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The Growth of Phonological Awareness: Response to Reading Intervention by Children with Reading Disabilities who Exhibit Typical or Below-Average Language Skills

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THE GROWTH OF PHONOLOGICAL AWARENESS: RESPONSE TO READING INTERVENTION BY CHILDREN WITH READING DISABILITIES WHO EXHIBIT TYPICAL OR BELOW-AVERAGE LANGUAGE SKILLS

by

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Under the Direction of (Rose A. Sevcik)

ABSTRACT

Phonological awareness (PA) can be defined as the ability to recognize that orthographic patterns represent specific phonemic elements of speech (Nitrouer, 1999). Alternatively, some view PA as a purely linguistic skill that involves the ability to recognize and manipulate specific speech sounds (e.g., Catts, 1991).

A large body of research indicates the primary problem for children who do not learn to read is a deficit in PA (e.g., Morris et al., 1998; Stanovich, 1988). Far less work has examined what drives the development of PA (Metsala & Walley, 1998). Recently, it has been suggested that oral language skills influence the acquisition of PA (e.g., Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg, & Poe, 2003; Olofsson & Niedersoe 1999).

The primary purpose of this study was to examine the development of PA skills in children classified with a reading disability who evidenced either typical or below-average oral language skills based on measures of receptive vocabulary, expressive vocabulary, and listening comprehensions skills. In addition, this study examined whether differing conceptualizations of PA resulted in differential findings concerning the relationship between oral language skills and

PA. Finally, this study examined the relationships that exist between different domains of language and different aspects of reading achievement.

Elementary school age students participated in the study with 211 students receiving 70 hours of small group reading intervention. Sixty-eight students served as a control group. Children's PA was assessed at three time points throughout the school year.

Repeated measures ANCOVA and HLM analyses were conducted with letter sound knowledge and phonological processing skills as dependent variables. Students with below-average oral language skills evidenced significantly ($p < .05$) lower scores on both measures compared to students with typical oral language skills. Children with below-average oral language skills did not acquire PA skills at a significantly slower rate than children with typical oral language skills. Analyses also indicated that the relationship between oral language skills and PA skills remains consistent across different conceptualizations of PA. SEM analyses showed that receptive vocabulary and expressive vocabulary knowledge independently contributed to PA skills. Only expressive vocabulary knowledge entered into a relationship with word identification skills.

INDEX WORDS: Phonological awareness, Reading disabilities, Oral language skills, Acquisition, Reading intervention, Receptive vocabulary, Expressive vocabulary, Listening comprehension skills

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Developmental reading disability (RD) is generally characterized as a difficulty in reading compared to same aged peers in the absence of low intelligence or any physical or psychological problems (Serniclaes, Sprenger-Charolles, Carre, & Demonet, 2001). RD is the most common learning disability classification among school-aged children (Stanovich, 1988). Prevalence estimates indicate that RD is present in 8-10% of the general population (Shaywitz, 1998). Historically, higher proportions of males have received a classification of RD than females. Some have attributed this greater incidence of RD in males, at least in the school setting, to a referral bias (e.g., Shaywitz, Shaywitz, Fletcher, & Escobar, 1990). These same researchers further have demonstrated that when objective achievement measures are used to make classifications of RD, males do not receive a disproportionately higher number of classifications compared to females.

Debate exists, however, concerning the criteria that should be used to identify children with RD and frequently different criteria are employed across studies and between research and educational domains. In order for children to receive special education services, federal regulations require children to meet criteria for an IQ-discrepancy (i.e., IQ-D, specific reading disability/dyslexia; Stuebing et al., 2002). Under these criteria, children must display reading skills that are substantially lower than their scores on intelligence tests (IQ). It has been suggested that those children who evidence low reading achievement in the absence of this discrepancy (i.e., “garden-variety” poor readers) are qualitatively different from those children who meet specific reading disability criteria (Stanovich, 1988).

There is no evidence, however, to suggest that these RD groups are meaningfully different. In support of this view, Francis and colleagues (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1994) followed groups of children who either met IQ-discrepancy or low achievement RD criteria from the 1st through the 6th grade. Using hierarchical linear modeling techniques, these researchers found that the different RD classification groups evidenced similar trajectories in their development of reading achievement and did not differ significantly in the age at which a plateau of reading achievement occurred. Stanovich (1988) has proposed the phonological-core variable-difference model that suggests that although garden-variety poor readers may be cognitively similar to younger children reading at the same level, these garden-variety poor readers share the same phonological problems seen in children with specific reading disability. In support of this, a meta-analysis conducted by Stuebing et al. (2002) found that IQ-discrepant and low achievement reading groups did not differ significantly on those constructs shown to be closely associated with reading achievement and reading disability (i.e., phonological awareness, verbal short-term memory, and vocabulary/lexical skills). Finally, the two RD classification groups have been shown to respond similarly to intervention attempts (Fletcher et al., 2002). These results highlight the increasingly accepted assumption that despite the criteria used to identify children with RD, all identified children with RD possess the same phonological-core deficits and respond similarly to intervention attempts.

Both environmental and genetic factors have been implicated in the etiology of RD; however, the exact role each factor plays in a child with RD is not completely understood. Currently, the only firm conclusion that can be drawn is that both environmental and genetic factors contribute to the development of RD. Support for a genetic etiology of RD comes from studies indicating that RD occurs more frequently in close relatives than in the general

population, more frequently in twins than in siblings, and more frequently in monozygotic twins than in dizygotic twins (Vellutino et al., 1996). Although research has implicated specific genetic loci for the development of RD, to date no one has been able to isolate and identify the exact genetic base responsible (Flax et al., 2003). Problematic in the identification of the genetic loci involved in RD is the fact that reading is a complex process that involves the execution and integration of a number of skills that are unlikely to be the result of the transmission of a single gene (Olson, Wise, Conners, Rack, & Fulker, 1989).

The influence of environmental factors on the development of RD is evidenced by the fact that children from families with a low socioeconomic status are at a greater risk for RD than those children with average or above average socio-economic status (SES) backgrounds (Whitehurst & Lonigan, 1998). For example, African American children consistently evidence higher rates of reading difficulties than Caucasians with 60% of African American children (compared to 25% of Caucasians) reading below basic levels by the fourth grade (Donahue, Daane, & Grigg, 2003). This overrepresentation of reading difficulties among African American children is likely a result of a disproportionate number of African American families living in poverty (Whitehurst, 1997).

Children from impoverished financial backgrounds also have been shown to be moderately impaired in syntactic ability and severely impaired in semantic and metalinguistic abilities (e.g., knowledge that a sentence can be parsed into words and words can be parsed into phonemes; Whitehurst, 1997). These linguistic deficits are considered, at least in part, to reflect the consequence of being reared in an impoverished linguistic environment. Because reading is a language-based skill, findings such as these suggest that the poor linguistic skills evidenced by

low SES children contribute to the increased risk of RD typified by children reared in a low SES environment.

The purpose of the proposed study is to examine the relationship between linguistic ability and reading achievement in a sample of children with RD. A number of relevant areas will be reviewed including: 1) a brief historical account of reading instruction philosophies; 2) an overview of the concept of phonological awareness (PA) that includes its importance to reading achievement and the research concerning some of the theoretical etiologies of PA; 3) a review of recent research that has examined the relationship between oral language skills and reading achievement; and 4) a review of the literature that has reported on the relationship between RD and oral language impairment including research on both children with Specific Language Impairment and children with Nonspecific Language Impairment.

The Great Debate

There is an ongoing debate concerning what are the most appropriate methods for teaching young children to read. The two factions involved in this debate are divided on the issues of a phonics-based approach to reading instruction versus a more naturalistic unfolding of reading skill acquisition through exposure to contextually related print. Despite the instructional differences, however, both positions share the belief that oral language skills are influential in the development of written language skills.

Many early educators and reading researchers have suggested that written language is a natural extension of oral language (for a review see Foorman, 1995). This view typifies the whole language approach to teaching reading skills. The whole language approach emphasizes the need for children to learn to read in the same manner in which they learned to speak, that is, immersion within the context and discourse of reading. According to such a view, it is thought that children recognize words holistically as opposed to utilizing a decoding process and use contextual information to successfully identify unfamiliar words. Evidence from eye movement studies, however, indicates that each letter is attended to in every word during the reading process rather than perceiving words holistically (Foorman, 1995). Because young and poor readers lack efficient decoding skills, therefore, they are more reliant on context for word identification than skilled readers. Even skilled readers, however, have difficulty identifying words based solely on contextual cues (Adams, 1990). This evidence suggests that children must first master specific word decoding skills that eventually afford automatic and fluent word identification.

As a result, a number of current researchers and educators have emphasized the role of phonics instruction in teaching children to learn to read. Emphasizing the role of phonic instruction suggests that for children to become successful readers they must learn basic decoding skills that allow them to recognize grapheme-phoneme relationships. A criticism levied against a focus on phonics instruction is that it is too reductionistic in nature and takes away from the natural learning process (Pressley & Allington, in press). A large body of research, however, has indicated that phonics instruction has demonstrated significant gains in helping children learn how to read and that the primary problem for children who do not learn to read is a deficit in phonological awareness (PA; e.g., Catts, Fey, Zhang, & Tomblin, 2001; Morris et al., 1998; Olson et al., 1989; Simos, 2002; Stanovich, 1988; Vellutino et al., 1996).

Phonological Awareness

Definitions of PA vary widely. Some researchers consider PA to be a linguistic ability that involves the capacity to recognize the individual phonemes, or letter sounds, in the structure of a language (Catts, 1991). Others, however, consider PA to be more directly tied to the reading process and encompasses the ability to recognize that arbitrary, written symbols represent specific speech sounds (Nitrouer, 1999). Finally, some researchers conceptualize PA as a combination of abilities and believe it represents the bridge between phonology (i.e., sounds in spoken language) and phonics (i.e., grapheme-phoneme correspondences; Stahl & Murray, 1998). Despite the definition used, however, research consistently indicates that the primary deficit in children with RD is a difficulty in performing tasks that rely on these abilities.

Findings from typically developing children that indicate PA is an important skill children must develop to become a successful reader are supported by data from children with Down Syndrome (Cupples & Iacono, 2000) and William Syndrome (Laing, Hulme, Grant, & Karmiloff-Smith, 2001). Further, this relationship between PA and reading achievement has been evidenced cross-linguistically (e.g., Spanish; Chiappe, Siegel, & Wade-Woolley, 2002). Importantly, cross-linguistic evidence of a relationship between PA and reading achievement has been evidenced in languages previously considered to be primarily logographic in nature (e.g., Chinese; Durunoglu, Nagy, & Hancin-Bhatt, 1993; Gottardo, Yan, Siegel, & Wade-Woolley, 2001; Korean; Pae, Sevcik, & Morris, 2004.).

Oral Language Influences on the Acquisition of Phonological Awareness

A deficit in PA has been associated with difficulties in the phonological recoding of words (i.e., recoding of spelling patterns into speech sounds; Serniclaes, 2001) and phonological

recoding has been described as the primary learning mechanism children possess to develop successful reading skills (Rayner, Foorman, Perfetti, Pestsky, & Seidenberg, 2001). It has been suggested that phonological recoding skills are established through shared reading experiences. Related to this idea is the concept of phoneme identity proposed by Stahl and Murray (1998). According to these researchers, phoneme identity is the process by which children begin to associate specific articulatory gestures with specific orthographic patterns through re-occurring exposure to paired speech and print stimuli. Stahl and Murray believe the concept of phoneme identity forms the basis of the ability to perform phonological awareness tasks. Children cannot begin to make grapheme/phoneme associations until they realize that the phonetic elements of speech can be represented by orthographic patterns. Once this association is established, repeated shared reading experiences may improve PA skills because a lexical-orthographic knowledge store is created that fosters well-defined grapheme/phoneme representations.

In support of this view, a review of the literature spanning more than thirty years (1960-1993) by Scarborough and Dobrich (1994) led the authors to conclude that reading to pre-school children was positively associated with later reading outcomes. The association was weak, however, with shared reading during pre-school ages accounting for only 8% of the variance in later reading achievement. In addition, shared reading has not been found to improve phonological skills to a significant degree (Whitehurst & Lonigan, 1998).

An explanation for these somewhat counterintuitive findings is that oral language skills mediate the relationship between shared reading and the development of PA skills. According to the mediational hypothesis, shared reading fosters the development of semantic and syntactic knowledge that, in turn, will influence the development of PA skills. Support for this idea comes from the review by Scarborough and Dobrich (1994) that indicated reading to pre-school aged

children was positively related to later lexical-semantic abilities. Further, a structural model presented by Whitehurst and Lonigan (1998) indicated that the only home environment factor to influence the attainment of phonological skills was the number of siblings. Literacy environment was not found to contribute directly to the development of PA skills. It was suggested by the authors that the divided attention among children reduced verbal interaction between parents and children results in less experience with spoken language, and in turn, yields less developed PA skills.

Etiology of Phonological Awareness

Although a large body of research has indicated that a deficit in PA is a primary symptom in children with RD, few studies have been conducted to determine the etiology of PA (Metsala & Walley, 1998). Because PA represents the link between speech sounds (phonology) and their written representations (phonics), the development of PA may be grounded in the ability to perceive the phonetic elements of speech. Some have argued that phonological awareness develops out of an innate ability related to phoneme detection in spoken language (e.g., Liberman, 1997). Others have argued, however, that phoneme perception is developed out of exposure to, and experience with, oral language (e.g., Best, 1994; Kuhl, 1992; Metsala & Walley, 1998).

Speech is Special. Liberman (1997) has proposed that processing the rapidly changing array of sounds characterized by the speech signal is made possible through the processing of articulatory gestures of the vocal tract. He argued that speech is a phonetic code and the key to the code is an innate mechanism called the phonetic module. The phonetic module deciphers the speech code by identifying and recognizing speech sounds associated with particular articulatory gestures. Further, it has been theorized that the phonetic module is independent of perception

and cognition. Liberman suggested that a phonetic module working improperly, either because of genetic variability or because of environmental influences, would result in a difficulty establishing grapheme-phoneme relationships that ultimately could lead to a deficit in phonological awareness.

Support for an innate mechanism responsible for speech perception is evidenced in infant studies that have examined phoneme perception. For example, Werker and Tees (1984) found that infants as young as 6 months-of-age were able to discriminate between two nonnative phonemes for which adults fail to discriminate. Additionally, Werker and Tees found that this ability to discriminate between nonnative phonemes diminished over time with a significant drop in performance occurring around 10-12 months-of-age. This loss of discriminative ability has been suggested to occur because of neural loss/restructuring due to an increased sensitivity to an infant's native language (Best, 1994; Kuhl, 1992).

Experiential Influences on Speech Perception. Other studies, however, have not provided support for an innate sensitivity to phonemes. For example, Mehler et al. (1988) found that infants as young as four days old were capable of discriminating between their native language and a nonnative language. Further, when the speech stimuli were subjected to a low-pass filter process, which leaves only the prosodic elements of speech, children were still able to make the distinction. This finding suggests that infants were making phonetic distinctions based on information other than the phonetic elements of the speech stimuli. Other evidence discounting an innate sensitivity to phonemes comes from studies showing that nonhuman animals are capable of making phonetic discriminations. For example, Kuhl and Miller (1978) demonstrated that chinchillas were able to discriminate between phonemes at levels greater than expected by

chance. Findings such as these have led some to argue that phonemic perception is not innate, but instead is experiential (e.g., Best, 1994; Kuhl, 1992; Metsala & Walley, 1998).

Support for the experiential nature of phoneme perception comes from studies such as Jusczyk and his colleagues (Jusczyk, Friederici, Wessels, Svenkerund, & Jusczyk, 1993). Their research indicated that 9 month-old infants' preference for their native language disappeared when speech stimuli were low-pass filtered. In contrast, 6 month-old infants showed no preference whether the speech was low pass-filtered or not. Taken together, these results suggest that at 6 months of age, infants begin to focus on the sound segments contained within the speech stream. This pattern of results developmentally mirrors infants' eventual loss of the ability to make discriminations between phonetic categories that do not exist in their native speech environment (Werker & Desjardins, 1995). Results such as these suggest that the statistical properties of speech (e.g., the structural patterns found in the distributions of sounds in words; Saffran, 2003) are available to humans at birth. It is not until later in development, however, that the human speech perception system begins to integrate and process the phonetic elements of speech that map onto the statistical properties of speech.

Although one view of the origin of speech perception is grounded in nativism and the other view is grounded in constructivism, both perspectives of speech perception make the assumption that PA skills are reliant on the ability to perceive speech efficiently. According to the speech is special perspective, an improperly working phonetic module will interfere with the process of forming the appropriate grapheme-phoneme correspondences necessary for the development of PA skills. The extant literature, however, indicates a more experiential basis for speech perception. Within this perspective, exposure to speech stimuli will influence the development of representations of the phonological categories defined by a particular language.

Thus, children with more well-defined phonological categories should evidence less difficulty in establishing grapheme-phoneme correspondences.

Lexical Restructuring Model

Metsala and Walley (1998) have proposed an experiential account of how children come to understand that the speech stream is composed of increasingly smaller phonetic elements. According to their Lexical Restructuring Model (LRM), early in the language acquisition process children represent words holistically. Over time, children build a lexical base that allows them to make comparisons between internally represented words. These comparisons eventually allow children to recognize words at the syllable level and eventually at the level of the phoneme. Metsala and Walley (1998) argue that this is not a system-wide process, but rather is a word-by-word process influenced by neighborhood density and word frequency. Words that have a greater neighborhood density (i.e., those words that differ by one phoneme; bar, bat, bag) will afford greater comparison, and those words that are used more frequently will provide more opportunities for comparison between words. Once children begin to recognize the phonemic elements of spoken words, they then can begin to establish grapheme-phoneme correspondences that provide the basis for PA skills. The authors suggest that the lexical restructuring process is developmentally impaired in children with reading disabilities and may be the source of their deficits in phonological awareness. Suggestions as to how this process becomes atypical in children with RD, however, have not been put forth.

Limited research has been conducted that has assessed directly Metsala and Walley's theoretical view of how phonological awareness develops. Metsala (1997) conducted a cross-sectional study utilizing a gating task with 7-, 9-, 11-year olds, and adults. Participants were given small parts of a spoken word that increased in length over a number of trials until the word

could be identified. Results indicated a negative relationship existed between age and amount of speech input need for word identification. Older children and adults needed less speech-like input to identify target words than younger children. Further, the 7- and 9- year olds needed more information for words that represented sparse neighborhoods, those words with few counterparts that differ by one phoneme, and low frequencies compared to 11-year olds and adults. It also was found that 7-year olds required more speech-like input than 11-year olds for words that were high frequency but represented sparse neighborhoods. Walley, Metsala, and Garlock (2003) argue that these findings are an indication of more holistic word representation in younger children. Additional evidence for Metsala and Walley's LRM comes from studies showing that children parse syllables and intrasyllabic units before they attempt to parse phonemic units in tasks requiring the segmenting of words or sentences. For example, in a series of three studies Nitrouer (1992) found evidence of children between the ages of 3 and 7 extracting syllables from the speech stream instead of phonetic segments. During the first two experiments, groups of children representing the ages of 3, 5, and 7 years demonstrated increased reliance on intrasyllabic formant transitions compared to adults during a monosyllabic identification task. In the final experiment, the children evidenced less sensitivity than adults to formant transitions across syllable boundaries when making identification judgments of disyllabic stimuli. Nitrouer's overall interpretation of the three experiments was that as children mature, they gradually move from the perception of holistic speech units, such as the syllable, to eventually reach a point at which they become aware of the existence individual phonemes in the speech stream.

Oral Language Skills and Reading Achievement

Although limited research has specifically addressed the LRM proposed by Metsala and Walley (1998), there is evidence to suggest that early oral language skills are influential in later reading achievement outcomes. Some of the studies supporting this link between linguistic skill and reading achievement are reviewed below.

Scarborough (1990) conducted a longitudinal study that demonstrated that syntactic skills measured at age 2 were correlated with phonological awareness measured at age 5. Further, syntactic skill at age 2 discriminated between disabled or non-disabled reading classifications made in the same sample of children during the 2nd grade. Scarborough's research provides support for a relationship between early oral language skills and later reading achievement. Additionally, a longitudinal study by Olofsson and Niedersoe (1999) found that early language awareness (e.g., a sum of rhyming tasks and syllable and phoneme awareness tasks) in kindergarten was predictive of sentence reading in Grade 4. Moreover, a strong causal relationship was found between receptive language and the development of language awareness. Finally, a recent study by Cooper, Roth, Speece, and Schatschneider (2002) found that the background variables home literacy environment and SES accounted for a large amount of unique variance in oral language skills (i.e., standardized measures of syntactic skill, receptive language, and expressive language) assessed during kindergarten. Further, these general oral language skills measured in kindergarten predicted a significant amount of unique variance in PA through 2nd grade. These authors concluded that any effect background variables may have on reading achievement may be mediated through the development of phonological awareness.

Given these findings, linguistic ability is seen as playing an important role in the development of skills necessary for successful reading achievement. The exact nature of this relationship, however, cannot be explicated by these findings. The only conclusion that can be drawn is that children evidencing better oral language skills also evidence better reading achievement outcomes. Further, many studies are associated with a number of conceptual and methodological flaws and limitations.

Issues of internal validity and generalizability of results plague research conducted with RD samples. One confound associated with RD research is the inconsistent and vague criteria used to identify children with reading difficulties (Lyon & Moats, 1997). Difficulties with reading achievement can be assessed either in terms of word identification or in terms of reading comprehension. Difficulties with word identification and deficits in phonological awareness are generally associated with the definition of dyslexia while difficulties in reading comprehension are associated with weak comprehension skills in the presence of adequate decoding skills (Fletcher et al., 2002). Less research has been conducted on comprehension based classifications of RD, however, and there is less consensus as to what reading comprehension tests measure compared to that of what word recognition tests measure (Fletcher et al., 2002).

