What Do We Know About Joint Attention in Shared Book Reading?
An Eye-tracking Intervention Study

by

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Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor of Philosophy in the Department of
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ABSTRACT

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Abstract

Joint attention is critical for social learning activities such as parent-child shared book reading. However, there is a potential disassociation of attention when the adult reads texts while the child looks at pictures. I hypothesize that the lack of joint attention limits children's opportunity to learn print-related skills. The current study tests the hypothesis with interventions that enhance real-time joint attention. Eye movements of parents and children were simultaneously tracked when they read books together on computer screens. I also provided real-time feedback to the parent regarding where the child was looking, and vice versa. Changes of dyads' reading behaviors before and after the joint attention intervention were measured from both eye movements and video records. Baseline data showed little joint attention in parent-child shared book reading. The real-time attention feedback significantly increased the joint attention and children's print-related learning. These findings supported my hypothesis that engaging in effective joint attention is critical for children to acquire knowledge and skills during shared reading and other collaborative learning activities.

Dedication

For my family

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1. Introduction

Reading books with young children (hereafter called parent-child shared book reading) helps to build a solid foundation for children's learning (Ezell & Justice, 2005). Especially, shared book reading is a primary context in which pre-reading children are exposed to print. In the following introduction, I will review empirical research on the relation between shared book reading and reading development. Specifically, I will focus on limitations of existing research. Traditional interventions often do not address the dynamic nature of shared book reading. Transactional theories provide a framework for thinking about interactions between parents and children in shared book reading, but they are limited by our ability to measure joint attention. A number of factors modulate the relation between shared book reading and literacy acquisition. I will discuss (a) parental beliefs and strategies and (b) children's interests in reading.

I will analyze the challenges, and propose a number of solutions to the limitations. The solutions involve the use of state-of-the-art eye-tracking technologies. First, I seek to objectively monitor joint attention in shared book reading, by simultaneously tracking the eye gaze of parents and children. Second, I investigate whether a technology-assisted intervention enhances parent-child joint attention in real-time. I hypothesize that the new paradigm can help dyads regulate joint attention and help children learn reading.

1.1 Shared Book Reading and Emergent Literacy Development

There is ample evidence that the home literacy environment plays a crucial role in young children's literacy and social-emotional development (Bus, 2003; Evans, Shaw, & Bell, 2000; van Steensel, 2006). One aspect of children's literacy experiences that has perhaps received the greatest attention is parent-child shared book reading.

Parent-child shared book reading has long been a family tradition and is a daily routine in many families. Not only is parent-child shared book reading a form of entertainment, but the interactions that happen between parents and children also have consequences in multiple areas of children's development. Some researchers believed that shared book reading may be the best activity to prepare children for becoming successful readers (Anderson, Hiebert, Scott, Wilkinson, & The Commission on Reading, 1985). Particularly, researchers agreed that reading books with preschool children enhances children's emergent literacy skills (Allor & McCathren, 2003; Bus, van IJzendoorn, & Pellegrini, 1995; Evans & Shaw, 2008; Ezell & Justice, 2005; Reese & Cox, 1999; Senechal & LeFevre, 2002; Sulzby, 1991).

Emergent literacy refers to concepts, knowledge, and skills that young children have about reading and writing prior to beginning their formal literacy instruction in elementary school (Crain-Thoreson & Dale, 1992; Lonigan, Burgess, & Anthony, 2000; Whitehurst & Lonigan, 1998). Generally speaking, emergent literacy skills include the awareness of the conventions and purposes of book reading, letter knowledge, print awareness, knowledge of letter-sound correspondence, and so forth (Ezell & Justice, 2005; Scarborough & Dobrich, 1994a; Whitehurst & Lonigan, 1998). Specifically,

researchers distinguished between two types of home literacy practices and emergent literacy - those that focus on inside-out literacy skills (also referred as print-related skills) and those that focus on outside-in literacy skills (also referred as comprehension and vocabulary skills) (Cabell, Justice, Vukelich, Buell, & Han, 2008; Lonigan & Whitehurst, 1998; Scarborough & Dobrich, 1994b; Senechal, LeFevre, Smith-Chant, & Colton, 2001; Whitehurst & Lonigan, 1998). I will discuss the relations between shared book reading and emergent literacy development from these two perspectives.

1.1.1 Shared Book Reading and Children's Development of Inside-out Skills

The inside-out literacy skills refer to children's knowledge of the rules for translating texts into sounds (or sounds into print for writing), including letter knowledge, phonological awareness, knowledge of letter-sound correspondence, print knowledge, sight word recognition, and so forth (Cabell et al., 2008; Lonigan & Whitehurst, 1998; Scarborough & Dobrich, 1994b; Senechal et al., 2001; Whitehurst & Lonigan, 1998). Inside-out emergent literacy skills are critically important in the earliest stage of learning to read when the focus is on decoding texts, especially for children who are at risk of reading difficulties (Whitehurst & Lonigan, 1998).

Researchers believe that inside-out literacy skills are learned in part through exposures to print during reading (A. E. Cunningham & K. E. Stanovich, 1998; Gaskins & Labbo, 2007; Lomax & McGee, 1987). To ensure a smooth transition into formal schooling, children are expected to learn the rudiments of these print-related knowledge and skills through shared book reading in preschool years (Lonigan & Whitehurst, 1998;

Pullen & Justice, 2003; Reese, Cox, Harte, & McAnally, 2003). Since these skills are strongly correlated with children's subsequent performance on traditional achievement tests in school, many researchers use inside-out outcome measures to examine the efficacy of shared book reading on children's literacy development (Justice & Ezell, 2004; Pullen & Justice, 2003; Sulzby, 1991).

Empirical findings on the relationship between shared book reading and children's development of inside-out literacy skills remain controversial. Some researchers believe that inside-out skills are learned through print exposure - children learn to read by being exposed to the sound and the spelling of words simultaneously during shared reading (A. E. Cunningham & K. E. Stanovich, 1998; Ehri & Sweet, 1991; Gaskins & Labbo, 2007; Lomax & McGee, 1987). However, recent eye movement studies showed that the focus of young children's attention during shared book reading is rarely on the print (Evans & Saint-Aubin, 2005; Evans, Saint-Aubin, & Landry, 2009; Feng & Guo, 2010, under revisions; Justice, Pullen, & Pence, 2008; Justice, Skibbe, Canning, & Lankford, 2005). For example, regardless of the layout of the book and the richness of the illustrations displayed on a computer monitor, 4-5-year-old French-speaking children spent very little time exploring the print while reading books with adults, and their fixations on words were uncorrelated with the length of the text (Evans & Saint-Aubin, 2005).

These results raise questions about how children develop the inside-out literacy skills through shared book reading: If children generally avoid looking at texts, there is

little print exposure and children can hardly learn about print through shared book reading interactions.

One explanation for the little print exposure is that the majority of children need some guidance to take advantage of print exposure and they usually obtain the guidance through repeated interactions with adults. However, such interactions are rare during real-life shared reading (Stahl, 2003).

Teaching print-related knowledge is not a pedagogical goal for many parents (Senechal, LeFevre, Thomas, & Daley, 1998; Snow & Ninio, 1986). In these parents' mind, shared book reading is an opportunity for children to interact with print implicitly and informally (Senechal et al., 1998; Snow & Ninio, 1986). Therefore, these parents rarely make reference to the print when they read to preschoolers (Justice & Lankford, 2002).

This viewpoint was supported by research examining interactions between parent and child during storybook reading. For example, Senechal et al. (1998) found no correlation between parents' exposing their children to storybooks and parent-reported efforts to teach their preschoolers to read or print words. Justice and Ezell (2000) examined the verbal (questions, comments, and requests) and nonverbal (tracking and pointing to print) references when parents read storybooks with their 4-year-old children. They found that parents rarely pointed to or commented on print and this pattern was stable over a 4-week period. Instead, parents spent a lot of time on illustrations, clarifying words and story meanings. Similarly, Sonnenschein and Munsterman (2002) examined verbal interactions when parents or siblings read both familiar and unfamiliar storybooks

to 5-year-old children at home. They found that most of the comments during story reading interactions were about the content of the storybook. When parents or siblings read a familiar storybook, they rarely discussed the print with the focal child, and there was virtually no comment about the print when the storybook was unfamiliar. Similar results were found in other investigations (Phillips & McNaughton, 1990; Shapiro, Anderson, & Anderson, 1997; Yaden, Smolkin, & Conlon, 1989).

Together, these studies suggest parents believe as long as children are exposed in a rich print environment, children will learn literacy automatically. This belief may not be true in reality. Ezell and Justice (2000) found that preschool children rarely talked about or asked questions about print during storybook reading, even when the print had salient features. Recent eye movement studies also showed that preschool children engaged in minimal visual attentions on the print during shared book reading (Evans & Saint-Aubin, 2005; Evans et al., 2009; Feng & Guo, 2010, under revisions; Justice et al., 2008; Justice, Skibbe, et al., 2005).

Not only are adult-child interactions on print rare, they are also ineffective in many circumstances. Even when parents believe shared book reading is an instructional context for teaching print awareness (Dickinson & Tabors, 2002; Senechal et al., 1998), they may not have the right knowledge and strategies to effectively recognize children's attention states and assess children's understanding in real-time . For example, when parents talk about print, children may not attend to the same text and literacy topics. Parents' lack of awareness of children's current situation may result in failures of the

parental scaffolding and loss of interests in children. In this situation, children may not gain much print knowledge from the shared book reading experience.

Home-based book reading intervention studies showed that parental use of print-referencing behaviors (e.g., asking questions about print, and pointing or tracking print) fosters children's print-related knowledge and skills (Justice & Ezell, 2000, 2002; Justice, Weber, Ezell, & Bakeman, 2002; Lovelace & Stewart, 2007). For example, Justice and Ezell (2002) found that after participating in an 8-week period of shared reading training sessions with a print focus, children in the experimental group outperformed their control-group peers on measures of print awareness and the overall performance. On the other hand, although parental strategies could temporarily change children's behaviors, the overall effect of shared book reading is moderate ($d = 0.59$), revealed by recent research syntheses (Bus et al., 1995; Dunning, Mason, & Stewart, 1994; Fletcher & Reese, 2005; Lonigan, 1994; Scarborough & Dobrich, 1994a, 1994b).

I argue that one critical explanation for the moderate intervention effect is the lack of effective communications of attentional states among reading dyads. When parents frequently refer to print, it is hard for preschool children to continuously focus on the text and literacy topics. These children can easily lose interest and even feel frustrated during the print focused type of reading interactions. What the reading dyads need is an effective and efficient type of communication in which children can learn print and enjoy stories simultaneously. In our newly developed technology-assisted intervention paradigm, we focus on improving both the frequency and quality of the adult-child interactions on print.

1.1.2 Shared Book Reading and Children's Development of Outside-in Skills

Children's outside-in literacy skills refer to their semantic, phonological, and syntactic abilities when understanding and speaking languages, including the awareness of the conventions and purposes of print, vocabulary skills, understanding and producing narrative, pretending to read, and so forth (Cabell et al., 2008; Lonigan & Whitehurst, 1998; Scarborough & Dobrich, 1994b; Senechal et al., 2001; Sulzby, 1991; Whitehurst & Lonigan, 1998). Compared to inside-out skills, outside-in skills play a more important role in later stages of reading development when children begin to read more complex texts for meaning and pleasure (Whitehurst & Lonigan, 1998).

Snow and Ninio (1986) suggested that shared book reading could enhance preschoolers' outside-in skills due to repeated exposures to more complex and more decontextualized language than any other kind of parent-child interactions. Moreover, children's ability to understand and produce decontextualized language is a crucial prerequisite to literacy (Snow & Ninio, 1986). This is consistent with findings that preschoolers' outside-in skills predicted their literacy achievements in later school years (Scarborough & Dobrich, 1994b).

Among various outside-in literacy skills, children's vocabulary knowledge is most extensively studied and closely related to shared book reading experiences. Vocabulary knowledge is essential for children's reading comprehension and literacy acquisition. Researchers believed that shared book reading is a primary activity associate with vocabulary development. Exposure to books promotes children's vocabulary growth

because reading books with children can introduce novel words that are typically not included in other parent-child interactions. For example, parents use richer vocabulary during shared book reading than during everyday conversations or free play (Crain-Thoreson, Dahlin, & Powell, 2001). Children's books are found to include 50% more rare words than primetime television or conversations among college students (Cunningham & Stanovich, 2003; Hayes & Ahrens, 1988).

Previous research showed a consistent, robust positive relation between shared book reading and children's vocabulary skills (Bus et al., 1995; Frijters, Barron, & Brunello, 2000; Scarborough & Dobrich, 1994b; Senechal, 2006; Senechal & LeFevre, 2002; Senechal, LeFevre, Hudson, & Lawson, 1996; Senechal, Pagan, Lever, & Ouellette, 2008). For example, Senechal and Cornell (1993) showed that vocabulary learning was robust during a single session of shared reading of a storybook for 4- and 5-year-old children. Many intervention studies have shown large and enduring intervention effects on measures of vocabulary skills (Arnold, Lonigan, Whitehurst, & Epstein, 1994; Lonigan, 1994; Whitehurst, Arnold, et al., 1994; Whitehurst, Epstein, et al., 1994; Whitehurst, Fischel, et al., 1988). Moreover, shared book reading and vocabulary development are mutually promoting: children's vocabulary helps them understand the text, and book reading further increases children's vocabulary (Coyne, McCoach, & Kapp, 2007; Jenkins, Stein, & Wysocki, 1984; Senechal, Cornell, & Broda, 1995; Vivas, 1996). Shared book reading is seen as an important clinical tool to foster vocabulary development for children, such that children with language impairment have been found

to produce more complex oral language in shared reading than in play (Davie & Kemp, 2002; De Temple & Snow, 2003; Justice, Meier, & Walpole, 2005).

In the current study, I measured children's inside-out emergent literacy skills such as their print knowledge (e.g., interviewing children about the concept of print and the direction of how words are read) and sight word recognition (e.g., asking children to name print words sampled from the books they read). Additionally, I assessed children's outside-in emergent literacy skills by asking children to utilize their vocabulary to retell the stories they read from the books in the experiment reading session. I am interested in how our technology-assisted interventions enhance children's inside-out and outside-in emergent literacy skills respectively.

1.1.3 Challenges to Traditional Shared Book Reading Research

As one of the most common literacy practices, parent-child shared book reading has been extensively studied over the past few decades. It remains a challenging topic due to the dynamic nature of this activity and its complex relationships with numerous variables in terms of reading partners and book materials.

First of all, traditional studies lack a good way to measure the dynamic interactions in real time. Shared book reading is a highly collaborative activity involving two partners with different goals and various levels of skills. It resembles a complex mind-guessing game, in which both partners must understand what is going on in the other partner's mind, negotiate a common goal, and make dynamic decisions in response

to the other partner's thinking process and attention state. Failure to communicate between partners may hinder children from learning to read. Understanding this joint interaction requires objective and continuous monitoring of moment-by-moment cognitive and social processes.

Existing studies tried to improve reading partners' communications by providing adult readers off-line video demonstration and trainings or adopting different types of reading materials (De Jong & Bus, 2004; Evans & Saint-Aubin, 2005; Ezell & Justice, 2000; Gong & Levy, 2009; Justice & Ezell, 2000, 2004; Justice, Skibbe, et al., 2005). But their materials and formats are not responsible to the child's real-time attention state and therefore the intervention effects were limited. My research addresses these limitations by using the advanced eye-tracking technique to study real-time parent-child interaction and its contribution to children's learning.

Second, complex relations exist between shared book reading practices and children's short-term/long-term gains in different literacy domains, which can lead to the seemingly contradictory results on the efficacy of shared book reading (Dickinson & Smith, 1994; Haden, Reese, & Fivush, 1996; Reese & Cox, 1999; Stahl, 2003). Variations in intervention time period, outcome measures, and the time point to measure the outcomes would change the intervention effects of particular reading strategies (Dunning et al., 1994; Lonigan, 1994; Scarborough & Dobrich, 1994a, 1994b). Most of the existing research examines children's immediate language gains after the shared reading interventions. In my dissertation, I asked parents to record their daily shared book

reading experiences after they participated in our intervention study. Then I invited those parent-child dyads to come back to read books again in our lab one week after the intervention. I am interested in whether dyads adopt some types of the interactions they learned through the short-term intervention in their daily readings and how children improve their reading concepts and behaviors during this period of time.

1.2 Shared Book Reading as a Joint Attentional Interaction

In order to acquire print-related skills during dynamic shared reading interactions, children and adults must coordinate their joint attention (Fletcher & Reese, 2005; Pellegrini & Galda, 2003). This requires the reading partners to maintain a triangular attentional structure, i.e., attending simultaneously to the target of learning and among themselves (Carpenter, Nagell, & Tomasello, 1998; Mundy & Newell, 2007; Tomasello & Farrar, 1986a). Transactional theory provides a framework for thinking about joint attentional interactions between parents and children in shared book reading.

1.2.1 Transactional Theory

According to the transactional theory of reading, children learn knowledge and skills through interacting with more knowledgeable individuals in a social context (Fletcher & Reese, 2005; Pellegrini & Galda, 2003; Wood & Hood, 2004). This social interaction does not happen as unidirectional knowledge transmission from adults to young children, but happens in a social context jointly constructed by partners around a specific task. In other words, social contexts are transactional: Not only do adults play

tutorial roles and socialize children, but children also impact adults in return. Adults and children have dynamic effects on each other, and these interactions are influenced by their past experiences, their prior knowledge, and their moment-by-moment attention states (Fletcher & Reese, 2005; Heath, 1982; Pellegrini & Galda, 2003; Pellegrini, Perlmutter, Galda, & Brody, 1990).

Studies on one-on-one reading tutoring showed that the interaction between two partners enabled them to jointly construct an understanding that neither partner initially understands. Experienced tutors reconstruct students' thinking, tailor and adapt the instructional moves to the understanding of individual students. Students are more likely to repair their own flawed mental models if they recognize that their mental models conflict with the text model (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Cromley & Azevedo, 2005). These findings have important implications on the shared book reading research.

Similar to reading tutoring, parent-child shared book reading is a highly transactional learning activity. From numerous transcripts of dialogues between preschoolers and their mothers during shared reading sessions, Snow and Ninio (1986) identified seven basic "contracts of literacy" relating to books, written texts, and reading conventions. Specifically, the "contracts of literacy" include (a) books are for reading, not for manipulating; (b) books are in control of shared reading interactions, and the role of the reader is to be led by the book; (c) pictures and words are symbolic presentations of real things; (d) pictures and printed words are meant to elicit spoken words; (e) static pictures and words can represent dynamic actions and events; (f) book events occur

outside real time; (g) books create an autonomous fictional world (Snow & Ninio, 1986). Most preschool children are inducted into these literacy contracts within the context of shared reading interactions. For example, if children do not attend to the book, parents would draw children's attention to it and make children understand that the conversation topic is determined by the current book they are reading. Children with increased attention and interest on books will initiate more literacy related questions and parents will then be more motivated to introduce the literacy knowledge while reading with children. With increased active participation in the shared reading activity, children will gradually acquire the literacy rules concerning the nature of books and written texts.

1.2.2 Joint Attention in the Naturalistic Shared Book Reading

Joint attention, the capacity to coordinate attention with a social partner on a particular action or object, is essential for communication, collaborative visual search and problem solving tasks, and many other collaborative learning activities (Brennan, Chen, Dickinson, Neider, & Zelinsky, 2008; Carletta et al., 2010; Nüssli, Jermann, Sangin, & Dillenbourg, 2009; Richardson, Dale, & Kirkham, 2007). Numerous scholars have emphasized the importance of joint attention in children's social and cognitive development (Adamson & Chance, 1998; Fletcher & Reese, 2005; Mundy et al., 2007; Mundy & Newell, 2007; Mundy, Sullivan, & Mastergeorge, 2009; Pellegrini & Galda, 2003; Sulzby, 1991; Tomasello & Farrar, 1986b). For example, joint attention helps babies learn the name of an object when their parents show them the object and label the object (Baldwin, 1995; Karrass, Braungart-Rieker, Mullins, & Lefever, 2002). Children

develop their joint attention skills as they mature. By 18 months of age, children are able to establish frequent and sustained periods of joint attention with adults using a variety of means, such as gestures, sounds, and words (Adamson & Chance, 1998).

Engaging in sustained periods of joint attention on books is essential for children to acquire language and literacy skills in shared reading (Adamson & Chance, 1998; Baker, Scher, & Mackler, 1997; Lyytinen, Laakso, & Poikkeus, 1998; Pile, Girolametto, Johnson, Chen, & Cleave, 2010; Senechal, Cornell, et al., 1995). Indeed, the more children engage in joint attention, the more optimal the social-learning opportunities they create for themselves. For example, children's recall of objective actions was significantly related to the degree of joint mother-child attention to the story (Clarke-Stewart & Beck, 1999). Moreover, children with high levels of attention and interest in books may elicit more frequent reading interactions with parents (Fletcher & Reese, 2005). Research evidence even suggested that the frequency with which children engage in joint attention during shared reading predicts their language acquisition and childhood IQ status (Acra, Goldstein, Claussen, & Fletcher, 2002; Mundy et al., 2007).

On the other hand, parents can also influence their children's attention capacities and parents' encouragement of child attention enhances language acquisition (Belsky, Goode, & Most, 1980; Bornstein & Tamis-LeMonda, 1997; Lawson, Parrinello, & Ruff, 1992; Tamis-LeMonda, Bornstein, & Baumwell, 2001; Tamislemonda & Bornstein, 1989). As a matter of fact, shared reading has been used by researchers and practitioners to enhance children's ability to sustain attention (Baker et al., 1997; Karrass,

VanDeventer, & Braungart-Rieker, 2003; Laakso, Poikkeus, & Lyytinen, 1999; Snow & Goldfield, 1983).

Previous studies usually assessed joint attention through parental report as well as observations of dyads' behaviors during shared book reading, such as children's general alertness, the frequency that children looked at the pages, their body orientation relative to the book, and the intensity and duration of task involvement (Bee et al., 1982; Ortiz, Stowe, & Arnold, 2001). Clarke-Stewart and Beck (1999) created a measure of joint mother-child attention by counting the number of conversational turns in which mother and child were both on task (e.g., talking about the story), divided by the total number of turns in their discussion. Although these studies demonstrate a link between joint attention and the early literacy acquisition, the correlational nature of those studies should be noted and the mechanism of how joint attention influences literacy learning requires much more empirical support.

Merely looking at the same pages together does not imply joint attention. Pre-reading children spend most of the time looking at illustrations (Evans & Saint-Aubin, 2005; Evans et al., 2009; Feng & Guo, 2010, under revisions; Justice et al., 2008; Justice, Skibbe, et al., 2005), whereas parents must attend to the text in order to read. As discussed in the last section, the mismatch of attention may hinder learning in shared reading. Traditional measures of joint attention fail to distinguish attentions to print versus illustrations, and thus they likely over-estimate the amount of joint attention during reading. In this study I seek to measure joint attention on texts directly and

objectively by calculating the percentage of time reading partners spend looking at the same texts simultaneously on the screens.

Ambiguity about others' attentional state is not only a problem for researchers but also a challenge for children and parents involved in shared reading. Where one attends to is a private state that can sometimes be inferred but rarely observed (without equipments such as an eye-tracker). Other than the rare cases when parents point to words on the page (Justice & Ezell, 2000), adults make no effort to show children where they are looking and how they translate words to sounds. This leaves children few clues to model the reading behavior. While some children mimic external reading behaviors such as holding up a book and pretending to read, most preschoolers focus on illustrations – which they can understand – and simply ignore texts, in part because they see no evidence that the words are relevant to story reading.

Meanwhile, adults have no first-hand information on where on the page children are looking at. Without the information of children's attention state, parents are not accurate in assessing children's understanding and interest. Therefore, while both partners are looking at the book, there is no guarantee of joint attention. Parents cannot effectively adjust their strategies in response to children's attention and understanding during shared book reading.

1.2.3 Monitoring Joint Attention in the Current Study

Transactional theory of reading suggests that children learn reading skills through interacting with adults in a social context which is jointly constructed by both partners

(Fletcher & Reese, 2005; Sulzby, 1991). These dynamic transactions have been documented using verbal protocols and behavioral coding, but existing methods do not directly monitor and measure real-time joint attention, one key to the high quality interactions between adults and children (Justice et al., 2008; Justice, Skibbe, & Ezell, 2006).

1.2.3.1 Existing Research on Joint Attention in Shared Reading

There is converging evidence that a key to develop print-related skills is to engage children in a joint attention on print words (Breit-Smith, Justice, McGinty, & Kaderavek, 2009; Cabell et al., 2008; Ezell & Justice, 2000; Gong & Levy, 2009; Justice et al., 2008; Justice et al., 2006; Zucker, Ward, & Justice, 2009). This could be achieved by pointing to words while reading and by having print-focused conversations (Ezell & Justice, 2000; Justice et al., 2008; Justice et al., 2006; Justice et al., 2002), both of which are key elements in a joint attentional interaction. However, those traditional print-referencing reading strategies have some inherent limitations.

One problem is that the two partners do not have accurate knowledge of where the other person is attending to at any particular moment, which makes attention regulation difficult and ineffective. In addition, most existing reading strategies are adult-centered - i.e., the parent regulates the child's attention without much information about the child's real-time attention and interest. The child may temporarily look at or listen to things he/she is required to attend to. For the following few minutes, the child may already lose his/her interest and turn to something else. In such case, the adult fails to provide the child the optimal learning opportunity.

1.2.3.2 Solutions to Monitor Joint Attention in Current Study

I conjecture an effective solution to the limitations of existing research is to provide reading partners consistent, individualized, and real-time feedbacks on where the other person is attending to. By externalizing adults' reading processes, the pre-reading children will have a model which they can observe and internalize. Children can constantly follow adults' attention cues (e.g., eye contacts or verbal attention regulations) to the things which adults want them to pay attention to and learn. Children with increased joint attention on books may initiate more literacy related questions. They may even try to reengage in joint attention with eye contacts, facial expressions, or verbalizations when they realize their joint attention with adults is temporarily broken.

On the other hand, with a projection of children's attention and thinking process, adults will be able to scaffold and strategize pedagogical goals accordingly. Adults usually follow where children's attentions are and talk about things children have interests in. They may also constantly draw children's attention to books and make children understand the conversation topic is determined by the current book they are reading.

