedural reliability was calculated by an independent coder for 10% (two) of the story reading interactions by viewing the DVDs from Session 2. The individual used a copy of the interaction script to determine all procedures were followed accurately. The results revealed 97.8% procedural reliability for the condition interaction administrations.

RESULTS

A one-way ANOVA was used to evaluate the effectiveness of the counterbalancing scheme. No significant differences were found between the four conditions for frequency or duration of the forms of joint attention $F(3,60) = .17$, $p = .92$ and $F(3,60) = .14$, $p = .94$) indicating that the order of book or experimental condition did not have an impact on the results.

There were no significant condition differences on the overall frequency or duration of PJA episodes in aligned versus divided AAC system placement conditions, $t(15) = -1.68$, $p = .114$, $d = .40$ (M aligned $= 3.44$, $SD = 2.25$; M divided $= 5.38$, $SD = 3.98$) and $t(15) = -.62$, $p = .545$, $d = .15$ (M aligned $= 44.19$, $SD = 66.10$; M divided $= 58.63$, $SD = 45.43$). There were also no significant condition differences for the overall frequency or duration of CJA episodes in the aligned versus divided AAC system placement conditions, $t(15) = 1.26$, $p = .226$, $d = .30$ (M aligned $= 5.06$, $SD = 2.93$; M divided $= 3.88$, $SD = 2.30$) and $t(15) = -.22$, $p = .826$, $d = .05$ (M aligned $= 119.63$, $SD = 61.90$; M divided $= 125.31$, $SD = 72.17$).

Although there were no significant condition differences for the overall frequency and duration of joint attention including the AAC system and book, the effects of AAC system placement on episodes of joint attention that the infants shared with the AAC system were of particular interest (i.e., alternations between the AAC system and adult), as the addition of the AAC system to the interaction is the novel aspect of this study. We

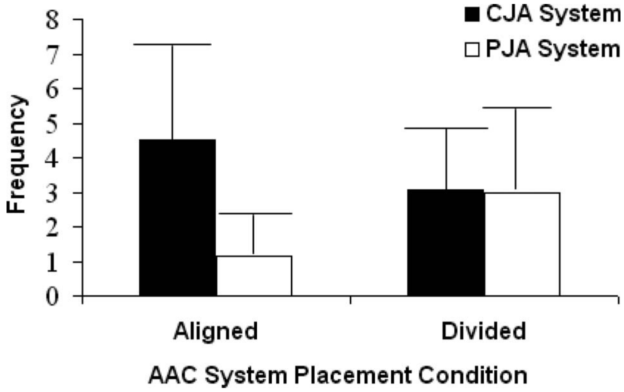

Figure 2. Mean frequency of coordinated joint attention (CJA) and passive joint attention (PJA) as a function of AAC system position.

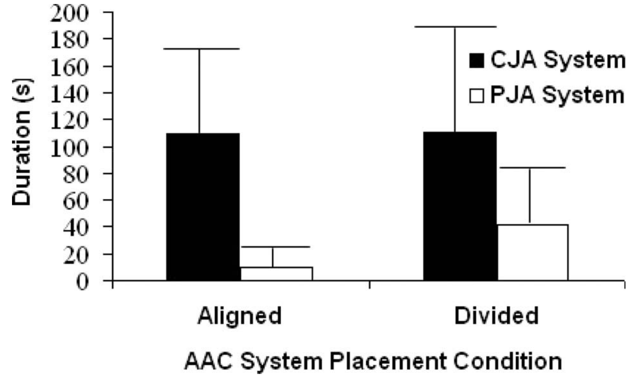

Figure 3. Mean duration (s) of coordinated joint attention (CJA) and passive joint attention (PJA) as a function of AAC system position.

hypothesized that, in the aligned condition, there would be more coordinated than passive joint attention episodes in bouts involving the AAC system. Within the aligned condition, the frequency of CJA was significantly greater than the frequency of PJA with the AAC system, $t(15) = 4.33$, $p = .001$, $d = 1.03$. However, there were no significant differences between PJA and CJA in the divided gaze condition, $t(15) = .08$, $p = .940$, $d = .02$ (See Figure 2).

Significant duration differences between CJA and PJA with the AAC system were also found in both the aligned and the divided gaze condition, $t(15) = 5.91$, $p = .000$, $d = 1.40$ and $t(15) = 2.81$, $p = .013$, $d = .67$, when using a p level of .05. However, after adjusting the p level to account for use of multiple t-tests (.05/4) the latter finding between JA types in the divided gaze condition was no longer significant (see Figure 3).