In terms of reading comprehension, it appears that the ability to comprehend a written sentence is dictated by the ability to comprehend the same sentence when it is spoken (Reyner et al., 2001). It may be that once decoding skills have been mastered and a high degree of fluency and automaticity are present in the processing of orthographic-phoneme correspondences, the same basic processes underlie all comprehension regardless of linguistic mode. In addition, performance on measures of phonological awareness is considered to be independent of IQ, while IQ is expected to influence reading comprehension (Stanovich, 1988). Those students

evidencing superior vocabulary and problem solving skills will evidence higher levels of reading achievement through the use of compensatory processing. Thus, comparisons across studies using different reading achievement criteria may lead to misleading interpretations.

A second confound associated with RD research is that many studies do not acknowledge the developmental nature of reading achievement. Early in the learning process, reading is confined to word identification skills. It is not until around the 2nd grade that children begin to read for meaning (Adams, 1990). Failing to take into account this developmental shift limits interpretations of a study's findings. This is an especially important consideration for RD samples because this developmental shift may be delayed because these children still struggle to master basic decoding skills in later elementary years.

A conceptual difficulty associated with RD research is the highly discrepant manner in which phonological awareness has been defined. As already discussed, definitions of PA vary from a purely linguistic ability to one that involves the pairing of specific sounds of speech with specific orthographic patterns. Without consistent definitions of important reading related concepts, replication and generalization of findings can be limited.

Finally, many studies incorporate composite measures of oral language skills (e.g., semantic measures and syntactic measures) and reading achievement (e.g., word decoding measures and reading comprehension measures) to examine the relationship between oral language skills and reading achievement. While this may provide for a more comprehensive assessment of a child's linguistic and reading skills, analyzing the relationship between oral language skills and reading achievement in such a manner does not allow researchers to examine the potentially unique relationships between different aspects of oral language and reading achievement.

The nature and the number of confounds in addition to the conceptual problems outlined above highlight the difficulty in trying to explicate the exact nature of the relationship between oral language skills and reading achievement. Some have argued (e.g., Vellutino, Scanlon, & Tanzman, 1994) that the different domains comprising language (e.g., phonology, semantics, and grammar) may influence reading development in a differential manner and at different developmental periods. In support of this view some research suggests that semantic knowledge is strongly related to phonological awareness while grammar skills are strongly related to reading comprehension.

A small number of studies have examined independently the relationship between semantic knowledge and decoding skills. For example, Purvis and Tannock (1997) conducted a study examining the language abilities of children with Attention Deficit Hyperactivity Disorder (ADHD), RD, and children comorbid with both disorders: ADHD + RD. In this study, RD classifications were made using measures assessing real-word identification. It was found that groups composed of children with a classification of RD (RD only and ADHD+RD) exhibited deficits in receptive and expressive language, while the ADHD only group evidenced typical receptive and expressive language skills. These findings suggest a unique relationship may exist between semantic knowledge and decoding skills. Other evidence supporting a unique relationship between semantic knowledge and decoding skills comes from Catts (1993) who found evidence of PA skills mediating the relationship between measures of receptive and expressive language and measures of single word recognition. These results support the assumption that lexical knowledge influences the development of PA skills, which in turn influences single word identification accuracy. Finally, Dickinson and colleagues (Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg, & Poe, 2003) found that receptive language skills

significantly predicted performance on phonological awareness tasks in a large sample (n = 533) of Head Start preschool-aged children. Interestingly, these researchers also found that this relationship was stronger in those children who evidenced typical phonological awareness skills than in those children who evidenced low phonological sensitivity. This latter finding suggests that children with a deficit in phonological awareness possess a particular difficulty in utilizing the enhancing effects of vocabulary knowledge for the acquisition of phonological awareness.

Few studies have examined directly the relationship between grammatical ability and reading comprehension. The limited research does, however, support the contention that syntactic skill is important for reading comprehension achievement. For example, Nation, Clarke, Marshall, and Durand (2004) compared the oral language skills of children evidencing poor comprehension skills with a group of typically developing children. The study revealed that the two comprehension groups differed significantly on measures of expressive vocabulary, measures assessing knowledge of conceptual relations among words, and measures of morphosyntactic understanding. The two comprehension groups, however, did not differ on measures of phonological processing, nonword reading, or text reading accuracy. In a related study of typically developing African American children, Craig, Connor, and Washington (2003) found that syntactic competence in language samples measured during preschool and kindergarten predicted reading comprehension at age 9. Taken together these results suggest that it is the understanding of the conceptual relations among words that is implicated in reading comprehension abilities while decoding skills make relatively small contributions to the comprehension process.

Although the previously outlined studies suggest unique relations exist between different language domains and different aspects of reading achievement, they do not indicate that

different language domains are independent in their influence. Rather, it is argued that vocabulary knowledge is a primary factor in the development of decoding skills (i.e., phonological awareness), however, other linguistic components also may contribute to this development (e.g., syntax, morphology). For example, Dickinson et al. (2003) have used the term the “Jabberwocky effect” to refer to the use of morphological knowledge (e.g., prefixes and suffixes) to identify unknown words. Support for this idea comes from Nagy, Berninger, Abbott, Vaughn, and Vermeulen (2003) who examined the contribution of morphological knowledge and oral expressive vocabulary knowledge to reading achievement by 2nd grade students who had failed the district oral reading standards and were identified as at-risk readers. Structural equation modeling indicated that morphological awareness indirectly influenced the students’ real-word reading through their oral expressive vocabulary skills. This study supports previous research suggesting that semantic knowledge is influential in the word identification process, but it also reveals the potential for interaction effects (e.g., the “Jabberwocky effect) of other oral language skills on word identification performance.

There also is the possibility that the knowledge of rule-based relations involved in grammar will generalize to the rules involved in grapheme-phoneme correspondences. In support of this view, a large (n = 858) longitudinal study found that syntactic awareness measured in kindergarten significantly predicted real-word reading measured in first grade (Chiappe et al., 2002). These findings were evidenced in both a group of children with English as a first language and a group of children with English as a second language. Further, the study conducted by Dickinson et al. (2003) found that receptive language was predictive of early literacy skills (e.g., environmental print, letter knowledge, discrimination between real-words and nonwords).

Finally, the development of PA has been described as having a bi-directional relationship with reading experience (Foorman, 1995). When children enter school, they possess basic PA skills such as the ability to discriminate onset versus rime (Stahl & Murray, 1998), however, as children begin to engage in reading activities, they gain experience with sound and print correspondences that foster greater PA skills. These skills in turn foster more fluent and automatized reading skills. The more linguistically complex a phonological awareness task is, the stronger this bi-directional relationship becomes. For example, Stahl and Murray (1993) found that more simple PA tasks such as discriminating onset versus rime precedes early word identification. More complex PA tasks such as deleting a syllable from an orally presented word to produce a new word, however, are preceded by some word identification abilities.

With respect to reading comprehension, it is obvious that a larger semantic store can facilitate comprehension skills. Only successful readers, however, use contextual information to identify unfamiliar words (Adams, 1990). In children who are learning to read and those that continue to struggle with the learning process, most resources available to the child will be devoted to word identification. Therefore, there is less opportunity for the child to incorporate lexical information into a more global and meaningful interpretation. Further, if a word cannot be identified, the definitional knowledge of that word cannot contribute to the comprehension of written material. In support of this assertion, there is evidence to suggest that different linguistic domains influence decoding skills and reading comprehension at different developmental periods.

For example, a longitudinal study by Cooper and colleagues (Cooper, Roth, Speece, & Schatschneider, 2002) found that phonological awareness measured in kindergarten predicted single word reading in 1st and 2nd grades, while semantic knowledge measured in kindergarten

predicted word reading in the 1st grade but not during the 2nd grade. Further, semantic knowledge measured in kindergarten was a significant predictor of comprehension skills measured in the 2nd grade, but not in the 1st grade. In an additional longitudinal study, Storch and Whitehurst (2002) used structural equation modeling techniques to show that early elementary school reading achievement assessed by single word reading was primarily dictated by print knowledge and phonological awareness measured in kindergarten. Further, during pre-kindergarten and kindergarten time points, a significant relationship between code-related skills and oral language skills was evidenced. Oral language skills, however, did not evidence a significant relationship with single word reading skills. In later elementary school years, however, decoding and comprehension skills appeared to be separate skills that were influenced by different oral language skills. Their results were similar to those reported by Roth et al. (2002) in that semantic knowledge did not enter into a significant relationship with reading comprehension until the 3rd and 4th grades. These findings are not surprising considering this is the developmental period during which typical children are expected to be reading for meaning as a result of their decoding skills having become more fluent and automatized.

The results previously outlined demonstrate the importance of examining the differential impact of the separate domains of language on decoding skills and on reading achievement. Further, they highlight the importance of clearly defining reading as it is being conceptualized for a particular study (i.e., decoding vs. comprehension) and at specific developmental periods of reading achievement. Finally, they also emphasize the developmental aspect of reading achievement and the potential for relationships to change over time.

As previously outlined, a large corpus of studies has indicated oral language competence influences reading achievement outcomes. This influence may be indirect, however, operating

through the development of phonological awareness. The reviewed studies suggest that the development of phonological awareness is driven by an underlying construct involving linguistic skill, namely semantic knowledge. Therefore, it is of interest to examine reading achievement in a group of children exhibiting impaired language development.

Language Impairment and Reading Disability

Little research, to date, has examined the relationship between developmental reading disability and language impairment. According to Bishop (2001), partly responsible for this limitation is that research concerning language impairment has been subsumed under the domain of speech-language therapy, while research concerning reading disabilities has been confined to the domain of special education. Thus, little communication existed between research areas focused on children with language impairment and research focused on children with RD. Recent research indicating that RD and language impairment significantly overlap in many children, however, has sparked interest into the nature of the relationship between the two disorders.

Specific Language Impairment

Historically, specific language impairment (SLI) has been estimated to be present in 1% to 3% of preschool children; however, more recent evidence suggests that the prevalence rate may by as high as 7% (Gleason, 2001). The profile associated with SLI is the failure to develop language at a typical rate despite average or above average nonverbal intellectual skills (Bishop, Carlyon, Deeks, & Bishop, 1999). The language impairments seen in these children involve moderate difficulties acquiring new words and significant difficulties acquiring grammatical morphology (Goulandris, Snowling, & Walker, 2000). In addition, some children with SLI have been shown to exhibit phonological processing difficulties (Bishop, 2001).

Like RD research, the study of SLI does not adhere to a uniform set of classification criteria and comparison of results across studies is complicated by the use of different

terminology. As with RD, there is some debate as to whether IQ should be considered when making classifications of children with language impairments. Currently, in order to meet a classification of SLI, a child must score below 85 on standardized measures of linguistic ability while also scoring equal to or greater than 85 on standardized measures of nonverbal IQ (Catts, Fey, Tomblin, & Zhang, 2002).

Although children with SLI evidence linguistic competencies that are similar to younger, typical children (Gleason, 2001), their linguistic difficulties are not attributed to a developmental delay or to exposure to an impoverished linguistic environment (Watkins, 1997). Rather, these difficulties are considered to be persistent, constitutional difficulties that are never fully overcome. The linguistic difficulties seen in children with SLI cluster around lexical and morphosyntactic domains, however, the severity of these linguistic deficits varies across children (Watkins, 1997). Further, the discrepancy between nonverbal intelligence and linguistic competence has been reported to vary in children with SLI, with the discrepancy narrowing over time because linguistic deficits limit the cognitive skills a child may develop (Watkins, 1997). Some (e.g., Hall & Aram, 1996; McArthur, Hogben, Edwards, Heath, & Mengler, 2000) have questioned the "specificity" of the language impairments seen in these children and suggest that, under close scrutiny, these children also may exhibit motor deficits and cognitive deficits.

Family studies have indicated that a genetic component contributes to the development of SLI. The percentage of children reported to have at least one other family member with SLI has ranged from 24%-63% (Flax et al., 2003). Further, family members of a child with SLI have been found to have significantly higher rates of SLI than that found in the general population (Fisher, 2003).

Studies examining the existence of sex differences in the prevalence rate of SLI have produced mixed results. The majority of studies, however, have reported that males are more often affected than females (e.g., Lewis, 1992; Tallal et al., 2001).

Specific Language Impairment and Reading Disability

SLI and RD have a number of similarities. First, both are considered to be a focal impairment in a linguistic domain (one in written language and the other in oral language) despite normal intelligence and the absence of other physical or psychological problems. Second, both disorders have evidence of a genetic basis. Third, both disorders have been shown to include phonological processing difficulties. Finally, there is debate as to what the role of IQ plays in the classification of both developmental disabilities. These similarities have generated recent interest in the relationship between SLI and RD.

Co-occurrence of SLI and RD. The use of inconsistent classification criteria utilized across studies, such as the implementation of different cutoff levels on reading measures, has resulted in the description of a wide range of children with RD who also have oral language difficulties. For example, McArthur et al. (2000) reviewed ten studies examining the linguistic skills of children with RD. They reported the percentage of children with RD who also were categorized into a language-impaired group ranged from 19% to 63%. McArthur et al. also reviewed five additional studies examining the development of reading skills in young children with language difficulties. In this review, the number of SLI children who developed RD ranged from 12.5% to 85%.

In order to address the issue of different criteria utilized across studies, McArthur et al. (2000) analyzed data from seven studies not included in either of their previous reviews that documented the reading and oral language scores of children with RD and children with SLI.

Four of the seven studies examined children with RD and three of the studies examined children with SLI. The authors implemented a fixed real word reading achievement criterion to combine the samples of the four studies of children with RD to create a group 110 RD children. The researchers also implemented a fixed set of linguistic criterion to combine the samples of the three studies of children with SLI to create a group 102 SLI children. Their results revealed that 55% of the children classified as RD also fit criteria for SLI, and 51% of the children classified with SLI also fit criteria for RD. When the two groups were combined, 53% met criteria for both RD and SLI. The authors suggested that this finding may necessitate the implementation of new defining criteria for the two respective groups and the possibility that a new, language impaired-reading impaired group needs to be considered for classification.

Relationship Between SLI and RD . Although it is clear that RD and SLI are related, little research has been conducted to determine the nature of this relationship. Some have conceptualized RD as either a mild form of SLI that results in only phonological difficulties or as a resolved form of SLI (Goulandris et al., 2000). According to the second conceptualization, a preschooler's early oral language difficulties have resolved, but are still evidenced in phonological processing deficits. Others (e.g., Snowling, Bishop, & Stothard, 2000) argue that SLI is a risk factor for RD. According to this view, the two disorders are considered distinct, but a diagnosis of SLI puts a child at a disadvantage in learning to read because of weaker vocabulary and comprehension skills. Finally, others (e.g., Bishop, 2001) have suggested a genetic link between SLI and RD. This hypothesis suggests that RD and SLI share a common core linguistic deficit.

Longitudinal studies have shown consistently that children with language impairments are at a higher risk for developing RD than children in the general population (e.g., Aram,

Ekelman, & Nation; 1984, Bishop & Adams, 1990). These same studies, however, also have shown that a large variation in reading ability exists in these children and that not all SLI children develop reading difficulties.

Bishop and Adams (1990) conducted a longitudinal study with 83 children identified as SLI at the age of 4. These children were assessed on measures of linguistic skill and reading achievement at 5 ½ and 8 ½ years of age. Their results indicated that those children who appeared to resolve their linguistic difficulties at age 5 ½, did not evidence any significant impairments on language or literacy measures. Only those children with continued oral language deficits received a classification of RD. These findings do not support the hypothesis that RD is a resolved form of SLI because the children with reading difficulties also evidenced persisting oral language problems. Interestingly, it was found that those children meeting an IQ-discrepant definition of RD (using nonverbal IQ) were in greater proportion than those who met low-achievement criteria.

Further support for SLI as a risk factor for RD comes from a study by Goulandris et al., (2000) who compared the reading and linguistic performances of three groups of children: RD, persistent SLI, and children with resolved SLI. The children with RD performed similarly to the resolved SLI group on tests of vocabulary and sentence repetition, but performed similarly to the persistent SLI group on tests of reading and spelling. Thus, it was only those children with persistent language difficulties that also developed reading difficulties.

In a clinically referred sample of children with SLI, Bishop (2001) found evidence to suggest that RD and SLI were different manifestations of the same underlying genetic cause. Bishop also tested for a genetic link in a sample that was taken from the general population. In this sample, RD and SLI were not found to share a common genetic cause. Bishop's overall

conclusion was that a genetic predisposition to SLI is one of many risk factors to RD; however, in the general population, environmental risks (e.g., impoverished literacy environment) predominate the development of RD.

Consistent with previous findings, Flax et al. (2003) found that RD and SLI co-occurred more often within family members of an affected individual than co-occurred in the general population. Importantly, however, the authors also found that RD and SLI were more likely to co-occur in the same individual than to occur individually. This was true for both probands and their affected family members. These results support the idea that SLI and RD may have a common genetic etiology.

Interpretation of the Empirical Evidence Concerning the Relationship Between Specific Language Impairment and Reading Disability

As previously mentioned, problematic in the study of children with SLI is the use of inconsistent selection criteria across studies (Hall & Aram, 1996). Therefore, interpretation of research conducted with SLI children is difficult because the heterogeneity across different samples confounds comparison across studies and generalizability of findings to children that fit a particular SLI criterion. For example, some children included in studies of SLI have general developmental delays, but are assigned a classification of SLI because nonverbal IQ measures were not used and their linguistic difficulties were the most salient feature of their disorder (Bishop & Adams, 1990). Additionally, the findings reported by Bishop (2001), highlight the potential to obtain conflicting results based on whether a clinically referred sample or a sample recruited from the general population is studied. Adding to the difficulty of interpreting research on SLI children is the use of different terminology to refer to this group of children (e.g., language impaired, developmental language disorder; Hall & Aram, 1996). Finally, research

examining the relationship between SLI and RD has the compounded flaws associated with RD research that has been previously outlined. Therefore any conclusions based on the extant literature should be made cautiously.

With the limited research available and the limitations of the research that has been conducted, it is difficult to determine which of the three previously outlined hypotheses concerning the relationship between RD and SLI is the correct one. The suggestion that RD is a recovered form of SLI, however, appears to receive the least amount of theoretical or empirical support. The finding that only those children with persistent oral language difficulties have been classified subsequently with RD is strong evidence against the idea that RD is a recovered form of SLI.

Although a genetic base appears to be involved in both RD and SLI to some degree, at present there are no studies that have identified similar genetic loci between RD and SLI (Flax et al., 2003). Further, findings indicating that RD and SLI co-occur more often than occur alone, do not rule out the possibility that SLI is a risk factor for the development of RD. Additionally, if the disorders share a common genetic linguistic core, there is no developed theory as to what would cause this shared genotype to manifest itself as an oral language deficit, a written language deficit, or both an oral and written language deficit. Supporters (e.g., Bishop, 2001; Flax et al., 2003) of this hypothesis suggest that differential manifestation may be a result of an interaction between genetic and environmental factors; however, they do not offer any specific explanations for how this might occur. Finally, because children meeting low-achievement and IQ-discrepant RD criteria are considered to share the same deficit (i.e., phonological awareness), a common genetic core should not result in one RD group evidencing a larger proportion of

children with SLI than the other RD group, as supported by the study conducted by Bishop and Adams (1990).

At this time, the idea that SLI is a risk factor for RD appears to be the most appropriate. First, the available research has consistently shown that those children evidencing early linguistic difficulties are at a higher risk for developing RD than children in the general population. Further, evidence from children with typical language development indicates that early linguistic skill is predictive of later reading achievement. The studies reporting that recovered SLI children went on to become successful readers do not support this theory, however, one must question as to whether this recovered group truly were children with SLI. Many studies recruit their participants from schools or language intervention sites and rely on previous clinical diagnoses of SLI. In general, clinicians are probably better at identifying a language disorder than standardized psychometric tests because of the inability of these tests to accurately reflect the entire child. In terms of research where replication and generalizabiltiy are important for assessing validity of results, however, this method may be too subjective (Hall & Aram, 1996).

Other evidence suggesting that SLI is a risk factor for developing RD is that not all children who are classified with RD have a history of early linguistic difficulties. It is not necessary, therefore, to exhibit language problems to develop RD. This finding, however, may be explained by the presence of subtypes of RD such as the visual naming speed deficit suggested by Wolf and Bowers (1999). The occurrence of RD as a result of a visual naming speed deficit at present is low (Morris et al., 1998) and would not account for the number of RD children who do not have a history of language difficulty. While SLI children have been shown to have difficulties with phonological processing, this is the not the hallmark characteristic of the disorder and not all SLI children evidence these difficulties. If the development of phonological

awareness were heavily influenced by linguistic skill, then the lexical and morphosyntactic deficits combined with phonological difficulties seen in children with SLI would pose a significant risk factor for becoming RD.

In support of this assertion and consistent with the LRM (Metsala & Walley, 1998), Maillart, Schelstraete, & Hupet (2004) conducted a study examining the phonological representations in a French-speaking sample of children with typical language abilities and children with SLI who were matched on receptive language skill. The researchers found that across both groups those children with higher levels of receptive language skills were better at distinguishing words from nonwords that were presented orally. The children with SLI, however, performed worse than the children with typical language abilities in rejecting nonwords as words. This difference was magnified when nonwords were more similar to real words. The authors concluded that their results suggest children with SLI have more poorly defined phonological representations than typically developing children. Thus, these poorly defined phonological representations may increase the risk of children with SLI developing difficulties with PA.