The state of eye-tracking technologies allows us to show where the partner is looking at in real-time. It allows us to show parents or children a cursor on the computer screen that corresponds to the gaze location of the other person. This process of helping people understand real-time eye movements may be called the eye-gaze awareness training. Eye movements provide critical information that is missing in the traditional shared reading task.

First, the location of the eye gaze indicates the focus of attention at any given moment (Rayner, 1998; Rayner, Chace, Slattery, & Ashby, 2006). I expect that discovering children's real-time attention state will trigger adults' regulations of joint attention during shared reading. The real-time eye gaze information is more instructional to pre-reading children, who will see where and how grown-ups look when they read. I expect that children will be more likely to repair their own flawed mental models if they recognize that theirs conflict with adults' reading model. Children may even start to follow adults' scanning patterns and pay more attention to texts, which in turn provides more teachable moments for parents to introduce print-related knowledge and skills.

Second, the scanning pattern of the eyes can be used to gauge children's cognitive processes. For example, recent psycholinguistic studies have shown that the eye typically follows the order of words in sentence comprehension (Chambers, Tanenhaus, Eberhard, Filip, & Carlson, 2002; Griffin & Bock, 2000; Tanenhaus, 2005). It is intuitive that a child is not paying attention or is having difficulty comprehending a story if his or her eyes do not keep up with things mentioned by the adults. In such scenarios those informed adults can slow down the pace of reading and help children catch up with the storyline.

Lastly, having access to the other partner's eye movements may change the dynamics of shared reading as well as greatly reduce the time and energy that two partners spend on reengaging joint attention. Gone is the need to ask "Are you looking at here?" because the answer is on the screen. The success or failure of a pedagogical attempt is immediately seen on the screen as well. Adults can give children more prompt

and precise feedback when they watch children's real-time eye movements. If a parent has the goal of teaching print but notices that his/her child's eye movements only focus on pictures, the parent probably would not ignore this information and keep talking about the print by himself/herself. Instead, the parent may first follow the child's interest on pictures and then utilize verbal or nonverbal strategies to draw the child's attention from pictures to texts.

The technology-assisted interventions proposed in this dissertation build on prior research on effective shared book reading strategies. Not only do I objectively and continuously measure joint attention, I also provide the parent or the child with real-time eye gaze information indicating where the other person is looking at. The awareness of gaze facilitates shared reading interactions because reading partners can use this communication modality to manage their interactions and to identify the possible difficulties of learning to read. I hypothesize that this new shared book reading paradigm will lead to more effective attentional regulations and better learning.

1.3 Parents' Belief and Strategy in Shared Book Reading

1.3.1 Previous Research on Parents' Belief in Shared Book Reading

Within the triangular attention transaction in shared book reading, the characteristics of adults, children, and the learning targets will interact to affect the quality of this interaction. Parents' reading belief is one of the moderating factors. Parental beliefs about the importance and function of shared book reading, how they perceive their influence on their children's literacy development, and how they view their

children's developmental process of acquiring the literacy skills may all affect the frequency and quality of shared reading interactions with preschoolers (Audet, Evans, Williamson, & Reynolds, 2008; Curenton & Justice, 2008; Debaryshe, 1995; Debaryshe & Binder, 1994; Korat & Levin, 2001; Meagher, Arnold, Doctoroff, & Baker, 2008; Palacios, Gonzalez, & Moreno, 1992; Skibbe, Justice, Zucker, & McGinty, 2008).

Take Palacios et al. (1992)'s longitudinal study as an example: Palacios et al. analyzed the relations among parents' educational beliefs, parents' educational behaviors, and developmental outcomes of children. The researchers differentiated three different types of parents by their educational beliefs: "traditional", "modern", and "paradoxical". "Traditional" parents had innatist interpretations of individual differences, pessimistic developmental expectations and low perceptions of their own ability to influence children's development. In contrast, "modern" parents attributed individual differences to nature-nurture interaction. Also, they had optimistic developmental expectations and high perceptions of their influence on children's development. "Paradoxical" parents resembled modern parents in their optimistic developmental expectations. However, they were close to "traditional" parents in their ideas about when and how to teach children. "Paradoxical" parents also believed their influence on children's development was limited. When linking parental beliefs with their shared reading practices, Palacios et al. found that in the course of reading story books with 22-month-olds, parents with modern beliefs asked children more questions and did so more consistently compared to parents with either traditional or paradoxical beliefs. Moreover, parental beliefs significantly influenced children's verbal performance during shared reading sessions. Children of

"modern" parents had the best level of verbal production among all the children participants (Palacios et al., 1992).

Researchers also reported that parental beliefs determined what type of knowledge their children learn during shared book reading. In Neuman et al. (1995)'s study with African-American teenage mothers and their children, the authors revealed that these mothers held different views on children's learning and literacy development in preschool years. Only half of them emphasized that children should learn language skills from early age. Others believed their children were still too young to be read to. Those beliefs would result in the mothers' different behaviors and instructions during shared book reading, and consequently, their children would present individual differences on the level of language skills at the beginning of formal schooling (Neuman, Hagedorn, Celano, & Daly, 1995).

Corresponding with various parental beliefs about reading development, parents have various goals for reading with their children. In one survey study, Audet et al. (2008) summarized 5 distinctive parental goals for shared book reading, including stimulating development, fostering reading, bonding with child, soothing child, and enjoying books. Results showed that parents who rated fostering reading as the highest goal engaged in more echo reading with their children and adopted more print-referencing strategies compared to parents who rated other goals highest (Audet et al., 2008).

1.3.2 Previous Research on Parents' Strategy in Shared Book Reading

To better understand the variability of parent-child shared book reading interactions, we should also be aware that parents' reading strategy affects the quality of this dynamic interaction. Summarizing from previous observational studies, parents often use the following reading strategies: labeling and commenting on pictures or story lines, pausing for clarification or discussion, sentence recasting, reading of text with syntax simplification, asking questions, and retelling stories (Anderson-Yockel & Haynes, 1994; Blom-Hoffman, O'Neil-Pirozzi, & Cutting, 2006; Crain-Thoreson et al., 2001; Kaderavek & Sulzby, 1998; Pellegrini, Brody, & Sigel, 1985; Resetar, Noell, & Pellegrin, 2006; Stadler & McEvoy, 2003). In fact, many parents use various combinations of these scaffolding methods in response to children's interest, language level, and understanding of the reading materials (Arnold et al., 1994; Fletcher & Reese, 2005; Lonigan & Whitehurst, 1998; Whitehurst, Falco, et al., 1988).

Except for the combined reading techniques, researchers also suggest parents adopt some specialized strategies in order to improve children's literacy skills in a particular domain. For instance, print-referencing technique is a good method for improving children's print-related skills. Print-referencing technique refers to adults' applying nonverbal and verbal cues to direct children's attention to the forms, features, and functions of written language. For example, adults may point or track print while reading narrative storybooks with children. They may also ask questions and make comments on print. It is believed that print-referencing behaviors during shared book

reading will increase the proportion of children's verbal utterances referring to print, and thus enhance children's print-related literacy skills (Ezell & Justice, 2000; Justice & Ezell, 2000, 2002; Justice et al., 2002; Lovelace & Stewart, 2007).

Similarly, to the end of helping children learn vocabulary, Senechal and Cornell (1993) suggested that parents use the following strategies: use extensions and ask clarifying questions to continue discussion; structure children's dialogue to facilitate comprehension; request the best answer children can provide; repeat and emphasize certain words (Senechal & Cornell, 1993).

Adults' reading strategies are highly related to preschoolers' later language gains (Arnold et al., 1994; Crain-Thoreson & Dale, 1999; Dickinson & Smith, 1994; Haden et al., 1996; Kaderavek & Sulzby, 1998; Reese & Cox, 1999). For example, Haden et al. (1996) divided a group of American mothers into three categories according to their different reading strategies: describers (consistently labeled and described pictures and requested evaluations from children), comprehenders (consistently provided high level inferences and evaluations and requested personal experiences), and collaborators (initially used confirmations and later changed to higher level inferences with the development of children). The longitudinal correlation results showed that mothers' different reading strategies resulted in different outcomes for children's reading skills. At age 6, among the children of the three groups of mothers, children of comprehender mothers got the highest scores on receptive vocabulary and story comprehension measures; while children of collaborator mothers performed best on a letter recognition test (Hayden & Hayden, 1996).

1.3.3 The Interaction between Parents' Belief and Strategy

Parents' reading strategy interacts with their reading belief and the interaction changes across time in the home literacy environment. More specifically, if parents believe that children can learn some literacy skills with appropriate parental help before entering elementary schools, parents would adopt various strategies according to children's individual characteristics and developmental level. When those parents receive objective and constant feedback of children's interest and attention state at each moment of the shared book reading interaction, parents could effectively utilize those strategies and encourage children to be active participants in reading, such as pointing on texts in storybooks, asking children print-related questions, following children's answers and interests, giving them timely and precise feedback, and repeating or expanding children's verbalizations. If parents do not have the access to children's real-time attention state, their pedagogical attempt may not work so well even if they have the goal of teaching print during shared book reading.

On the contrary, if parents are pessimistic about children's potential of learning literacy before formal education and their own influence on children's development, they will not be very responsive to children's needs and interests. Neither could they adopt effective reading strategies even when provided with the real-time feedback of their children's attention information.

In sum, with the combination of optimistic developmental expectations, clear goal of helping children learn literacy skills, and the appropriate reading strategies, parents can effectively regulate joint attention with children in the shared book reading interaction.

The more involved have children got into the shared reading interaction, the greater gains they will get for literacy development. And when children get more knowledge and skills, they would be more capable and interested in this interactive literacy activity.

1.4 Children's Interest in Shared Book Reading

1.4.1 Previous Research on Children's Interest in Shared Book Reading

There are individual differences in how young children are interested in reading books (Laakso et al., 1999). Research has acknowledged the role that children's interest plays in their reading activities, such that interested children usually spend more time and effort on the reading activity, have more interactions with adults, internalize the book meaning more fully, and feel better about what has been learned (Bracken & Fischel, 2008; Bus et al., 1995; Crain-Thoreson & Dale, 1992; Dale, Crainthoreson, & Robinson, 1995; Deckner, 2004; Fletcher & Reese, 2005; Frijters et al., 2000; Karrass et al., 2002; Karrass et al., 2003; Laakso et al., 1999; Lyytinen et al., 1998; Morgan & Fuchs, 2007; Ortiz et al., 2001; Pellegrini & Galda, 2003; Scarborough & Dobrich, 1994a, 1994b; Scarborough, Dobrich, & Hager, 1991; Senechal, Cornell, et al., 1995). For example, Scarborough and Dobrich (1994) found that preschoolers' perceived interest in literacy had an even stronger relationship to children's language and literacy outcomes than did measures of the frequency and quality of shared book reading. Frijters et al. (2000) found that kindergartners' literacy interest played a small but significant role in their letter-name and letter-sound knowledge.

Previous studies assessed children's interest through parent survey (Senechal et al., 1998), parental report (Almy, 1949; Wells, 1985, 1986), and interviews of the mothers of precocious readers (Durkin, 1966; Thomas, 1984). Moreover, since shared book reading is an activity that built on joint attention during which both participants share a common site of interest (Adamson & Chance, 1998), attention to books has always been used as a method to measure children's interest in books (Crain-Thoreson & Dale, 1992; Ortiz et al., 2001; Senechal, Cornell, et al., 1995). Researchers measured children's attention to books by coding children's non-verbal behaviors and verbal responsiveness during shared book reading, such as the frequency that children look at the book being read, their body orientation relative to the book, and the proportion of time they talk about the book and book related things (Ortiz et al., 2001; Senechal, Cornell, et al., 1995). Recently, researchers started using more advanced eye tracking technique to monitor children's attention and interest even when they are not particularly vocal (Evans & Saint-Aubin, 2005; Evans et al., 2009; Feng & Guo, 2010, under revisions; Justice et al., 2008; Justice, Skibbe, et al., 2005).

Some researchers showed that young children's interest was not correlated with parental reading behaviors such as questioning, feedback, and enthusiasm (Crain-Thoreson & Dale, 1992; Laakso et al., 1999). Paradoxically, other intervention studies did indicate that there was strong association between children's interest in books and parents' reading strategies. For example, Ortiz et al. (2001) examined the effects of a reading intervention with middle-income parents to encourage 2-year-old children's interest in books. After the parents were trained to use specific techniques such as letting

their children choose books and following children's lead, their children were more likely to initiate reading at home and demonstrated increased interest during observations than children whose parents did not participate in the reading intervention. These intervention studies suggested that parents' reading behaviors would change the quality of parent-child interactions which have complex, bi-directional relationships with children's interest in books. Enhanced quality of parent-child reading interactions will lead to increased interest on children's part, and correspondently, children will initiate more readings and parents will be more motivated to read with children.

The contradictions between the correlational studies and intervention studies might lie in the fact that parents in the correlational studies did not successfully draw children's attention to the reading activity; while for the intervention studies, researchers offered trainings for parents to take effective strategies to make children interested and involved in the shared book reading activities. When children actively interact with parents during reading, they are more likely to attend to books and the discussion topics.

1.4.2 Measurement of Children's Reading Interest in the Current Study

Child interest can be promoted through two channels during shared book reading. First, the joint attentional interaction makes shared book reading a more meaningful and intrinsically motivating activity to children.

Blumenfeld (1992) suggested that activities that intrigues children usually have the following qualities: it could draw on a learner's prior knowledge or experience; it

could explain why doing the task is important and what skills it is designed to teach; or it could challenge a learner and therefore activate his desire for mastery (Blumenfeld, 1992). When a child engages in effective joint attention with an adult reading partner, he/she would have the opportunity to know exactly what the partner is paying attention to and how the adult is reading texts on a book. The child may relate what he/she sees with what he/she previously thinks about the reading process, corrects his/her own model if applicable, or even starts to imitate what the adult is doing. The adult reader could then more efficiently explain to the child that texts should be read from left to right and word-by-word. With the correct and explicit reading model right in front of the child, he/she may feel well challenged and become eager to acquire those reading skills.

Second, the joint attentional interaction during shared book reading provides children the immediate and precise feedback which is essential to sustain their interest in reading. According to the Self-Efficacy theory, a person's self-efficacy is developed through verbal persuasion or feedback, including guidance and direction on how to improve or succeed, providing correction of errors and remedies to problems, and a linking of success with effort (Bandura, 1986; Pintrich & Schunk, 1996). When an adult reader has the access to a child's moment-by-moment attention information during shared book reading, he/she could constantly draw the child's attention to important materials, provide the child the immediate and precise feedback about whether the child looks at the right place, and advise the child to quickly find the correct answers. With such supportive and thorough feedback, children's intrinsic motivation for the reading activity would not only sustain for long term but also increase ultimately.

In the current dissertation, three measurements (parental report, reading logs, and direct observations) are proposed to investigate how joint attention regulation affects children's reading interest during the shared book reading.

First, adapting from children's reading interest measurements in previous studies (Morrow, 1983; Ortiz et al., 2001; Thomas, 1984), I constructed a C*hildren's Reading Interest Survey.* This survey includes *Brief Reading Interest Scale* (BRISC,(Ortiz et al., 2001) in which parents are asked to rate their children's overall interest in shared book reading compared to other activities. In addition, parents need to answer four questions about how often their child asks to be read to, how often their child reads alone, the degree of concentration their child displays in reading, and how long the child chooses to spend on reading activities. All five items in the C*hildren's Reading Interest Survey* are presented in Appendix 1. Parents will fill out this survey during the first lab visit and one week follow-up. The changes of parents' survey answers across the two visits will show whether the joint attention intervention influences children's reading interest.

Second, two interest measurement questions (adapted from Ortiz et al. (2001)'s study) are imbedded in a *Home Reading Log* (see the specific questions of the *Home Reading Log* in Appendix 2). Parents will be asked to record who initiated the shared reading session and how well the child maintained his/her interest on a daily basis. Initiating a reading session refers to the act of asking the other person in the parent-child dyad to join in a session of shared book reading. Parents' recordings on these two questions will be compared between the eye-gaze awareness training group and the control group.

Third, I measure children's interest through direct observations from both videotapes and eye movement recordings. Previous studies showed that the frequency that children looked at books being read, their body orientation relative to books, and the proportion of time they talked about books and book related things indicated their reading interest (Bus & Vanijzendoorn, 1988; Crain-Thoreson & Dale, 1992; Ortiz et al., 2001). One interest measurement adapted from Ortiz et al. (2001)'s study was added into the coding system of children's reading behaviors in the current dissertation. Children's general interest level will be rated every reading trial, where 3 indicated maximum interest and 1 indicated no interest. The average of these ratings is used as the measure of child interest. This rating will be based on four factors: 1) the child's overall level of alertness as indicated by posture and eagerness of expression, 2) the child's physical orientation towards the screen/book and the parent, 3) the amount and emotiveness in the child's verbalizations, and 4) the proportion of time the child talks about the book being read or things related to the book as compared to non book subjects. The inter-rater reliability of the coding (Cohen's Kappa) will be calculated using 20% of the sample.

In addition, recent eye movement studies showed that children's eye movements can be used as an effective measurement for children's engagement and interest in the reading activity (Evans & Saint-Aubin, 2005; Evans et al., 2009; Feng & Guo, 2010, under revisions; Justice et al., 2008; Justice, Skibbe, et al., 2005). The eye movement data analyses in my dissertation will suffice this purpose.

Parental reports of children's interest may be affected by parents' expectations or demand characteristics. But the daily parent records and the objective observations are

expected to be less subject to those biases. All these three measurements provide a multimodal assessment of the relationships among the joint attention intervention, parents' change of reading behaviors, and children's change of reading interest.

1.5 Summary of the Current Study

Utilizing the advanced eye-tracking technique to measure and facilitate joint attention provides a new perspective of understanding the joint attentional transaction in shared book reading. This is the first time joint attention is monitored in real-time in the research area of shared storybook reading. While there are a handful of published studies looking at children's eye gaze, none has investigated the correlation and contingency between eye movements of children and parents. Utilizing two eye trackers in the current study, I track both reading dyads' eye movements and measure their joint attention objectively and constantly. The data and methodology will be useful to a wide array of researchers interested in joint attention and collaborative behaviors.

Furthermore, I seek to intervene in the dynamic interactions by showing dyads the other partner's eye gaze positions. To improve pre-readers' understanding of reading, I show children their parents' eye gaze positions in real time. A moving cursor on the computer screen shows where their parents are looking at any moment. Pilot studies showed that preschoolers readily understand the correspondence between the moving cursor and parents' visual attention, and seeing how the parents move their eyes changes

children's conception about reading. I also investigate how parents use the real-time eye gaze information of their children to regulate joint attention.

As such, three studies are conducted in the current dissertation. Study 1 serves as the control condition for two intervention studies: Study 2 and 3. To rule out the influences of schooling and children's natural maturity, the three studies were simultaneously carried out. Parent-child dyads were randomly assigned to Study1, 2, or 3 when they walked into our lab.

In Study 1, I measure how much joint attention on print exists during the naturalistic shared book reading. Both partners are eye tracked in a naturalistic shared reading task. Children's word recognition is measured before and after the reading. I anticipate little joint attention on print and therefore limited print learning occurs during this naturalistic shared reading activity. This result may confirm with previous research on the moderate efficacy of shared book reading on children's literacy development.

In the next two intervention studies, I investigate whether the new technology with the real-time feedback of eye movements enhances parent-child joint attention and children's print-related learning. In Study 2 children are provided the opportunity of watching how their parents read texts while parents only look at static book pages. In Study 3 parents are shown their children's real-time eye movements while children only look at static book pages. I hypothesize that seeing where the other partner is looking will help dyads regulate joint attention and help children learn reading. Note that I did not create the two-way-feedback condition (i.e., simultaneously providing a parent and a

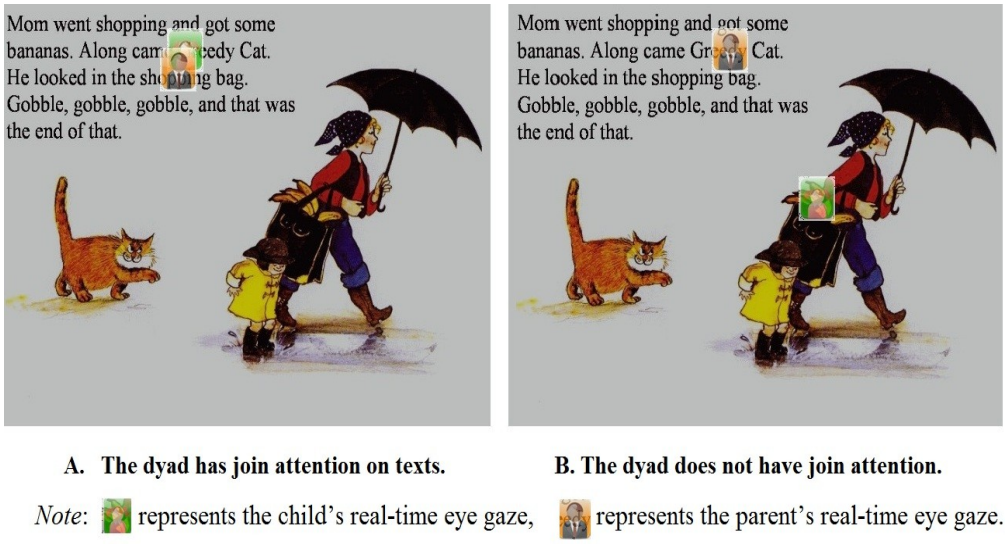
child the real-time eye-gaze feedback from the other partner) in the current dissertation. The main issue here is that the two-way condition will create a feedback loop in which the dyads will chase each other's eye gaze. I will discuss the potential solutions to this issue in the General Discussion section. The research methods and results of the current three studies are illustrated as follows.

2. Study 1: Joint Attention in the Naturalistic Parent-Child Shared Book Reading

2.1 Design and Hypotheses

Study 1 is the baseline in which I measure how much joint attention on print exists during the naturalistic shared book reading. For each reading dyad, both the parent and the child are eye tracked and video-taped in a naturalistic shared reading task. Before and after the reading session, I measure children's sight word recognition to see if they have learned some new words.

I define joint attention as when the reading partners look simultaneously at (or near) the same visual object on a page (see the examples in Figure 1).



A. The dyad has join attention on texts. **B. The dyad does not have join attention.**

Note: represents the child's real-time eye gaze, represents the parent's real-time eye gaze.

Figure 1: Examples of Parent-Child Joint Attention on One Book Page During Shared Reading.

If the distance of the eye gaze locations between a parent and a child at any moment is smaller than a certain cut-off value (which will be determined empirically), this parent-child dyad is said to have joint visual attention at that particular moment, and

vice versa. The percentage of time in which the dyad has joint attention on texts during the entire reading session is treated as the dependent variable of how much joint attention on texts the dyad engages in the naturalistic shared book reading activity.

Based on previous studies (Evans & Saint-Aubin, 2005; Evans et al., 2009; Feng & Guo, 2010, under revisions; Justice et al., 2008; Justice, Skibbe, et al., 2005), I predict children rarely look at texts and therefore there is little joint attention on print between children and parents. This in turn implies limited print learning during the reading session, as measured by children's gains in the sight word recognition. If confirmed, these data will suggest that parent-child dyads do not have much joint attention on print during the naturalistic shared book reading and the lack of joint attention limits children's literacy acquisition in this activity. Additionally, to the extent there are individual differences in children's visual attention, children who have higher joint attention with their parents on texts are expected to learn more keywords from the reading materials. Finally, I hypothesize that parent-child dyads would increase their joint attentional interactions on print related to the repeated readings and the experiment instruction of word teaching. Study 1 also serves as the control condition for subsequent intervention studies.

2.2 Methods

2.2.1 Participants

Thirty-seven dyads (mean age of children was 58.76 months) participated in Study 1. They also serve as the control group for the subsequent intervention studies.

These reading dyads were recruited through Children Participants Database in the Department of Psychology and Neuroscience at Duke University as well as flyers at area preschools, day care centers, local libraries, museums, and Craigslist. Child participants are required to be 4-5 year old English speakers who have received no kindergarten instructions and have no history of hearing, vision, or cognitive impairments. The *Woodcock-Johnson Letter-Word Identification Test* (Woodcock, Mather, & Schrank, 2004) was used to screen out children who have insufficient alphabetic knowledge and children who are already readers. One additional child was tested but not included in the data analysis due to insufficient alphabetic knowledge. Children's average raw score in the *Woodcock-Johnson Letter-Word Identification Test* was 15.78 (out of 26 items, *SD*=6.12), suggesting that these children did have some letter knowledge but could not read all words independently. Parent participants are required to be the person who reads most frequently with children at home. Parents were paid $10 for their participation, and children received small prizes such as crayons.

There were 23 Caucasian children, 13 African American children and 1 Asian American children in this sample. Thirty-four out of the 37 parents had a college degree or higher, reflecting a middle- to upper-SES sample. According to parents' report, 81% of these children were read to routinely 5-7 times per week, 20-30 minutes each time.

2.2.2. Materials

Four age appropriate storybooks Greedy Cat (Cowley, 1983), Where Are They (Tallarico, 1989), Bertie at Bedtime (Pfister, 2008), and Alligator Boy (Rylant, 2007) were presented for dyads to read together. The first three books were read during a dyad's

first visit in our lab. In the dyad's one week follow-up visit, they read one of the first three books and the fourth book Alligator Boy.

The four books are dominated by illustrations on every page, with predictable narratives that encourage children to make predictions. The four books are not significantly different in the complexity features including the total number of pages and the number of words per page (see Table 1). The pages of the books were scanned in full color and presented on computer monitors one page at a time during the study.

Table 1:The Complexity Features of Four Storybooks

Book Name	Number of Pages per Book	Average Number of Words per Page
Greedy Cat (Cowley, 1983)	11	16
Where Are They (Tallarico, 1989)	10	11
Bertie at Bedtime (Pfister, 2008)	12	17
Alligator Boy (Rylant, 2007)	13	13

Children's sight word learning was measured before and after reading with a *Keyword Recognition Test* (reliability α=0.96), i.e., asking each child to name 10 content keywords sampled from one of the storybooks (*see the* Keyword Recognition Test *in Appendix 3*). The keywords were shown to each child one at a time on a piece of paper. Scoring is straightforward: A response will be either correct or incorrect (including "I

don't know"). I also used the *Woodcock-Johnson Letter-Word Identification Test* (Woodcock et al., 2004) to measure children's pre-existing literacy level.