The relationships among age and the JA measures were examined using one-tailed Pearson product-moment correlations (see Table 2). Age was significantly related to the frequency and duration of CJA as well as the duration of PJA in the aligned condition, all $r > .43$. Age was not significantly associated on these variables in the divided condition. Frequency and duration of CJA were highly correlated in both conditions; however, the frequency and duration of PJA were significantly correlated only in the divided condition.

DISCUSSION

Summary of Major Findings

There were no significant differences between the aligned divided conditions for overall frequency and duration of the types of joint attention involving all elements of the interaction. The aligned condition resulted in more and longer episodes of coordinated joint attention than passive joint attention when only bouts involving the AAC system were considered. In contrast, there were no significant differences in frequency or duration of coordinated versus passive episodes involving the AAC system in the divided condition. These findings suggest that pairing an AAC system with adult eye gaze in an interaction may support beginning communicators in their efforts to coordinate their attention between a novel AAC system and the interaction partner. The correlation of age with frequency and duration of coordinated joint attention were significant in the aligned but not the divided condition.

Factors Impacting Results

There are several possible explanations for the findings, related to the variety of JA categories captured, the nature of the task, and the characteristics of the participants. JA encompassed episodes involving multiple potential combinations (e.g., it involved combinations between the book, AAC system, and the adult). By looking at overall JA, these differences may have been lost, and the comparison of the two conditions may not be representative of the benefits of the aligned condition. For individuals requiring AAC, the ability to coordinate attention with the AAC system is particularly important because communication via aided AAC requires this coordination to happen on a regular basis. The diversity in potential JA episodes distinguishes this line of research in AAC from previous JA studies (where attention was only coordinated between an adult and a single object of interest; Bakeman & Adamson, 1984; Carpenter et al., 1998; Tomasello & Farrar, 1986) and requires further theoretical

TABLE 2 Correlations (Pearson r) between Age and the Frequency and Duration of Joint Attention Episodes.

		Frequency				Duration			
	Age (Months)	CJA aligned	CJA divided	PJA aligned	PJA divided	CJA aligned	CJA divided	PJA aligned	PJA divided
Age (mos)	—	.67**	.40	.54*	−.19	.43*	.25	−.19	−.38
Frequency CJA Aligned		—	−.02	.48*	−.18	.60**	−.19	−.26	−.28
Frequency CJA Divided			—	−.18	.09	−.17	.68**	−.08	−.16
Frequency PJA Aligned				—	−.02	.14	−.24	−.02	−.28
Frequency PJA Divided					—	.03	−.27	−.36	.73**
Duration CJA Aligned						—	−1.5	−.50*	.31
Duration CJA Divided							—	.31	−.34
Duration PJA Aligned								—	−.380
Duration PJA Divided									—

Note. $^*p < .05$, $^{**}p < .01$.
CJA = coordinated joint attention; PJA = passive joint attention.

consideration. It is hoped the results of the current study will advance the discussion particularly as it relates to how attention is coordinated with an AAC system rather than as an overall measure with all objects in the environment.

A second factor contributing to the results was the structured nature of the interaction. It may have been more difficult to detect overall differences in JA between the two conditions because the task was adult-led with a predictable turn structure. Ultimately, the infant had a very limited set of persons or objects with which to coordinate his or her attention. Additionally, the researcher had to turn the pages on the AAC system and in the book frequently, perhaps drawing infants' attention to objects that otherwise may not have interested them. Regardless of condition, the structured nature may have affected the infants' engagement in JA. It was only when JA with the AAC system was analyzed specifically that a difference was detected between the conditions.

Furthermore, since the children in the study were responding to but not initiating bids for JA developmentally, the structured nature of the task may have lent itself more to specific rather than general changes in JA behavior. The infants in this study were able to follow into the adult's line of attention (i.e., the experimenter was pointing at the AAC system), but they were not actively directing attention. There is a smaller possibility for differences because the adult is following the same script in both conditions and the child responds to the adult, than when the child could initiate more of the JA routines.

It is not surprising that age significantly correlated with several of the JA measures in the aligned condition. Infants are just beginning to develop the skills necessary to sustain and coordinate their attention with objects and people in the environment around 9 months of age (Bakeman & Adamson, 1984; Carpenter et al., 1998; Tomasello, 1999). The findings suggest that the aligned condition may be more facilitative of CJA episodes for children who are developmentally ready to coordinate their attention.