Despite mounting evidence of SLI being a risk factor for RD, the only firm conclusion that can be drawn at this point it that RD and SLI are related. The nature of this relationship, however, remains unclear. A much larger corpus of research needs to be carried out in order to explicate this relationship. Further, much more rigorous research methods need to be implemented in this area of research in order to increase the internal validity and generalizability of results.

Nonspecific Language Impairment

Children evidencing standard scores below 85 on both measures of nonverbal IQ (but > 70) and linguistic ability are classified as having a nonspecific language impairment (NLI). Arguments have been made for conceptual and clinically relevant differences between the SLI and NLI groups on the basis that the NLI group would be limited in their response to intervention because of their level of cognitive functioning (Casby, 1992). Research studies, however, have not shown a differential response to language intervention between SLI and NLI groups (e.g., Cole, Dale, & Mills, 1990; Fey, Long, & Cleave, 1994).

Empirical findings concerning the relationship between NLI and RD have generally produced results similar to those seen in a population of SLI. For example, Catts et al. (2002) conducted a longitudinal investigation of reading outcomes in a group of children with language impairment classified as either SLI or NLI while in kindergarten. The results of the study indicated that both groups (approximately 50% of the groups combined) were at risk for being classified with a RD in the 2nd and 4th grades. The children classified as NLI, however, had a greater risk of being classified as RD (approximately 65%) than the group classified as SLI (approximately 40%).

While these findings suggest that children with NLI are at a greater risk for developing RD, this finding can be explained by the fact that the researchers assessed RD status through reading comprehension measures. Because children classified as SLI evidence higher scores of IQ, this group may engage in compensatory processing by which their cognitive ability compensates for their deficit in phonological skills (Stanovich, 1988). In another study examining the relationship between RD and speech-language impairments in 1st and 2nd grade students, Catts (1993) found that children meeting research criteria for speech-language

impairments were at risk for RD; however, articulation ability was not related to reading achievement. This finding is not surprising considering that a difficulty in articulation is a speech motor/planning problem as opposed to a linguistic problem.

Consistent with previous research conducted with children with SLI, results from the Catts et al. (2002) study also indicated that degree of language impairment was related to reading achievement in both language impaired groups. Further, those language-impaired children with SLI who appeared to resolve their language difficulties did not evidence reading achievement scores as low as those children with persistent language difficulties. These results are especially important considering that a reading comprehension measure was used to assess reading outcomes. Because SLI and NLI children exhibit severe deficits in morphosyntactic abilities, these findings support the suggestion that reading comprehension skills are tied to oral comprehension skills.

Purposes and Hypotheses

Considering the large number of children with RD that previous research has indicated also meet criteria for either SLI or NLI, it is important to conduct studies with children evidencing both oral and written language difficulties to further our understanding of the relationship between these two linguistic modes. Additionally, because research has indicated that oral language competency is associated with reading achievement outcomes, it is of particular interest to examine whether children with RD who evidence linguistic deficits respond similarly to intervention attempts as those children with RD without such linguistic deficits. Despite whether children exhibit the specific cognitive and linguistic behaviors associated with SLI or NLI, the research previously outlined suggests that children with RD who also evidence linguistic deficits, especially semantic deficits, may pose a unique challenge for reading intervention attempts (McArthur et al., 2000).

No study, however, has examined whether children with RD who exhibit typical language development respond to reading intervention attempts differently than those children with RD who exhibit language deficits. It was of interest, therefore, to identify children representing RD groups with and without language deficits and track the development of their reading skills while participating in a reading intervention program.

The primary purpose of this study was to examine the growth of PA skills in children with RD assigned to either a reading intervention or control group who evidenced differential linguistic abilities. The extant literature suggests that semantic knowledge shares a unique relationship with the acquisition of PA skills when compared to morphological and syntactical knowledge. To date, however, few studies have specifically examined the relationship between

different domains of the linguistic system (e.g., receptive vocabulary, expressive vocabulary) and the development of PA. Most studies have used composite measures of oral language skills and have assessed PA skills indirectly through single word reading ability. Further, no studies have been conducted that have examined the influence of oral language skills on the development of PA in response to a phonologically based reading intervention program. Examining the development of PA in children evidencing linguistic deficits across a number of linguistic domains, therefore, will provide needed insight into the relationship between these variables.

According to Metsala and Walley's (1998) LRM, it is the size and nature of the lexical store that is influential for the development of PA and not the child's ability to communicate their semantic knowledge. This suggests that receptive vocabulary has a unique relationship with the development of PA when compared to other linguistic domains such as expressive vocabulary or listening comprehension skills. No research, however, has yet to directly make these comparisons. Subsequently, children in this study were classified into typical and below-average linguistic skills groups based on receptive vocabulary skills, expressive vocabulary skills, both receptive and expressive vocabulary skills, and listening comprehension skills. Classifications into linguistic groups were based purely on linguistic ability with no emphasis placed on IQ scores with the exception that all students evidenced an IQ of at least 70. Research conducted with children with SLI and children with NLI has indicated that degree of language impairment is related to reading achievement and is relatively independent of IQ level (e.g., Catts et al., 2002). This study, therefore, was primarily interested in how linguistic ability was related to PA and was not concerned with classifications made with respect to IQ.

Based on previous research and the theoretical underpinnings of Metsala and Walley's LRM (1998), it was hypothesized that the below-average receptive vocabulary group (B-ARV)

group would enter the study with significantly lower levels of PA skills than the typical receptive vocabulary group (TRV). Further, it was hypothesized that the children in the B-ARV group would evidence slower growth in their PA skills than those children in the TRV group.

With regard to the typical and below-average linguistic groups that were formed based on expressive vocabulary and listening comprehension skills, it was expected that the below-average groups would evidence significantly lower PA skills than the typical groups. This expectation was based on the fact that expressive vocabulary and listening comprehension skills are dependent on an internalized vocabulary set. Thus, the below-average groups created based on measures of these linguistic skills should evidence the lower PA skills expected to accompany children with below-average receptive vocabulary levels.

With regard to rate of acquisition of PA skills, however, analyses were more exploratory in nature. According to Metsala and Walley's (1998) LRM, it is the size and nature of the lexical store that is influential for the development of phonological awareness and not the child's ability to communicate their semantic knowledge. Because measures of expressive vocabulary are production tasks in nature, as opposed to recognition tasks such as measures of receptive vocabulary, no specific hypotheses were made about the relationship between expressive language skills and rate of acquisition of PA skills. Additionally, because listening comprehension involves higher ordered processes that require the integration of a number of pieces of information, both linguistic and contextual, no specific hypotheses were made concerning the relationship between listening comprehension skills and rate of acquisition of PA skills.

A second purpose of the study was to explore two different conceptualizations of PA skills and their relationship with oral language skills. According to Stahl and Murray (1998), PA

is best conceptualized as a single factor of linguistic complexity instead of being represented by distinct PA tasks. Subsequently, differences found between tasks assessing PA skills may be the result of confounding linguistic complexity with task. Further, misleading results may arise because different levels of linguistic complexity may exist within a specific PA task. Because the definition of PA has varied dramatically across studies, however, it was of interest to examine whether knowledge of grapheme/phoneme correspondences differed developmentally from the ability to recognize and manipulate phonological segments of speech. It was also of interest to examine whether differential findings would result with respect to the relationship between oral language skills and differing conceptualizations of PA. Two different phonological awareness tasks, therefore, were utilized as dependent variables and analyzed separately. The first PA task assessed children's knowledge of grapheme/phoneme correspondences while the other task required children to manipulate phonetic elements of speech and was conceptualized as a phonological processing (PP) task.

The final purpose of the current study was to examine the relationships that exist among different linguistic domains and different measures of reading achievement. At the baseline time point, it was hypothesized that relationships would be strongest between semantic knowledge, PA, and word identification and between listening comprehension and reading comprehension. Although it was expected that semantic knowledge would enter into a relationship with reading comprehension at the 70 hour intervention time point, the strongest relationship was hypothesized to exist between listening comprehension and reading comprehension. Further, it was expected that the relationship between semantic knowledge and word identification would be fully mediated through PA.

Despite the fact that some students in the study were in the third grade, it was expected that at the baseline time point none of the children would have made the developmental shift from decoding to reading for meaning. During this time point, participants were expected to be struggling to master basic decoding skills that would allow them to engage in reading for meaning. It was hypothesized, however, that receptive vocabulary skills would be related to reading comprehension abilities during the 70 hour intervention time point. Though students varied in their school grade at entry into the study, differences observed likely are attributable to the developmentally advanced cognitive processing of older students as opposed to a developmental shift in the nature of reading achievement.

Method

Participants

The proposed study utilized archival data collected from a large, multi-site, longitudinal study examining intervention effects on young school-aged children with RD. Participants from this study were 305 first to third grade students from public elementary schools who were referred by their teachers for difficulties in learning to read. Twenty-six of these 305 students did not complete the study or had missing data. This left 279 students with data available for analysis. The students not included in the subsequent analyses did not differ significantly from the children who remained in the study on demographic, intellectual, or reading achievement measures. One hundred thirty-five students (48.4%) were African American while 144 students (51.6 %) were Caucasian; 38.7 % (n = 108) were female students and 61.3 % (n = 171) were male. Their mean chronological age in months at the time of referral was 93.56 (SD = 6.08), and ranged from 80 to 110 months. The average IQ of the students was 91.49 (SD = 11.16). Almost equal numbers of students met average SES (n = 139) and below average SES (n = 140) classifications. Of the 279 students who were included in the data analyses, 211 had been randomly selected to receive a reading intervention program. The remaining 68 students had been randomly selected to serve as a control group. This group was offered a reading intervention program the following year. The demographic breakdown of each of these groups is contained in Table 1.

In order to meet criteria for RD, students could have met either Low Achievement (LA) and/or IQ-Discrepant (IQ-D) definitions. Individuals with a K-BIT IQ Composite score greater than 70 and whose reading skills were equal to, or less than, a reading achievement standard

score of 85 (15th percentile) met LA criteria. Participants with a K-BIT IQ Composite score greater than 70 and whose actual reading performance was at least one standard error of the estimate below their expected achievement level (calculated based on an average correlation of .60 between measures of reading performance and IQ) met IQ-D criteria. Participants could, and frequently did, meet criteria for both classifications. The distribution of children meeting criteria for RD is as follows: 77 (27.6 %) met the LA only classification, 24 (8.6 %) met the AA-D criteria only classification, and 178 (63.8%) met both LA and AA-D classifications.

Children with English as a second language, histories of hearing impairment, and uncorrected vision greater than 20/40 were excluded from the study. Further, any children diagnosed with emotional/psychiatric disorders (e.g., major depression, psychotic, or pervasive developmental disorder) or who had chronic medical/neurological conditions (e.g., seizure

Table 1.
Means and Standard Deviations of Age and Non-Verbal IQ for the Control and Intervention Groups

		Control Group			Intervention Group		
	Demographic Variables	n	Age in Months	K-Bit Matrices	n	Age in Months	K-Bit Matrices
Ethnicity	African American	33	94.85 (6.75)	93.61 (12.30)	102	93.47 (5.27)	93.86 (9.92)
	Caucasian	35	93.37 (6.71)	94.63 (10.34)	109	93.32 (6.40)	94.28 (10.88)
SES	Low	34	92.64 (5.99)	95.85 (10.82)	106	93.10 (5.89)	93.75 (9.72)
	Average	34	95.54 (7.17)	92.41 (11.59)	105	93.69 (5.85)	94.41 (11.09)
Gender	Female	27	94.87 (6.96)	94.30 (11.57)	81	94.45 (5.68)	92.09 (9.81)
	Male	41	93.58 (6.59)	94.04 (11.19)	130	92.74 (5.90)	95.32 (10.60)
Receptive Vocabulary	B-ARV*	35	94.44 (7.05)	89.54 (9.81)	101	93.52 (5.64)	91.23 (8.84)
	TRV*	33	93.72 (6.44)	99.00 (10.75)	105	93.28 (6.13)	96.77 (11.28)
Expressive Vocabulary	B-AEV*	24	94.97 (7.79)	89.79 (9.79)	84	93.65 (5.79)	93.26 (8.97)
	TEV*	40	94.14 (6.01)	95.85 (10.99)	119	92.93 (5.96)	95.61 (10.87)
Receptive/Expressive Vocabulary	B-AREV*	18	95.71 (8.00)	87.79 (9.68)	56	93.41 (5.08)	91.30 (7.77)
	TREV*	48	93.91 (6.06)	96.02 (10.53)	142	93.15 (5.89)	93.35 (11.01)
Listening Comprehension	B-LC*	19	96.77 (7.00)	88.94 (11.41)	55	93.25 (5.66)	89.81 (8.51)
	TLC*	45	93.16 (6.47)	95.83 (10.90)	150	93.42 (6.00)	95.67 (10.68)

*Note: Below-Average Receptive Vocabulary (B-ARV); Typical Receptive Vocabulary (TRV); Below-Average Expressive Vocabulary (B-AEV); Typical Expressive Vocabulary (TEV); Below-Average Receptive/Expressive Vocabulary (B-AREV), Typical Receptive/Expressive Vocabulary (TREV); Below-Average Listening Comprehension (B-ALC); Typical Listening Comprehension (TLC)

disorder, developmental neurological conditions, acquired brain injuries) did not qualify for recruitment into the study.

For the purposes of the proposed study, children in the control and intervention groups were divided into typical and below-average linguistic skill groups based on three measures of linguistic ability. These measures allowed for the classification of children into groups based four different linguistic criteria: receptive vocabulary level, expressive vocabulary level, receptive/expressive vocabulary level, and listening comprehension skills. The classifications made were not mutually exclusive (see Table 2). Students in this study, therefore, could have met multiple linguistic classifications. The demographic information associated with each of these classification groups can be seen in Table 3.

For the first domain, a typical receptive vocabulary group (TRV) and a below-average receptive vocabulary group (B-ARV; a score of 1 SD or greater below the mean on the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981) was created. The second linguistic classification was based on expressive vocabulary skills. The below-average expressive vocabulary group (B-AEV) evidenced a scaled score that was 1 SD or greater below the mean on the Vocabulary subtest of the Wechsler Intelligence Scale for Children-3rd Edition (WISC-III; Wechsler, 1991). Standard scores could not be computed for this subtest; therefore, scaled scores were used to make expressive vocabulary group classifications. Children not meeting this criterion were classified as a typical expressive vocabulary (TEV) group. A third below-average linguistic group, those students evidencing below-average receptive and expressive vocabulary skills (B-AREV), was created by identifying those children who met criteria for both below-average receptive and expressive vocabulary classifications. Children not meeting criteria on both linguistic domains, were classified as evidencing either typical receptive

Table 2.
The Number of Students Who Met Linguistic Classifications in the Control and Intervention Groups

	Control Group (n = 68)	Intervention Group (n = 211)
Below-Average Receptive Vocabulary	35 (51.5%)	101 (48.9%)
Below-Average Expressive Vocabulary	24 (35.3%)	84 (39.8%)
Below-Average Receptive/Expressive Vocabulary	19 (27.9%)	56 (26.5%)
Below-Average Listening Comprehension	18 (26.5%)	55 (26.1%)
Multiple Linguistic Classifications		
Primary Classification (Also Met Criteria For)**		
B-AEV (B-ARV)*	24 (19; 79.2%)	84 (56; 66.7%)
B-AREV (B-ARV)*	19 (19; 100%)	56 (56; 100%)
B-AREV (B-AEV)*	19 (19; 100%)	56 (56; 100%)
B-ALC (B-ARV)*	18 (13; 72.2%)	55 (47; 85.5%)
B-ALC (B-AEV)*	18 (10; 55.6%)	55 (41; 74.5%)
B-ALC (B-AREV)*	18 (9; 50.0%)	55 (36; 65.5%)

*Note: Below-Average Receptive Vocabulary (B-ARV); Typical Receptive Vocabulary (TRV); Below-Average Expressive Vocabulary (B-AEV); Typical Expressive Vocabulary (TEV); Below-Average Receptive/Expressive Vocabulary (B-AREV), Typical Receptive/Expressive Vocabulary (TREV); Below-Average Listening Comprehension (B-ALC); Typical Listening Comprehension (TLC)
**Note: The first reported number represents the number of students who met the primary linguistic classification, while the reported number in parentheses represents the number of students within this primary classification who also met criteria for an additional linguistic classification.

Table 3.
The Number of Students who Met Linguistic Classifications Reported Across Demographic Variables

	Demographic Variables	Control Group (n = 68)							
		B-ARV*	TRV*	B-AEV*	TEV*	B-AREV*	TREV*	B-ALC*	TLC*
Ethnicity	African American	18	15	12	19	11	20	9	24
	Caucasian	17	18	12	21	8	25	9	24
SES	Low	20	14	13	18	11	20	8	26
	Average	15	19	11	22	8	25	10	22
Gender	Female	15	12	11	14	8	17	7	19
	Male	20	21	13	26	11	28	11	29

	Demographic Variables	Intervention Group (n = 211)							
		B-ARV*	TRV*	B-AEV*	TEV*	B-AREV*	TREV*	B-ALC*	TLC*
Ethnicity	African American	66	33	50	51	41	57	34	65
	Caucasian	35	72	34	68	15	85	21	85
SES	Low	56	49	48	53	34	66	29	75
	Average	45	56	36	66	22	76	26	75
Gender	Female	42	36	37	40	23	51	21	56
	Male	59	69	47	79	33	91	34	94

*Note: Below-Average Receptive Vocabulary (B-ARV); Typical Receptive Vocabulary (TRV); Below-Average Expressive Vocabulary (B-AEV); Typical Expressive Vocabulary (TEV); Below-Average Receptive/Expressive Vocabulary (B-AREV), Typical Receptive/Expressive Vocabulary (TREV); Below-Average Listening Comprehension (B-ALC); Typical Listening Comprehension (TLC)

or expressive vocabulary skills (TREV). The final linguistic skill classification was made based on listening comprehension skills assessed by the Listening Comprehension subtest of the Wechsler Individual Achievement Test (WIAT; Wechsler, 1996). Again, those students evidencing a standard score 1 SD or greater below the mean were classified into a below-average listening comprehension (B-ALC) group, while students with standard scores above the 1 SD cutoff point were considered to evidence typical listening comprehension skills (TLC). The means and standard deviations of the three language measures for each linguistic classification can be seen in Table 4.

Materials

Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 1990). The K-BIT is composed of two sections measuring verbal (vocabulary) and nonverbal (matrices) abilities and can be administered to individuals ranging in age from 4 through 90. Split-half reliability coefficients for the Vocabulary subtest have been shown to be high, ranging from .89 to .98 (mean = .92; Kaufman & Kaufman, 1990). Matrices split-half coefficients ranged from .74 to .95. Test-retest reliability for the Vocabulary subtest ranged from .86 to .97 (mean = .94) and test-retest reliability values for the Matrices subtest ranged from .80 to .92 (mean = .85).

Wide Range Achievement Test-3 (WRAT-3; Wilkinson, 1993). The WRAT-3 includes three subtests that measure reading, spelling, and arithmetic skills. For the purpose of this study, only the Reading subtest was used. The Reading subtest assesses single word decoding skills. Participants are presented with a list of 42 words that increase in difficulty. Internal consistency using coefficient alpha for the reading subtest ranged from .90 to .95 (Wilkinson, 1993). Test-retest reliability ranged from .91 to .98.

Table 4.
Performance on Language Measures for the Below-Average and Typical Linguistic Classification Groups

		Control Group			
	Linguistic Classification	n	PPVT	WISC Vocabulary*	WIAT Listening Comprehension
Receptive Vocabulary	B-ARV*	35	69.49 (11.34)	7.21 (2.53)	88.17 (11.78)
	TRV*	33	97.18 (9.83)	9.45 (2.47)	99.10 (13.00)
Expressive Vocabulary	B-AEV*	24	72.08 (14.13)	5.83 (1.34)	85.23 (9.26)
	TEV*	40	88.83 (15.26)	9.78 (2.24)	96.53 (13.12)
Receptive/Expressive Vocabulary	B-AREV*	18	67.32 (11.70)	5.63 (1.42)	84.68 (9.74)
	TREV*	48	88.98 (14.42)	9.42 (2.34)	95.98 (12.85)
Listening Comprehension	B-LC*	19	73.72 (17.30)	7.11 (2.03)	78.22 (5.83)
	TLC*	45	86.21 (16.84)	8.89 (2.85)	98.96 (10.86)

		Intervention Group			
	Linguistic Classification	n	PPVT	WISC Vocabulary**	WIAT Listening Comprehension
Receptive Vocabulary	B-ARV*	101	71.92 (10.71)	6.89 (2.35)	85.46 (9.50)
	TRV*	105	99.84 (9.91)	9.49 (2.89)	102.01 (12.99)
Expressive Vocabulary	B-AEV*	84	77.58 (15.36)	5.45 (1.37)	86.24 (10.83)
	TEV*	119	91. 85 (16.20)	10.16 (2.04)	98.87 (13.43)
Receptive/Expressive Vocabulary	B-AREV*	56	69.70 (10.69)	5.23 (1.33)	82.65 (8.94)
	TREV*	142	92.45 (15.06)	9.41 (2.54)	97.86 (13.21)
Listening Comprehension	B-LC*	55	71.87 (13.90)	6.00 (2.00)	78.18 (5.73)
	TLC*	150	91.62 (15.67)	8.97 (2.83)	99.12 (11.29)

**Note: Below-Average Receptive Vocabulary (B-ARV); Typical Receptive Vocabulary (TRV); Below-Average Expressive Vocabulary (B-AEV); Typical Expressive Vocabulary (TEV); Below-Average Receptive/Expressive Vocabulary (B-AREV), Typical Receptive/Expressive Vocabulary (TREV); Below-Average Listening Comprehension (B-ALC); Typical Listening Comprehension (TLC)

*Note: Reported scores for the WISC Vocabulary subtest are scaled scores. All other reported scores are standard scores.