During the first lab visit, each parent filled out a brief *Home Literacy Survey* (see Appendix 4), in which I investigate the contextual information about children's literacy environment and parent-child shared reading experiences at home. In both the first and the one week follow-up visit, each parent filled out the *Children's Reading Interest Survey*, in which I investigate whether children significantly change their reading interest after participating in the naturalistic shared book reading study. At the end of each dyad's first visit, I provided the *Home Reading Log* for the parent to take home and record their shared reading experiences for the following week. I collected the *Home Reading Log* during the dyad's follow-up visit.

2.2.3 Apparatus

Two contact-free eye trackers, a Tobii X50 (see http://www.tobii.se) and an Eyelink 1000 system (www.eyelinkinfo.com), were used in the study. The Tobii X50 system is a video-based remote eye tracking system that makes no contact with the participant. It samples at 50Hz, and has a typical accuracy of approximately 1 visual degree (measured by repeated calibrations). The system uses infrared cameras to automatically capture eye images from a reading distance. A 5-point calibration for Tobii X50 was used in all studies. Eyelink 1000 is also an infrared-based system, but with much higher accuracy (0.5 visual degree) and sampling rate (500 Hz) than the Tobii X50 system. As a remote system, it also allows contact-less operations. The only thing we

need to do is to put a reflective sticker on the forehead of the participant during the study. This is a way to track and compensate head movements during eye tracking. A 9-point calibration for Eyelink 1000 was used in all studies. For each dyad, the parent was eye tracked by Tobii X50 and the child was eye tracked by Eyelink 1000. Both eye tracking systems have message-passing functionality so that the real-time eye gaze information of two reading partners can be communicated between two systems.

For each dyad, the parent and the child sat across a child-sized table at a 90 degree angle. One LCD monitor (1280x1024 pixels resolution) and Eyelink 1000 were put approximately 60cm away from the child; while another LCD monitor (1280x1024 pixels resolution) and Tobii X50 were put approximately 60cm away from the parent (see Figure 2 for details of the set-up). Stimuli were presented simultaneously on both monitors. Stimulus presentation and eye movement calibration and recording were done using the Double Tracker program developed in our lab. The data were then exported offline for statistical analyses.

Figure 2: The Apparatus and Experiment Set-Up.

The child and the parent were individually calibrated on the Eyelink and Tobii eye trackers. They were monitored throughout the study and recalibrated as necessary. Both remote eye trackers use the corneal reflection to compensate for head movements. Our past experience shows that neither exhibits substantial drifts that affect results in our experimental paradigms.

To the extent both eye trackers are accurately calibrated, aligning the gaze positions is straightforward. Because identical images are shown on both monitors, we took the gaze position in terms of screen coordinates and mapped to the other screen. This is essentially the same as the standard technique of displaying a gaze cursor on the same monitor as the participant is viewing.

Two video recorders were used to record verbal and non-verbal interactions among each dyad. One webcam was placed on the top edge of one LCD monitor to

record the behaviors of the child from a front view. Another camcorder was placed in one corner of the lab room to record the interactions between the dyad from a side view.

2.2.4 Procedures

The study was conducted with one dyad at a time in our on-campus lab. When a parent- child dyad arrived in the lab during their first visit, I first introduced the dyad the eye-tracking apparatus as a warm-up session. Then the dyad was presented with a pretest session, a reading session, and a posttest session.

During the reading session, the parent was instructed to read naturally as he/she would do at home. The dyad read three books (*Greedy Cat, Where Are They,* and *Bertie at Bedtime*) in four reading trials. They read one same storybook in the first and fourth trial, and the other two storybooks in the second and third trial. In the fourth trial the parent was asked to teach three words that the child did not recognize based on the *Keyword Recognition Test*. To tease apart the impact of the instructions from the moving cursor in the subsequent Study 2, I asked children in Study 1 to follow the parent's eye gazes while listening to stories, even though they could not actually see the eye gazes in this study. The presentation order of the three books was randomized and counterbalanced among all participating dyads. Both the parent and the child were eye tracked and video-taped during the reading session which lasted about 15 minutes.

I assessed the child's sight word learning with the *Keyword Recognition Test* in both the pretest and posttest sessions. For example, the child who read *Greedy Cat* in the first and fourth trial was tested by the same 10 keywords from the *Greedy Cat*. The child

was also tested the pre-existing letter and word knowledge by the *Woodcock-Johnson Letter-Word Identification Test*. The parent filled out the *Home Literacy Survey* and *Children's Reading Interest Survey* in the posttest. At the end of each dyad's first visit, I provided the parent the *Home Reading Log* for the purpose of recording their shared reading experience at home for the following week and asked the parent to bring the log back in the follow-up visit.

During the dyad's one week follow-up visit, the dyad first read the storybook which they read in the first and fourth trials in their previous lab visit. Then the child was encouraged to retell the story page-by-page on the screen by himself/herself or with adults' help. After finishing the first storybook, the dyad went through the same procedures (shared book reading and retelling the story) with the new book *Alligator Boy*. The child's keyword recognition for words sampled from the two books was also measured. The parent was eye tracked when reading the two books, while the child was eye tracked when reading the books and retelling the stories. The parent was asked to fill in the *Children's Reading Interest Survey* again after the reading session. In the end of this visit I collected the *Home Reading Log* and discussed the log details with the parent.

2.2.5 Data Transcription and Coding

For the eye movement data, areas of interest (AOIs) were defined for pictures and texts on each page of the four books. An AOI includes a margin of approximately 1.3cm on each side of object it encloses. Eye movements fell outside of any AOIs (e.g., on the white background) were excluded from analyses. Data were also discarded when

the eye trackers lost track, which could occur when the participant looked away from the monitor, moved the head rapidly, or closed his/her eyes. On average 31.6% of the eye movement samples were excluded. The average percentage of children's fixations on text AOIs in the first reading trial was compared with that in the fourth reading trial.

To measure the real-time joint attention during the reading session, I compared the distance of two partners' eye gaze locations with a cut-off value which was determined empirically. Before reading the first storybook, the dyad was asked to look at an animal picture (220 x 220 pixels) on the center of both screens and talk about the animal for 30 seconds. Ideally, the parent and child should have the perfect joint attention (i.e., they look at exactly the same locations on the screen) during these 30 seconds. In a minority of cases the parent or the child may look away from the target picture and therefore the distance between the two gaze points will vary and most likely larger than when joint attention is present. According to the frequency distribution table (see Table 2) and the histogram (see Figure 3) of the distance (pixels) of all reading dyads' eye gaze locations, the 80th percentile (201.18 pixels) and the 85th percentile (262.69 pixels) are two reasonable cut-off values because they could cover most of the effective eye movement data points in the distance distribution. Any data points larger than 262.69 pixels could be treated as random errors. Therefore, I chose 201.18 and 262.69 pixels as the potential cut-off values to calculate the percentage of joint attention in the reading trials. These are liberal measures, i.e., they likely include all cases of true joint attention and cases where parents and children's attention diverge to a moderate degree. In this first attempt to objectively measure the amount of joint attention in shared book reading,

I would rather err on the side of over-estimating than unfairly dismissing potential joint attention instances.

Table 2: Frequency Distribution of the Distance (pixels) between Dyads in the Joint Attention Trial

N	Valid	77128
	Missing	0
Mean		196.98
Mode		105.38
Standard Deviation		279.42
Percentiles	25	63.91
	50	106.68
	75	176.42
	80	201.18
	85	262.69

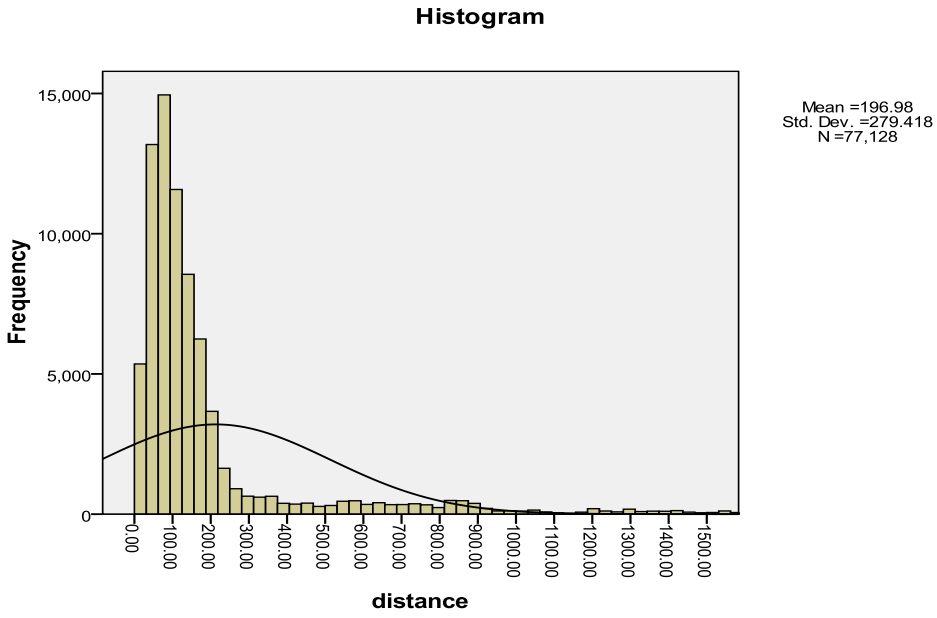


Figure 3: Histogram of the Frequency Distribution.

The percentages of joint attention on texts under the two different cut-off values were highly correlated ($r = .95$, $p < .01$) and presented the similar patterns in terms of the comparison between the first and fourth reading trials, suggesting that the measurement of joint attention is consistent and does not depend on the specific cut-off value. The cut-off value of 201.18 pixels is more appropriate than the 262.69 pixels for two reasons. First, the visual angle which corresponds to the 201.18 pixels is about 10 degrees (Eyelink systems typically have 20 pixels / degree). The human fovea, where we have clear vision, is about 2 degrees. So the visual angle of 10 degrees is not a too small window size for a definition of joint attention. Second, the 201.18 pixels are close to the size of two 5-letter-long print words in pixels (the average length of a 5-letter-long word is 100 pixels). Therefore, we believe this is a very reasonable window to define joint attention in reading. Hereafter I only report the results under the cut-off value of 201.18 pixels; results from the larger cut-off value are available upon requests.

I determined that joint attention exists if the distance is smaller than 201.18 pixels and does not exist if the distance is larger than or equal to 201.18 pixels. The percentage of time when the distance of two partners' eye gaze locations is smaller than 201.18 pixels represents how much joint attention the dyad has when reading together.

Video recordings of the parent-child shared book reading interactions were transcribed and coded with the InqScribe software. Adapting from the coding systems in previous studies (Chi et al., 2001; Ortiz et al., 2001; Sulzby, 1985; Whitehurst, Fischel, et al., 1988), I have developed a coding system to analyze dyads' global scale behaviors (including children's reading interest and parents' enthusiasm) and counted reading

behaviors (see Appendix 5). In addition to the measures of parent-child joint attention interactions and parents' reading strategies, I also examined children's verbal and non-verbal responsiveness during the reading interactions since researchers suggested that children's responsiveness plays an important role in the quality of shared book reading. For example, young children with high levels of vocalizations were asked more questions and provided with more feedback from parents than children with lower rates of vocalizations (Senechal, Cornell, et al., 1995). All together, there are 11 types of counted reading behaviors, including parents looking at children, children looking at parents, parents' verbal attention regulation, parents asking children to look at specific words, parents teaching specific words, parents providing children specific feedback, parents pointing to words on the screen, children reading texts along with parents, children pointing to texts on the screen, children completing a sentence with parental prompt, and children talking about print. The inter-rater reliability analysis (Cohen's Kappa) of the behavior coding was performed using 20% of the sample.

2.3 Results

2.3.1 Eye-tracking Results and Print Learning Outcomes

During dyads' first lab visit, the average percentage of time children fixated on text AOIs in the first reading trial was 9.2% (*SD*=7.69) and the average percentage of time children had joint attention with parents on texts in the first reading trial was even smaller (2.91%, *SD*=2.89). In the fourth reading trial, when adults were asked to teach children three keywords while reading the same book, children significantly increased

their attention on texts to 14.42% (*SD*=14.82, *t* (36) = 2.69, *p*=.011). By the same token, the average parent-child join attention on texts in the fourth reading trial (6.41%, *SD*=9.76) was significantly higher than that in the first reading trial (*t* (36) = 2.48, *p*=.018).

Children's average pre-test raw score of the Keyword Recognition Test were 1.81 (out of 10 words, *SD*=3.25), which was lower than the post-test raw score of 2.19 (out of 10 words, *SD*=3.37), *t* (36) = 3.19, *p*=.003. Children's average word learning gain was measured by the difference of the pre- and post-test raw scores of the Keyword Recognition Test (children's average number of learned new words is .38, *SD*=.72).

There were individual differences in dyads' joint attention on texts. I did a median-split based on the dyads' average percentage of joint attention on texts: the group with a low level of joint attention on texts (the dyads' average percentage of joint attention on texts was 1.33%, *SD* =.73) vs. the group with high level joint attention on texts (the dyads' average percentage of joint attention on texts was 7.82%, *SD* = 6.68).

Children who have higher joint attention with their parents on texts are expected to learn more words during reading. The results showed that this group of children showed an average number of .53 (*SD*=.84) words as the pretest-to-posttest gain in the Keyword Recognition Test. The average number of learned words for children in the low level of joint attention on texts was .22 (*SD*=.55). However, the difference of the word learning gains between the two groups was not significant (*t* (35) = 1.3, *p*=.204). Neither was the correlation between children's average joint attention on texts and their pretest-to-posttest word learning gain (*r*=.23, *p*=.18). The lack of the significant difference of the

word learning gains between the two groups could be caused by the small power of the statistical test or the floor effect. Neither the high nor the low level joint attention group of children learned more than one new word from the pretest to posttest.

On the other hand, the individual difference in dyads' average joint attention on texts was strongly correlated with children's pre-existing keyword recognition level (r=.58, p<.01): the more words children recognized before reading, the higher the percentage of joint attention on texts they showed during the naturalistic shared book reading. I divided children into two groups based on whether they could recognize any words in the *Keyword Recognition Test* before the first reading trial: the group of low level word recognition (none of the 23 children in this group could recognize any words) vs. the group of high level word recognition (the average number of recognized words for the 14 children in this group was 4.79). The average percentage of joint attention on texts for the former group was 2.78% (SD=2.69), significantly lower than the 7.76% (SD=7.97) for the latter group (t (35) = -2.77, p=.009).

To further examine the relationships among children's pretest-to-posttest keyword learning gain, their level of join attention on texts, and their pre-existing word recognition level, I did a repeated measures ANOVA using the *Keyword Recognition Test* as the within-subjects variable (pretest vs. posttest), children's level of join attention on texts as the between-subjects factor (low vs. high joint attention level), and children's pre-existing word recognition level as a covariate. The results showed that the main effect of the pre-existing word recognition level was significant, F (1, 34) =38.22, p=.000, partial eta squared=.53, power=.99; the main effect of the level of join attention on texts was

marginally significant, F (1, 34) =3.46, p=.072, partial eta squared=.09, power=.44. However, the within-subjects effect was not significant, F (1, 34) =.003, p=.96, suggesting that children did not significantly increase the number of keywords they could recognize from pretest to posttest (see the descriptive statistics in Table 3).

Table 3: Children's Keyword Recognition Performance in Pretest and Posttest

Keyword Recognition Test	Joint Attention Level	Mean (Number of Recognized Keywords)	SD	N
Pretest	Low	.72	1.90	18
	High	2.84	3.92	19
	Total	1.81	3.25	37
Posttest	Low	.94	2.18	18
	High	3.37	3.90	19
	Total	2.19	3.37	37

The interaction effect between children's keyword recognition performance and their pre-existing keyword recognition level was not significant, F (1, 34) =1.09, p=.30. Neither was the interaction effect between children's keyword recognition performance and their level of joint attention on texts, F (1, 34) =1.12, p=.30. These non-significant interaction effects suggested that the number of recognized keywords in the posttest did not increase more among either those children who knew more keywords in the pretest or those children with high level of joint attention on texts.

Taken together, during dyads' first lab visit, both children's average attention on texts and their joint attention with parents on texts in the naturalistic shared book reading trial were small. Children's average number of learned keywords from the pretest to the posttest was limited. Children showed individual difference in their joint attention on texts and this difference was significantly correlated with their pre-existing sight vocabulary. However, there was no clear evidence that the difference in children's level of joint attention on texts would affect their sight word learning after reading those storybooks. Neither was there clear evidence that children's pre-existing keyword recognition level influenced their keyword learning from the pretest to posttest.

2.3.2 Behavioral Coding Results

Only thirty-six parent-child dyads were included in the behavioral data analysis for the first lab visit. Another dyad was video-taped but their data could not be used due to the poor recording quality. The inter-rater reliabilities for the global scale behaviors and the counted reading behaviors were found to be 0.76 ($p<.01$) and 0.79 ($p<.01$), respectively. As indicated by previous research (Landis & Koch, 1977; Ortiz et al., 2001), those *Kappa* values between .61 and .80 could be claimed as good levels of agreement.

For the global scale behaviors, children's average reading interest was 2.24 (on a 1-3 scale, $SD=.42$); parents' average enthusiasm was 2.43 (on a 1-3 scale, $SD=.45$). For the counted reading behaviors, I divided 11 types of behaviors into three categories: parent-child joint attention interactions, parents' reading strategies, and children's responses. The frequencies (times per minute) of these behaviors in the first reading trial

(word teaching was not required) were compared with those in the fourth reading trial (word teaching was required, see Table 4).

Table 4: Mean (Standard Deviation) of the Behavior Occurrences per Minute in Study 1

Category of Behaviors	Types of Behaviors	Reading Trial 1	Reading Trial 4
Parent-child Joint Attention Interactions	Parents look at Children	.42(.96)	1.46(2.35)**
	Children look at Parents	.90(1.07)	2.48(2.86)**
	Parents' Verbal Attention Regulation	.07(.25)	.26(.38)**
Parents' Reading Strategies	Parents ask Children to Look at Specific Words	0(0)	.53(.76)**
	Parents Point to Words on the Screen	.01(.05)	.15(.53)
	Parents Teach Specific Words	.01(.07)	.17(.44)*
	Parents Provide Specific Feedback	0(0)	.01(.04)
Children's	Children Read Along with Parents	.01(.05)	.25(.42)**

Responses	Children Complete a Sentence with Parents' Prompt	.06(.34)	.32(1.15)
	Children Point to Texts on the Screen	.01(.08)	.13(.36)
	Children Talk about Print	0(0)	.27(.5) **

* Significant differences were observed between reading trial 1 and 4 *(P*<.05);

**Significant differences were observed between reading trial 1 and 4 *(p*<.01).

Parent-child dyads significantly increased their joint attention interaction types of behaviors from the first reading trial to the fourth reading trial, such that parents increased the frequency of looking at children (t (35) =-2.88, p=.007) and the frequency of verbally regulating joint attention (t (35) =-3.30, p=.002), while children also increased the frequency of looking at parents during reading (t (35) =-3.98, p=.000).

Parents significantly increased their frequencies of two types of reading behaviors from the first reading trial to the fourth trial, including asking children to look at specific words on the screen (t (35) = -4.15, p=.000) and teaching those words (t (35) = -2.16, p=.038). Children also increased their responses to parents' reading strategies from the first reading trial to the fourth trial, such that children more frequently read along with adults (t (35) = -3.31, p=.002) and talked about print (t (35) = -3.23, p=.003) during the shared reading.

2.3.3. Follow-up Visit Results

Twenty-one out of the previous thirty-seven parent-child dyads participated in the one week follow-up study in our lab. The analyses of the *Reading Interest Survey*, *Home Reading Log*, children's eye movements during reading and story retelling as well as their learning outcomes are reported in the following sections.

2.3.3.1 Children's Reading Interest in the First and Follow-up Visit

The means and standard deviations of the variables in the measurement of children's reading interest are presented in Table 5. The *Brief Reading Interest Scale* (BRISC) showed how parents rated their children's overall interest in shared book reading compared to other 10 activities (1=like reading most; 11=like reading least). Parents' answers about how often their child asks to be read to and how often their child reads alone were coded on 1-5 scale (1 refers to "Hardly ever"; 2 refers to " < 3 times/month"; 3 refers to "< 3 times/week"; 4 refers to "Almost daily"; 5 refers to " > once/day", see details in Appendix 1).

Table 5: Means (SD) for Children's Reading Interest Measurement Variables in Study 1

	Reading Interest Survey (Parental Report)					Home Reading Log	
	Child's interest in reading compared to 10 other activities (BRISC)	Child asks to be read to	Child chooses to read alone	Child's degree of concentration in reading (1=lowest concentration; 5=highest concentration)	Duration child chooses to read (minutes)	Proportion of sessions child initiated	Child interest (1=least interested; 5=most interested)
The First Visit	4.24(2.07)	4.33(.66)	4.29(.64)	4.52(.68)	24.05 (7.52)		
The Follow-up Visit	3.33(1.59)	4.38(.59)	4.29(.56)	4.57(.51)	26.19(10.24)	.53(.29)	4.49(.51)

According to the parental report in the survey, children did not change much of their reading interest after participating in the naturalistic shared book reading session in our lab. For example, the rank of children's interest in reading in the first lab visit was not significantly different from that in the follow-up visit (t (20) = 1.36, p = .18).

Children did not significantly increase the frequency of asking to be read to (t (20) = .44, p = .666) and the frequency of reading alone (t (20) = 0, p = 1). Parent did not think that their children changed their degree of concentration in reading neither (t (20) = .33, p = .748). Lastly, the duration of time children chose to spend on reading activities did not change after they participated in our study (t (20) = 1.4, p = .176). These comparisons of the parental reports of children's reading interest between the first lab visit and the follow-up indicated that children's reading interest is a relatively consistent and stable construct in the naturalistic shared book reading.

Children's interest in reading was also assessed by the *Home Reading Log* recorded by parents. During the one week after those children participated in our naturalistic shared book reading study, children overall initiated about half of the reading sessions at home and they maintained very high level of interest during those sessions.

2.3.3.2 Children's Eye Movements during Reading and Story Retelling

Eighteen out of the twenty-one children were included in the eye movement data analysis (three children were excluded due to their poor data quality). When children read the old book which they already read in the first and fourth trials during the first lab visit, the average percentage of time children fixated on text AOIs was 11.71% (*SD*=10.47), which was not significantly from children's average percentage of attention on texts in either the first trial (9.56%, *SD*=8.75, t (17) = 1.16, p = .262) or the fourth trial (16.05%, *SD*=15.55, t (17) = 1.41, p = .178) during the first lab visit. Similarly, the average percentage of time children had joint attention with parents on texts was 4.82%

(*SD*=5.14), which was not significantly from the average parent-child joint attention on texts in either the first trial (3.3%, *SD*=3.4, t (17) = 1.63, p = .122) or the fourth trial (7.71%, *SD*=12.02, t (17) = 1.23, p = .234) during the first lab visit. The above comparisons between the first lab visit and one-week follow-up visit suggested that children did not change much of their reading eye movements after participating in the naturalistic shared reading study.

When children read the new book *Alligator Boy* which they did not read in the first lab visit, children spent 12.88% (*SD*=9.22) of their time focusing on texts. And the average parent-child join attention on texts for the new book was 6.11% (*SD*=5.37). There was no difference of either children's average attention on texts (t (34) =.36, p = .724) or parent-child joint attention on texts (t (34) =.73, p = .469) between the old and the new book.

With respect to children's eye movements when they were retelling the two stories on the screen, there was no difference of children's average percentages of time spending on texts between the old book (16.68%, *SD*=15.17) and the new one (16.23% , *SD*=19.49; t (34) =.08, p = .94).

2.3.3.3 Children's Learning Outcomes

After reading the new storybook *Alligator Boy*, children on average could successfully recognize 2.43 (out of 10 keywords, *SD*=3.38) keywords. For the old storybook which children have read in their first lab visit, the average number of keywords they successfully recognized in the follow-up visit was 2.05 (out of 10

keywords, *SD*=3.12), which was not significantly different from the number of keywords (2.19 out of 10, *SD*=3.66) children could recognize before they read the book in the first lab visit (t (20) = .37, p= .715). This result suggested that children could not recognize more keywords after they read the same book twice in our lab. In other words, participating in the naturalistic shared book reading study did not improve children's keyword recognition performance in a short term of one week.

When children were asked to retell the story of the old book page-by-page on the screen, they used on average 5.39 (*SD*=3.71) keywords from the book. When children retold the story of the new book, they used on average 4.28 (*SD*=2.82) keywords. The results suggested that although children may not be able to recognize many sight words in the *Keyword Recognition Test*, they could utilize those keywords to retell a story with the help of the pictures, the print, or their own memory.

2.4 Discussion

Study 1 examines parent-child real-time joint attention during the naturalistic shared book reading and how different levels of joint attention on print affect children's sight word learning outcomes. From both eye-tracking and behavioral coding results, we can draw the following conclusions. First, these data supported our hypotheses that parent-child dyads did not have much joint attention on texts and children did not learn many keywords from the pretest to the posttest. Additionally, children did not change much of their reading interest, reading eye movements, or their sight word recognition performance from the first lab visit to the one week follow-up visit, suggesting that the

naturalistic shared book reading activity could not significantly influence children's reading habits and print learning in short term.

These results were also consistent with previous research findings (Evans & Saint-Aubin, 2005; Evans et al., 2009; Feng & Guo, 2010, under revisions; Justice et al., 2008; Justice, Skibbe, et al., 2005). When children read books with adults, they usually prefer pictures and avoid looking at texts. Since adults read from texts most of the time, children's ignorance of texts would lead to little adult-child joint attention on print during the naturalistic shared book reading. The lack of joint attention on print would further limit children's print exposure. In such case, children can hardly improve their sight word learning from the shared book reading activity.

One possible reason for the lack of joint attention in the naturalistic shared book reading is that children have no idea where parents are looking at on a book when telling stories and children may assume parents get the story information from pictures. Children may try to establish the joint attention with parents by looking at pictures which they believe are also focused by their parents. If we could use new technologies to let children see parents' real-time eye movements and help children understand that adults get the story information from texts, children may focus more on texts during the shared reading and their literacy learning may be greatly improved in the long run. This hypothesis is tested in Study 2.