Clinical Implications

While the findings of the current study are preliminary and should be considered with caution, the results are promising and may be helpful when introducing AAC to beginning communicators. The findings suggest that aligning an AAC system with adult eye gaze may facilitate communication and learning because two of the factors in a quadratic attention setting are combined. Because beginning communicators are still developing their ability to coordinate JA among multiple entities, pairing the AAC system with eye gaze may facilitate their ability to attend to clinicians' models more regularly than if the AAC system were placed to the side of the interaction where models could go unnoticed due to lack of ability to smoothly coordinate attention.

It may not be simple, or even always feasible, for clinicians or caregivers to balance an AAC system near their own faces while interacting with clients and other therapy materials. Therefore, it is important that the clinicians prepare in advance and develop strategies for managing the variables involved in therapeutic interactions. Facilitators should prepare to align their eye gaze with AAC systems, by becoming comfortable with balancing a system with one hand while navigating the pages needed for the target activity while viewing the AAC system upside down.

Additionally, when attempting to lessen the quadratic attention demands created by introducing an AAC system to a play interaction, aligning the AAC system with eye gaze is only one of the potential pairing options. Clinicians should also consider creating activities, such as storybook reading interactions, which include only the AAC system, so that the AAC system acts as a tool but also contains the activity (Light & Drager, 2007). However, this arrangement is more difficult to implement in everyday common play situations, because simulated moving objects within the AAC system are likely less appealing than using a tangible toy. In instances when incorporating the activity into the AAC system is not easily accomplished, the AAC system could be incorporated into the activity (Light & Drager, 2007); using light-tech picture symbols with the actual toys would be one way to accomplish this. Clinicians could use the same symbols as those representing the target concepts within AAC systems (if an AAC system is being introduced), but the pictures could be attached to actual objects during play, thus pairing the variables and lessening the task demands. This would allow children to begin understanding the relationship between symbols and real objects, which is necessary to using AAC to communicate.

Aligning AAC systems with adult eye gaze may result in additional challenges for individuals who require AAC who also have concomitant physical or visual impairments. Clinicians must consider the ideal placement of the AAC system and activity materials in relation to the area in which individuals could access and see the AAC system; the position seems to be the most important factor; alignment with adult eye gaze with the AAC system would be a secondary factor.

Limitations and Future Directions

The limitations of the present study should be considered when interpreting the results. First, the participants were infants without disabilities, in order to represent the early social and communicative level of beginning communicators. None of the infants in the study was delayed developmentally or in need of an AAC system to help them communicate. Future research should replicate this study with children with disabilities who require AAC in order to determine the effect of an AAC system placement on the types of JA they demonstrate. Future research should also aim to determine how long the pairing is advantageous for beginning users.

The structured nature of the interaction may have limited the generalizability of the current study. Possible research directions could include an investigation with parents or caregivers in free-play interactions that include the AAC system and other objects. Future investigations should also consider the role of other individual differences beyond age, such as children's temperament and parent-child interaction style. The results of this study are preliminary and there is room for the field to consider the mechanics of measuring joint attention with children requiring AAC and the developmental trajectory of these engagement states in contextualized and decontextualized interactions. Furthermore, traditional joint attention schemes may not be the most applicable for all AAC interactions. An expanded framework that considers the role of symbolic communication (Adamson, Bakeman, & Deckner, 2004) and supported joint attention (Adamson, Bakeman, Deckner, & Romski, 2009) may better reflect the level of co-construction that takes place in AAC and provide a useful structure for evaluating interfaces with people of all ages and aided AAC in the future.

Author Note

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Notes

1 ESCS coding manual is available online at: http://www.ucdmc.ucdavis.edu/mindinstitute/ourteam/faculty_staff/ESCS.pdf

2 Boardmaker with Speaking Dynamically Pro® software is manufactured by Mayer-Johnson, a division of Dynavox Technologies. Address: 2100 Wharton Street Suite 400, Pittsburgh, PA 15203. Tel: +1 866 396 2869. Website: http://www.dynavoxtech.com.

3 The Sahara TufTab i310XT Tablet PC is available from TabletKiosk, 2832 Columbia Street Torrance, CA 90503, USA. Tel: +1 310 782 1201; Fax: +1 310 782 1205; E-mail: info@tabletkiosk.com

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