The Comprehensive Test of Reading Related Phonological Processes (CTRRPP; Torgeson & Wagner, 1996). Experimental versions of two subtests of the CTRRPP were used to assess reading accuracy; the Word Reading Efficiency subtest (WRE). The WRE subtest is a word identification measure that contains two lists (A & B) of 104 words increasing in difficulty. Word reading efficiency is scored as the mean number of words read on both lists in 45 seconds.

Woodcock Reading Mastery Test-Revised (WRMT-R; Woodcock, 1987). Two subtests of the WRMT-R were used in the data analyses, the Word Identification and Passage Comprehension subtests. The Word Identification subtest is a measure of single word decoding skills. The passage comprehension subtest requires participants to read a segment of prose with a missing word and provide an appropriate substitution for the missing word. Internal consistency reliability coefficients of the WRMT-R obtained by split-half reliability for first grade through third grade ranged from .91 to .98 (M = .94) (Woodcock, 1987).

Knowledge of Grapheme/Phoneme Correspondences; Sound Symbol Identification (SSI; Lovett et al., 1994). The SSI test is composed of four subtests; Letter Sound Identification, Sound Combination Identification, Onset Identification, and Rime Identification. All four subtests present the child with letters or letter combinations one at a time on small cards similar to playing cards. The task is to report the sound represented by the letter or letter combinations. The Letter Sound Identification task is composed of individual letters and the Sound Combinations task is composed of frequent English orthographic patterns. The Onset Identification task presents pairs of orthographic patterns that frequently are together at the beginning of English words. The final subtest, the Rime Identification task, is composed of orthographic patterns often found at the end of English words.

Phonological Processing; The Comprehensive Test of Reading Related Phonological Processes (CTRRPP; Torgeson & Wagner, 1996). Experimental versions of three subtests of phonological processes in reading were used in the data analyses; Blending, Elision, and Nonword Repetition. The Blending subtest presents words in serial syllabic and phonological segments. The goal of the subtest is to combine the smaller parts to identify the whole word. The Elision subtest is a phoneme deletion task. A word is presented orally and the participant is asked to identify the new word that that is formed after a phoneme is deleted from the target word (e.g., "Say tiger without saying /g/."). The nonword repetition task presents a series of nonsense words from a audiocassette recorder. Participants are asked to repeat the word exactly as it was presented to them.

Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981). The PPVT-R is a standardized measure of receptive language skills. Each easel page of the PPVT-R contains four numbered pictures. Participants are required to choose the picture that best depicts a word orally presented by the test administrator. The test manual reports internal consistency coefficients that ranged from .67 to .88 (median = .80) for Form L and from .62 to .86 (median = .81) for Form M. Immediate re-test alternate form reliability coefficients ranged from .73 to .91 (median = .82) and delayed re-test alternate form reliability coefficient ranged from .52 to .90 (median = .78).

Wechsler Individual Achievement Test (WIAT; Wechsler, 1996). The Listening Comprehension subtest is composed of three sections. The first section, receptive vocabulary, requires participants to choose the picture that visually depicts an orally given word by the test administrator. Participants are presented with four pictures for each word. The second section, sentence comprehension again presents four pictures on each easel page. This section requires

participants to choose the picture that exactly matches an orally presented sentence. In the final section, expressive vocabulary, participants are presented with a single picture and an orally presented definition. Participants are required to speak the one word that matches both the picture and the oral definition. The three sections are combined to generate a composite score for the Listening Comprehension subtest. The WIAT manual reports a mean reliability coefficient for the Listening Comprehension subtest of .83 (range = .80 to .86) for ages 6 thru 17 years. The test-retest reliability reported mean for grades 1, 3, 5, 8, and 10 is .78 (range = .74 to .81)

Wechsler Intelligence Scale for Children-3rd Edition (WISC-III; Wechsler, 1991). The Vocabulary and Backwards Digit Span subtests of the WISC-III were used in the following analyses. The Vocabulary subtest is a measure of expressive vocabulary. Children are presented a word orally and are required to provide a verbal definition of the target word. Internal reliability coefficients for the Vocabulary subtest of the WISC-III range from .79 to .91 (mean = .87) for participants 6 to 16 years of age. Test-retest reliability statistics were computed on a sample utilizing six age groups: 6, 7, 10, 11, 14, and 15. Reliability coefficients ranged from .82 to .89 (mean = .89).

Intervention Programs. At the core of all created reading intervention conditions was the Phonological Analyses and Blending/Direct Instruction program (PHAB/DI; Lovett et al., 2000). The PHAB/DI instruction program involved a focus on direct instruction on blending and segmenting words. This instruction program was carried out in two phases. During the first phase of the program, children were taught the sounds of individual letters. In the second phase of the program, the children were taught to parse the individual phonemes of a word orally and

then blend the individual sounds together as they would normally be spoken in the speech stream.

Because reading is a complex, multicomponent process, it involves skills that extend beyond the domain of phonological processing. Intervention programs were created, therefore, that contained other reading related components. One intervention condition served as a comparison group and combined the phonological instruction base with a Classroom Survival Skills (CSS) program, PHAB/DI + CSS program. The CSS is an instructional component designed to improve study and organizational skills and incorporated instruction in the areas of: classroom etiquette, life skills, and organizational strategies.

Two of the three intervention conditions included additional, theoretically-based reading instruction components; PHAB/DI + Word Identification Strategy (WIST; Lovett et al., 2000) and PHAB/DI + Retrieval-rate, Accuracy, Vocabulary Elaboration, and Orthography (RAVE-O; Wolf, Miller, & Donnelly, 2000). The WIST intervention program incorporated a metacognitive component focused on teaching a list of key words to be used as a template for the identification of unfamiliar words. The RAVE-O instruction program was focused on the development of vocabulary and orthographic knowledge. Because all intervention programs incorporated a phonological instruction base and because intervention fidelity was not a primary interest to the current study, the three reading intervention groups were collapsed into one group for analyses.

Control Condition. A control condition was created to serve as a comparison group to the children who were enrolled in a reading intervention program. This condition combined a math instruction program with the CSS program. The Math Instruction program was composed of both direct instruction of mathematical concepts and metacogntive instruction of problem-

solving strategies. The metacognitive instruction aspect of the Math program was taught for both mathematic and word problems.

Design and Procedure

Referred children were given a recruitment packet to take home that contained a description of the study and a consent form. Children who returned a signed consent form were screened into the study. Psychologists or doctoral students who were trained extensively in test administration conducted testing. Participants were administered all measures in their schools, and were in the second or third grade in the years spanning 1996-2000. Because there was the potential for children in this study to demonstrate reading difficulties, children were asked to follow along as the individual conducting the assessment read instructions and choices to the children where appropriate.

If a child met the study criteria, he/she was randomly assigned to one of four conditions with the restriction that no factorial cell (based on the original 2 [socioeconomic status] X 2 [race] X 2 [IQ level] factorial design developed by the study's researchers) contained more than 5 students from any one of the three data collection sites.

The students assigned to a reading intervention received 70 hours of small group instruction (4 students per group) led by teachers trained in the implementation of one of the project's intervention programs. Students were taught for one hour each day in their home schools. Teachers were hired directly by the research project and were not affiliated with any of the schools that the participants attended. The students who were selected to serve as a control group completed 70 hours of instruction dictated by the MATH + CSS program.

Students were tested at various points throughout the school year. Measures were classified as either being core variables or treatment variables. Core variables (i.e., measures of

cognitive ability and measures of linguistic ability) did not have a theoretical justification for being influenced by exposure to a reading intervention program, and were therefore assessed at various points throughout the time spanning the 70-hour intervention period. Conversely, treatment variables (i.e., measures of phonological processing and reading achievement) were assessed at baseline, 35 hours of intervention, and 70 hours of intervention time points. For an outline indicating which measures were administered at each time point, see Table 5.

Results

Initial analyses involved a data screening process carried out to identify outliers, missing data, unusual data points, or atypical distributions that may influence results of statistical analyses. All statistical analyses were conducted using the Statistical Package for the Social Sciences 11.0 (SPSS). In order to examine the acquisition of phonological awareness skills in response to a reading intervention, the data were first analyzed using repeated measures ANCOVAs.

Because the measure assessing knowledge of grapheme/phoneme correspondences involved an orthographic component, it was decided that combining performance on this measure with performance on tasks that were purely auditory in nature could confound results and inappropriately influence interpretations. Performances on the Sound Symbol Identification task (SSI) and the CTRRPP, therefore, were analyzed separately. This decision to analyze the two types of tasks separately was validated further in the structural equation modeling (SEM) analyses reported later. These analyses indicated that the measures assessing knowledge of grapheme/phoneme correspondences loaded on both PA and word reading accuracy latent variables. These findings will be discussed in more detail in the section concerning the SEM analyses.

For all ANCOVA analyses examining the acquisition of grapheme/phoneme correspondence knowledge, a composite score of the four subtests comprising the SSI was created. Because the SSI subtests were composed of different numbers of items, a composite

Table 5.
Outline of Study Measures and Administration Time Point.

	Baseline	35 Hours of Instruction	70 Hours of Instruction	Single Administration Any Time During the Study
Core Variables				
K-BIT				X
PPVT				X
WIAT Listening Comprehension				X
WISC Vocabulary				X
WISC Digit Span				X
Treatment Variables				
WRAT Reading	X		X	
WRMT Word Identification	X		X	
WRMT Passage Comprehension	X		X	
CTRRP WRE	X		X	
CTRRP Blending	X	X	X	
CTRRP Elision	X	X	X	
Sound Symbol Task	X	X	X	

measure was created by first transforming raw scores into proportion of items correct. This ensured that all subtests were on the same scale and had equal influence when combined. The final composite score was computed by averaging the proportion correct across the four subtests. This final composite score was used as the dependent variable representing knowledge of grapheme/phoneme correspondences.

As with the SSI subtests, a composite measure of PP was created and utilized as a dependent variable by combining performances on the Blending and Elision subtests of the CTRRPP (Torgeson, & Wagner, 1999). As with the SSI task, each subtest was transformed into proportion correct and the final composite score was an average of the proportion correct for the two subtests.

ANCOVA Analyses Conducted with the Control Group

The same repeated measures ANCOVA analysis was conducted for each of the linguistic skill classification groups. A 2 (sex) X 2 (ethnicity) 2 (linguistic classification group) X 3 (time point) repeated measures ANCOVA was conducted with SES, nonverbal IQ, and age as covariates. Analyses were conducted with the composite scores created for the SSI and PP tasks as dependent variables. In instances where the assumption of sphericity was violated, Greenhouse-Geisser adjusted degrees of freedom are reported.

Because the same ANCOVA analysis was conducted for each linguistic skill classification, significant effects independent of linguistic variables were replicated across analyses. In order to facilitate a more parsimonious reporting of results, these replicated significant findings will be described once. Missing data and the composition of the different linguistic groups, however, can influence sum of squares calculations. The specific ANCOVA statistics associated with each linguistic classification, therefore, are reported in Table 6.

Main Effects and Interactions Found for All Linguistic Classifications. No significant main effects or interactions were found that were common to all ANCOVA analyses conducted with the SSI task as a dependent variable. Analyses using PP composite scores as a dependent variable revealed a significant main effect for time point. Tukey post hoc analyses indicated that all three time points differed significantly from each other ($p < .05$). No other significant main effects were found that were common to all linguistic classifications.

One significant interaction was found between ethnicity and time point for analyses conducted with the receptive vocabulary group classifications. Caucasian students acquired PP skills at a significantly faster rate than African American students (see Figure 1). This interaction approached the $p < .05$ level of significance for analyses conducted with the expressive and receptive/expressive vocabulary group classifications, however, for analyses conducted with the listening comprehension group classifications, this interaction effect was well above accepted levels of significance (i.e., $p = .23$; see Table 6).

Receptive Vocabulary Groups. For the SSI task, analyses revealed a significant main effect of receptive vocabulary group, $F(1, 55) = 5.02$, $p = .029$, $\eta^2 = .08$. The B-ARV performed significantly worse on the SSI task than the TRV group (see Figure 2).

In addition, analyses revealed a significant receptive vocabulary group by time point interaction, $F(2, 110) = 3.43$, $p = .036$, $\eta^2 = .06$. The TRV group performance on the SSI task increased at a faster rate than the B-ARV group (see Figure 3). Tukey post hoc analyses indicated that the performance of B-ARV group was significantly lower ($p < .05$) than the performance of the TRV group at all time points.

Figure 1. Ethnicity by Time Point Interaction in the Control Group for Receptive Vocabulary Classifications

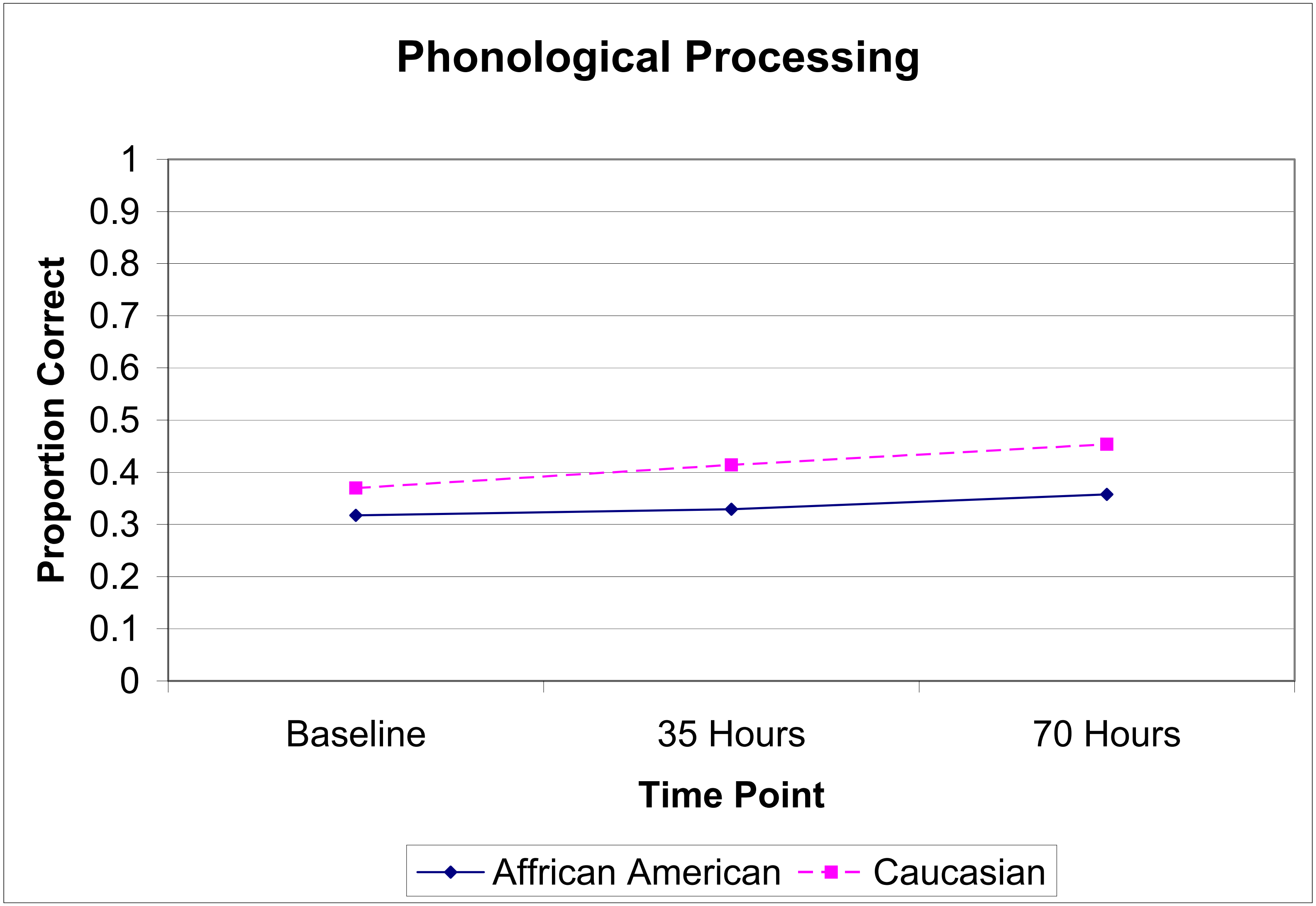
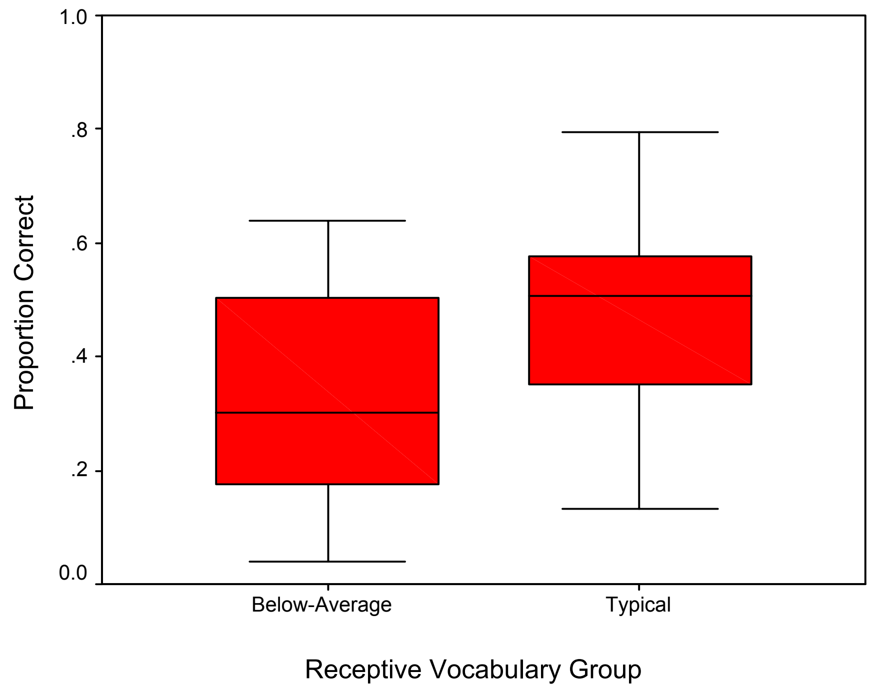


Table 6.
Main Effects and Interaction Effects Common to all Linguistic Classifications for PP Skills Conducted with the Control Group.

Main Effect of Time Point				
Linguistic Classification	**Df**	**F Value**	**Significance Level**	η^2
Receptive Vocabulary	2, 112	5.58	p = .005	.09
Expressive Vocabulary	1.79, 92.85	6.83	p = .002	.12
Receptive/Expressive Vocabulary	2, 104	6.62	p = .002	.11
Listening Comprehension	2, 104	6.39	p = .002	.11
Ethnicity by Time Point Interaction				
Linguistic Classification	**Df**	**F Value**	**Significance Level**	η^2
Receptive Vocabulary	2, 112	3.39	p = .037	.06
Expressive Vocabulary	1.79, 92.85	2.95	p = .063	.05
Receptive/Expressive Vocabulary	2, 104	2.67	p = .073	.05
Listening Comprehension	2, 104	1.503	p = .227	.03