Furthermore, I found that children had individual difference in their joint attention with parents on texts and this individual difference was significantly correlated to children's pre-existing sight vocabulary. The more keywords children could recognize

before reading the books, the more joint attention on texts they would engage in with adults. This result replicated our previous shared reading study (Feng & Guo, 2010, under revisions). However, results in Study 1did not show that children's individual difference in the level of joint attention on texts would affect their sight word learning during the naturalistic shared book reading. Neither did I find clear evidence that children's pre-existing sight vocabulary would determine how well children learned those keywords.

The lack of direct evidence that the individual difference of parent-child joint attention level would influence children's print learning may be due to the floor effect. To put it another way, no matter whether children have more or less joint attention on texts during the reading, children in general learn few new words during the naturalistic shared book reading sessions. If children significantly improve the sight word recognition performance when they increase their joint attention on texts, it is evidence that children's joint attention level does affect their learning of emergent literacy skills. This will be tested in the following intervention studies.

The naturalistic nature of this data set and the analyses I have done in Study 1 mean that I can only draw correlational conclusions about the relationship between the dyads' joint attention on texts and children's print learning. After collecting all the data, I divided the children participants into two groups (high vs. low levels of joint attention) based on a median-split of the frequency distribution of children's percentage of joint attention on texts. Then I compared the two group children's sight word learning gains which turned out to be not significantly different. Moreover, the baseline correlation between children's percentages of joint attention and their pretest-to-posttest keyword

recognition gains was in the expected direction. However, the magnitude was modest, and the direction of causality unclear. All these results point to the need for the experimental evaluation of the relationship between children's joint attention on texts and their sight word learning.

A natural follow-up to Study 1 would be to keep everything else (e.g., the reading materials, study set-up and procedures) the same, and use our newly developed eye tracking technology to significantly increase children's joint attention on texts in Study 2. Then I could compare children's keyword learning gain in Study 2 with that in Study 1 to explore the causal relationship between the dyads' joint attention on texts and children's print learning. If children learn more keywords from pretest to posttest in Study 2, we could claim that the increase of joint attention level causes the improvement of children's keyword recognition performance.

Lastly, the behavioral coding analysis showed that from the first reading trial to the fourth reading trial, adults increased the frequencies of their joint attention regulation and word teaching strategies such as constantly looking at children and verbally asking children to pay attention on words on the screen. In return, children more frequently responded to adults' attention regulations and reading instructions such as reading along with adults and talking about print in the books. Parent-child dyads' increase of joint attention and reading interactions was partly due to the repeated readings of the same book in the first and fourth reading trial. Previous research also revealed that repeated readings increased the number and complexity of comments and questions made by both adult readers and children (Crowe, 2000; Lyytinen et al., 1998; Morrow, 1988; Penno,

Wilkinson, & Moore, 2002). More importantly, in the fourth reading trial I instructed the parents to teach three words that their children did not recognize based on the pretest of keyword recognition. This instruction additionally encouraged parents to use more strategies to draw children's attention on texts. In Study 2, if the technology-assisted shared reading paradigm facilitates parent-child joint attention regulation, I predict that reading dyads would show more frequent and effective reading interactions.

To sum up, Study 1 suggests that the traditional shared book reading paradigm have limitations in terms of helping parent-child dyads effectively regulate joint attention on texts and improving children's sight word learning during the reading activity. Study 1 serves as the baseline condition for the following intervention studies in which I use advanced eye tracking technology to facilitate joint attention interactions during the shared book reading activity. I would compare the average percentages of adult-child joint attention on texts in Study 2 and Study 3with that in Study 1 to examine whether our interventions significantly improve dyads' join attention on texts. Children's sight word learning gains in Study 2 and 3 would also be compared with that in Study 1to reveal whether and how the increased level of joint attention on texts causes children's improvement of print learning.

3. Study 2: Externalizing Adults' Visual Attention for Children in Shared Book Reading

3.1 Design and Hypotheses

Study 2 investigates whether the real-time feedback of parents' eye movements changes parent-child joint attention interaction as well as how this change enhances children's understanding of the reading process and their print learning. Our pilot studies showed that most preschool children are unaware of facts about reading that we take for granted, such as adults pay attention to print during shared book reading and they read texts from left to right. Prior reading research also revealed that before children understand that an adult is reading the print, not the pictures, they are less likely to examine the print (Ehri, 1993). I argue that the real-time feedback of adults' eye gaze locations could help children understand where adults pay attention to on a book and therefore children would adjust their own attention focus to print in order to build the joint attention with adults during shared book reading.

Furthermore, I hypothesize that observing how adults scan texts in real-time can promote children's learning of reading. According to the Social Cognitive Theory, "learning through watching" may be a key ingredient in a child's development (Bandura, 1986, 1989). It was suggested that children interpret and evaluate the behaviors they observe based on their previous experiences and then store this interpretation for their own future use (Bandura, 1994). However, reading is a mental process which cannot be easily observed, modeled, or verbally explained. For adults, they have no conscious access to reading. During shared book reading, adults do not usually use much language

to explicitly teach children how to read. The only external behavior of reading is the eye movements but children have never had the opportunities to see the real-time eye scanning patterns of adults while they are reading. Consequently, reading is an opaque process for children and they can not easily understand and imitate reading. In Study 2 when children see exactly how adults read texts with the real-time eye gaze feedback, they may compare what they see with their own hypothetical reading model and make some corresponding changes. For example, children may spend more time looking at texts and model adults' reading behaviors by scanning the texts from left to right.

A pretest-posttest control group design is adopted in Study 2. Children's understanding of reading and their keyword recognition are tested in both the pretest and posttest. The control group of Study 2 consists of all the parent-child dyads in Study 1. Children participants in Study 2 get the eye-gaze awareness training while children participants in Study 1 did not get such training. The eye-gaze awareness training is conducted by showing a child a moving cursor on the screen representing his/her parent's eye gaze location as the parent reads. This real-time visualization helps children understand that adults read stories from texts, not from pictures, and that they read by scanning texts from left to right. The average percentage of parent-child joint attention on texts and children's sight word learning outcomes in Study 2 are compared with those in Study 1.

Altogether, I have three hypotheses for Study 2. First, the eye-gaze awareness training would increase the time children spend scanning texts during the shared book reading. Second, seeing adults' reading eye movements changes children's understanding

of how reading is achieved. Third, the eye-gaze awareness training facilitates parent-child joint attention regulations and further improves children's acquisition of print related skills.

3.2 Methods

3.2.1 Participants

Twenty-nine parent-child dyads participated in Study 2 but two dyads were excluded in the final analysis due to poor eye movement data. The parent-child dyads were recruited and screened using the same approaches as Study 1. Children's average raw score in the *Woodcock-Johnson Letter-Word Identification Test* was 15.41 (out of 26 items, SD=5.69), suggesting that these children did have some letter knowledge but could not read all words independently. There was no difference of children's performance in the *Woodcock-Johnson Letter-Word Identification Test* between Study 2 and Study 1 (t (62) = -.25, p=.803).

These 27 dyads (mean age of children was 57.74 months) served as the experimental group and the 37 dyads in Study 1 (mean age of children was 58.76 months) served as the control group. There was no significant age difference between the two groups of children (t (62) = -.53, p=.6). There were 17 Caucasian children, 6 African American children and 4 Asian American children in the experiment group. Twenty-six of the 27 parents had a college degree or higher, reflecting a middle- to upper-SES sample. Parents reported that 82% of the children were read to routinely 5-7 times per

week, 20-30 minutes each time. The two groups of children were not significantly different on these basic aspects of their shared book reading background (see Table 6).

Table 6: Children's Basic Shared Book Reading Background in Study 2

Sample Size	Starting Age(months)	Frequency (times/week)	Duration Each Time (minutes)
Experiment Group (27 dyads)	9.70	6.26	22.15
Control Group (37 dyads)	8.95	6.5	21.78

3.2.2. Materials

The same three storybooks, Greedy Cat (Cowley, 1983), Where Are They (Tallarico, 1989), and Bertie at Bedtime (Pfister, 2008) were used in Study 2.

Children's sight word learning was also measured by the Keyword Recognition Test before and after the reading session. Parents filled out the Home Literacy Survey and Children's Reading Interest Survey in the posttest.

Two interview questions were developed to test children's understandings of how adults read storybooks, such as where adults look on a book (pictures vs. texts) to know how to tell a story and in which direction they read tests (Justice & Ezell, 2001). To ensure children can understand and answer the questions, the experimenter made some demonstrations with stuffed animals and asked children to select one answer choice to

those questions. Appendix 6 provides examples of the two interview questions which were asked before and after the reading session.

3.2.3 Apparatus

The apparatus and the set-up were the same as in Study 1. The only difference is that by using the Double Tracker program developed in our lab, I connected the two eye tracking systems so that adults' eye gaze position recorded by Tobii eye tracker was passed to the computer screen of Eyelink 1000 eye tracker, displayed as an eye gaze cursor. In such case, children can see the information indicating where their parents are looking at on the screen in real time.

3.2.4 Procedures

The study was conducted with one dyad at a time in our on-campus lab. When a parent-child dyad arrived in the lab, I first introduced the dyad the eye-tracking apparatus as a warm-up session. Then the dyad was presented with a pretest session, a reading session, and a posttest session.

During the reading session, the parent was instructed to read naturally as he/she would do at home. The dyad read the three books (Greedy Cat*,* Where Are They*,* and Bertie at Bedtime*)* in four reading trials. They read one same storybook in the first and fourth trial, and the other two storybooks in the second and third trial. In the fourth trial the parent was asked to teach three words that the child did not recognize based on the

Keyword Recognition Test. The presentation order of the three books was randomized and counterbalanced among all participating dyads. Both the parent and the child were eye tracked and video-taped during the reading session which lasted about 15 minutes.

In contrast to the children participants in Study 1 (the control group), who received the identical procedures for all four reading trials in which they did not see adults' real-time eye movements information, the children participants in Study 2 (the experiment group) were exposed to adult readers' eye movements from the second to the fourth reading trial. More specifically, each child was shown a moving cursor overlaid in each book page on the screen; the moving cursor indicated the location of the adult reader's eye gaze in real-time. Children were asked to follow adults' eye gazes in the reading trials.

In order to ensure that each parent-child dyad understood the gaze indicator, an iSpy-like game was employed. Before the second reading trial started, a picture consisting of 5 unrelated objects was presented on both screens. While a parent was scanning this picture, his/her child saw which object the parent was looking at shown by a moving cursor on the screen in front of the child. I first explained to the child what the moving cursor represents, and then asked the child to guess which object his/her parent was staring at. This guessing game familiarized the child with the gaze cursor display. Children responded enthusiastically about the gaze game and performed at ceiling after a few tries. Even the youngest children had no problem understanding the correspondence.

When I was certain that the child could understand that the moving cursor represents the parent's eye scanning, the second storybook was presented on both

screens. The child could see the parent's real-time gaze patterns superimposed on the book pages while reading the story. For the first two pages of the book, I just watched the child read the story without any interruption. For the next three pages, I stopped the parent for a while and further explained the eye gaze patterns to make sure the child knew how to follow the parent's reading eye movements. The procedures of the third and fourth reading trials were identical to that of the second reading trial except that I did not interrupt the reading process at all. Altogether the child got the eye-gaze awareness training for three reading trials. For all the four reading trials, the adult reader looked at a normal, static display of book pages.

In both the pretest and posttest sessions, I used stuffed animals as props to interview each child about his/her understanding of how adults get textual information when reading storybooks. Additionally, each child's sight word learning was measured by the *Keyword Recognition Test* in both the pretest and posttest sessions (e.g., a child who read *Greedy Cat* in the first and fourth trial was tested by the same 10 keywords from the *Greedy Cat)*. Each child was also assessed the pre-existing letter and word knowledge by the *Woodcock-Johnson Letter-Word Identification Test*. Adult participants filled out the *Home Literacy Survey* and *Children's Reading Interest Survey* in the posttest.

3.2.5 Data Transcription and Coding

The transcription and coding for the eye movement data were the same as in Study 1.

The change of children's average percentage of fixations on text AOIs from the first reading trial to the fourth reading trial in Study 2 (the experiment group) was compared with that in Study 1 (the control group). The reading dyads' average change of joint attention on texts from the first reading trial to the fourth reading trial in Study 2 (the experiment group) was also compared with that in Study 1 (the control group).

For the behavioral data, I examined children's conceptual changes of reading by comparing their answers to the interview questions between the pretest and posttest. Children's pretest-to-posttest gain in the Keyword Recognition Test in Study 2 (the experiment group) was compared with that in Study 1(the control group).

Video recordings of the parent-child shared book reading interactions were transcribed and coded with the same software and coding system as Study 1. The inter-rater reliability analysis (Cohen's Kappa) of the coding was performed using 20% of the sample. I compared reading dyads' pretest-to-posttest changes of counted reading behaviors (including joint attention interactions, parents' reading strategies, and children's responses) in Study 2 (the experiment group) with those in Study 1(the control group).

3.3 Results

3.3.1 Eye-tracking Results

In the first reading trial when there was no eye-gaze feedback for children, the average percentage of time children fixated on text AOIs was 12.3% (*SD*=13.74), while the average percentage of time children had joint attention with parents on texts was 5.35% (*SD*=8.15). After the eye-gaze awareness training, children significantly increased their attention on texts to 33.18% (*SD*=16.76, t (26) = 7.11, p=.000) in the fourth reading trial when the eye-gaze feedback was provided. There was also a large increase (t (26) =8.01, p=.000) of the average parent-child join attention on texts in the fourth reading trial (22.7%, *SD*=13.5) compared to that in the first reading trial.

To further compare the eye movement changes from the first to the fourth reading trial between the experiment (Study 2) and control group (Study 1), I did a repeated measures ANOVA using children's average percentage of attention on texts as the within-subjects variable (the first vs. the fourth reading trial) and whether children received the eye-gaze awareness training as the between-subjects factor (experiment vs. control group). The results showed that the main effect of the within-subjects variable was significant, F (1, 62) =59.54, p=.000, partial eta squared=.49, power=.99, suggesting that children on average significantly increased their attention on texts from the first to the fourth reading trial. The main effect of whether children received the eye-gaze awareness training was also significant, F (1, 62) =13.84, p=.000, partial eta squared=.18, power=.96, suggesting that overall children who received the eye-gaze awareness training spent more time looking at texts than children did not receive the training.

The interaction effect between the within-subjects and between-subjects variable was significant, F (1, 62) =21.42, p=.000, partial eta squared=.26, power=.99, suggesting that the increase of percentage of attention on texts from the first to the fourth reading trial among children who received the eye-gaze awareness training was significantly higher than that among children who did not receive this training. This significant interaction effect was concurrent with the direct comparison of the increase of children's attention on texts from the first to the fourth reading trial between the two groups, such that the experiment group children increased 20.89% (SD=15.27) of attention on texts, which was significantly higher (t (62) = 4.63, p=.000) than the 5.22% (SD=11.8) of attention the control group children increased (see Figure 4).

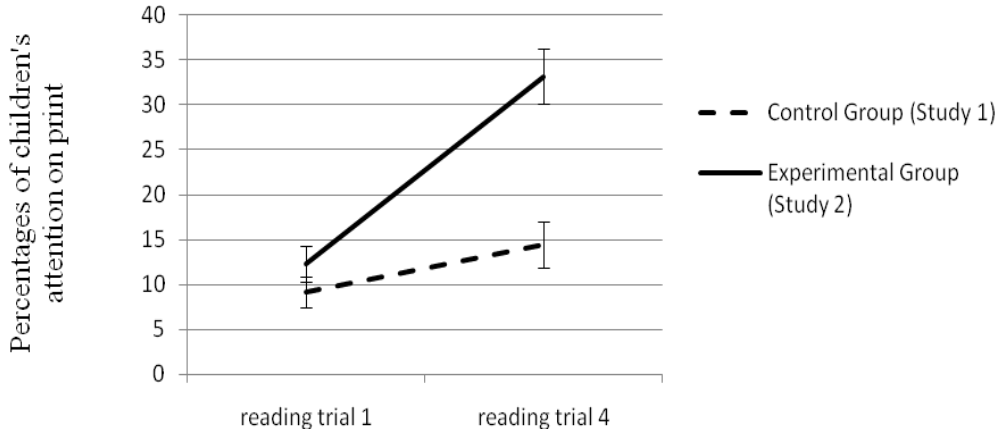


Figure 4: Percentages of Children's Attention on Print From Reading Trial 1 to 4 Between Experimental and Control Group in Study 2.

By the same token, I did a repeated measures ANOVA using the average percentage of parent-child joint attention on texts as the within-subjects variable (the first vs. the fourth reading trial) and whether children received the eye-gaze awareness training as the between-subjects factor (experiment vs. control group). The results showed that the main effect of the within-subjects variable was significant, F (1, 62) =70.8, p=.000, partial eta squared=.53, power=.99, suggesting that reading dyads on average significantly increased their joint attention on texts from the first to the fourth reading trial. The main effect of whether children received the eye-gaze awareness training was also significant, F (1, 62) =23.51, p=.000, partial eta squared=.28, power=.99, suggesting that overall children who received the eye-gaze awareness training engaged in more joint attention with parents on texts than children who did not receive the training.

The interaction effect between the within-subjects and between-subjects variable was significant, F (1, 62) =31.24, p=.000, partial eta squared=.34, power=.99, suggesting that the increase of percentage of joint attention on texts from the first to the fourth reading trial among children who received the eye-gaze awareness training was significantly higher than that among children who did not receive this training. This significant interaction effect was concurrent with the direct comparison of the increase of children's joint attention on texts from the first to the fourth reading trial between the two groups, such that the experiment group children increased 17.35% (SD=11.25) of joint attention on texts, which was significantly higher (t (62) = 5.59, p=.000) than the 3.5% (SD=8.58) of joint attention the control group children increased (see Figure 5).

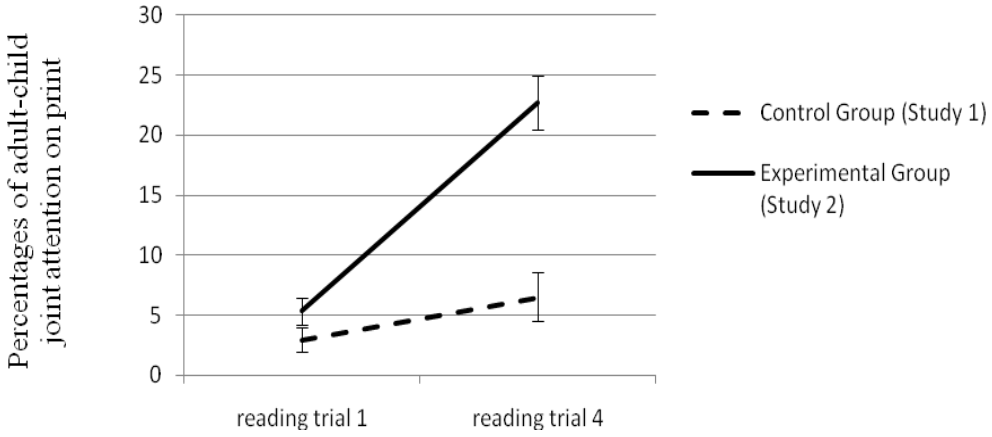


Figure 5: Percentages of Parent-Child Joint Attention on Print From Reading Trial 1 to 4 Between Experimental and Control Group in Study 2.

3.3.2 Children's Conceptual Changes

Seeing adults' eye movements was hypothesized to induce children's conceptual changes in Study 2. And the analysis of children's answers to the two interview questions supported this hypothesis. Before the eye-gaze awareness training, the percentage of children who believed that parents read from texts instead of pictures was 62.96% (*SD*=.49), which was not different from the chance level (X^2 (1) = 1.82, *p*=.178). After the eye-gaze awareness training, the percentage of children who had this same belief increased to 88.89% (*SD*=.32), which was significantly above the chance level (X^2 (1) = 16.33, *p*=.000).

In terms of the question on the directionality of print, children were at chance (51.85% (*SD*=.51)) in the pretest answering that adults read print from left to right (X^2 (1) = .04, *p*=.847). After the eye-gaze awareness training, the correct rate increased to 81.48% (*SD*=.4) which was significantly above chance (X^2 (1) = 10.7, *p*=.001).

3.3.3 Children's Print Learning Outcomes

Not only did the eye-gaze awareness training significantly changed children's attention on print and their conception of reading, it also resulted in more sight word learning for children in Study 2. I did a repeated measures ANOVA using children's keyword recognition performance as the within-subjects variable (pretest vs. posttest) and whether children received the eye-gaze awareness training as the between-subjects factor (experiment vs. control group). The results showed that the main effect of the within-subjects variable was significant, F (1, 62) =27.57, p=.000, partial eta squared=.31, power=.99, suggesting that on average children significantly increased the number of keywords they could recognize from the pretest to posttest. The interaction effect between the within-subjects and between-subjects variable was also significant, F (1, 62) =5.61, p=.02, partial eta squared=.08, power=.65, suggesting that children who received the eye-gaze awareness training learned significantly more keywords from the pretest to posttest than children in the control group did (see the descriptive statistics in Figure 6).

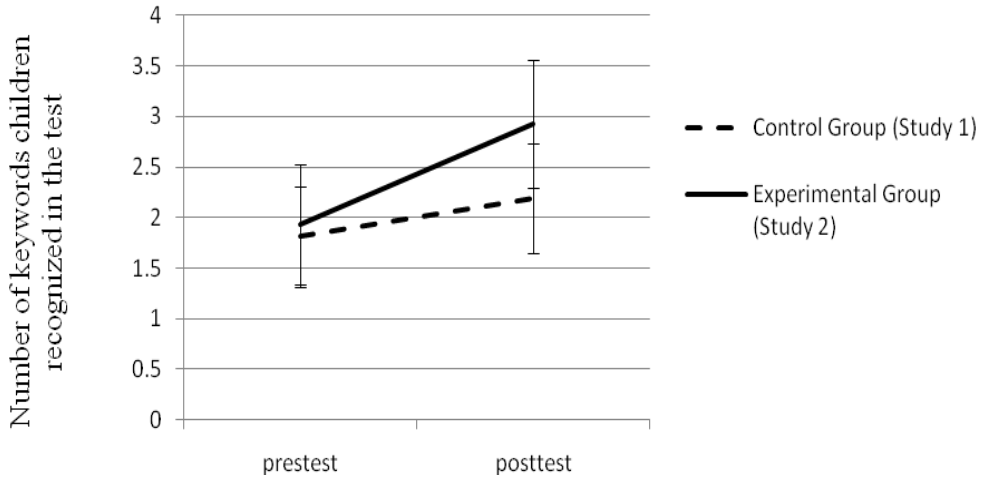


Figure 6: Children's Keyword Recognition Performance From the Pretest to Posttest Between the Experimental and Control Group in Study 2.

The main effect of whether children received the eye-gaze awareness training was not significant, F (1, 62) =.29, p=.59. Children's pre-existing keyword knowledge in Study 2 were not significantly different from that of children in Study 1 (t (62) = .15, p =.882). Neither did children's keyword recognition performance in the posttest (t (62) = .89, p =.378). To rule out the influence of the asymmetric interaction effect,
I further analyzed the difference score between the pretest and posttest in a simple t-test. The direct comparison of the pretest-to-posttest keyword learning gains between the two groups of children showed that children in the experiment group learned on average 1.0 word (*SD*=1.36), which was significantly higher than the 0.38 words which children in the control group learned (t (62) = 2.37, p =.02). This result indicates that children who received the eye-gaze awareness training learned more keywords from the pretest to the posttest than children who did not receive this training.

3.3.4 Behavioral Coding Results

All the twenty-seven parent-child dyads were included in the behavioral data analysis for Study 2. The inter-rater reliabilities for the global scale behaviors and the counted reading behaviors were found to be 0.77 (p<.01) and 0.81 (p<.01), respectively. As indicated by previous research (Landis & Koch, 1977; Ortiz et al., 2001), those *Kappa* values between .61 and .80 could be claimed as good levels of agreement.

For the global scale behaviors, children's coded reading interest in Study 2 was 2.55 (on a 1-3 scale, *SD*=.31), which was significantly higher than that in Study 1(2.24, t (61) = 3.22, p=.002). Parents' coded enthusiasm in Study 2 was 2.69 (on a 1-3 scale, *SD*=.42), which was also significantly higher compared to that in Study 1(2.43, t (61) = 2.29, p=.026). These coding results suggested that when children saw adults' real-time reading eye movements during shared book reading, they showed more interests in the books and the reading activity itself. Children's enhanced reading interests further improved parents' enthusiasm when talking about book-related things or teaching print during shared book reading.

For the counted reading behaviors, I divided 11 types of behaviors into three categories: parent-child joint attention interactions, parents' reading strategies, and children's responses. The changes of frequencies (times per minute) of these behaviors from the first to the fourth reading trial were compared.

Parents significantly increased the frequency of verbally regulating joint attention from the first reading trial to the fourth reading trial (t (26) = -2.42, p=.023). But parents did not significantly change the frequencies of their reading strategies from the first

reading trial to the fourth trial. On the other hand, after the eye-gaze awareness training, children significantly increased their three types of responses to parents' reading strategies from the first reading trial to the fourth trial, such that children more frequently read along with parents (t (26) = -3.38, p=.002), completed a sentence with parents' prompt (t (26) = -2.63, p=.014), and pointed to texts on the screen (t (26) = -2.06, p=.05).

The frequencies of the counted behaviors in the fourth reading trial between Study 1 and Study 2 were shown in Table 7.

Table 7: Mean (Standard Deviation) of the Behavior Occurrences per Minute in Reading Trial 4 between Study 1 and Study 2

Category of Behaviors	Types of Behaviors	Study 1	Study 2
Parent-child Joint Attention Interactions	Parents look at Children	1.46(2.35)	.69(1.22)
	Children look at Parents	2.48(2.86)	1.33(2.18)
	Parents' Verbal Attention Regulation	.26(.38)	.17(.34)
Parents' Reading Strategies	Parents ask Children to Look at Specific Words	.53(.76)	.24(.54)
	Parents Point to Words on the Screen	.15(.53)	.01(.06)

	Parents Teach	.17(.44)	.08(.18)
	Specific Words Parents Provide Specific Feedback	.01(.04)	0(0)
Children's Responses	Children Read Along with Parents	.25(.42)	.61(.93)*
	Children Complete a Sentence with Parents' Prompt	.32(1.15)	1.14(2.21)*
	Children Point to Texts on the Screen	.13(.36)	.13(.33)
	Children Talk about Print	.27(.5)	.37(.67)

* Significant differences were observed between Study 1 and Study 2 *(P*<.05).

To compare the changes of the frequencies of the counted behaviors from the first to the fourth reading trial between Study 1 and Study 2, I did 11 repeated measures ANOVAs using the average frequency of each of the 11 types of counted reading behaviors as the within-subjects variable (the first vs. the fourth reading trial) and whether children received the eye-gaze awareness training as the between-subjects factor (experiment vs. control group). The results are illustrated as follows:

For the "parents looking at children" type of behavior, the main effect of the within-subjects variable was significant, F (1, 61) =4.02, p=.05, partial eta squared=.06, power=.51. So was the interaction effect, F (1, 61) =5.76, p=.02, partial eta squared=.09,

power=.66 (see Figure 7). The results suggested that parents in the experiment group did not change much of their looking at children behavior, while parents in the control group significantly increased the occurrences of this behavior from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 61) =.4, p=.53.

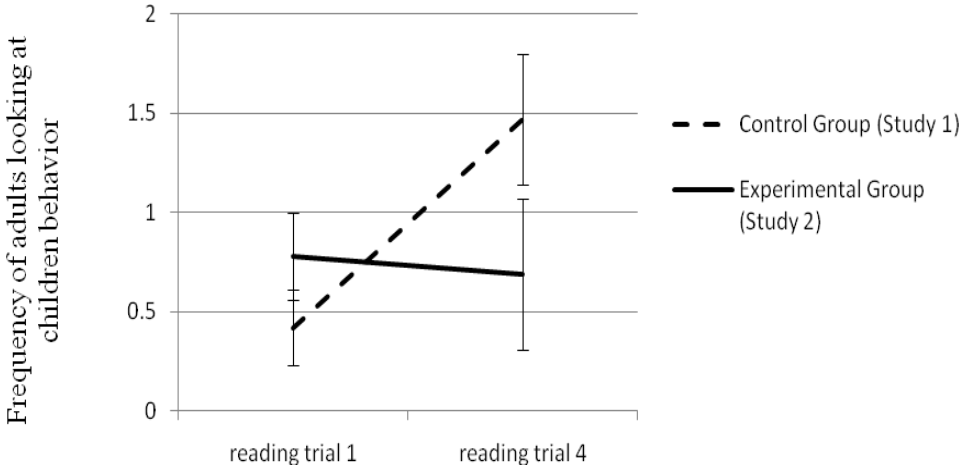


Figure 7: The Frequency of Parents Looking at Children Behavior From the First to Fourth Reading Trial Between Experimental and Control Group in Study 2.

For the children's "looking at parents" type of behavior, the main effect of the within-subjects variable was significant, F (1, 61) =11.88, p=.001, partial eta squared=.16, power=.92. So was the interaction effect, F (1, 61) =4.09, p=.047, partial eta squared=.06, power=.51 (see Figure 8). The results suggested that children in both the experiment and control groups increased the occurrences of the behavior of looking at parents from the first to fourth reading trial, but children in the control group showed a

significantly larger increase. The main effect of the eye-gaze awareness training was not significant, F (1, 61) =1.87, p=.18.

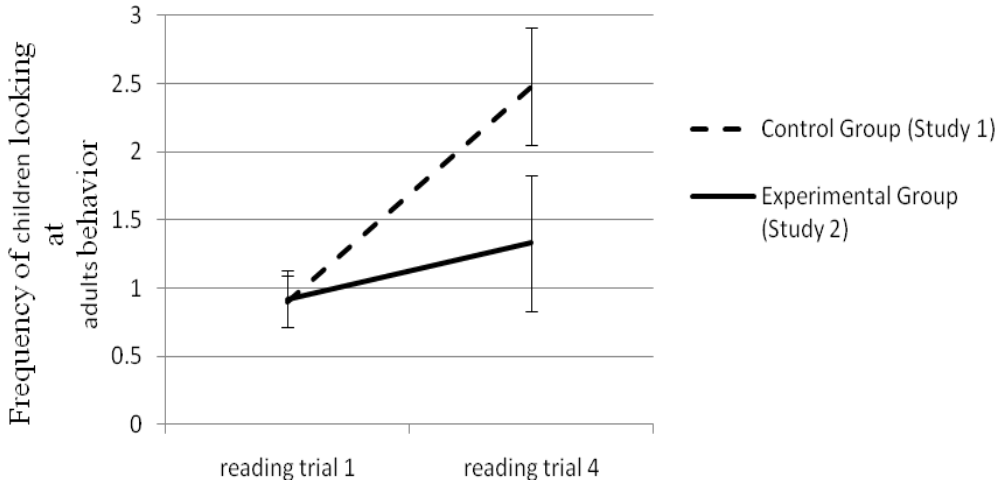


Figure 8: The Frequency of Children Looking at Parents Type of Behavior From the First to Fourth Reading Trial Between the Experimental and Control Group in Study 2.

For parents' verbal attention regulation type of behavior (e.g., parents saying "Look at the screen/words/ pictures."), the main effect of the within-subjects variable was significant, F (1, 61) =15.8, p=.000, partial eta squared=.21, power=.98, suggesting that parents on average significantly increased the occurrences of the behavior of verbal attention regulation from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 61) =1.45, p=.234. Neither was the interaction effect, F (1, 61) =.21, p=.651.

Summarizing the comparisons of the above three types of behaviors, the experiment group dyads did not increase the frequency of regulating joint attention as

much as the control group dyads did when asked to teach words in the fourth reading trial. The major reason is that children were more responsive when seeing parents' real-time eye gazes so that parents did not need to constantly check children's responses. And children did not need to look at parents to know where adults were attending to because the answer was on the screen. These results supported my hypothesis that seeing real-time eye movements saved reading dyads much effort to look at each other's physical eyes to regulate joint attention.

The experiment group and the control group dyads did not show much difference in terms of parents' reading strategies. Specifically, for the parents asking children to look at specific words type of behavior (e.g., "Can you help me find the word 'cat' on the screen?"), the main effect of the within-subjects variable was significant, F (1, 61) =15.01, p=.000, partial eta squared=.20, power=.97. So was the interaction effect, F (1, 61) =4.91, p=.03, partial eta squared=.07, power=.59 (see Figure 9). The results suggested that parents on average increased the occurrences of the behavior of asking children to pay attention to specific words from the first to fourth reading trial, but parents in the control group showed a significantly larger increase. The main effect of the eye-gaze awareness training was not significant, F (1, 61) =.83, p=.366.

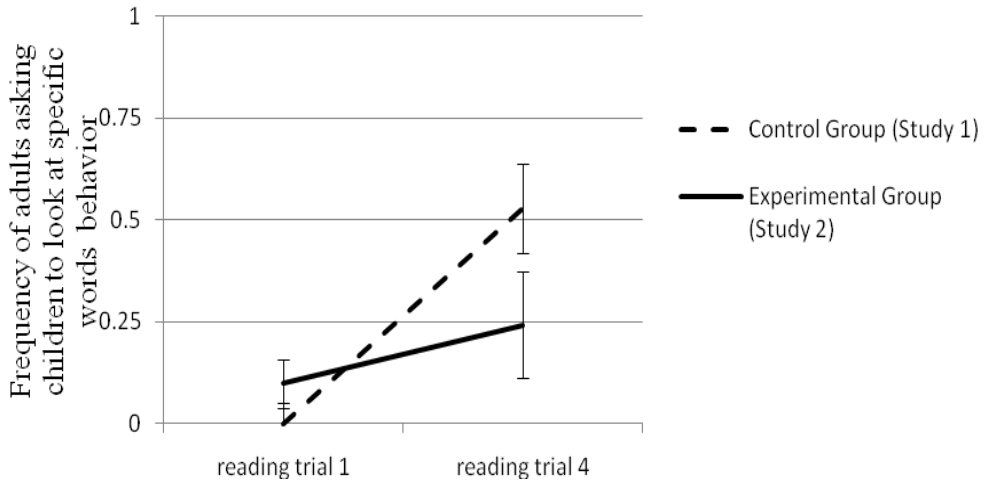


Figure 9: The Frequency of Parents Asking Children to Look at Specific Words Behavior From the First to Fourth Reading Trial Between Experimental and Control Group In Study 2.

For parents' "pointing on the screen" type of behavior, the main effect of the within-subjects variable was not significant, F (1, 61) =.85, p=.36. Neither were the main effect of the eye-gaze awareness training (F (1, 61) =.85, p=.361) and the interaction effect (F (1, 61) =2.33, p=.132). The results suggested that parents in both the experiment and control groups did not change the occurrences of the behavior of pointing on the screen from the first to fourth reading trial.

For parents' "teaching specific words" type of behavior (e.g., parents saying "The word 'book' starts with a letter 'B' and ends with a letter 'K'"; "The first word on the second line starts with a 'buh' sound, can you try to sound it out?"; "Can you tell me what the word 'greedy' means?"), the main effect of the within-subjects variable was significant, F (1, 61) =5.63, p=.021, partial eta squared=.08, power=.65, suggesting that

parents on average significantly increased the occurrences of the behavior of teaching specific words from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 61) =.96, p=.332. Neither was the interaction effect, F (1, 61) =1.16, p=.285.

For parents' "providing specific feedback" type of behavior (e.g., parents saying "Yes, you are looking at the right place."; "No, you are not looking at the place I want you to look."), the main effect of the within-subjects variable was not significant, F (1, 61) =.75, p=.391. Neither were the main effect of the eye-gaze awareness training (F (1, 61) =.75, p=.391) and the interaction effect (F (1, 61) =.75, p=.391). The results suggested that parents in both the experiment and control groups did not change the occurrences of the behavior of providing specific feedback from the first to fourth reading trial.

When shown parents' real-time eye scanning patterns, children did respond more to parents' reading strategies. Specifically, for children's reading texts along with parents type of behavior, the main effect of the within-subjects variable (F (1, 61) =23.09, p=.000, partial eta squared=.28, power=.99) and the interaction effect (F (1, 61) =4.31, p=.042, partial eta squared=.07, power=.53) were both significant (see Figure 10). The results suggested that children in both the experiment and control groups significantly increased the occurrences of the behavior of reading texts along with parents from the first to fourth reading trial, but children who received the eye-gaze awareness training showed a significantly larger increase. The main effect of the eye-gaze awareness training was also significant, F (1, 61)=4.34, p=.041, partial eta squared=.07, power=.54,

indicating that overall children who received the eye-gaze awareness training read texts along with parents more frequently than children in the control group did.

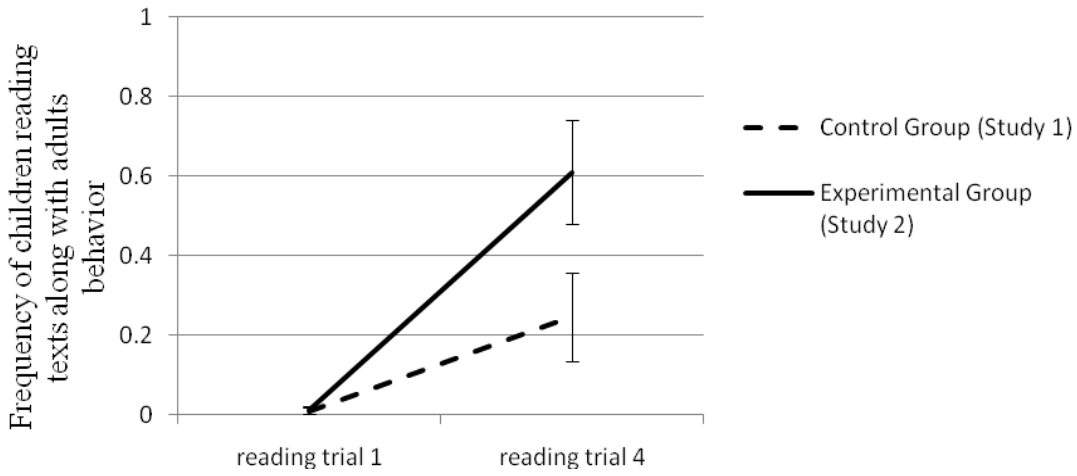


Figure 10: The Frequency of Children's Reading Texts Along With Parents Behavior From the First to Fourth Reading Trial Between Experimental and Control Group in Study 2.

For children's "completing a sentence with parental prompt" type of behavior (e.g., children finished reading the last word of a sentence after parents stopped reading and waited for children's responses), the main effect of the within-subjects variable (F (1, 61) =11.9, p=.001, partial eta squared=.16, power=.92) and the interaction effect (F (1, 61) =4.17, p=.046, partial eta squared=.06, power=.52) were both significant (see Figure 11). The results suggested that children in both the experiment and control groups significantly increased the occurrences of the behavior of completing a sentence with parental prompt from the first to fourth reading trial, but children who received the eye-gaze awareness training showed a significantly larger increase. The main effect of the eye-gaze awareness training was marginally significant, F (1, 61)=3.02, p=.087, partial

eta squared=.05, power=.4, indicating that relatively children who received the eye-gaze awareness training finished reading sentences with parents' prompt more frequently than children in the control group did.

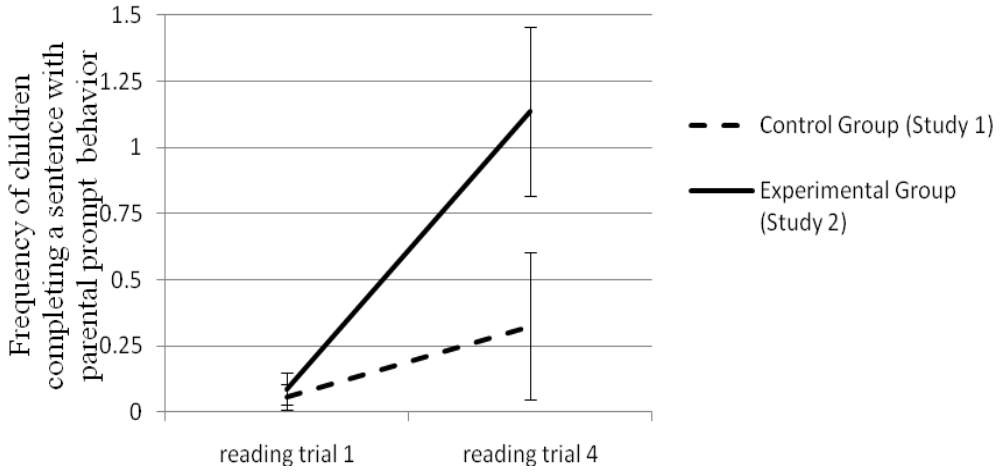


Figure 11: The Frequency of Children's Completing a Sentence With Parental Prompt Behavior From the First to Fourth Reading Trial Between Experimental and Control Group in Study 2.

For children's "pointing on the screen" type of behavior, the main effect of the within-subjects variable was significant, F (1, 61) =7.39, p=.009, partial eta squared=.11, power=.76, suggesting that children on average significantly increased the occurrences of the behavior of pointing on the screen from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 61) =.1, p=.91. Neither was the interaction effect, F (1, 61) =.03, p=.87.

For children's "talking about print-related things" type of behavior, the main effect of the within-subjects variable was significant, F (1, 61) =10.09, p=.002, partial eta squared=.14, power=.88, suggesting that children on average significantly increased the

occurrences of the behavior of asking or answering print-related questions from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 61) =1.58, p=.21. Neither was the interaction effect, F (1, 61) =.03, p=.87.

3.3.5 Measurement of Children's Reading Interest

The means and standard deviations of the variables in the measurement of children's reading interest are presented in Table 8. The *Brief Reading Interest Scale* (BRISC) showed how parents rated their children's overall interest in shared book reading compared to other 10 activities (1=like reading most; 11=like reading least). Parents' answers about how often their child asks to be read to and how often their child reads alone were coded on 1-5 scale (1 refers to "Hardly ever"; 2 refers to " < 3 times/month"; 3 refers to "< 3 times/week"; 4 refers to "Almost daily"; 5 refers to " > once/day", see details in Appendix 1).

Table 8: Means (SD) for Children's Reading Interest Measurement Variables in Study 2

	Reading Interest Survey (Parental Report)				
	Child's interest in reading compared to 10 other activities (BRISC)	Child asks to be read to	Child chooses to read alone	Child's degree of concentration in reading (1=lowest concentration; 5=highest concentration)	Duration child chooses to read (minutes)
Experiment Group	5.33(2.42)	4.33(.73)	4.27(.78)	4.48(.7)	23.56(11.73)
Control Group in the First Visit	4.24(2.07)	4.35(.72)	4.29(.72)	4.68(.53)	24.38(10.13)
T tests for the two groups	t (62) = 1.94, P = .057	t (62) =.11, P = .917	t (54) = .33, P = .746	t (62) =.49, P = .626	t (62) =.6, P = .548

Parental reports of children's reading interest in the experiment group were compared to those in the control group during their first lab visit, using *t* tests for independent samples. None of the differences in the five dimensions of children's reading interest measurement between the experiment and control groups were statistically significant (see Table 8). The results suggested children in the two groups were not

different with respect to their pre-existing level of interest in reading and therefore their differences in the eye movement data, reading behaviors, and print learning outcomes were mainly caused by the eye-gaze awareness training for children.

3.4 Discussion

Study 2 examines whether the real-time eye-gaze awareness training changes parent-child joint attention on print and how this change improves children's conception of reading and their sight word learning. Concurring with my hypothesis, seeing parents' eye movements did make children pay more attention to texts. Before the eye-gaze awareness training, children in Study 2 showed no difference from children in Study 1 in terms of either children's own attention or their joint attention with parents on texts. When children in Study 2 received the eye-gaze awareness training, they showed a large increase on both their own attention and joint attention on texts during reading. In other words, although children in Study 1 and Study 2 both paid more attention to texts from the first to the fourth reading trial, the increase of children who received the training was significantly higher than that of children who did not have the opportunities of seeing how adults read.

As predicted, children's increased attention on print induced conceptual changes in Study 2. Children were at chance in the pretest answering questions on where adults look at during reading and in which way adults scan the text. After the eye-gaze awareness training the correct rates for both questions were significantly above chance,

suggesting that most of the children achieved better understandings about how adults read books after being shown adults' moment-by-moment reading eye movements.

Additionally, more print-directed joint attention resulted in more sight word learning. Except for the eye-gaze awareness training, the experiment instructions for the reading dyads in Study 1 and 2 were the same. However, the learning outcomes for the two groups of children were significantly different. Children in Study 2 learned on average 1 word while children in Study 1 only learned .38 words from the pretest to posttest. Previous examinations of word learning in reading suggested that children can learn some sight vocabulary due to two possible mechanisms: incidental word learning (e.g., children hear adults read texts while looking at the corresponding words and then learn the correspondence between the sound, form, and meaning of the words) vs. adults' structured teaching of words (Coyne et al., 2007; A. E. Cunningham & K. E. Stanovich, 1998; A. E. Cunningham & K. E. Stanovich, 1998; De Temple & Snow, 2003; Ehri, 1997; Ehri & Sweet, 1991; Senechal & Cornell, 1993; Stahl, 2003). I argue that parent-child dyads engaging in effective joint attention on words can optimize children's incidental as well as structured word learning opportunities.

Children in both Study 1 and 2 had the opportunity of incidental word learning by being exposed to the sound and the spelling of words simultaneously during shared book reading. But showing children adults' real-time and continuous eye gaze feedback could help children make best of this opportunity. In the traditional shared book reading paradigm in Study 1, children did not see exactly how adults scanned texts and therefore children did not know where or how to look at those words to obtain the relevant

information. In contrast, children in Study 2 had clear clues about which word adults were paying attention to at any particular moment. Thus, it was much more straightforward and easier for children to quickly learn the correspondence among the sound, form, and meaning for a certain word. Children's behavior change from the first reading trial to the fourth trial in Study 2 supported this point, such that children more frequently read texts along with adults, sounded out the last word in a sentence with adults' prompt, and pointed to texts on the screen. The rated children's higher reading interest in Study 2 than that in Study 1also indicated that this new reading paradigm was more likely to intrigue children to learn reading.

Furthermore, when adults intentionally and explicitly teach children some words, the real-time eye gaze feedback could help adults more efficiently draw children's attention to those target words and then make their pedagogical efforts. For example, the comparison of the parent-child joint attention regulation type of behaviors between Study 1 and 2 showed that reading dyads in Study 2 spent less time looking at each other to build joint attention than reading dyads in Study 1 did. The reason for this difference was that children in Study 1 had to look at adults' physical eyes to get the joint attention clue while children in Study 2 could get the more precise attention information from their parents' eye gaze points on the screen. On the other hand, adults in Study 1 need to constantly look back at children to help them reengage in joint attention on books while children's seeing the external form of adults' attention on texts in Study 2 saved adults much of this effort. The above comparison suggested that the technology-assisted shared book reading paradigm facilitates parent-child joint attention regulations.

Overall, Study 2 suggested that we can change children's understanding of the reading activity by showing them adults' moment-by-moment reading process. And the communication of the real-time eye gaze positions can be efficient in facilitating parent-child attention interactions and children's sight word learning. One limitation for Study 2 is that only children had the opportunities of knowing where adults look at on books but adults were still unaware to children's attention states. As a trade-off to this limitation, a natural follow-up to Study 2 would be to show parents where children pay attention to during shared book reading, and then to compare the parent-child joint attention and children's keyword learning outcomes with those in Study 1 to determine whether and how the eye-gaze awareness training for adults improves reading dyads' join attention and children's print learning.

4. Study 3: Informing Parents of Children's Real-Time Visual Attention in Shared Book Reading

4.1 Design and Hypotheses

Study 3 investigates whether informing parents of children's real-time visual attention helps parents regulate joint attention in shared book reading. Parents control the reading activity in the traditional shared reading paradigm, but they have little knowledge about where their children are paying attention to and whether their reading strategies are effective. I argue that this is a consequence of the lack of joint attention.

Using a pretest-posttest control group design in this intervention study, I provide the similar eye-gaze awareness training for parents (i.e., showing parents a moving cursor on the screen representing their children's eye gaze location as children read), and measure how parents use this real-time visual attention information to regulate joint attention during shared book reading. Both eye movements and dyads' verbal/non-verbal behaviors during the reading session are recorded and analyzed. Children's keyword recognition is measured in both the pretest and posttest.

The control group of Study 3 consists of all the parent-child dyads in Study 1. Adult participants in the experimental group (Study 3) get the eye-gaze awareness training while adult participants in the control group (Study) 1 did not get such training. The average percentage of parent-child joint attention on texts and children's sight word learning outcomes in Study 3 are compared with those in Study 1.

In addition to the measurement of reading dyads' eye movements and verbal/non-verbal behaviors, I interview parents in Study 3 about their belief of where children look

at on books, and how they utilize strategies to teach children to read. Pilot studies showed that most parents felt surprised when discovering that their children did not follow the words they read during the shared book reading. Based on this result, I hypothesize that seeing children's real-time visual attention will make parents in the experiment group realize that the incidental word learning mechanism itself may not work well due to children's paying no attention to print. Therefore, these parents may change their pedagogical beliefs and adjust their reading strategies accordingly. The changed parents' reading behaviors would enhance the efficiency of joint attention regulation and therefore significantly increase the time children spend scanning texts in reading. Children in the experiment group on average learn more sight words due to the increased print exposure.

In parallel with Study 1, each parent-child dyad in Study 3 was invited to participate in a one week follow-up study. More specifically, each dyad was asked to come back to read two more storybooks approximately one week after their first lab visit. The one week delay was chosen according to the previous shared reading intervention studies (Ezell & Justice, 2000; Justice, Meier, et al., 2005; Senechal & Cornell, 1993; Senechal, Thomas, & Monker, 1995). Since parents tend to decrease their use of the techniques they learned through the intervention over time, the one week is an appropriate time period to study the short-term intervention effects.

The changes across the two visits in terms of children's reading interest, reading eye movements and print learning outcomes as well as parents' reading behaviors were compared between the dyads in the experiment group and the control group. I hypothesize that parents in the experiment group would continue to display more efficient

joint attention regulation and word teaching behaviors compared to parents in the control group in the follow-up. Meanwhile, children in the experiment group would sustain their improved reading eye movements and learning outcomes, such that they spend more time attending to print and recognize more sight words in the *keywords Recognition Test*. The experiment group children would also utilize larger vocabulary when retelling the stories. In contrast, children in the control group would remain the same levels of the percentage of eye fixations on texts and the keyword learning performance across the two visits.

4.2 Methods

4.2.1 Participants

Thirty-one parent-child dyads participated in Study 3 but three dyads were excluded in the final analysis due to their poor eye movement data. The parent-child dyads were recruited and screened using the same approaches as Study 1. Children's average raw score in the *Woodcock-Johnson Letter-Word Identification Test* was 14.39 (out of 26 items, SD=4.65), suggesting that these children did have some letter knowledge but could not read all words independently. There was no difference of children's performance in the *Woodcock-Johnson Letter-Word Identification Test* between Study 3 and Study 1 (t (63) = -1, p=.32).

These 28 dyads (mean age of children was 58.11 months) served as the experimental group and the 37 dyads in Study 1 (mean age of children was 58.76 months) served as the control group. There was no significant age difference between the two groups of children (t (63) = -.35, p=.73). There were 20 Caucasian children, 5 African

American children and 3 Asian American children in the experiment group. Twenty-one of the 28 parents had a college degree or higher, reflecting a middle- to upper-SES sample. Parents reported that 83% of the children were read to routinely 5-7 times per week, 20-30 minutes each time. The two groups of children were not significantly different on these basic aspects of the shared book reading background (see Table 9).

Table 9: Children's Basic Shared Book Reading Background in Study 3

Sample Size	Starting Age(months)	Frequency (times/week)	Duration Each Time (minutes)
Experiment Group (28 dyads)	7.67	6.3	23.6
Control Group (37 dyads)	8.95	6.5	21.78

4.2.2. Materials

Four storybooks, Greedy Cat (Cowley, 1983), Where Are They (Tallarico, 1989), Bertie at Bedtime (Pfister, 2008), and Alligator Boy (Rylant, 2007) were used in Study 3. The first three books were read during a dyad's first visit in our lab. In the dyad's one week follow-up visit, they read one of the first three books and the fourth book Alligator Boy.