Figure 2. Boxplots for Receptive Vocabulary Groups in the Control Group

Sound Symbol Identification Task



Phonological Processing

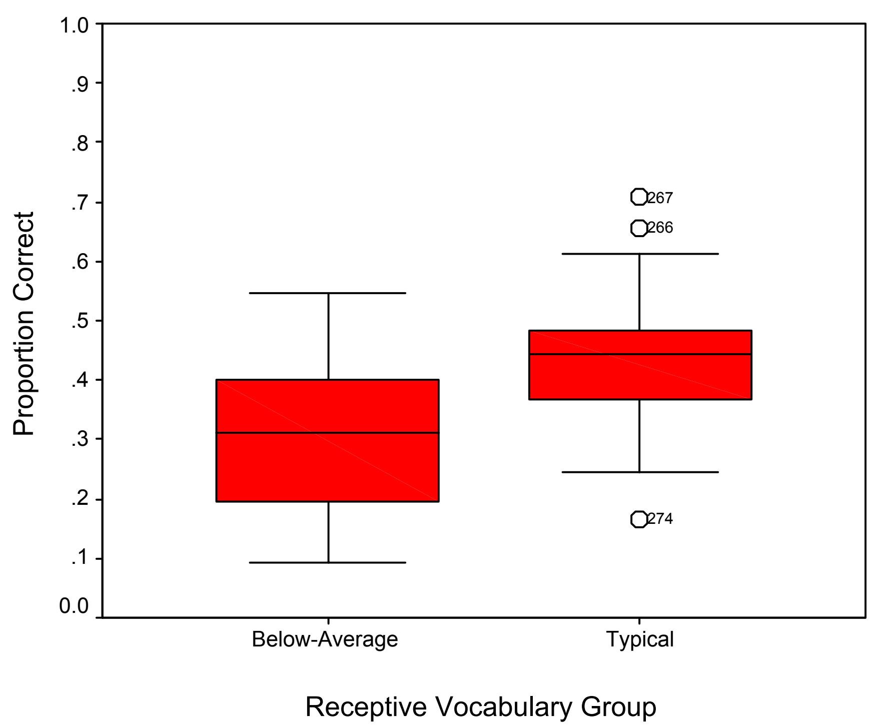
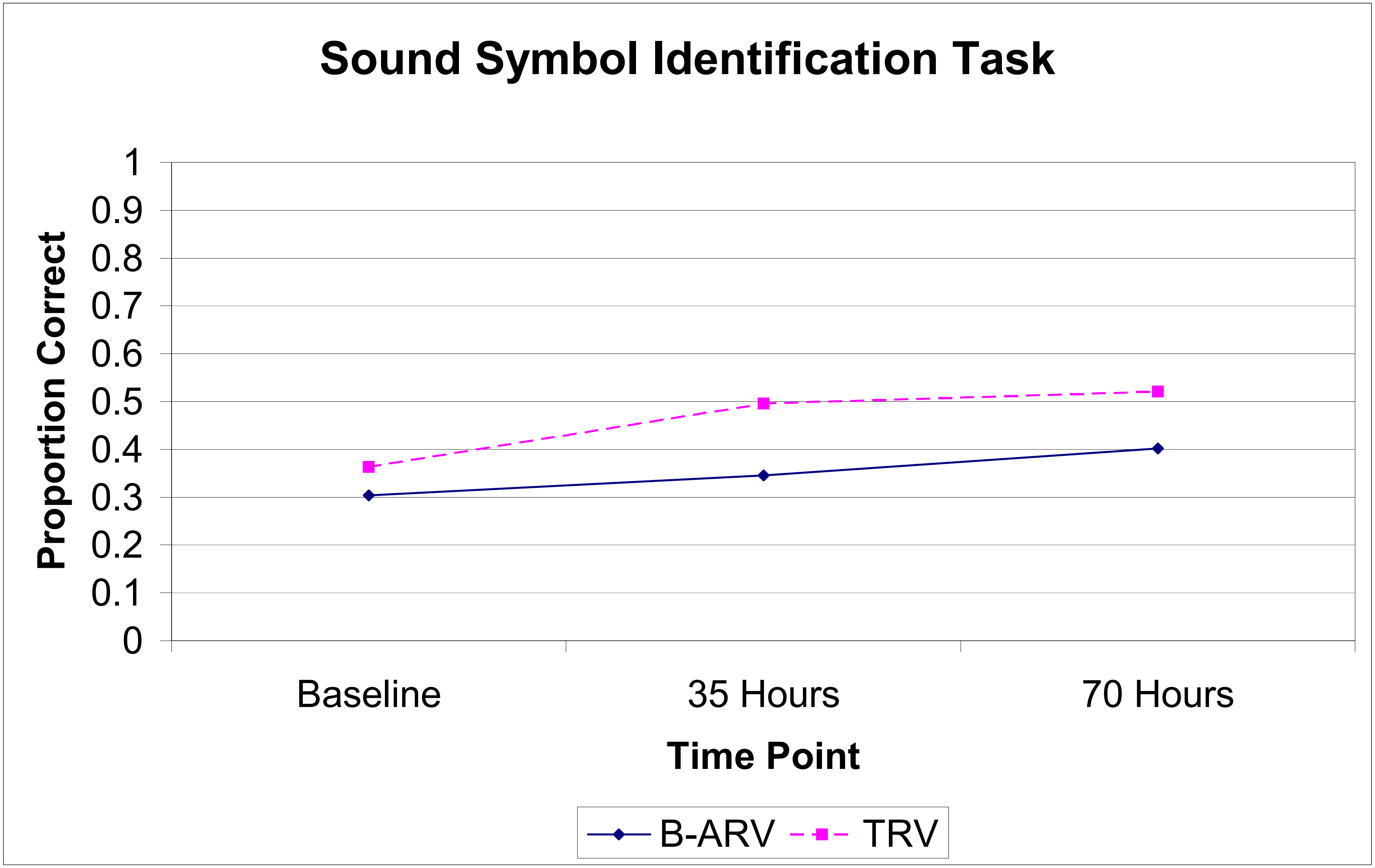


Figure 3. Receptive Vocabulary Group by Time Point Interaction in the Control Group



For PP skills, a main effect was found for receptive vocabulary group, $F(1, 56) = 10.03$, $p = .002$, $\eta^2 = .15$. The B-ARV group evidenced significantly lower PP skills than the TRV group (see Figure 2). A second significant main effect was found for ethnicity, $F(1, 56) = 6.62$, $p = .013$, $\eta^2 = .11$. Caucasians evidenced significantly higher PP skills ($M = .34$, $SD = .12$) than African Americans ($M = .41$, $SD = .14$). No significant interactions were found for PP skills.

Expressive Vocabulary Groups. No significant main effects were found for the SSI task. A significant interaction between sex and ethnicity was found, $F(1, 51) = 4.03$, $p = .05$, $\eta^2 = .07$. Scores for male and female Caucasian students were essentially equal, while scores for African American females were higher than those for African American males (see Figure 4).

A significant main effect for ethnicity was found for PP skills, $F(1, 52) = 4.80$, $p = .033$, $\eta^2 = .08$. Caucasians ($M = .41$, $SD = .14$) evidenced significantly higher PP scores than African Americans ($M = .33$, $SD = .12$). No significant interactions were found for PP skills.

Receptive and Expressive Vocabulary Groups. A significant main effect for vocabulary group was found for the SSI task, $F(1, 51) = 5.69$, $p = .021$, $\eta^2 = .10$. The students who met below-average criteria for both receptive and expressive vocabulary skills demonstrated significantly lower SSI scores than the group evidencing typical receptive and expressive vocabulary skills (see Figure 5).

When PP skills were used as a dependent variable, a main effect was found for vocabulary group, $F(1, 52) = 5.00$, $p = .03$, $\eta^2 = .09$. The B-AREV group demonstrated significantly worse PP skills than the TREV group (see Figure 5). For both SSI and PP dependent variables, no significant interactions were detected.

Figure 4. Sex by Ethnicity Interaction in the Control Group for Expressive Vocabulary Classifications

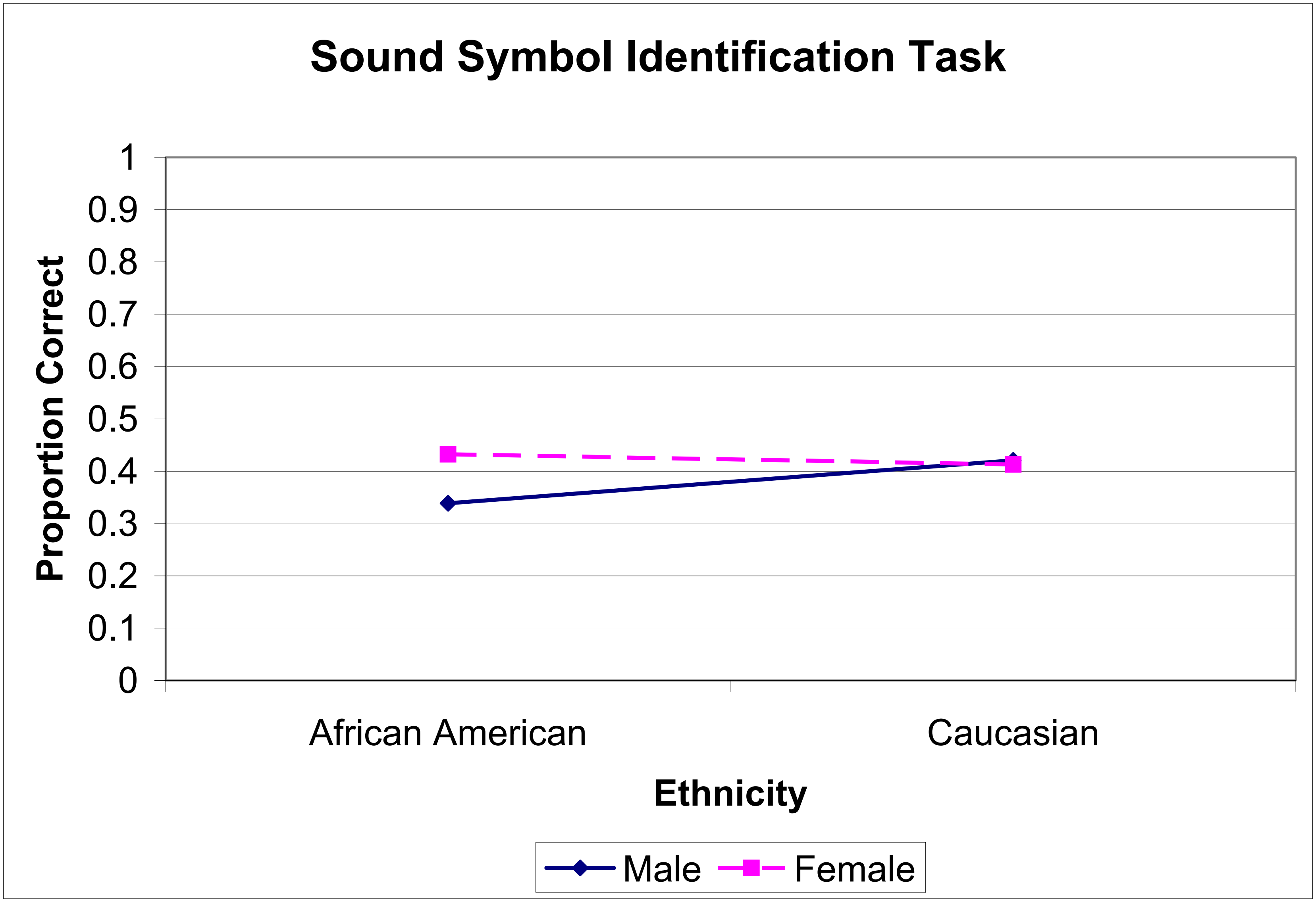
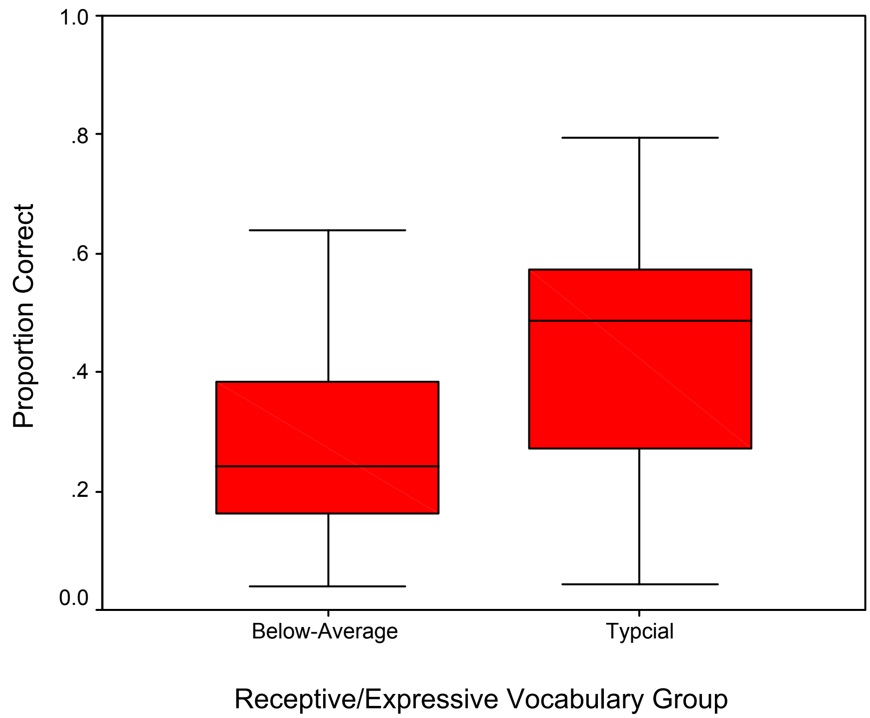
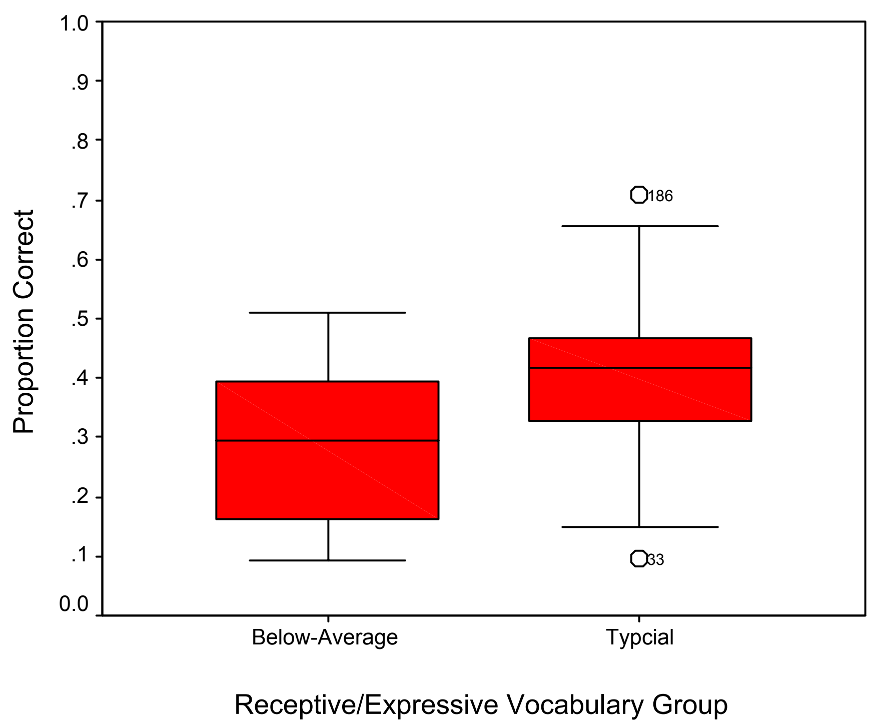


Figure 5. Boxplots for Receptive/Expressive Vocabulary Groups in the Control Group

Sound Symbol Identification Task



Phonological Processing



Listening Comprehension Groups. For the SSI task, a significant main effect of listening comprehension group was found, F 9 (1, 53) = 5.12, p = .028, η^2 = .09. The B-ALC group performed significantly worse on the SSI task than the TLC group (see Figure 6). Analyses also revealed a significant ethnicity by listening comprehension group interaction, F (1, 53) = 6.78, p = .012, η^2 = .11. For African Americans, there was little difference in scores between the B-ALC and TLC groups. For Caucasians, however, the TLC significantly (as assessed by a Tukey post test, p < .05) outperformed the B-ALC group (see Figure 7).

For PP skills, a significant main effect was found for listening comprehension group, F (1, 54) = 6.09, p = .017, η^2 = .10. The B-ALC group evidenced significantly lower PP skills than the TLC group (see Figure 6). No significant interactions were found.

ANCOVA Analyses Conducted with the First Year Intervention Group

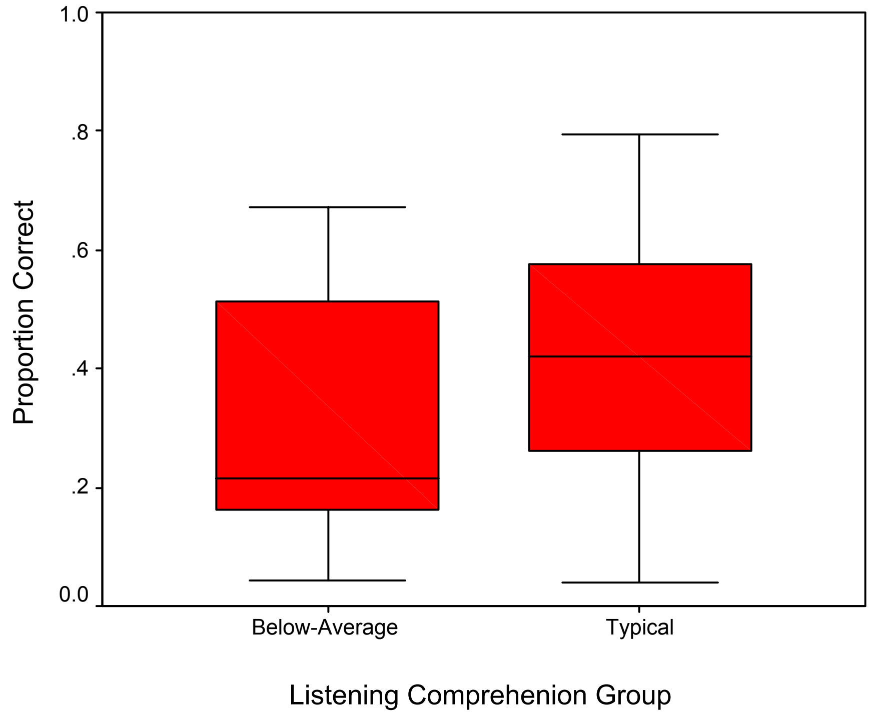
For the students who were enrolled in a reading intervention group, a 2 (sex) X 2 (linguistic group) X 3 (time point) repeated measures ANCOVA was conducted for each of the dependent variables representing knowledge of grapheme/phoneme correspondences and PP skills. The variables of ethnicity, nonverbal IQ, SES, and age were entered as covariates for all analyses. For instances where the assumption of sphericity was violated, Greenhouse-Geisser adjusted degrees of freedom are reported.

As with the analyses conducted with the control group, duplicated results across linguistic classification will be described once and the specific statistics associated with each significant effect are reported in Tables 7 and 8.

Main Effects and Interactions Found for All Linguistic Classifications. Analyses conducted with the SSI task as the dependent variable revealed a significant main effect of time point. A Tukey post hoc test indicated that knowledge of grapheme/phoneme correspondences

Figure 6. Boxplots for Listening Comprehension Groups in the Control Group

Sound Symbol Identification Task



Phonological Processing

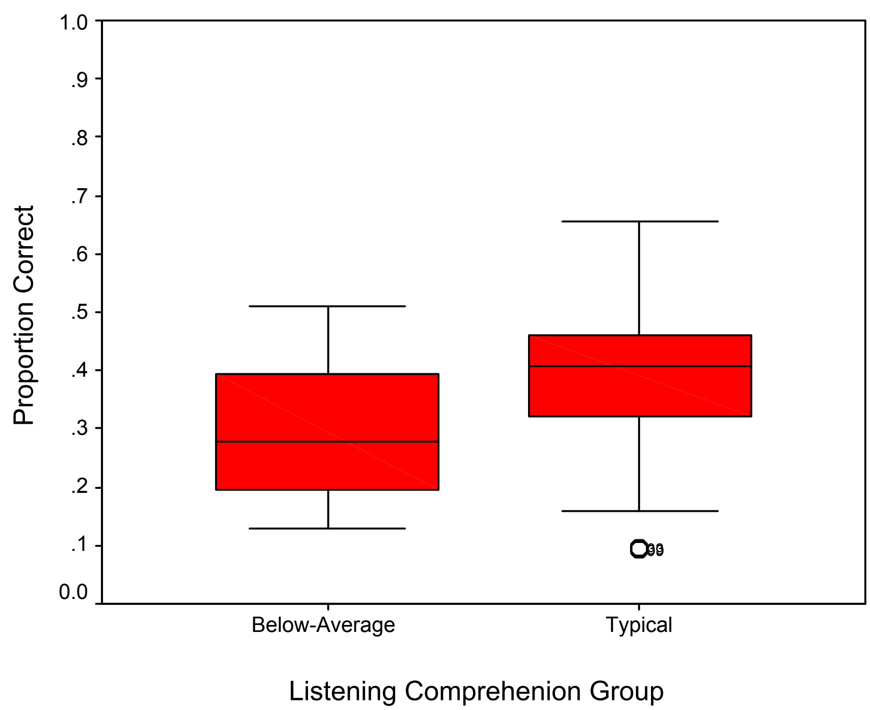


Figure 7. Ethnicity by Listening Comprehension Group Interaction in the Control Group

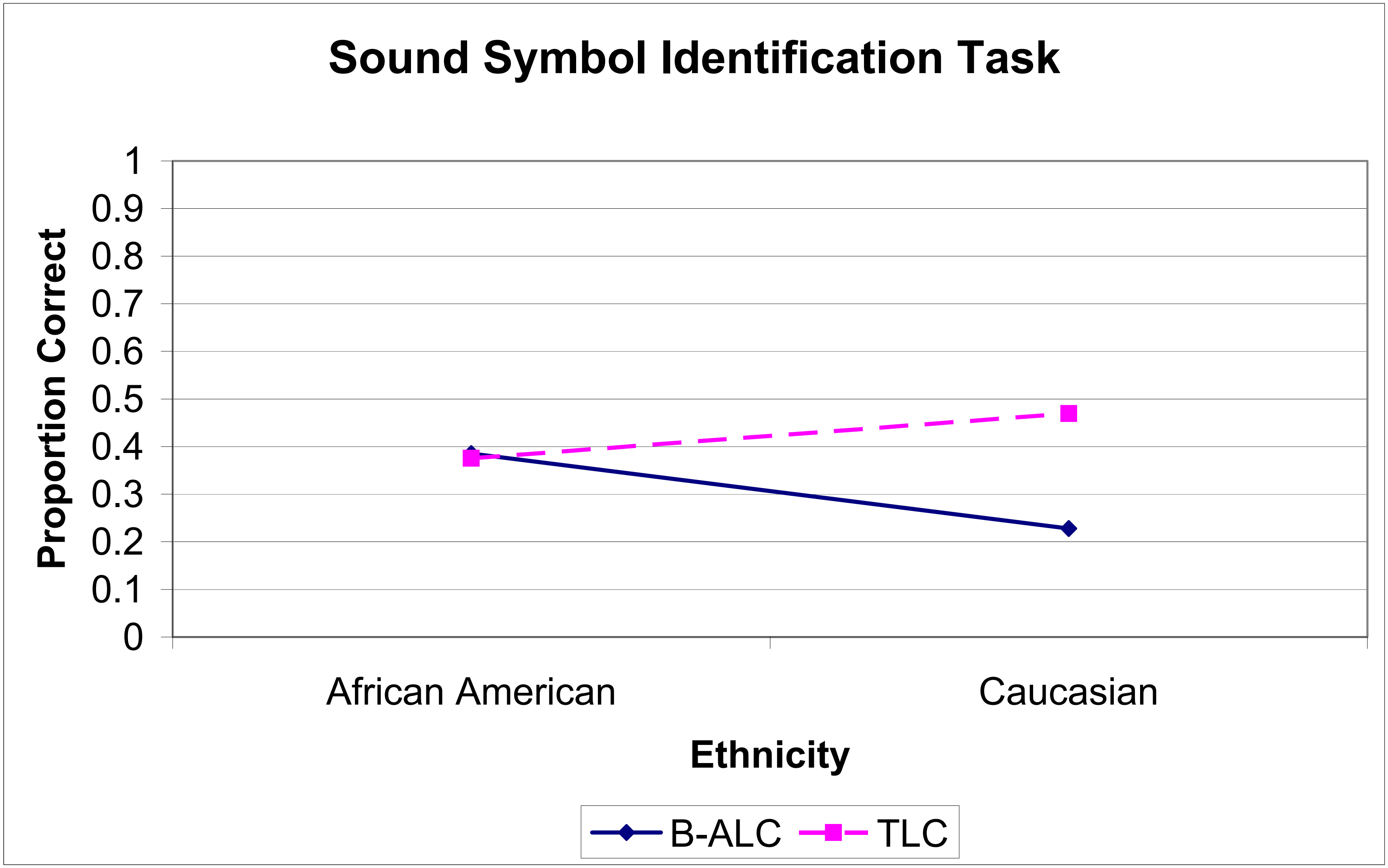


Table 7.
Main Effects Common to all Linguistic Classifications for the SSI task Conducted with the Reading Intervention Group.