Children's sight word learning was also measured by the Keyword Recognition Test before and after the reading session. Parents filled out the Home Literacy Survey in the posttest during the first visit. In both the first and the one week follow-up visit, parents filled out *Children's Reading Interest Survey.* At the end of the first visit, I

provided the *Home Reading Log* for parents to take home and record their shared reading experience for the following week. I collected the *Home Reading Log* during the follow-up visit.

A set of interview questions were developed for parents about their understandings of children's reading process and the strategies parents usually use for the shared book reading activity (see Appendix 7). The questions were asked before and after the reading session in the first lab visit. Parents' comments and suggestions about this intervention technology were asked in the end of the study.

4.2.3 Apparatus

The apparatus and the set-up were the same as in Study 1. The only difference is that by using the Double Tracker program developed in our lab, I connected the two eye tracking systems so that children's eye gaze information recorded by Eyelink 1000 eye tracker was passed to the display computer of Tobii eye tracker. In such case, adults can see the eye gaze cursor indicating where their children are looking at on the screen in real time.

4.2.4 Procedures

The study was conducted with one dyad at a time in our on-campus lab. When a parent-child dyad arrived in the lab, I first introduced the dyad the eye-tracking apparatus as a warm-up session. Then the dyad was presented with a pretest session, a reading session, and a posttest session.

During the reading session, the parent was instructed to read naturally as he/she would do at home. The dyad read the three books (Greedy Cat, Where Are They, and Bertie at Bedtime) in four reading trials. They read one same storybook in the first and fourth trial, and the other two storybooks in the second and third trial. In the fourth trial the parent was asked to teach three words that the child did not recognize based on the *Keyword Recognition Test*. The presentation order of the three books was randomized and counterbalanced among all participating dyads. Both the parent and the child were eye tracked and video-taped during the reading session which lasted about 15 minutes.

In contrast to the adult participants in Study 1 (the control group), who received the identical procedures for all four reading trials in which they did not see children' real-time eye movements information, the adult participants in Study 3 (the experiment group) were exposed to their children's eye gaze patterns from the second to the fourth reading trial. More specifically, each parent was shown a moving cursor overlaid in each book page on the screen; the moving cursor indicated the location of a child's eye gaze in real-time. Parents were encouraged to use this new information in the last three reading trials.

I ensured that each parent-child dyad understood the gaze indicator using the same iSpy training game. Before the second reading trial started, an irrelevant picture consisting of 5 unrelated objects was presented on both screens. While a child was scanning this picture, his/her parent saw which object the child was looking at shown by a moving cursor on the screen in front of the parent. I first explained to the parent what the moving cursor represents and then asked the parent to guess which object his/her

child was staring at. This guessing game familiarized the parent with the gaze cursor display.

When I was certain that the parent could understand that the moving cursor represents the child's eye scanning, the second storybook was presented on both screens. The parent can see the child's real-time eye gaze patterns superimposed on the book pages while reading the story. For the first two pages of the book, I just watched the dyad read the story without any interruption. For the next three pages, I would stop the parent for a while and further explained the eye gaze patterns to make sure the parent knows how to utilize the eye movement information to regulate joint attention. The procedures of the third and fourth reading trials were identical to that of the second reading trial except that I did not interrupt the reading process at all. Altogether the parent got the eye-gaze awareness training for three reading trials. For all the four reading trials, the child looked at a normal, static display of book pages. To tease apart the impact of the instructions from the moving cursor in Study 2, I asked children in Study 3 to follow the parent's eye gazes while listening to stories, even though they could not actually see the eye gazes in this study.

In both the pretest and posttest sessions of the first lab visit, the parent was interviewed about his/her understanding of how the child reads as well as his/her strategies in reading with the child. Additionally, the parent filled out the *Home Literacy Survey* and *Children's Reading Interest Survey* in the posttest.

The child's sight word learning was measured by the *Keyword Recognition Test* in both the pretest and posttest sessions (e.g., a child who read *Greedy Cat* in the first and

fourth trial was tested by the same 10 keywords from the *Greedy Cat)*. The child was also assessed the pre-existing letter and word knowledge by the *Woodcock-Johnson Letter-Word Identification Test*.

At the end of the dyad's first lab visit, I provided the parent the *Home Reading Log* for the purpose of recording their shared reading experience at home for the following week and asked the parent to bring the log back in the follow-up visit.

During the dyad's one week follow-up visit, the dyad first read the storybook which they read in the first and fourth trials in their previous lab visit. Then the child was encouraged to retell the story page by page on the screen by himself/herself or with adults' help. After finishing the first storybook, the dyad went through the same procedures (shared book reading and retelling the story) with the new book *Alligator Boy.* The child's keyword recognition for words sampled from the two books was also measured. The parent was eye tracked when reading the two books, while the child was eye tracked when reading the books and retelling the stories. The parent was asked to fill in the *Children's Reading Interest Survey* again after the reading session. In the end of this visit I collected the *Home Reading Log* and discussed with the parent about whether/how the parent has used things he/she learned from the first lab visit during the past week shared readings as well as whether/how the child has changed his/her reading interest since the previous lab visit.

4.2.5 Data Transcription and Coding

The transcription and coding for the eye movement data were the same as in Study 1.

The change of children's average percentage of fixations on text AOIs from the first reading trial to the fourth reading trial in Study 3 (the experiment group) was compared with that in Study 1 (the control group). The reading dyads' average change of joint attention on texts from the first reading trial to the fourth reading trial in Study 3 (the experiment group) was also compared with that in Study 1 (the control group).

Video recordings of the parent-child shared book reading interactions were transcribed and coded with the same software and coding system as Study 1. The inter-rater reliability analysis (Cohen's Kappa) of the coding was performed using 20% of the sample. I compared reading dyads' pretest-to-posttest changes of counted reading behaviors (including joint attention interactions, parents' reading strategies, and children's responses) in Study 3 (the experiment group) with those in Study 1(the control group).

I examined parents' change of beliefs on shared book reading by comparing their answers to the interview questions between the pretest and posttest. Children's pretest-to-posttest gain in the Keyword Recognition Test in Study 3 (the experimental group) was compared with that in Study 1(the control group).

4.3 Results

4.3.1 Parents' Belief Changes

Before receiving the eye-gaze awareness training, twelve out of twenty-eight (42.86%) parents overestimated their children's proportion of time spent on texts, such that they thought their children spend at least half of the time on texts during shared book reading. After the eye-gaze awareness training, this group of parents were surprised that their children actually spend most of the time on pictures. These parents reported that they realized that merely reading to their children is not effective enough to teach children print and they should actively and constantly draw their children's attention to print for the pedagogical purposes. The rest of the parents were more realistic to believe that their children mainly looked at pictures and they did not feel surprised when they saw their children's real-time eye movements during the eye-gaze awareness training. But those parents agreed that they need to regulate the parent-child joint attention more efficiently if they want to teach vocabulary during shared book reading.

Eighteen out of the twenty-eight parents (64.29%) thought this new technology-assisted shared reading paradigm is interesting and helpful because the parents could find out where their children are interested in and whether their own strategies (e.g., pointing to words to help children sound out or spell words) work. Twenty-four out of the twenty-eight parents (85.71%) reportedly tried to use the real-time eye movement information during the shared book reading. For example, one parent reported that when she discovered that her child was looking at a picture, she tried to draw the child's attention to the corresponding word in the same page and help the child learn the picture-word

correspondence. Another parent reported that watching her child's eye gazes made her realize her child was not following the storyline, and the parent then slowed down the reading pace and tried to help the child catch up with storyline. Only four out of the twenty-eight adults (14.29%) felt the eye cursor on the screen was a little bit distracting.

To sum up, parents' answers to the interview questions suggested that about half of the experiment group parents did have some biased beliefs about their children's reading processes before they participated in our study; while our eye-gaze awareness training could help those parents build more comprehensive understandings about where and how their children pay attention to during the shared book reading activity. Those improved understandings could further encourage parents to adopt more efficient reading strategies to regulate joint attention and teach print.

4.3.2 Eye-tracking Results

In the first reading trial, the average percentage of time children fixated on text AOIs was 10.3% (*SD*=12.04), while the average percentage of time children had joint attention with parents on texts was 3.48% (*SD*=4.38). After the parents received the eye-gaze awareness training, their children significantly increased the attention on texts to 25.4% (*SD*=16.78, t (27) = -4.65, p=.000) in the fourth reading trial. There was also an increase (t (27) =-5.05, p=.000) of the average parent-child join attention on texts in the fourth reading trial (12.87%, *SD*=10.56) compared to that in the first reading trial.

To further compare the eye movement changes from the first to the fourth reading trial between the experiment (Study 3) and control group (Study 1), I did a repeated

measures ANOVA using children's average percentage of attention on texts as the within-subjects variable (the first vs. the fourth reading trial) and whether parents received the eye-gaze awareness training as the between-subjects factor (experimental vs. control group). The results showed that the main effect of the within-subjects variable was significant, F (1, 63) =31.9, p=.000, partial eta squared=.34, power=.99, suggesting that children on average significantly increased their attention on texts from the first to the fourth reading trial. The main effect of whether parents received the eye-gaze awareness training was also significant, F (1, 63) =4.88, p=.031, partial eta squared=.072, power=.59, suggesting that overall children in the experiment group spent more time looking at texts than children in the control group.

The interaction effect between the within-subjects and between-subjects variables was significant, F (1, 63) =7.53, p=.008, partial eta squared=.12, power=.77, suggesting that the increase of percentage of attention on texts from the first to the fourth reading trial among children in the experiment group was significantly higher than that among children in the control group. This significant interaction effect was concurrent with the direct comparison of the increase of children's attention on texts from the first to the fourth reading trial between the two groups, such that the experiment group children increased 15.1% (SD=17.2) of attention on texts, which was significantly higher (t (63) = 2.74, p=.008) than the 5.22% (SD=11.8) of attention the control group children increased (see Figure 12).

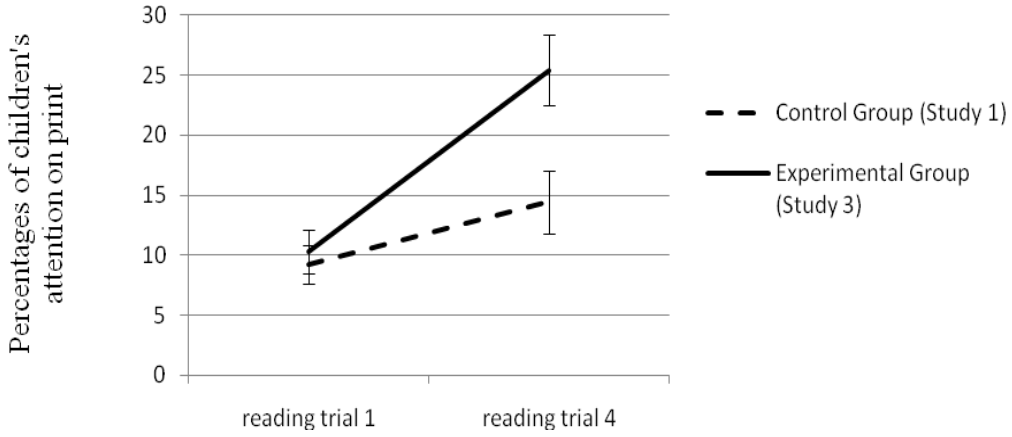


Figure 12: Percentages of Children's Attention on Print From Reading Trial 1 to 4 Between Experimental and Control Groups in Study 3.

By the same token, I did a repeated measures ANOVA using the average percentage of parent-child joint attention on texts as the within-subjects variable (the first vs. the fourth reading trial) and whether children received the eye-gaze awareness training as the between-subjects factor (experimental vs. control group). The results showed that the main effect of the within-subjects variable was significant, F (1, 63) =31.72, p=.000, partial eta squared=.34, power=.99, suggesting that reading dyads on average significantly increased their joint attention on texts from the first to the fourth reading trial. The main effect of whether parents received the eye-gaze awareness training was also significant, F (1, 63) =5.35, p=.024, partial eta squared=.078, power=.62, suggesting that overall children in the experiment group engaged in more joint attention with parents on texts than children in the control group did.

The interaction effect between the within-subjects and between-subjects variables was significant, F (1, 63) =6.62, p=.012, partial eta squared=.095, power=.72, suggesting that the increase of percentage of joint attention on texts from the first to the fourth reading trial among children in the experiment group was significantly higher than that among children in the control group. This significant interaction effect was concurrent with the direct comparison of the increase of children's joint attention on texts from the first to the fourth reading trial between the two groups, such that the experiment group children increased 9.39% (*SD*=9.83) of joint attention on texts, which was significantly higher (t (63) = 2.57, p=.012) than the 3.5% (*SD*=8.58) of joint attention the control group children increased (see Figure 13).

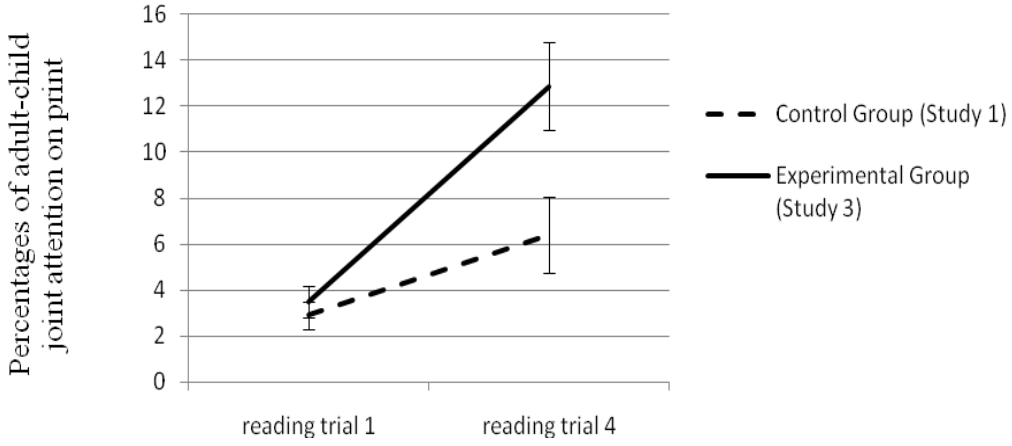


Figure 13: Percentages of Parent-Child Joint Attention on Print From Reading Trial 1 to 4 Between Experimental and Control Groups in Study 3.

4.3.3 Children's Print Learning Outcomes

After being exposed to children's real-time visual attention information, parents not only were better at regulating the parent-child joint attention on print, they also

became more effective in facilitating children's sight word learning. I did a repeated measures ANOVA using children's keyword recognition performance as the within-subjects variable (pretest vs. posttest) and whether parents received the eye-gaze awareness training as the between-subjects factor (experimental vs. control group). The results showed that the main effect of the within-subjects variable was significant, F (1, 63) =51.25, p=.000, partial eta squared=.45, power=.99, suggesting that on average children significantly increased the number of keywords they could recognize from the pretest to posttest. The interaction effect between the within-subjects and between-subjects variable was also significant, F (1, 63) =14.68, p=.000, partial eta squared=.19, power=.97, suggesting that children in the experiment group learned significantly more keywords from the pretest to posttest than children in the control group did (see the descriptive statistics in Figure 14).

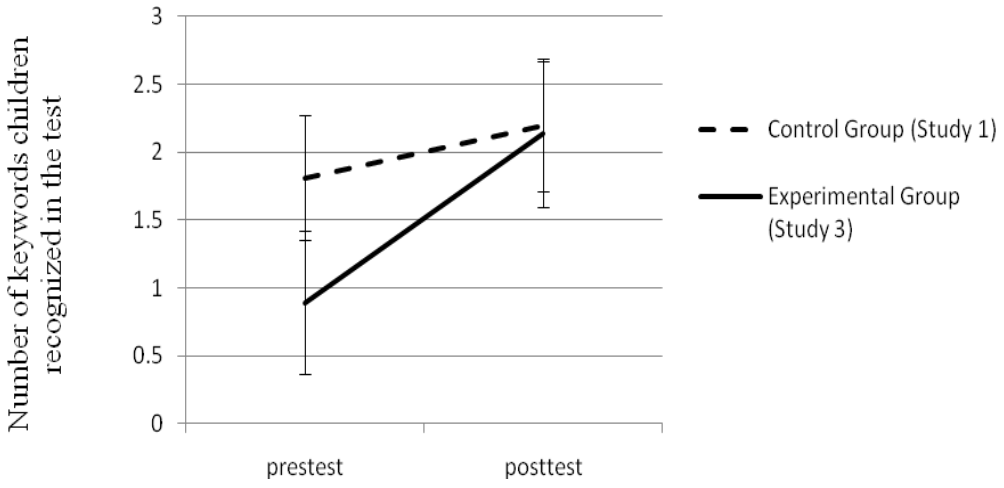


Figure 14: Children's Keyword Recognition Performance From the Pretest to Posttest Between Experimental and Control Groups in Study 3.

The main effect of whether parents received the eye-gaze awareness training was not significant, F (1, 63) =.47, p=.496. Children's average pre-existing keyword knowledge in Study 3 was not significantly different from that of children in Study 1 (t (63) = -1.32, p =.193). Neither did the experiment group children's keyword recognition performance in the posttest compared to that of the control group children (t (63) =.064, p =.95). To rule out the influence of the asymmetric interaction effect,

I further analyzed the difference score between the pretest and posttest in a simple t-test. The direct comparison of the pretest-to-posttest keyword learning gains between the two groups of children showed that children in the experiment group learned on average 1.25 words (*SD*=1.11), which was significantly higher than the 0.38 words which children in the control group learned (t (63) = 3.83, p =.000). This result further confirmed that

children in the experiment group learned more keywords from the pretest to the posttest than children in the control group did.

4.3.4 Behavioral Coding Results

All the twenty-eight parent-child dyads were included in the behavioral data analysis for Study 3. The inter-rater reliabilities for the global scale behaviors and the counted reading behaviors were found to be 0.75 ($p<.01$) and 0.78 ($p<.01$), respectively. As indicated by previous research (Landis & Koch, 1977; Ortiz et al., 2001), those *Kappa* values between .61 and .80 could be claimed as good levels of agreement.

For the global scale behaviors, children's coded reading interest in Study 3 was 2.73 (on a 1-3 scale, $SD=.38$), which was significantly higher than that in Study 1(2.24, $t(62) = 4.82$, $p=.000$). Parents' coded enthusiasm in Study 3 was 2.88 (on a 1-3 scale, $SD=.32$), which was also significantly higher compared to that in Study 1(2.43, $t(62) = 4.42$, $p=.000$). These coding results suggested that when parents received the real-time feedback of children's reading eye movements during the shared book reading, they were more enthusiastic at drawing children's attention to print and involving children in print-related talks. Parents' enhanced enthusiasm further improved children's reading interests.

For the counted reading behaviors, I divided 11 types of behaviors into three categories: parent-child joint attention interactions, parents' reading strategies, and children's responses. The changes of frequencies (times per minute) of these behaviors from the first to the fourth reading trial were compared.

Parent-child dyads significantly increased their joint attention interaction type of behaviors from the first reading trial to the fourth reading trial, such that parents increased the frequency of looking at children (t (27) =-2.09, p=.046) and the frequency of verbally regulating joint attention (t (27) =3.69, p=.001), while children also increased the frequency of looking at parents during reading (t (27) =2.79, p=.010).

After the eye-gaze awareness training, parents significantly increased their frequencies of three types of reading behaviors from the first reading trial to the fourth trial, including asking children to look at specific words on the screen (t (27)= 6.25, p=.000), teaching those words (t (27)=4.42, p=.000), and providing specific feedback for children (t (27)=4.59, p=.000). The increase of the frequency of parents' pointing to texts on the screen behavior was marginally significant (t (27) = 1.92, p=.066).

On the other hand, children significantly increased their four types of responses to parents' reading strategies from the first reading trial to the fourth trial, such that children more frequently read along with parents (t (27) = 2.56, p=.016), completed a sentence with parents' prompt (t (27) = 2.17, p=.039), pointed to texts on the screen (t (27) = 3.45, p=.002), and talked about print (t (27)=6.03, p=.000).

The frequencies of the counted behaviors in the fourth reading trial between Study 1 and Study 3 were shown in Table 10.

Table 10: Mean (Standard Deviation) of the Behavior Occurrences per Minute in Reading Trial 4 between Study 1 and Study 3

Category of Behaviors	Types of Behaviors	Study 1	Study 3
Parent-child Joint Attention Interactions	Parents look at Children	1.46(2.35)	1.56(1.82)
	Children look at Parents	2.48(2.86)	1.97(2.24)
	Parents' Verbal Attention Regulation	.26(.38)	.78(1.1) *
Parents' Reading Strategies	Parents ask Children to Look at Specific Words	.53(.76)	1.56(1.32) **
	Parents Point to Words on the Screen	.15(.53)	.22(.61)
	Parents Teach Specific Words	.17(.44)	.74(.88) **
	Parents Provide Specific Feedback	.01(.04)	.62(.72) **
Children's Responses	Children Read Along with Parents	.25(.42)	.27(.55)
	Children Complete a Sentence with Parents' Prompt	.32(1.15)	.27(.67)

Children Point to Texts on the Screen	.13(.36)	.39(.61)
Children Talk about Print	.27(.5)	1.26(1.1)**

* Significant differences were observed between Study 1 and 3 *(P*<.05);

**Significant differences were observed between Study 1 and 3 *(p*<.01).

To compare the changes of the frequencies of the counted reading behaviors from the first to the fourth reading trial between Study 1 and Study 3, I did 11 repeated measures ANOVAs using the average frequency of each of the 11 types of counted reading behaviors as the within-subjects variable (the first vs. the fourth reading trial) and whether parents received the eye-gaze awareness training as the between-subjects factor (experiment vs. control group). The results are illustrated as follows:

For parents' verbal attention regulation type of behavior (e.g., adults saying "Look at the screen/words/ pictures."), the main effect of the within-subjects variable was significant, F (1, 62) =24.53, p=.000, partial eta squared=.28, power=.99, suggesting that parents on average significantly increased the occurrences of the behavior of verbal attention regulation from the first to fourth reading trial. The interaction effect was significant, F (1, 62) =8.25, p=.006, partial eta squared=.12, power=.81 (see Figure 15). The results suggested that parents in both the experiment and control groups increased the occurrences of the behavior of verbally asking children to attend to print from the first to fourth reading trial, but parents in the experiment group showed a significantly larger increase. The main effect of the eye-gaze awareness training was also significant, F (1,

62) = 5.02, *p*=.029, partial eta squared=.08, power=.6, indicating that overall parents who received the eye-gaze awareness training verbally regulated joint attention more frequently than parents in the control group did.

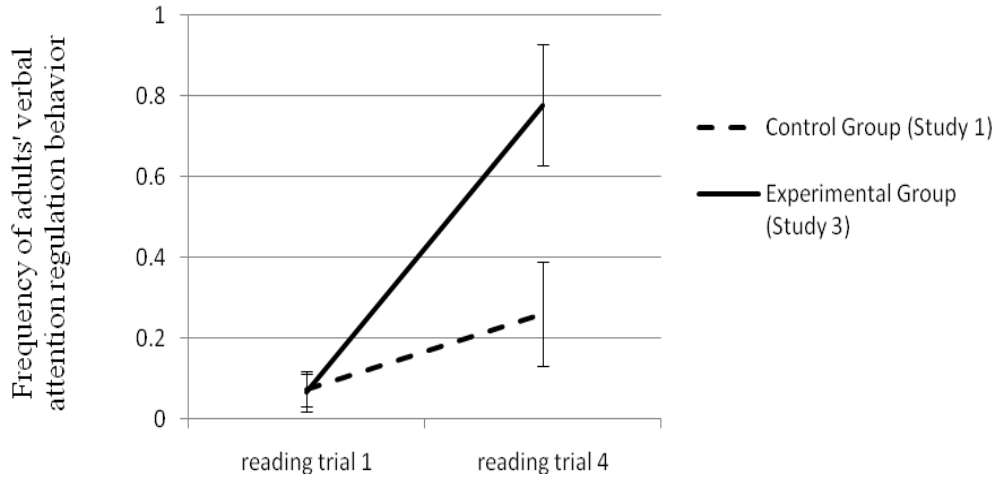


Figure 15: The Frequency of Adults' Verbal Attention Regulation Behavior From the First to Fourth Reading Trial Between Experiment and Control Group in Study 3.

For the "parents looking at children" type of behavior, the main effect of the within-subjects variable was significant, *F* (1, 62) =12.04, *p*=.001, partial eta squared=.16, power=.93, suggesting that parents on average significantly increased the occurrences of this looking behavior from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, *F* (1, 62) =.21, *p*=.648. Neither was the interaction effect, *F* (1, 62) =.07, *p*=.79.

For the "children looking at parents" type of behavior, the main effect of the within-subjects variable was significant, *F* (1, 62) =22.29, *p*=.000, partial eta squared=.26, power=.99, suggesting that children on average significantly increased the

occurrences of the behavior of looking at parents from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 62) =.67, p=.415. Neither was the interaction effect, F (1, 62) =.37, p=.545.

Compared to parents in the control group, parents in the experiment group did not need to more frequently look at children to check and reengage them in joint attention. Instead, parents in the experiment group knew where their children were paying attention to and therefore more frequently asked children to pay attention to print, suggesting that the feedback of children's real-time attention state helps with more effective joint attention regulations.

When seeing children's real-time eye scanning patterns, parents increased the frequencies of utilizing reading strategies. Specifically, for the parents asking children to look at specific words type of behavior (e.g., "Can you help me find the word 'cat' on the screen?"), the main effect of the within-subjects variable was significant, F (1, 62) =62.95, p=.000, partial eta squared=.50, power=.99. So was the interaction effect, F (1, 62) =15.32, p=.000, partial eta squared=.2, power=.97 (see Figure 16). The results suggested that parents on average increased the occurrences of the behavior of asking children to pay attention to specific words from the first to fourth reading trial, but parents in the experiment group showed a significantly larger increase. The main effect of the eye-gaze awareness training was also significant, F (1, 62)=15.32, p=.000, partial eta squared=.2, power=.97, indicating that overall parents who received the eye-gaze awareness training asked children to look at specific words more frequently than parents in the control group did.