Main Effect of Time Point				
Linguistic Classification	**df**	**F Value**	**Significance Level**	η^2
Receptive Vocabulary	1.78, 340.78	14.23	$p < .001$	.07
Expressive Vocabulary	1.78, 336.07	11.48	$p < .001$	.06
Receptive/Expressive Vocabulary	1.78, 327.35	11.18	$p < .001$	.06
Listening Comprehension	1.77, 337.67	14.28	$p < .001$	.07
Main Effect of Ethnicity				
Linguistic Classification	**df**	**F Value**	**Significance Level**	η^2
Receptive Vocabulary	1, 192	3.98	$p = .048$	.02
Expressive Vocabulary	1, 189	4.50	$p =.035$	.02
Receptive/Expressive Vocabulary	1, 184	1.73	$p = .190$	.01
Listening Comprehension	1, 191	8.01	$p = .005$	.04

Table 8.
Main Effects Common to all Linguistic Classifications for PP Skills Conducted with the Reading Intervention Group.

Main Effect of Time Point				
Linguistic Classification	**df**	**F Value**	**Significance Level**	**η^2**
Receptive Vocabulary	1.70, 322.85	10.97	$p < .001$	.06
Expressive Vocabulary	1.70, 318.52	10.34	$p < .001$	.05
Receptive/Expressive Vocabulary	1.70, 309.02	10.01	$p < .001$	.05
Listening Comprehension	1.70, 322.82	11.42	$p < .001$	.06
Main Effect of Ethnicity				
Linguistic Classification	**df**	**F Value**	**Significance Level**	**η^2**
Receptive Vocabulary	1, 190	10.39	$p = .001$	.05
Expressive Vocabulary	1, 187	15.35	$p < .001$	.08
Receptive/Expressive Vocabulary	1, 182	5.17	$p = .024$	.03
Listening Comprehension	1, 190	14.42	$p < .001$	.07

increased significantly across each time point ($p < .05$); however, the greatest increase in scores was seen between the baseline and 35 hours of instruction intervention time points. In addition, a significant main effect of ethnicity was found for all analyses except the analyses conducted with the receptive/expressive linguistic classifications. Caucasians ($M = .42$, $SD = .21$) demonstrated better knowledge of grapheme/phoneme correspondences than African Americans ($M = .37$, $SD = .18$). Analysis did not reveal any significant interactions.

For the dependent variable of PP skills, a significant main effect of time was revealed. Tukey post hoc analyses indicated that all time points differed significantly ($p < .05$) from each other, however, the greatest gains in PP skills were seen between the baseline and 35 hours of instruction time points. A significant main effect of ethnicity indicated Caucasians ($M = .41$, $SD = .14$) evidenced significantly higher PP scores than African Americans ($M = .34$, $SD = .12$). No significant interactions were revealed.

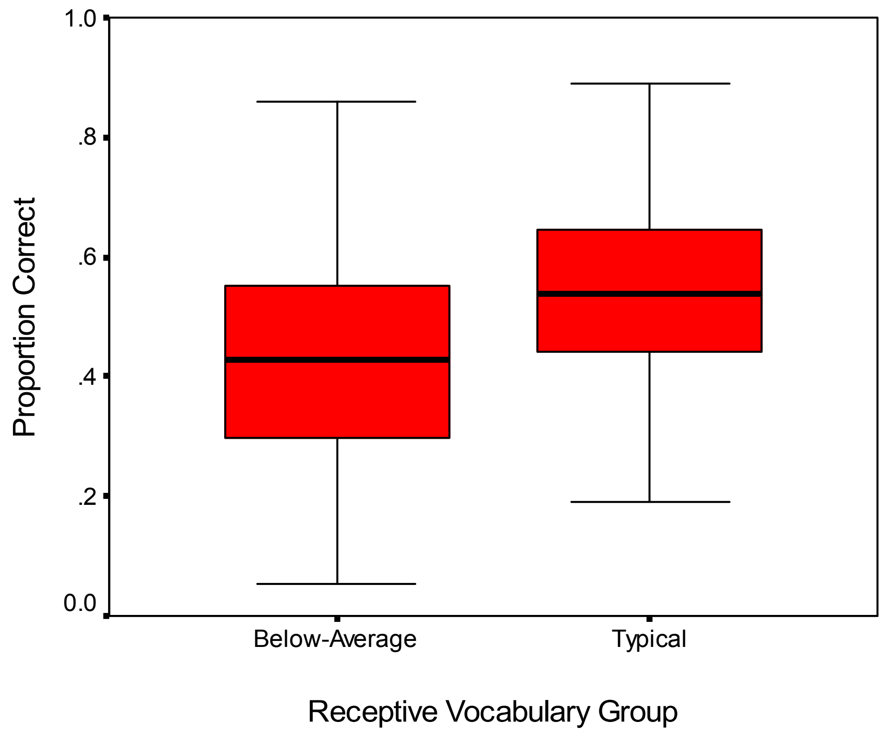
Receptive Vocabulary Groups. For the SSI task, a significant main effect was found for receptive vocabulary group, $F(1, 192)$, $= 5.24$, $p = .023$, $\eta^2 = .03$. The B-ARV group demonstrated significantly lower performance on the SSI test than the TRV group (see Figure 8).

A significant main effect also was found for receptive vocabulary group for PP skills, $F(1, 190) = 12.45$, $p = .001$, $\eta^2 = .06$. The B-ARV group evidenced significantly lower PP skills than the TRV group (see Figure 8). No significant interactions were found for the SSI task of PP skills.

Expressive Vocabulary Groups. A significant main effect was revealed for expressive vocabulary group, $F(1, 189) = 24.92$, $p < .001$, $\eta^2 = .12$. The students classified as B-AEV demonstrated significantly worse performance on the SSI task than students classified as TEV (see, Figure 9). The interaction between the variables of sex and ethnicity approached the level

Figure 8. Boxplots for Receptive Vocabulary Groups in the Intervention Group

Sound Symbol Identification Task



Phonological Processing

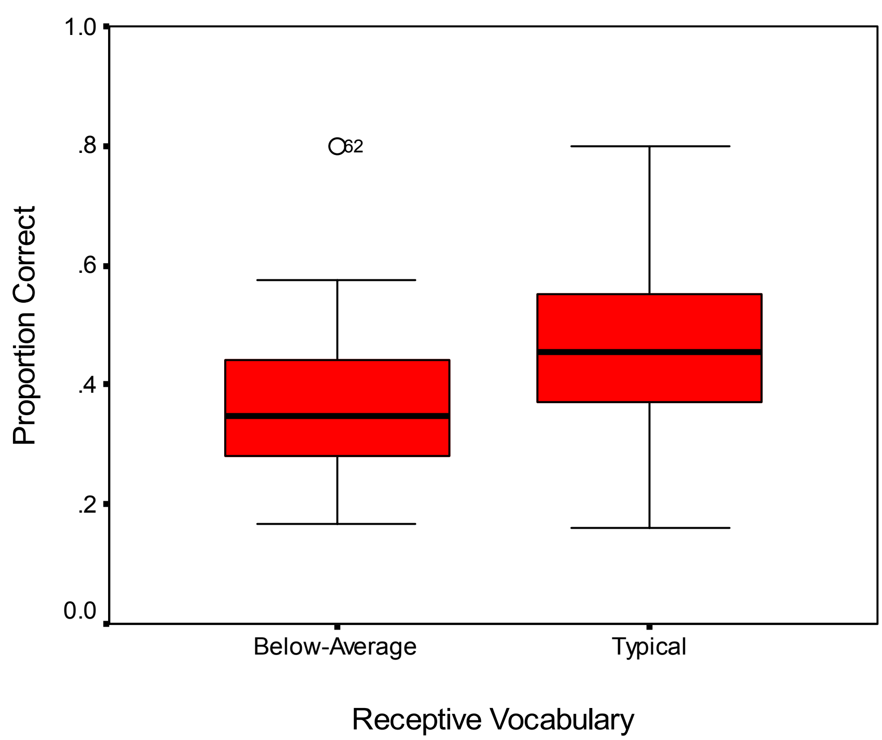
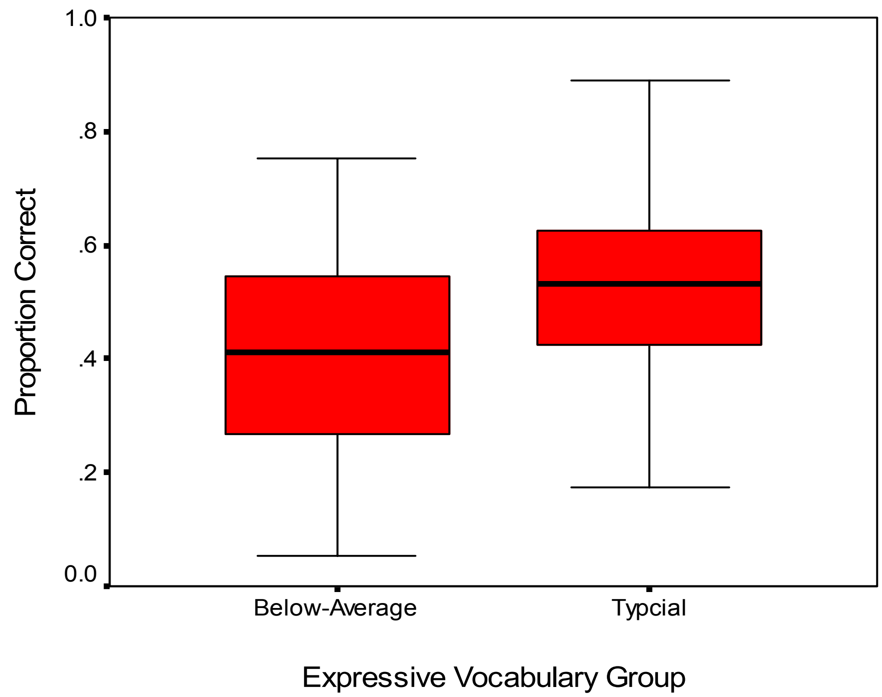
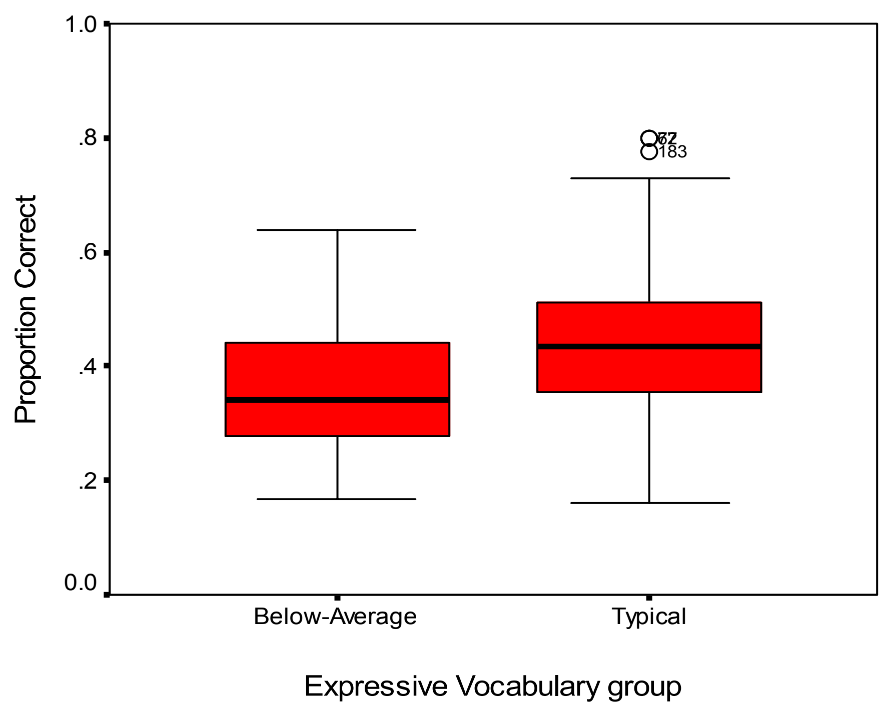


Figure 9. Boxplots for Expressive Vocabulary Groups in the Intervention Group

Sound Symbol Identification Task



Phonological Processing



of significance of $p < .05$, $F (1, 189)$, = 3.84, $p = .052$, $\eta^2 = .02$. For Caucasians, there was little difference in performance between males and females; however, for African Americans, females evidenced higher scores than males (see Figure 10).

When PP skills were analyzed as the dependent variable, a significant main effect was revealed for expressive vocabulary group, $F (1, 184) = 17.06$, $p < .001$, $\eta^2 = .09$. The B-AEV group possessed significantly lower PP skills than the TEV group (see Figure 9). For both dependent variables, no significant interactions were evidenced.

Receptive and Expressive Vocabulary Groups. For the SSI task, a significant main effect of receptive/expressive group was revealed, $F (1, 184) = 18.27$, $p < .001$, $\eta^2 = .09$. The students classified as the B-AREV group, performed significantly worse on the SSI task than the students classified as the TREV group (see Figure 11).

A significant interaction was evidenced between receptive/expressive vocabulary group and time point, $F (1.78, 327.35) = 3.67$, $p = .031$, $\eta^2 = .02$. This interaction indicated that the B-AREV group's performance on the knowledge of grapheme/phoneme correspondences was lower at the baseline time point and increased at a slower rate than the TREV group (see Figure 12). An additional significant interaction between sex and ethnicity was found, $F (1, 184) = 4.15$, $p = .043$, $\eta^2 = .02$ (see Figure 10). For Caucasians, there was little difference in performance between males and females; however, for African Americans, females evidenced higher scores than males.

A significant main effect of receptive/expressive vocabulary group was evidenced for PP skills, $F (1, 182) = 17.41$, $p < .001$, $\eta^2 = .09$. Those students in the B-AREV group demonstrated

Figure 10. Sex by Ethnicity Interaction in the in the Intervention Group for Expressive Vocabulary Classifications

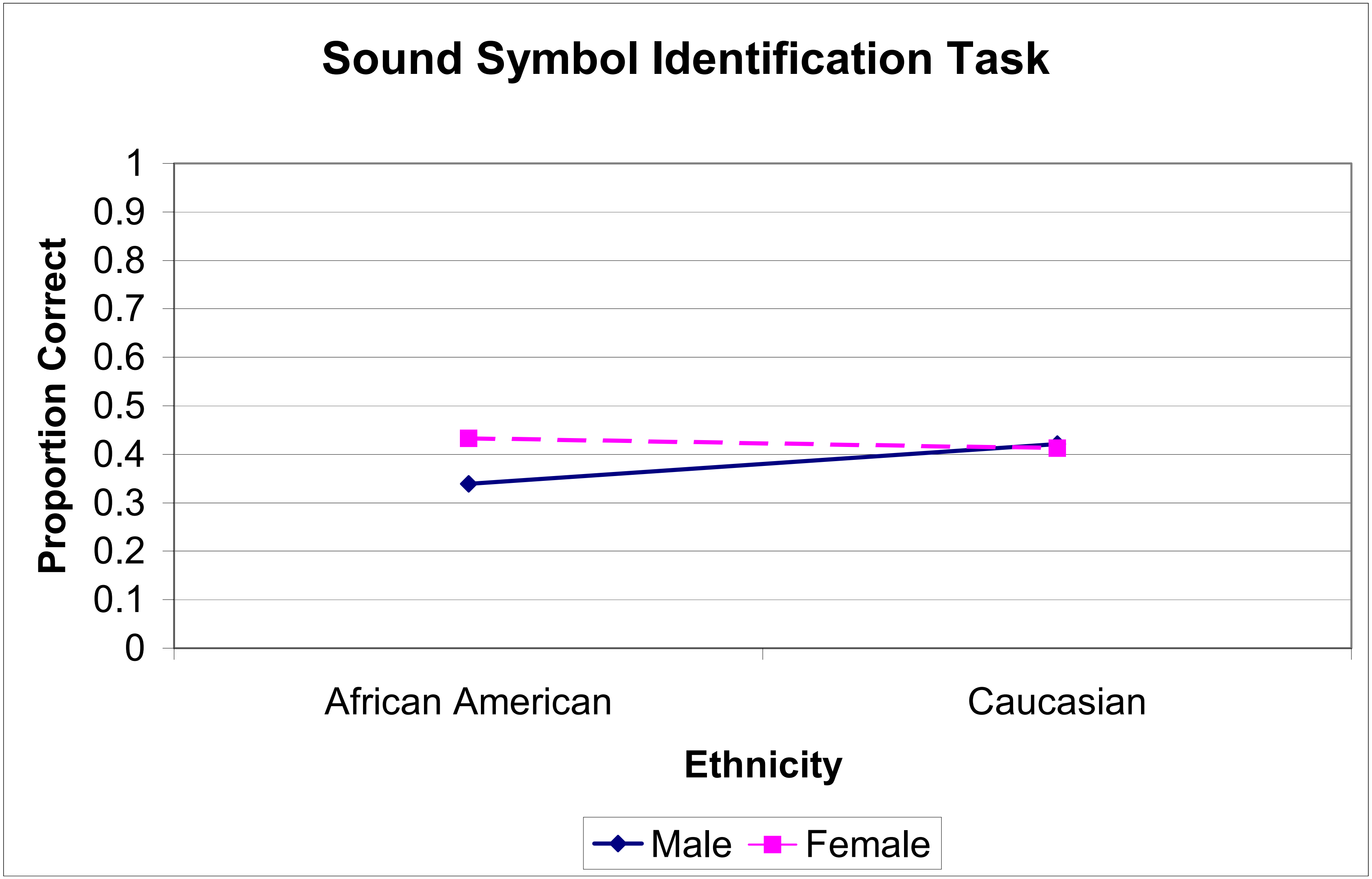
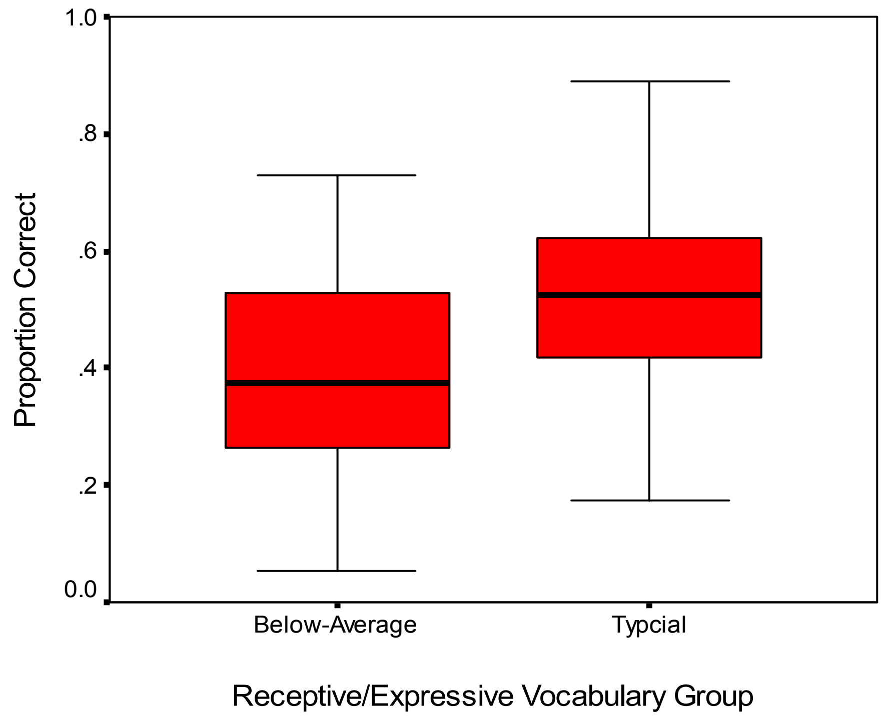


Figure 11. Boxplots for Receptive/Expressive Vocabulary Groups in the Intervention Group

Sound Symbol Identification Task



Phonological Processing

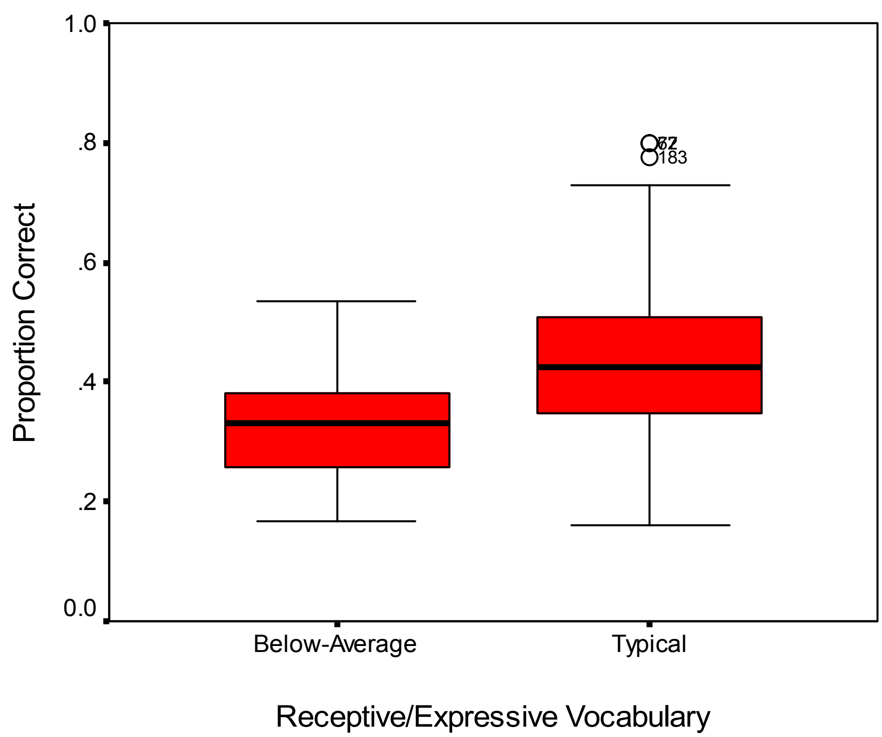
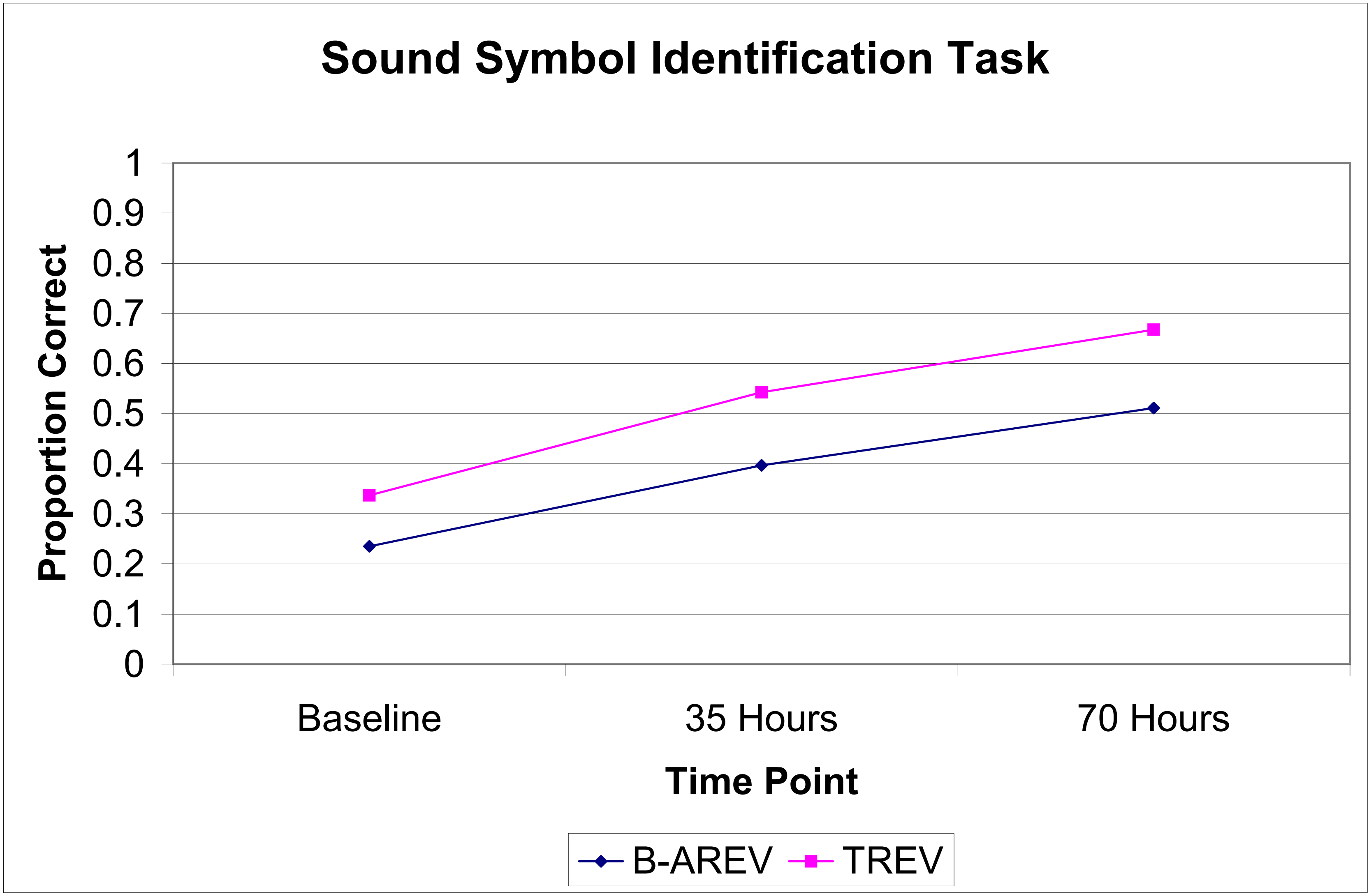


Figure 12. Receptive/Expressive Vocabulary Group by Time Point Interaction in the Intervention Group



significantly lower PP skills than those students in the TREV group (see Figure 11). No significant interactions were revealed for PP skills.

Listening Comprehension Groups. Utilizing the SSI task as a dependent variable, a significant main effect was found for listening comprehension group, F (1, 191) = 8.06, p = .005 η^2 = .04. The B-ALC group performed significantly worse on the SSI task than those students in the TLC group (see Figure 13). No other significant main effects or interactions were found.

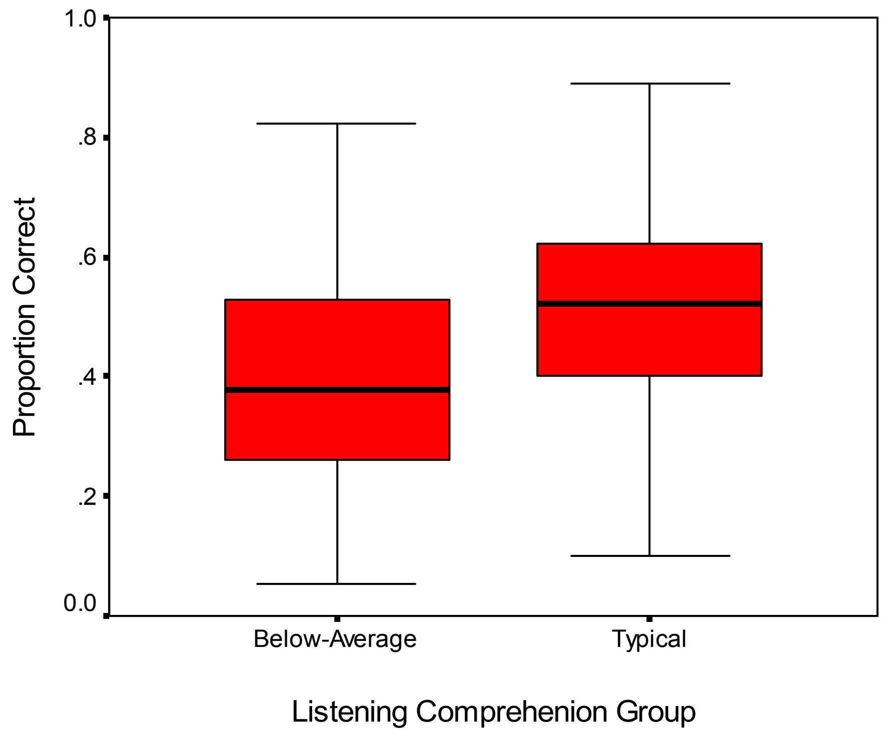
For PP skills, a significant main effect of listening comprehension group was revealed, F (1, 190) = 7.65, p = .006, η^2 = .04. Students in the B-ALC group evidenced significantly lower PP skills than those students in the TLC group (see Figure 13). No significant interactions were evidenced.

ANCOVA Analyses Conducted with Alternative Linguistic Classifications

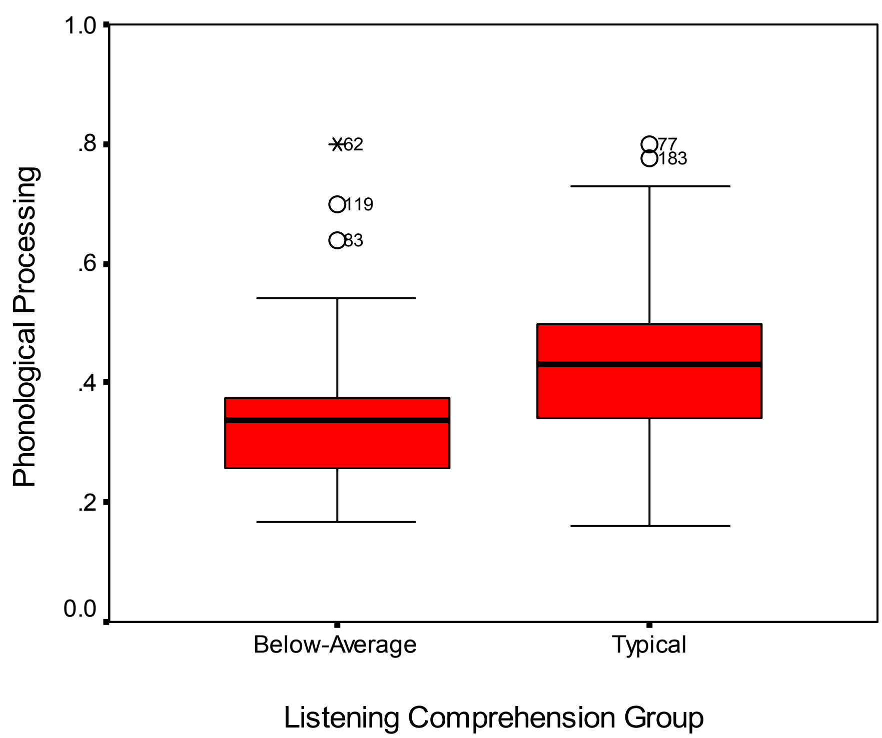
Linguistic Classifications Based on an IQ-Discrepancy Criterion. Because debate exists concerning the role of IQ in the classification of children with learning disabilities, it was of interest to conduct preliminary analyses in which linguistic classifications were made using an IQ-discrepancy definition (i.e., linguistic performance 1 SD or greater below nonverbal IQ performance). Only receptive vocabulary and listening comprehension classifications could be made because standard scores were not available for the expressive vocabulary measure. Using this classification system with the first year intervention students, 71 students met receptive vocabulary IQ-discrepant criteria. Within in this group, 86% also met the below-average criteria used in the previous analyses. In addition, 28 students met listening comprehension IQ-discrepant criteria. As with the receptive vocabulary group, 86% of the students who met listening comprehension IQ-discrepant criteria also met the below-average criteria.

Figure 13. Boxplots for Listening Comprehension Groups in the Intervention Group

Sound Symbol Identification Task



Phonological Processing



For both SSI and PP dependent variables, ANCOVA analyses did not indicate that the receptive vocabulary IQ-discrepant group differed significantly from the typical receptive vocabulary group ($p > .05$). Additionally, no significant differences were found between the listening comprehension IQ-discrepancy group and the typical listening comprehension group. Based on these null results, no further analyses using IQ-discrepant criteria were conducted.

Linguistic Classifications Based on SLI Criteria. In addition, alternative analyses were conducted that classified children into below-average language groups according to SLI criteria reported by Catts et al. (2002). According to these criteria a child must score below 85 on standardized measures of linguistic ability while also scoring equal to or greater than 85 on standardized measures of nonverbal IQ. Seventy-five students met criteria for B-ARV, while 135 students exhibited scores within the typical range. The pattern of ANCOVA analyses did not differ from those conducted with language classifications made with low achievement criteria. Therefore, further analyses with language classifications made using the criteria reported by Catts et al. (2002) were not carried out. The decision, instead, was to focus analyses on the group of children meeting a below-average classification in order to maintain a larger, more diverse sample of children evidencing linguistic difficulties.

Linguistic Classifications Based on Extreme Scores. The final alternative analyses were conducted in which more extreme below-average linguistic classifications were made (i.e., 1.5 SD greater below the mean on the Peabody Picture Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, 1981). Using these classification criteria resulted in a reduction of the B-ARV group by 39%. Similar decreases were seen in the B-AEV, B-AREV, and B-ALC groups. Again, the pattern of ANCOVA results based on these classifications did not differ from the pattern of results seen in the analyses using a 1 SD below the mean cutoff to classify children into low

linguistic ability groups. Measures of effect size, however, evidenced an increase. Additional analyses with these more extreme linguistic classifications, therefore, were not pursued.

Hierarchical Linear Modeling

In addition to ANCOVA analyses, Hierarchical Linear Modeling (HLM) techniques were used to model individual growth curves of PA skills. HLM is considered to be superior to traditional repeated measures analyses because of its ability to accurately represent change over time (Lyon & Moats, 1997). Unlike repeated measures analyses that rely on mean difference scores, HLM describes the rate and trajectory of individual change and allows the specification of models that take into account how individual subject characteristics may affect intraindividual change (Raudenbush & Bryk, 2002). HLM analyses were conducted using HLM 5.

For all subsequent HLM analyses, the composite score for the SSI task and the composite scores for PP skills used in the ANCOVA analyses were utilized as dependent variables. Thus, two sets of HLM analyses were conducted for each linguistic group. One set used scores from the SSI task as the dependent variable and one set used PP scores as the dependent variable. Predictor variables entered into both sets of analyses included: age in months at the baseline timepoint, sex, ethnicity, nonverbal IQ, SES, linguistic classification, and the two-way interaction terms derived from these variables.

For all HLM analyses, a two-level model was tested for each selected outcome measure. Level-1 (the individual growth rate model) included the repeated measures of PA skills. The Level-2 (the person level model) included the variables of age, nonverbal IQ, SES, ethnicity, sex, and linguistic classification.

HLM Analyses Conducted with the Control Group

Before person-level predictors were added to the model, the unconditional model (i.e., no level two predictors entered for either intercept or slope parameters) was analyzed. This allowed for the examination of whether the intercept and slope parameters evidenced enough individual variability to warrant modeling the level-1 parameters as a function of person-level variables.

Analyses of the unconditional model utilizing the SSI task as a dependent variable revealed that the reliability estimate for the intercept parameter was, $r = .86$, and the reliability estimate for the slope parameter was, $r = .23$. The variance estimate of the intercept parameter indicated that students differed significantly in their knowledge of grapheme/phoneme correspondences at the time they entered the study, χ^2 (61) = 425.23, $p < .001$. In contrast, the variance estimate of the slope parameter did not suggest that the students differed significantly in that rate at which they gained knowledge of grapheme/phoneme correspondences, χ^2 (61) = 78.72, $p > .05$. Based on these results, it was decided that the addition of person-level predictors was warranted for the intercept parameter, however, there was no justification for entering person-level predictors of the slope parameter.

The unconditional model analyzed with PP skills as the dependent variable produced a reliability estimate for the intercept parameter of $r = .91$ and produced a reliability estimate for the slope parameter of $r = .50$. The variance estimate of the intercept parameter indicated that the students varied significantly in PP skills at the beginning of the study, χ^2 (67) = 788.29, $p < .001$. Further, the variance estimate for the slope parameter indicated that the students differed significantly in the rate at which they acquired PP skills, χ^2 (67) = 788.29, $p < .001$. These results suggested that person-level predictors of the intercept parameter and slope parameter were warranted.

Receptive Vocabulary Groups. Analyses indicated that age, nonverbal IQ, receptive vocabulary group classification, the IQ by SES interaction, and the IQ by receptive vocabulary group interaction were significant predictors of the individual-level intercept (see Table 9). These results indicated that the older students were when they entered the study, the higher their performance on the SSI task at the baseline time point. In addition, the higher the nonverbal IQ students exhibited, the better they scored on the SSI task. The final significant main effect indicated that those students classified as B-ARV entered the study with significantly lower scores on the SSI task than the students in the TRV group.

The significant nonverbal IQ by receptive vocabulary group interaction (see Figure 14) indicated that students in the B-ARV group with higher nonverbal IQ scores evidenced similar performances on the SSI task compared to the students in the TRV group with lower nonverbal IQ scores at the beginning of the study. Students in the TEV group with higher nonverbal IQ scores evidenced the highest performance on the SSI task, while students in the B-AEV group evidenced the lowest performance. Finally, the significant nonverbal IQ by SES (see Figure 15) interaction showed that students classified as either low or average SES who exhibited higher nonverbal IQ scores evidenced better knowledge of grapheme/phoneme correspondences than students classified as either low or average SES who exhibited lower nonverbal IQ scores.

When person-level predictors were entered into the analyses in order to examine the acquisition of PP skills of the students in the study, age, receptive vocabulary group, and the nonverbal IQ by receptive vocabulary group interaction were significant predictors of the intercept parameter (see Table 9). Results revealed that older students entered the study with higher levels of PP skills than younger students. Analyses also indicated that students in the B-ARV group possessed significantly lower levels of PP skills than those children in the TRV

Table 9.
HLM Results for Receptive Vocabulary Groups Conducted with the Control Group

	Sound Symbol Identification Task			
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.01437	5.58	.000
	Non-verbal IQ	0.00434	2.44	.018
	SES	0.01158	0.65	.521
	Ethnicity	0.00467	0.25	.802
	Sex	0.00428	0.23	.822
	Receptive Vocabulary Group	0.04246	2.26	.028
	IQ X SES	-0.00355	-2.03	.047
	IQ X Receptive Vocabulary Group	-0.00578	-2.91	.006
Slope				
	N/A			
	Phonological Processing			
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.00986	4.78	.000
	Non-verbal IQ	0.00122	0.77	.445
	SES	-0.02412	-1.74	.087
	Ethnicity	0.01486	1.14	.261
	Sex	0.01087	0.83	.412
	Receptive Vocabulary Group	0.04496	3.13	.003
	IQ X Receptive Vocabulary Group	-0.00330	-2.23	.030
Slope				
	Age	-0.00244	-3.06	.004
	Non-verbal IQ	-0.00002	-0.04	.967
	SES	0.01249	2.51	.015
	Ethnicity	0.00692	1.49	.141
	Sex	-0.00189	-0.43	.669
	Receptive Vocabulary Group	-0.00169	-0.30	.768

Figure 14. Nonverbal IQ by Receptive Vocabulary Group Interaction in the Control Group for Receptive Vocabulary Classifications