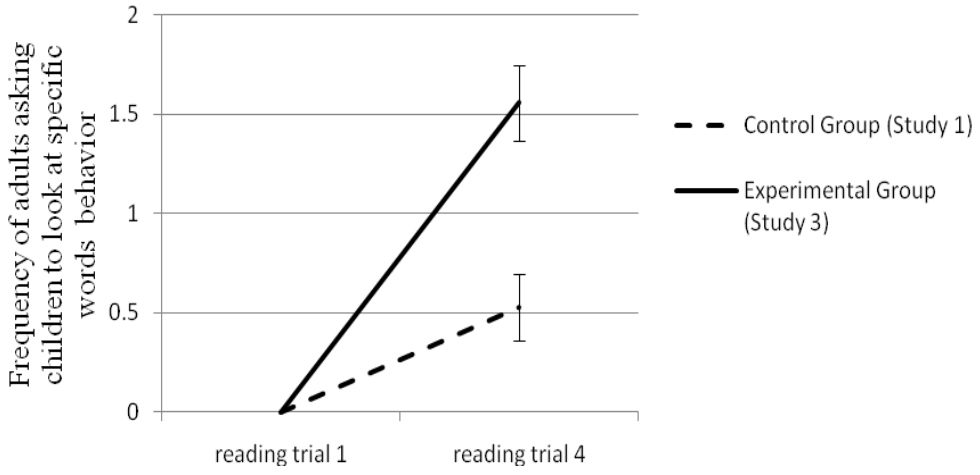


Figure 16: The Frequency of Adults Asking Children to Look at Specific Words Behavior From the First to Fourth Reading Trial Between Experimental and Control Group in Study 3.

For parents' "teaching specific words" type of behavior (e.g., adults saying "The word 'book' starts with a letter 'B' and ends with a letter 'K'"; "The first word on the second line starts with a 'buh' sound, can you try to sound it out?"), the main effect of the within-subjects variable was significant, F (1, 62) =28.19, p=.000, partial eta squared=.31, power=.99. So was the interaction effect, F (1, 62) =11.85, p=.001, partial eta squared=.16, power=.92 (see Figure 17). The results suggested that parents on average increased the occurrences of the behavior of teaching specific words from the first to fourth reading trial, but parents in the experiment group showed a significantly larger increase. The main effect of the eye-gaze awareness training was also significant, F (1, 62)=10.69, p=.002, partial eta squared=.15, power=.9, indicating that overall parents who received the eye-gaze awareness training taught children specific words more frequently than parents in the control group did.

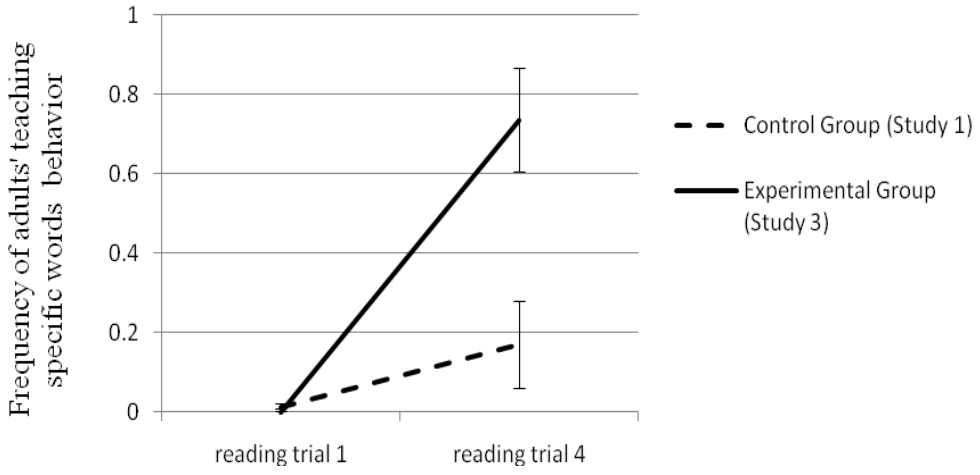


Figure 17: The Frequency of Adults Teaching Specific Words Behavior From the First to Fourth Reading Trial Between Experimental and Control Group in Study 3.

For parents' "providing specific feedback" type of behavior (e.g., adults saying "Yes, you are looking at the right place."; "No, you are not looking at the place I want you to look."), the main effect of the within-subjects variable was significant, F (1, 62) =27.63, p=.000, partial eta squared=.31, power=.99. So was the interaction effect, F (1, 62) =26.57, p=.000, partial eta squared=.3, power=.99 (see Figure 18). The results suggested that parents in the experiment group significantly increased the occurrences of the behavior of providing children the specific feedback from the first to fourth reading trial, but parents in the control group did not change much of this behavior. The main effect of the eye-gaze awareness training was also significant, F (1, 62) = 26.57, p=.000, partial eta squared=.3, power=.99, indicating that overall parents who received the eye-

gaze awareness training provided more specific feedback to children than parents in the control group did.

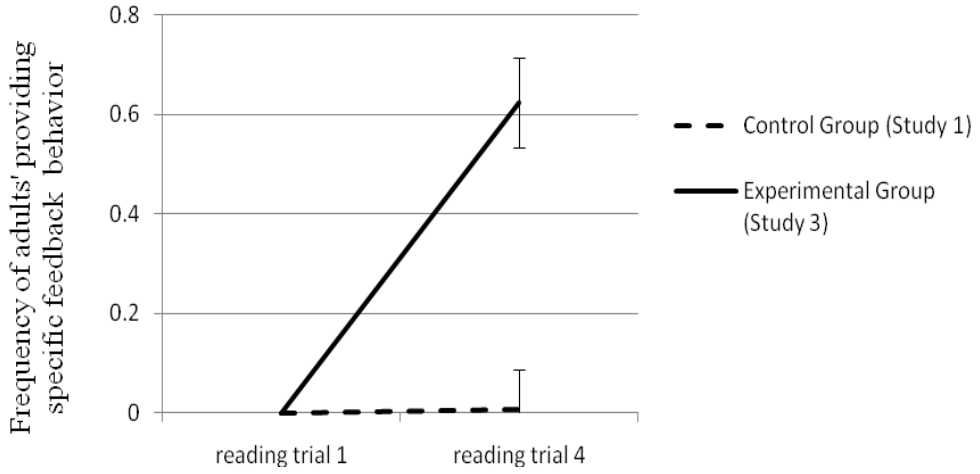


Figure 18: The Frequency of Adults Providing Specific Feedback Behavior From the First to Fourth Reading Trial Between Experimental and Control Group in Study 3.

For parents' "pointing on the screen" type of behavior, the main effect of the within-subjects variable was significant, F (1, 62) =6.19, p=.016, partial eta squared=.09, power=.69, suggesting that parents on average increased the occurrences of the behavior of pointing to texts on the screen from the first to fourth reading trial. The interaction effect was not significant, F (1, 62) =.34, p=.561. Neither was the main effect of the eye-gaze awareness training, F (1, 62) = .18, p=.671.

Compared to children in the control group, children in the experiment group more frequently talked about print-related things following parents' requests or questions, such that the main effect of the eye-gaze awareness training was significant, F (1, 62) = 22.71,

p=.000, partial eta squared=.27, power=.99. The main effect of the within-subjects variable was also significant, *F* (1, 62) =54.59, *p*=.000, partial eta squared=.47, power=.99. So was the interaction effect, *F* (1, 62) =22.64, *p*=.000, partial eta squared=.27, power=.99 (see Figure 19). The results suggested that children in both groups increased the occurrences of the behavior of asking or answering print-related questions from the first to fourth reading trial, but children in the experiment group showed a significantly larger increase.

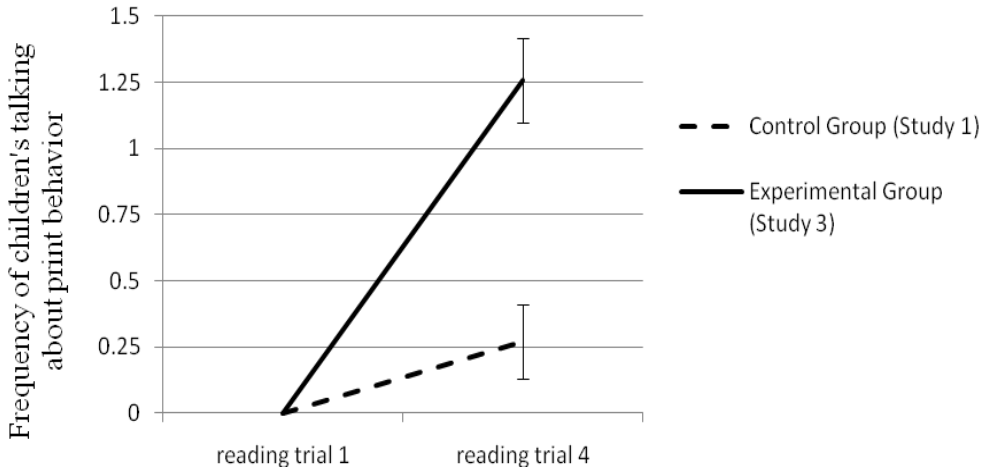


Figure 19: The Frequency of Children's Talking About Print Behavior From the First to Fourth Reading Trial Between Experimental and Control Group in Study 3.

Children in the experiment group and the control group did not show much difference in behaviors including reading texts along with adults, completing a sentence with parental prompt, and pointing on the screen. Specifically, for children's reading texts along with parents type of behavior, the main effect of the within-subjects variable was significant, *F* (1, 62) =16.88, *p*=.000, partial eta squared=.21, power=.98. The results

suggested that children on average significantly increased the occurrences of the behavior of reading texts along with parents from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 62) = .04, p=.839. Neither was the interaction effect, F (1, 62) =.07, p=.8.

For children's "completing a sentence with parental prompt" type of behavior (e.g., children finished reading the last word of a sentence after adults stopped reading and waited for children's responses), the main effect of the within-subjects variable was significant, F (1, 62) =7.7, p=.007, partial eta squared=.11, power=.78. The results suggested that children on average significantly increased the occurrences of the behavior of completing a sentence with parental prompt from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 62) = .13, p=.72. Neither was the interaction effect, F (1, 62) =.001, p=.98.

For children's "pointing on the screen" type of behavior, the main effect of the within-subjects variable was significant, F (1, 62) =6.19, p=.016, partial eta squared=.09, power=.69, suggesting that children on average significantly increased the occurrences of the behavior of pointing on the screen from the first to fourth reading trial. The main effect of the eye-gaze awareness training was not significant, F (1, 62) =.182, p=.671. Neither was the interaction effect, F (1, 62) =.34, p=.561.

Summarizing the above reading behavior comparisons between the two groups, parents in the experiment group greatly increased the frequencies of four types of behaviors from the first to the fourth reading trial, including asking children to pay attention to the book, asking children to look at some specific words, teaching some

specific words, and providing instant and precise feedback following children's responses. Parents' behavior changes also made children in the experiment group more frequently asked or responded to the print-related questions from the first to the fourth reading trial compared to children in the control group. As predicted, the more efficient parent-child joint attention regulation and reading interactions significantly improved children's reading eye movements and print learning.

4.3.5 Follow-up Visit Results

Twenty out of the previous twenty-eight parent-child dyads participated in the one week follow-up study. The analyses of the *Children's Reading Interest Survey*, *Home Reading Log*, parents' change of reading behaviors, children's eye movements during reading and story retelling as well as their learning outcomes are reported in the following sections.

4.3.5.1 Children's Reading Interest in the First and Follow-up Visit

The means and standard deviations of the variables in the measurement of children's reading interest are presented in Table 11. The *Brief Reading Interest Scale* (BRISC) showed how parents rated their children's overall interest in shared book reading compared to other 10 activities (1=like reading most; 11=like reading least). Parents' answers about how often their child asks to be read to and how often their child reads alone were coded on 1-5 scale (1 refers to "Hardly ever"; 2 refers to " < 3

times/month"; 3 refers to "< 3 times/week"; 4 refers to "Almost daily"; 5 refers to " > once/day", see details in Appendix 1).

Table 11: Means (SD) for Children's Reading Interest Measurement Variables in Study 3

	Reading Interest Survey (Parental Report)				
	Child's interest in reading compared to 10 other activities (BRISC)	Child asks to be read to	Child chooses to read alone	Child's degree of concentration in reading (1=lowest concentration; 5=highest concentration)	Duration child chooses to read (minutes)
The First Visit	3.3(2.27)	4.25(.85)	4.35(.59)	4.35(.75)	24.9(16.23)
The Follow-up Visit	3.35(1.81)	4.1(.91)	4.15(.59)	4.5(.61)	24.75(17.2)

Across the two lab visits, the experiment group children's reading interest remained similar on the five measurements of the reading preference (t (19) = .17, P = .871), the frequency of reading initiations (t (19) = 1.14, P = .267), the frequency of

reading alone (t (19) = 1.45, P = .163), the degree of concentration (t (19) = 1.37, P = .186) and the duration of reading (t (19) = .05, P = .959).

Changes in the experiment group children's reading interest from the five measurements were compared to those in the control group, using the repeated measures ANOVAs. The statistic tests showed that none of the changes of the five reports on children's reading interest between the two groups were significantly different (all five p values >.1). This result suggested that our intervention did not greatly influence children's reading interest in a short term of one week. To put another way, after parents received the eye-gaze awareness training and then used some of the attention regulation techniques when reading with children at home for the following week, their children did not feel bored about their parents' attention regulation strategies and they still displayed the same level of interest in reading activities. This conclusion was also supported by the analysis of the *Home Reading Log* which assesses children's reading interest with two questions.

The first question on the proportion of reading sessions child initiated was examined with an ANCOVA, with children's reading preference score in the first lab visit as the covariate to reflect children's pre-existing level of interest since no baseline reading logs were collected. The proportion of home reading sessions initiated by children in the experiment group was .5 (*SD*=.29), which was not higher than that by children in the control group (.53, *SD*=.29), F (1, 36) = .35, p = .561.

Children's interest was also examined through parental ratings of how children maintained interest in the home reading sessions (a higher rating indicates a child

maintains higher interest in reading at home). An ANCOVA using children's reading preference score in the first lab visit as the covariate indicated that children in the experiment group (4.55 out of 5, *SD*=.48) were not rated as more interested in the home reading sessions than children in the control group were rated (4.49 out of 5, *SD*=.51), $F(1, 36) = .08$, $p = .777$.

Alternatively, there is a possibility that the lack of child interest differences between the experiment group and control group may have been due to ceiling effects in both the parental report and the *Home Reading Log*. For example, according to the parental report of child reading interest, the average frequency of child asking to be read to across groups at the first lab visit was 4.29 out of a possible 5 and 4.24 out of 5 at the follow-up. The average degree of child's concentration in reading across groups at the first lab visit was 4.44 out of a possible 5 and 4.54 out of 5 at the follow-up. In terms of the *Home Reading Log,* the average child interest rate in the home reading sessions across groups was 4.52 out of a possible 5. Future studies should evaluate further the relation of specific shared reading interventions to child interest.

4.3.5.2 Parents' Change of Reading Behaviors in the Follow-up Visit

Eight-five percent of parents in the experiment group (17 out of 20) reported increasing the frequencies of joint attention regulation and word teaching behaviors in the home reading sessions after the eye-gaze awareness training study. In comparison, less than half of the control group parents (9 out of 21) reported the similar increase after the naturalistic shared book reading study. The proportion of parents who reported the

change of reading behaviors in the experiment group was significantly higher than that in the control group (X^2 (1) = 7.84, *p*=.005). Our laboratory observations support these reports.

Sixteen experiment group dyads' video-recordings (four dyads' data were excluded due to the poor video quality) and those of eighteen control group dyads (three dyads' data were excluded due to the poor video quality) were included in the behavior data analysis. Across the two reading books, the frequency of the experiment group parents regulating joint attention was .67 (*SD*=.5) instances per minute, which was significantly higher than the frequency of .34 (*SD*=.7) instances per minute by the control group parents (*t* (32) = 2.25, *p*=.028). The experiment group parents' word teaching frequency in the follow-up was 1.21 (*SD*=.96) instances per minute, which was significantly higher than the frequency of .54 (*SD*=.79) instances per minute by the control group parents (*t* (32) = 3.01, *p*=.005).

4.3.5.3 Children's Eye Movements during Reading and Story Retelling

Sixteen out of the twenty children were included in the eye movement data analysis (four children were excluded due to their poor data quality). Compared to the first reading trial (without eye-gaze feedback provided) during the first lab visit, the experiment group children greatly increased the proportion of time they fixated on text AOIs of the old book at the follow-up (with the eye-gaze feedback provided) from 12.33% (*SD*=15.04) to 22.15% (*SD*=17.3), *t* (15) =2.34, *p* = .033. And they significantly increased their percentage of joint attention on texts from 4.19% (*SD*=5.45) to 10.31% (*SD*=8.7), *t* (15) = 2.97, *p* = .01. Between the follow-up visit and the fourth reading trial

of the initial visit during both of which parents watched children's real-time eye-gazes, there was no difference of either children's average attention on texts (t (15) = 1.14, p = .273) or the joint attention on texts (t (15) = 1.57, p = .138). These results suggested that for a short term of one week, children retained the increased percentages of eye fixations on texts as long as the eye gaze feedback was provided during reading.

The further comparisons of the short-term effects of reading eye movements between the two groups of children confirmed our findings. Compared to the control group children, the experiment group children exhibited significant increases in the percentage of joint attention on texts by 6.12% from the first time they read the old book to one week later they read it again (t (32) = 2.11, p = .043). While the difference between the two groups with respect to children's average percentage of time fixating on texts only approached the level of statistical significance (t (32) = 1.74, p = .091), it was nonetheless large, with the experiment group increasing the time spent on texts by 9.82%. In contrast, both the percentages of children's attention and the joint attention on texts in the control group remained similar across the two visits.

When the experiment group children read the new book *Alligator Boy* with parents in the follow-up visit, children spent 29.08% (*SD*=17.07) of their time focusing on texts, which was higher than the 12.88% of time the control group children spent looking at texts during the follow-up visit (t (32) = 3.52, p = .001). And the experiment group's average parent-child join attention on texts for the new book was 17.06% (*SD*=12.53), which was higher than the 6.11% of joint attention on texts the control group children shared with their parents (t (32) = 3.4, p = .002). The difference between the two

group children's reading eye movements for the new book indicated that children's improved reading habits could sustain even when they read some new reading materials.

In terms of children's story retelling eye movements, the experiment group children spent on average 21.5% (*SD*=14.26) of time on texts when retelling the old book, while the control group children spent 16.68 % (*SD*=15.17) of time on texts. This difference between the two groups was in the predicted direction, although it did not reach the level of statistical significance (t (32) = .94, p = .355). It was the same case with respect to children's retelling the new book on the screen, such that the experiment group children spent average 21.41% (*SD*=17.98) of time on texts, which was not significantly different from the 16.23% (*SD*=19.49) of time the control group children spent on texts, t (32) = .79, p = .434.

4.3.5.4 Children's Learning Outcomes

Children's keyword recognition performance and the average number of keywords they used during the story retelling in both the experiment group and control group were presented in Table 12.

Table 12: Means (SD) for Children's Learning Outcome Variables in Study 3

	Keyword recognition (number of recognized keywords)		Story retelling (number of utilized keywords)	
	old story	new story	old story	new story
Experiment group	2.4(2.37)	2.6(2.93)	7.81(1.64)	7(1.67)
Control group	2.05(3.12)	2.43(3.38)	5.39(3.71)	4.28(2.82)

For the old storybook which the experiment group children have read in their first lab visit, the average number of keywords they successfully recognized in the follow-up visit was significantly larger than the number of keywords those children could recognize before they read the book in the first lab visit (.95 out of 10, *SD*=2.28, *t* (19) = 4.65, *p*= .000). The results indicated that participating in our eye-gaze awareness training study improved children's keyword recognition performance in a short term of one week.

When comparing children's keyword recognition performance between the two groups, the experiment group children recognized more keywords than the control group children did for both the old and new storybooks. However, none of the differences reached statistical significance (*p*= .687 and .863 respectively). But when I used the increase of the number of recognized keywords across the two visits as the dependent variable, the experiment group children increased on average 1.45 (out of 10, *SD*=1.39)

words, which was significantly higher (t (39) =3.19, p=.003) than the change of number of keywords the control group children displayed (.14 out of 10, SD=1.77).

The above comparisons suggested that reading dyads' change of reading interactions did facilitate children's print related skills, such that children in the experiment group significantly improved their keyword recognition performance even one week after participating in our study, while children in the control group did not show such an increase across the two visits.

The experiment group children also used more keywords when retelling stories compared to the control group children during the follow-up visit. More specifically, when the experiment group children retold the story of the old book page-by-page on the screen, they used on average 7.81 (SD=1.64) keywords, which was significantly higher than the 5.39 (SD=3.71) keywords used by the control group children (t (32) = 2.41, p=.022). In terms of retelling the new story, the experiment group children used on average 7(SD=1.67) keywords, which was significantly higher than the 4.28(SD=2.82) keywords used by the control group children (t (32) = 3.36, p=.002). These data supported the hypothesis that we can facilitate children's learning of print and vocabulary by informing parents of children's real-time visual attention during the shared book reading.

4.4 Discussion

Study 3 primarily investigated whether showing parents their children's real-time visual attention changed parents' pedagogical beliefs and strategies for the shared book

reading activity as well as how these changes facilitate parent-child joint attention interactions and children's sight word learning. In line with my hypothesis, the eye-gaze awareness training helped most of the experiment group parents establish the understanding that their pre-reading children mainly watch pictures while listening to stories. And those parents agreed that they should utilize more efficient strategies to draw children's attention to print when attempting to teach children print during the shared book reading. The majority of parents in the experiment group thought highly of our technology-assisted reading paradigm and reported using the real-time eye gaze feedback information to regulate children's attention in Study 3.

Parents' answers to the interview questions were supported by the analysis of their reading behaviors. The results suggested when parents in the experiment group received the real-time feedback of their children's visual attention during shared book reading, they were better at regulating children's attention and at providing specific feedback following children's responses. Many parents spontaneously adjusted their reading strategies in response to children's real-time attention states. There were a lot more attention regulation types of interactions in the experiment group, such that parents verbally asked children to pay attention to texts and constantly pointed to some specific words on the screen. Since the experiment group parents could see where children looked at after a request or question, the redundancy of frequently asking children "Are you following mom and looking at the place I talked about?" was significantly reduced. Instead, parents directly provided children with more prompt and precise feedback such

as “That’s great, I can see you are looking at the right word.” These reading behaviors are more efficient for accelerating communications between parents and children.

In addition, parents in the experiment group showed more frequent and effective print teaching behaviors compared to parents in the control group, such as asking questions about particular letters or sound within a word, helping children spell or sound out a word, and commenting on print-related contents. This finding is consistent with the results of other intervention studies indicating that parents can learn to increase their use of references to print following brief video training programs (Justice & Ezell, 2000; Justice et al., 2002; Pile et al., 2010).

Parents in the control group also used some strategies to teach print. But as they did not have any real-time visual attention feedback, their reading strategies were neither effective nor efficient comparatively. For example, the control group parents usually looked at their children and talked about one specific word for a long period of time while their children had already got bored and did not really look at that particular word. As a consequence children could hardly recognize that same word in the posttest.

In contrast, with the help of real-time eye gaze feedback, parents in the experiment group had better opportunities to observe their child's attention state and fine-tune their interactions to increase child interest and participation. This is consistent with Brennan et al. (2008)’s study indicating that eye gaze was highly efficient for coordinating visual search tasks because collaborators can provide each other targeted and moment-by-moment assistance (Brennan et al., 2008). Specifically in our shared reading task, these parents knew from children’s cursor exactly how to assist their

learning, and children knew that their parents were doing so. Thus parents could greatly reduce the time and energy spent on looking at children or verbally checking children's responses. Instead, they frequently and naturally incorporated varies efficient and well-organized literacy activities within children's short attention span. And children more readily learned those words when they had more frequent but shorter durations of learning experiences. Parents in the experiment group successfully retained these changed reading behaviors one week after the eye-gaze awareness training, indicating a substantial short-term intervention effect for Study 3.

Similarly, children who experienced positive direction, coaching, and correction more easily attended to and internalized the information and skills that parents attempted to teach them, and developed the interest and motivation to sustain their learning. This conclusion was supported by the comparisons of the reading eye movement and behavior coding data between children in the experiment group and children in the control group. Children in the experiment group not only spent more time looking at texts, but also engaged in more print-related conversations with parents compared to children in the control group. These changes in turn provided more teachable moments for parents. Children in the experiment group kept their changed reading habits when they read both old and new reading materials during the one-week follow-up.

Note that when directly comparing children's responses in the fourth reading trial between Study 2 and 3, the results showed that the frequency of behavior of reading texts along with adults by children in Study 3 (parents received the eye-gaze awareness training) was significantly lower than that by children in Study 2 (children received the

eye-gaze awareness training) (p = .043). The comparison of the frequency of children's behavior of completing sentences with adults' prompt showed the similar pattern (p = .039). The reason for this is that children in Study 3 did not directly see adults' real time eye movements so that it is relatively more difficult for them to efficiently follow adults' eye scanning patterns to read texts. But as parents in Study 3 utilized more efficient reading strategies to interact with children, children responded more frequently to parents' questions or requests by asking or answering print-related questions.

As predicted, the joint attention intervention effectively improved children's inside-out and outside-in emergent literacy skills within a one week period. In Study 3, children's increased print-directed joint attention resulted in their better sight word learning. The experiment group children on average learned 1.25 keywords from the pretest to the posttest, while the control group children did not greatly increase the number of keywords they could recognize across the two *Keyword Recognition Tests*. The comparison result between the two groups kept the same in terms of children's keyword recognition gains in the follow-up visit. Moreover, children in the experiment displayed a larger vocabulary when retelling the two stories than children in the control group did. These results are consistent with previous shared reading interventions for children with language disorders. For example, children have been found to increase their rate of verbal responses to questions, number of different words and mean length of utterance following a 6-8 week intervention program (Dale, CrainThoreson, NotariSyverson, & Cole, 1996).

Although many studies on the print referencing strategies were in concert with our intervention results suggesting that the increased amount of attention paid to print during shared book reading further enhanced children's print knowledge (Ezell & Justice, 2000; Justice & Ezell, 2002, 2004), some recent studies did not replicate this positive effect. For instance, the study of Evans and her colleagues revealed that although pointing to each word of the text increased the extent to which 4-year-olds looked at the print, it did not improve children's recognition memory for print elements (Audet et al., 2008; Evans, Williamson, & Pursoo, 2008). A potential explanation for this contradiction is the effect teaching and learning happen when two parties have the real-time joint attention which may not exist in the above mentioned studies. Adults' print referencing strategies or the special designs of reading materials may overall increase children's visual attention to print, but children still have difficulties finding the correspondence among the form, sound, and meaning of each single word. This comparison suggests adults take advantage of the real-time joint attention regulations to look for the most teachable and efficient moment to teach children print.

Altogether Study 3 provides strong evidence for four conclusions. First, the intervention of showing parents their child's real-time reading process successfully corrected parents' beliefs and strategies during shared book reading. Second, parents' adjusted reading strategies encouraged young children to actively participate in the reading activity and attend to and process print. Third, children's changed reading habits benefited their emergent literacy skill development. Fourth, both parents and children's

positive changes sustained after a one week period, indicating significant short–term intervention effects for our study.

5. General Discussion

This dissertation examines how parent-child joint attention interactions influence children's reading progress during shared book reading and children's emergent literacy skills development. Taken together, the current studies show evidence that joint attention is critical for children's learning and children could not effectively learn emergent literacy skills when the real-time joint attention is unavailable during shared book reading. Furthermore, these studies show evidence that externalizing adults' reading processes helps children establish print concepts and engage in effective joint attention on print with parents. Children's improved reading habits also benefit their sight word recognition skills. Finally, these studies demonstrate that informing parents of their children's real-time visual attention changes parents' reading beliefs and behaviors which further assist with parent-child joint attention interactions during shared book reading. Similarly, children's inside-out and outside-in emergent literacy skills are enhanced with the increased real-time joint attentional transactions. These findings suggest a number of ways to enhance early literacy acquisition in the context of shared book reading. The data and methodology of this dissertation would also be useful to a wide array of research topics on collaborative learning.

5.1 The Objective Measurement of Joint Attentional Interaction

To the best of my knowledge, this is the first study in which joint visual attention is directly and objectively measured in the research area of shared book reading. This

allows us to go beyond prior research that focuses exclusively on one single person in shared book reading, and study shared reading as a joint attentional interaction involving dynamic transactions between partners and real-time cognitive strategies within individuals. The new methodology may be used to study other social learning contexts which involve learning from or together with other social partners.

Previous reading studies usually assessed joint attention with some off-line methods including parental report and dyads' reading behavior coding (Clarke-Stewart & Beck, 1999; Ortiz et al., 2001). Those traditional methods are subject to some biases such as social desirability and evaluation apprehension. In contrast, our new eye-tracking technology provides a straightforward and objective measurement in which the moment a parent-child dyad has joint attention is quantitatively represented as the moment when the difference of the reading dyad's eye gaze locations is within a predefined distance. The higher proportion of those particular moments, the more joint attention exists between the dyad during shared book reading.

The new technology enables the investigations of a number of issues in shared book reading. Specifically, Study 1 showed that generally pre-reading children have minimal joint attention with their parents on print during the naturalistic parent-child shared reading and thus they learn very few new words after the reading sessions. These data further confirmed previous findings that children avoid texts during shared book reading and the efficacy of shared reading on literacy development is moderate (Bus et al., 1995; Evans & Saint-Aubin, 2005; Evans et al., 2009; Feng & Guo, 2010, under revisions; Fletcher & Reese, 2005; Justice et al., 2008; Justice, Skibbe, et al., 2005; Mol,

Bus, de Jong, & Smeets, 2008; Scarborough & Dobrich, 1994b; Tabors, Beals, & Weizman, 2001). More importantly, the present finding strongly supports my hypothesis that parent-child joint attention is highly influential in setting the stage for children's literacy development. When parent-child reading dyads do not engage in effective and efficient joint attention interactions during shared reading, children could not have optimal opportunities to learn those emergent literacy skills.

Additionally, children display individual difference in terms of their joint attention with parents on print and children's joint attention level is correlated with their pre-existing word recognition skill. This is consistent with past research which showed that infant cognitive abilities (especially the language ability) influence the duration and quality of mother-infant joint attention interactions (Markus, Mundy, Morales, Delgado, & Yale, 2000; Matheny, 1989). Previous studies also suggested that children who spend more time in an attentive, interested state have more cognitive resources available for literacy learning (Bloom, 1993). However, not as expected, children who had higher joint attention with their parents on print in Study 1 did not have higher pretest-to-posttest gains in the *Keyword Recognition Test*. This result could in part be accounted for by the floor effect since children generally learned very few new words no matter how they differ in their joint attention level during the naturalistic shared book reading.

Furthermore, Study 1 led to more thorough explorations to disentangle the relationship between joint attention and literacy development as well as to use advanced technologies to improve joint attention on print during parent-child shared book reading. Study 2 and 3 were two examples of these explorations. I hypothesize that parents

typically have little information about where children are attending to and children have even less idea about how adults actually read. This double lack of awareness results in a poorly regulated joint attentional interaction and children's minimal exploration of the print during shared book reading. The findings of the two intervention studies provide strong evidence for my hypotheses.

5.2 The Remedy of Joint Attentional Transaction with New Technologies

An important contribution of the present dissertation is the two intervention studies (Study 2 and 3) in which we remedy the joint attentional structure by leveraging the eye-tracking technology. The experimental designs of Study 2 and Study 3 allow for strong tests of causal influence. The results of the two studies suggest that our eye-gaze awareness trainings can have at least short-term effects on the changes of children's print concepts, parents' reading beliefs and parent-child dyads' joint attention interactions as well as children's learning of the emergent literacy skills.

By providing one partner the real-time feedback of the other partner's visual attention, I demonstrate significant improvements in the amount of joint attention on print during reading. Parents also greatly changed their beliefs and adjusted their reading strategies which led to more effective parent-child joint attentional transactions. More interestingly, children did not simply look at the moving cursor or print words, but actually read and processed the words. This was shown by increased word learning by children, along with children's changes of concept of reading processes.

With the visualization of adults' eye scanning patterns, children in the experiment group in Study 2 could see how adults read storybooks in real-time. Most children understood that adults read texts from left to right to get the storylines after the eye-gaze awareness training and some children even started to follow adults' eye scanning on texts. Seeing adults' scan paths in reading is the first step toward understanding the reading process. I do not believe that children can magically become readers by imitating the scan pattern. However, not knowing how others perform reading denies useful information that facilitates conceptual understanding of reading. Children's conceptual understanding of print and reading can further enhance their joint attentional transactions with adults, such that the experimental group children in Study 2 displayed more responses to parents' word teaching attempts, including reading texts along with parents and sounding out or pointing to words on the screen when requested.

These interactions in turn provide more opportunities for both incidental word learning and adults' intentional and explicit literacy teaching. Just as infants match words with objects in their environment much easier when they experience the repeated and predictable interactions with adults (Bruner, 1985; Tomasello & Farrar, 1986a), the effective joint attention interactions between children and parents during shared book reading make the learning environment more meaningful and thus provide children with predictable opportunities that set the stage for literacy development. As these interactions recur often, children are allowed a wide range of opportunities to identify and match the sounds and forms of words with objects that they are attending to.

More interestingly, parents in Study 2 did not have to point to the screen much more frequently even when they talked a lot more about print from the first to the fourth reading trial. This is an indication that the combination of verbal and eye gaze referring is more efficient than the finger pointing in terms of regulating joint attention. With the eye gaze direction more tightly tied to the focus of join attention, children saw an external representation of reading processes unfolding in real time and therefore responded more to parents' word teaching attempts, such as reading texts along with parents, sounding out or pointing to words on the screen when requested. Children's increased responses to parents' reading strategies further improved children's visual attention to print as well as their print learning outcomes. Our results are in line with Velichkovsky (1995)'s research on cooperative problem solving, in which he found that gaze-mediated reference had priority over manual pointing in terms of enhancing cooperative work between an expert and a novice (Velichkovsky, 1995).

On the other hand, our joint attention intervention helped parents in the experiment group in Study 3 understand where their children pay attention to during shared book reading. Many parents changed their prior understandings of children's reading process and spontaneously adjusted their reading strategies to more efficiently regulation joint attention. The increased joint attention further accelerated the parent-child interactions and promoted children's learning. The interviews about parents' reading strategies, their comments and suggestions on our new technology also provide invaluable recourses for future intervention research.

Results in Study 3 demonstrate that children benefit from the attention-regulating efforts of their parents, at least in terms of sight vocabulary learning. This data is in line with other research on the relationships among joint attention, parental behaviors, and children's literacy acquisition. For instance, researchers found that parental physical or verbal direction of attention as well as their verbal responsiveness to children (defined as affirmations, imitations or expansions, descriptions, questions, and play or exploratory prompts) affect the duration of joint attention and predict later language development (Carpenter et al., 1998; Tamis-Lemonda & Bornstein, 1989; Tamis-LeMonda et al., 2001; Tomasello & Farrar, 1986a). Additionally, the optimal language-learning environment occurs when adult language follows children's focus of attention (Bloom, 1993). All these studies support our hypothesis, such that when adults follow and direct children's attention moment-by-moment, and respond promptly, contingently, and appropriately to children' verbal or nonverbal behaviors, adults and children are engaging in an effective and efficient joint attentional interaction which further fosters children's literacy learning.

5. 3 Limitations

There are several limitations to the three studies in this dissertation. First of all, in Study 2 and Study 3, the intervention was brief as a child or a parent only received the eye-gaze awareness training for about 15 minutes. Since none of the children and parents has ever seen the real-time eye gazes before participating in the study, they may not be able to make best of this visual attention information through such a short time period of training. Additionally, the intervention entails only one reading of each book. But in the home, children's books are typically read multiple times and children's attention to print

and pictures might shift with repeated readings of the same book and increased story familiarity (de Jong & Bus, 2002). Although most of my predicted results were obtained under the circumstances that the intervention is brief and entails one reading for each book, I believe even stronger results might have been obtained with a more intensive intervention and with repeated readings. This hypothesis needs to be evaluated in the future.

The second limitation of this dissertation is the relatively homogenous and self-selected sample. Across all three studies, 88% of the adult participants were middle- to upper-SES parents. And 82% of the adult participants reported that their children were read to daily at home. In contrast, Scarborough and Dobrich (1994)'s review on shared book reading research revealed that typically 43% to 75% of preschoolers are read to on a daily basis or more (Scarborough & Dobrich, 1994b). For those low-SES families, the proportion of preschool children who are read to daily is even lower (Dickinson & Tabors, 2001; Raikes et al., 2006). Moreover, the adult participants were self-selected and thus were very motivated and enthusiastic about reading with their children. According to parents' answers to the interview questions in Study 3, the majority of the experiment group parents was excited about our new technology and reported utilizing the real-time eye gaze information to adjust their reading strategies. Conversely, less motivated parents may not benefit as much from such an intervention that requires them to take the initiative to utilize new information and change their reading behaviors. Therefore, the intervention may not work well with other samples and the findings may not generalize to other populations.

Thirdly, children's literacy outcome measurements were limited in this dissertation. Children's inside-out emergent literacy skills were examined through the *Keyword Recognition Test* and the interview on children's print concepts. I measured children's outside-in emergent literacy skills by asking children to retell stories in the one week follow-up visit. As I mentioned in the introduction section, the skills I tested are only small parts of the literacy knowledge and skills children could develop through the shared book reading activity. Meanwhile, storybook retelling may not be a direct and effective way of measuring the outside-in skills since children could retell a story on the basis of context and picture clues, previous knowledge and memories instead of their vocabulary. The explorations of how the intervention influences children's development of different levels of the emergent literacy skills could benefit greatly through the use of more precise and sophisticated measurements in future studies.

Fourth, the sample sizes of both the experiment group and control group during the follow-up visit in Study 3 are relatively small and thus may affect some of the short-term intervention results. For example, when retelling the story from the book children have read in their firs lab visit, the difference of the average percentage of time children spent on texts between the two groups was in the predicted direction, although it did not reach the level of statistical significance. And the statistical result might be significant if the number of participants was larger. Therefore, the short-term intervention effects of the eye-gaze awareness training should be interpreted cautiously.

5. 4 Educational Applications and Future Directions

Our intervention targets limitations in joint attention regulation in the traditional shared reading practice, but it is not specific to reading. To the extent learning involves joint attention (e.g., in math tutoring), the eye-gaze feedback may be an effective aid for learning. In the traditional classroom setting or the one-on-one tutoring setting, there is no real-time direct feedback for the teacher or tutor to identify students' difficulties right away. Neither do those off-line methods such as standardized tests can help children solve the learning problems right at the moment children are encountering them. In contrast, our newly developed eye gaze feedback paradigm can be very useful in planning educational interventions for children with learning difficulties. With the real-time eye-gaze feedback, the teacher or tutor can identify those children's difficulties immediately and spontaneously adjust their strategies to help children focus, understand, and learn. Moreover, since the impairment of joint attention development is one primary feature of autism (Mundy & Newell, 2007; Mundy et al., 2009), this technology has the potential to help with the diagnosis and treatment of children with autism, such as helping autistic children increase the engagement and communication during various learning activities.

The findings in the current dissertation raise a number of potentially interesting future research directions. Since repeated readings could help children pay more attention to texts although they could not read conventionally (de Jong & Bus, 2002; Fletcher & Reese, 2005; McDonnell, Friel-Patti, & Rollins, 2003; Penno et al., 2002), more powerful versions of the intervention with extended and repeated eye-gaze awareness training over the same book might be tried. Moreover, it will be especially important to evaluate longer

term effects of the intervention since most of the existing research including mine examines the short-term effects of shared reading interventions and measures children's immediate literacy gains (Ezell & Justice, 2000; Fletcher & Reese, 2005; Justice & Ezell, 2000, 2002; Ortiz et al., 2001). It is still unclear whether these effects would continue and have long-term influences on children's emergent literacy development. And even less is known about whether the print-oriented shared reading experiences would influence children's literacy skills in later school years. If we employ a longitudinal design and increase the strength of the intervention in future studies, it would not be difficult to transfer the ideas and techniques of the intervention to other settings such as homes and schools, where practical benefits might be even greater. For example, we could incorporate this methodology in a group training study, where we project the teacher's eye gaze to a group of students in a reading circle. We could even organize peer-to-peer learning partners, such that we present to the "novice" student the real-time eye gaze feedback of how the "expert" student integrates information from texts and graphic/alternative representations in learning science and social sciences.

Furthermore, the intervention studies need to be conducted with parents and children from more diverse ethnic and SES backgrounds. Some researchers suggest that encouraging minority or low-SES parent-child dyads to engage in some special types of shared reading interactions may be counterproductive if a family does not easily adapt to doing this (Anderson, Anderson, Lynch, & Shapiro, 2003; Janes & Kermani, 2001; McNaughton, 1995; Ping, 1995). But others argue that helping all parents to read with their children more effectively is important since many low- SES parents use similar

teaching strategies as middle-class parents during shared book reading (Pellegrini et al., 1990). Since the present intervention studies were designed to investigate whether the technology-assisted shared reading paradigm could assist with the joint attention transaction for dyads with different backgrounds, these hypotheses need to be extensively tested in future research.

Finally, although Study 2 provides evidence that the eye-gaze awareness training for children influences their reading behaviors while Study 3 shows that the similar intervention works well for parents, the investigations of how reading dyads interact with each other and with books when both parties can simultaneously access the visual attention information are unexplored yet important. A two-way-feedback study (i.e., simultaneously providing a parent and a child the real-time eye-gaze feedback from the other partner) could be potentially helpful for understanding a more dynamic and comprehensive mechanism on parent-child joint attentional transaction. One thing we should keep in mind for this type of intervention is that we need to find appropriate ways of presenting stimuli in order to reduce the potential distractions to both parties when they might chase each other's eye gazes on book pages concurrently. Another potential way to understand this dynamics is to alternate interventions in the new study, such that presenting the eye gaze feedback to parents first and then presenting the feedback to children for one half of the dyads, and changing the intervention order for the other half of the dyads. But this requires further research and is not dealt with here.

Appendix 1 Children's Reading Interest Survey

1. Please **rank** your child's interest in the following activities from1–11 (give a different number for each activity), with ***1*** being the activity he/she likes the ***most,***

   and ***11*** being the activity he/she likes the ***least***.

   ___Playing with blocks or other building toys
   ___Playing with stuffed animals, dolls, and so forth
   ___Watching television
   ___Playing ball
   ___Art activities (such as coloring, finger painting, etc.)
   ___Reading a book with parent or another person
   ___Playing outside
   ___Riding toys (tricycles, kid-sized cars, etc.)
   ___Playing with parent(s)
   ___Playing with another child
   ___Other (Please specify activity: _____)

2. How often your child **asks to be read to** (please ***circle*** one):

   Hardly ever < 3 times/month < 3 times/week Almost daily > once/day

3. How often your child looks at books **by himself or herself**? (please ***circle*** one):

   Hardly ever < 3 times/month < 3 times/week Almost daily > once/day

4. The degree of concentration that the child has displayed when engaged in reading activities (Please rate on a 1-5 scale):

   1 2 3 4 5

   Not at all Somewhat Very much

5. How long the child typically chooses to spend on reading activities? _____

Appendix 2 Home Reading Log

Home Reading Log Parent:_____ Child:_____ Date: From _____To_____						
	Was it you or your child who initiated this reading session?	Approximate time we spent reading	Things we talked about while reading	Reading strategies* I used while reading	My child's response to my strategies	How well did this session maintain your child's interest? (Rate on a 1-5 scale) 1 2 3 4 5 Lowest highest
Day 1						
Day 2						
Day 3						
Day 4						
Day 5						
Day 6						
Day 7						

Note: * Reading strategies include regulating attention, asking questions, pointing to pictures, labeling pictures, pointing to letters/words, teaching letters/words, repeated reading, encouraging, and etc.

Appendix 3 Items in the Keyword Recognition Test

Word Item	Storybook	Word Item	Storybook
mom	*Greedy Cat*	daddy	*Bertie At Bedtime*
cat	*Greedy Cat*	bed	*Bertie At Bedtime*
bag	*Greedy Cat*	eye	*Bertie At Bedtime*
look	*Greedy Cat*	food	*Bertie At Bedtime*
bun	*Greedy Cat*	big	*Bertie At Bedtime*
potato	*Greedy Cat*	play	*Bertie At Bedtime*
banana	*Greedy Cat*	teeth	*Bertie At Bedtime*
chocolate	*Greedy Cat*	table	*Bertie At Bedtime*
sausage	*Greedy Cat*	carpet	*Bertie At Bedtime*
pepper	*Greedy Cat*	yawn	*Bertie At Bedtime*
dad	*Where Are They*	boy	*Alligator Boy*
book	*Where Are They*	box	*Alligator Boy*
pen	*Where Are They*	head	*Alligator Boy*
key	*Where Are They*	alligator	*Alligator Boy*
head	*Where Are They*	dad	*Alligator Boy*
table	*Where Are They*	nose	*Alligator Boy*
glasses	*Where Are They*	tail	*Alligator Boy*
chair	*Where Are They*	long	*Alligator Boy*
glove	*Where Are They*	big	*Alligator Boy*
suitcase	*Where Are They*	happy	*Alligator Boy*

Appendix 4 Home Literacy Survey

1. How old was your child when you began reading routinely to him/her?
   _____
2. How many times a week do you read books with your child? _____
3. How many minutes do you spend reading with your child each time?
   _____
4. How many children's books do you have at home or from the library? _____
5. Which of the following strategies do you often use when telling stories? Please indicate the frequency you use of each strategy on a scale of 1-10.

	Least frequently									Most frequently
Pointing to pictures	1	2	3	4	5	6	7	8	9	10
Pointing to letters/words	1	2	3	4	5	6	7	8	9	10
Labeling pictures	1	2	3	4	5	6	7	8	9	10
Teaching letters/words	1	2	3	4	5	6	7	8	9	10
Repeated reading	1	2	3	4	5	6	7	8	9	10
Attention regulating	1	2	3	4	5	6	7	8	9	10
Asking questions	1	2	3	4	5	6	7	8	9	10
Encouraging	1	2	3	4	5	6	7	8	9	10

6. Please ***circle*** the education level of the person who reads the most with the child:

   Below high school ***High school*** ***College and above***

7. What languages are spoken at home? _____
8. If more than one language, what are the percentages of time each of these languages is spoken? _____

Appendix 5 Shared Book Reading Behavior Coding Sheet

Global Scale Behaviors:

1. Child's overall reading interest: ___(average of the following four items)

None	Some	High
1	2	3

A) the child's overall level of alertness as indicated by posture and eagerness of expression___

B) the child's physical orientation towards the screen/book and the adult (e.g. An interested child will arch his neck to try to get a better look at what is going on)__

C) the amount and emotiveness in the child's verbalizations___

D) the proportion of time the child talks about the book being read or things related to the book as compared to non book subjects___

2. Adult's enthusiasm (Any behaviors that imply interest, excitement, or enjoyment on the adult's behalf or that attempt to raise the level of **engagement** in the child by implying that the material is fun and enjoyable, such as higher than normal and fluctuating tone of voice, use of hands to emphasize a point, and visible excitement like smiling): ___

None	Some	High
1	2	3

Counted Reading Behaviors (frequency (times per minute) & starting time):

1. Parent-child joint attention interactions

(1) the parent looks at the child;

(2) the child looks at the parent;

(3) the parent verbally regulates the child's attention (e.g., "Look at the screen/words/ pictures.");

2. Adults' reading strategies

(4) the parent asks the child to look at specific words (e.g., "Can you help me find the word 'cat' on the screen?");

(5) the parent points to texts on the screen;

(6) the parent teaches a word (including behaviors of asking any questions or commenting on print-related contents, e.g., "The word 'book' starts with a letter 'B' and ends with a letter 'K'"; "The first word on the second line starts with a 'buh' sound, can you try to sound it out?"; "Can you tell me what the word 'greedy' means?");

(7) the parent gives the child specific feedback following children's eye movements (e.g., "Yes, you are looking at the right place."; "No, you are not looking at the place I want you to look.");

3. Children's responses

(8) the child reads texts along with the parent;

(9) the child completes a sentence with parental prompt (e.g., children finished reading the last word of a sentence after parents stopped reading and waited for children's responses);

(10) the child points to the texts on the screen;

(11) the child talks about print-related things (including children's self-initiated responses (e.g., initiating print-related conversations) and children's elicited responses (e.g., verbally responding to print-related questions).

Appendix 6 Interview Questions for Children in Study 2

Pretest (before the eye-gaze awareness training)

- Questions we are interested in: How do children think adults read before the eye-gaze awareness training?
    - The experimenter says to the child: “Baby Duck and Baby Bear both like reading storybooks with their moms. When Mommy Duck reads with Baby Duck, she looks at these (the experimenter points to the pictures) to know what to say; when Mommy Bear reads with Baby Bear, she looks at these (the experimenter points to the texts) to know what to say. When your mom/dad reads books with you, does she/he read like Mommy Duck? Or does she/he read like Mommy Bear? ”

    - The experimenter says to the child: “When Mommy Bear reads books with Baby Bear, she reads this way (making the stuffed bear walk from right to left on the texts of a book); when Mommy Duck reads books with Baby Duck, she reads this way (making the stuffed duck walk from left to right on the texts of a book). When your mom/dad reads stories with you, does she/he read like Mommy Bear or Mommy Duck?”

Posttest (after the eye-gaze awareness training)

- Questions we are interested in: How do children think adults read after the eye-gaze awareness training?
    - The experimenter says to the child: “Now we will play the reading game with Baby Bear and Baby Duck again. When Mommy Duck reads with Baby Duck, she looks at these (the experimenter points to the pictures) to know what to say; when Mommy Bear reads stories with Baby Bear, she looks at these (the experimenter points to the texts) to know what to say. When your mom/dad just read stories with you, did she/he read like Mommy Duck or Mommy Bear? ”

    - The experimenter says to the child: “When Mommy Bear reads stories with Baby Bear, she reads this way (making the stuffed bear walk from right to left on the texts of a book); when Mommy Duck reads stories with Baby Duck, she reads this way (making the stuffed duck walk from left to right on the texts of a book). When your mom/dad just read stories with you, did she/he read like Mommy Bear or Mommy Duck?”

Appendix 7 Interview Questions for Parents in Study 3

Pretest:

1. Where do you think your child looks at on a book when you read to him/her? (the experimenter opens a storybook and shows a page with pictures and texts)
2. What do you do during reading? What reading strategies do you usually use? How do you teach words when you read with him/her?

Posttest:

1. Are the areas your child looked at on the books different from what you expected?

2. Is the eye cursor distracting?

3. Did you try to use this eye movement information during reading?

4. How do you think about this new technology? Is it useful when you help your child learn to read? How can this be useful?

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PUBLICATIONS & CONFERENCE PRESENTATIONS

Guo, J. & Feng, G. (2011). How eye gaze feedback changes parent-child joint attention in shared storybook reading? An eye-tracking intervention study. *Proceedings in 2011 ACM International Conference on Intelligent User Interfaces (Workshop on Eye Gaze in Intelligent Human Machine Interaction,* pp. 1-8*)*. New York: ACM Press.

Wang, J., Shu, H., & **Guo, J.** (2002). Experimental evaluation of speech-mouse and keyboard-mouse based multi-modal interfaces. In *User Interaction Technology in the 21st Century* (*Proceedings of the 5th Asia Pacific Conference on Computer Human Interaction)*, *Vol. 2* (pp. 627-636). Beijing: Science Press.

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"Tracking joint attention during shared storybook reading: An intervention study using eye-tracking," American Educational Research Association Annual Meeting, New Orleans, LA, 2011.

"How does storytelling strategy promote children's print exposure and story comprehension? An eye movement study in shared book reading," *Society for the Scientific Study of Reading Fifteenth Annual Meeting*, Asheville, NC, 2008.

"The rich get richer: emergence of individual differences in an eye movement study of storybook reading," *The 48th Annual Meeting of the Psychonomic Society*, Long Beach, CA, 2007.

"Eye movements during shared storybook reading: Do children look at the text?" *Society for Research in Child Development Biennial Meeting*, Boston, MA, 2007.

HONORS & AWARDS

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