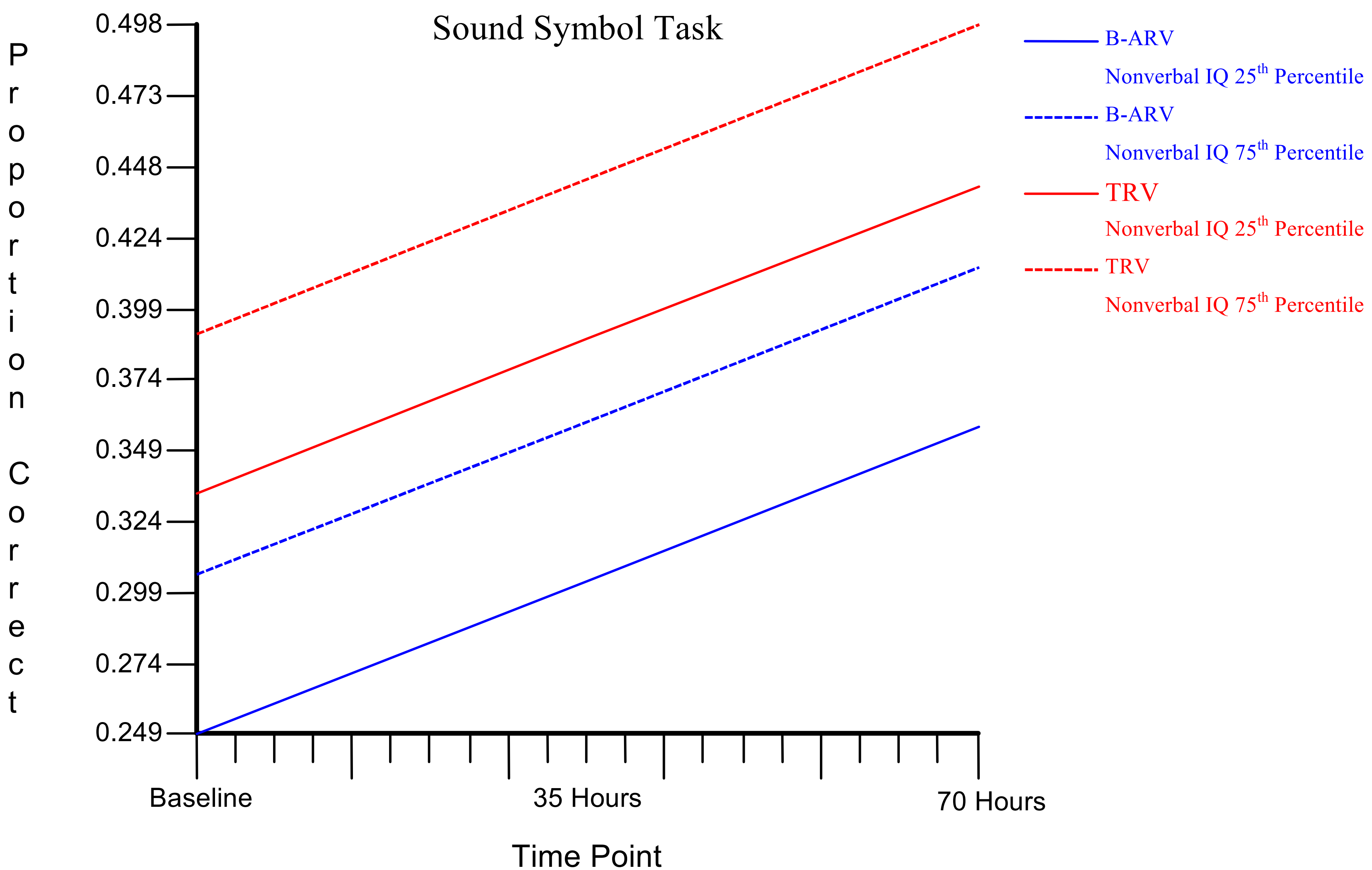
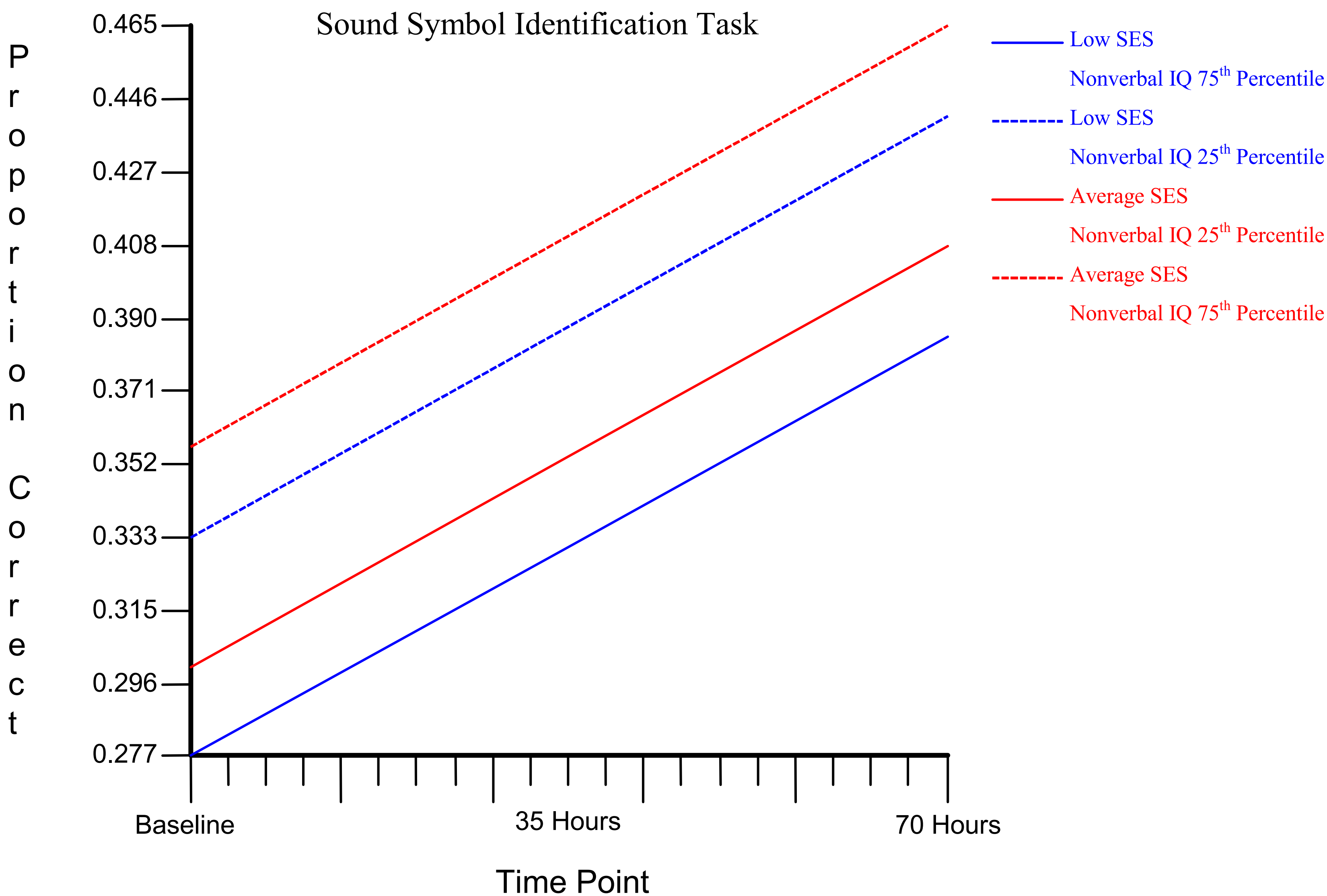


Figure 15. Nonverbal IQ by SES Interaction in the Control Group for Receptive Vocabulary Classifications



group. Further, the nonverbal IQ by receptive vocabulary group interaction indicated that students in the B-ARV group with high nonverbal IQ scores entered the study with PP skill levels that were closer to children in the TRV group with low nonverbal IQ scores than to children in the B-ARV group with low nonverbal IQ scores. Students in the TRV group with higher nonverbal IQ scores evidenced the highest PP skills, while students in the B-ARV group evidenced the lowest.

With respect to the rate of acquisition of PP skills, age at entry into the study and SES were shown to be significant predictors (see Table 9). Analyses indicated that the older the student was upon entering the study, the slower his/her acquisition of PP skills. The coefficient associated with SES indicated that students classified as average SES acquired PP skills at a faster rate than those students classified as low SES.

Expressive Vocabulary Groups. When expressive vocabulary group classification was included as a predictor of the intercept parameter of the SSI task, the predictors of age, nonverbal IQ, the nonverbal IQ by SES interaction, the nonverbal IQ by expressive vocabulary group interaction, and the ethnicity by sex interaction were found to be significant (see Table 10). Older children entered the program evidencing better knowledge of grapheme/phoneme correspondences than younger children. Similarly, children evidencing higher nonverbal IQ scores demonstrated higher scores on the SSI task than children evidencing lower nonverbal IQ scores.

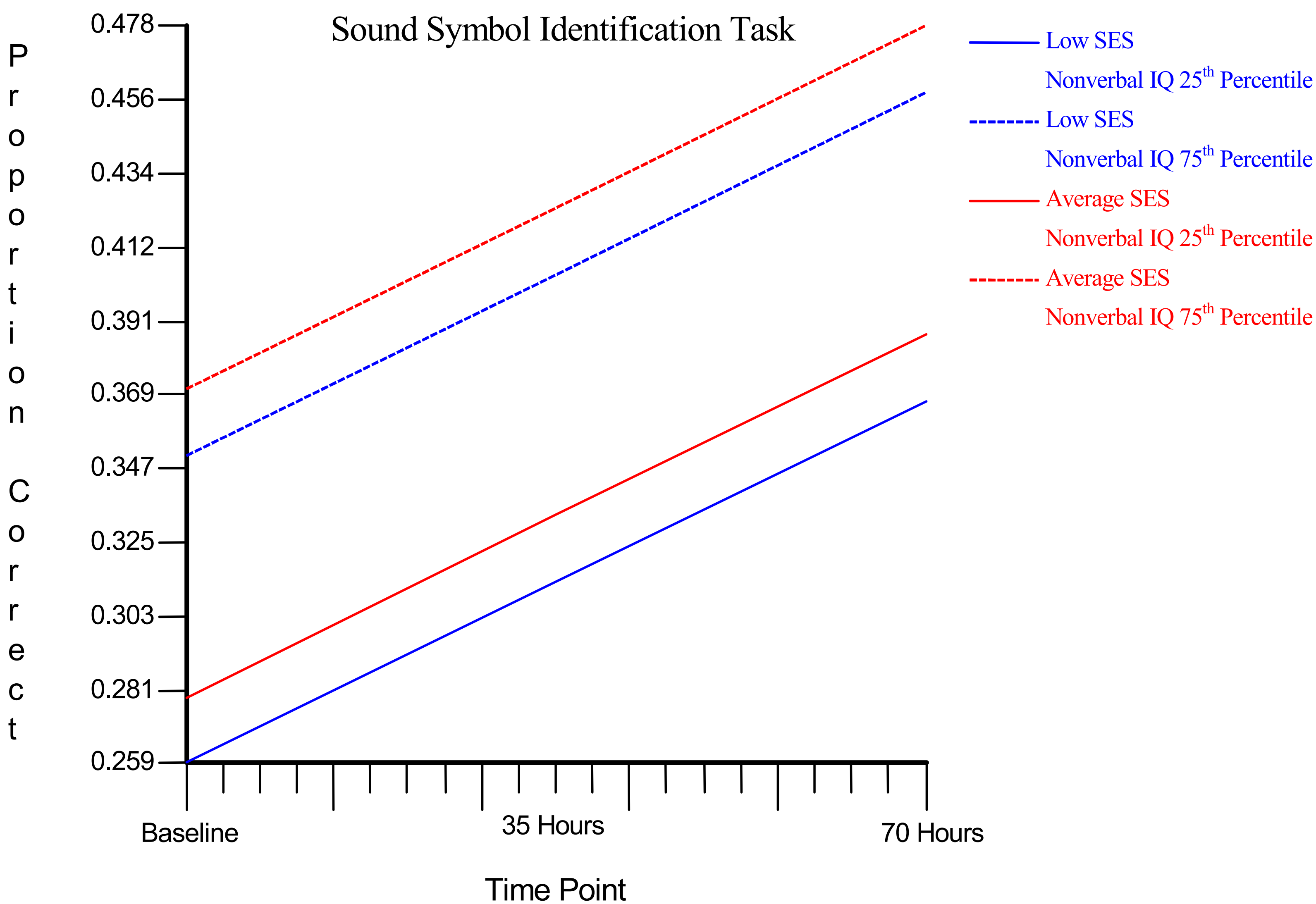
With regard to the significant IQ by SES interaction (see Figure 16), children classified as either low or average SES with higher nonverbal IQ scores entered the study with higher scores on the SSI task than children classified as either low or average SES who evidenced lower nonverbal IQ scores. The significant interaction between expressive vocabulary group and

Table 10.
HLM Results for Expressive Vocabulary Groups Conducted with the Control Group

	Predictor Variable	Coefficient	t-ratio	p value
Sound Symbol Identification Task				
Intercept				
	Age	0.01294	5.17	.000
	Non-verbal IQ	0.00706	3.66	.001
	SES	0.00990	0.49	.628
	Ethnicity	-0.00817	-0.45	.653
	Sex	-0.00055	-0.03	.978
	Expressive Vocabulary Group	0.03363	1.54	.130
	IQ X SES	-0.00416	-2.60	.012
	IQ X Expressive Vocabulary Group	-0.00453	-2.20	.033
	Ethnicity X Sex	0.04494	2.28	.027
Slope				
	N/A			

	Predictor Variable	Coefficient	t-ratio	p value
Phonological Processing				
Intercept				
	Age	0.00802	3.25	.002
	Non-verbal IQ	0.00181	1.05	.297
	SES	-0.02029	-1.39	.169
	Ethnicity	0.01546	1.18	.243
	Sex	0.00791	0.57	.568
	Expressive Vocabulary Group	0.04061	2.56	.014
Slope				
	Age	-0.00242	-2.93	.005
	Non-verbal IQ	-0.00013	-0.27	.789
	SES	0.01187	2.46	.017
	Ethnicity	0.00685	1.48	.145
	Sex	-0.00217	-0.50	.634
	Expressive Vocabulary Group	0.00150	0.29	.774

Figure 16. Nonverbal IQ by SES Interaction in the Control Group for Expressive Vocabulary Group Classifications



nonverbal IQ (see Figure 17) indicated that those children categorized as B-AEV who evidenced higher nonverbal IQ scores entered the study with scores on the SSI task that were similar to those the children in the TEV group who evidenced lower nonverbal IQ scores. The final significant interaction between sex and ethnicity (see Figure 18) showed that although females within both ethnic groups outperformed males, this discrepancy between males and females was greater in African Americans.

Utilizing PP skills as the individual-level outcome variable, analyses indicated that age at the baseline time point and expressive vocabulary group classification were significant predictors of beginning levels of PP skills (see Table 10). Results indicated that older children entered the study with higher levels of PP skills. In addition, students in the B-AEV group entered the study with significantly lower PP skills than students in the TEV group.

With respect to the rate of the acquisition of PP skills, age and SES were found to be significant predictors (see Table 10). The older a student was at entry into the study, the slower they acquired PP skills. Results also indicated that students classified as average SES gained PP skills at a faster rate than students classified as low SES.

Receptive/Expressive Vocabulary Groups. HLM analyses conducted with the SSI task as the outcome variable revealed that age, nonverbal IQ, the IQ by SES interaction, the nonverbal IQ by receptive/expressive vocabulary group, and the ethnicity by SEX interaction were significant predictors (see Table 11). As in the previous analyses, older children evidenced higher scores on the SSI task than younger children at the beginning of the study. In addition, children with higher nonverbal IQ scores demonstrated higher entering levels of grapheme/phoneme correspondence knowledge than children with lower nonverbal IQ scores.

Figure 17. Expressive Vocabulary Group by Nonverbal IQ Interaction in the Control Group

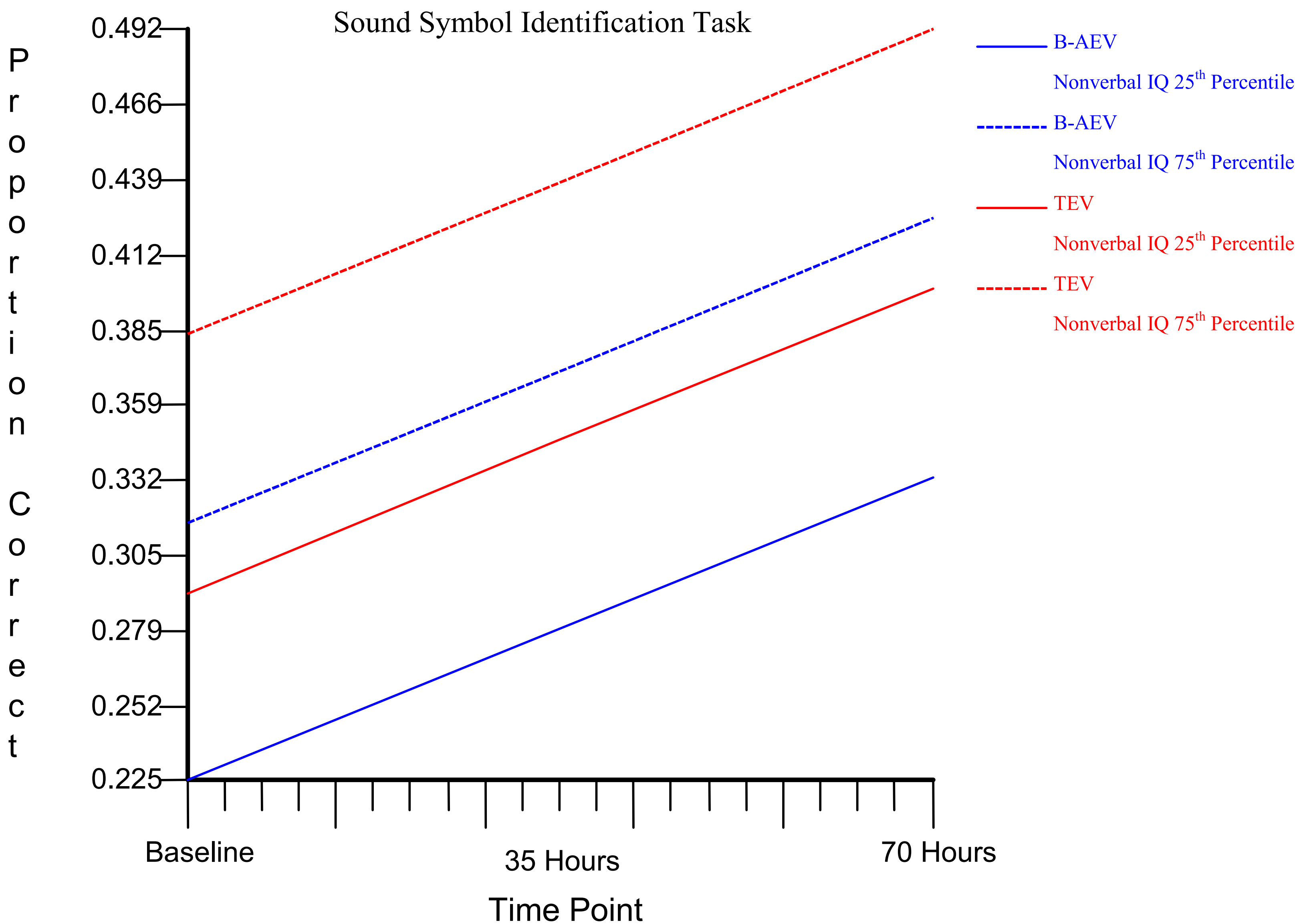


Figure 18. Sex by Ethnicity Interaction in the Control Group for Receptive/Expressive Vocabulary Classifications

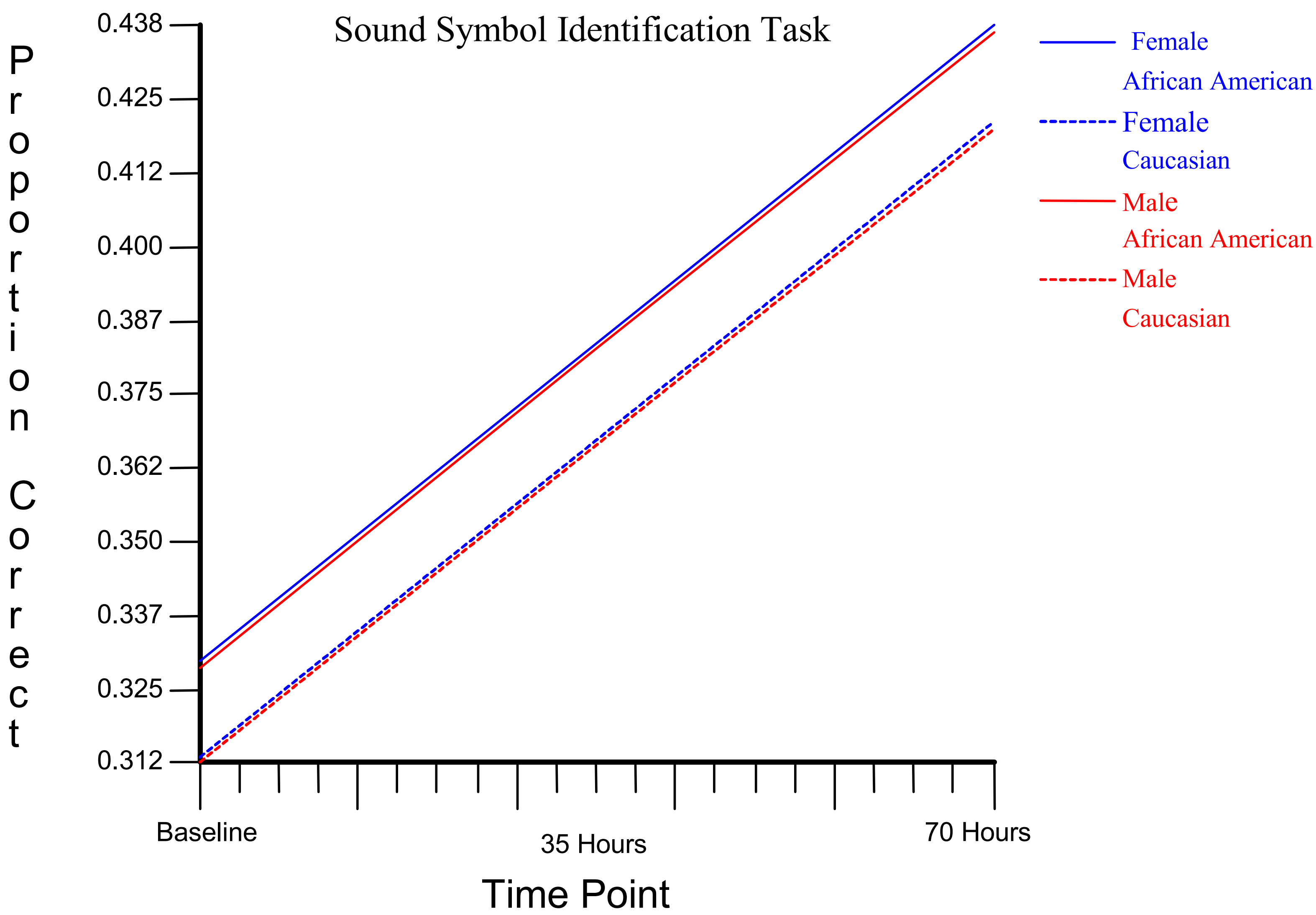


Table 11.
HLM Results for Receptive/Expressive Vocabulary Groups Conducted with the Control Group

	Predictor Variable	Coefficient	t-ratio	p value
Sound Symbol Identification Task				
Intercept				
	Age	0.01361	5.49	.000
	Non-verbal IQ	0.00736	3.37	.002
	SES	0.00957	0.47	.638
	Ethnicity	-0.00883	-0.50	.619
	Sex	-0.00137	-0.07	.942
	Receptive/Expressive Vocabulary Group	0.03615	1.56	.125
	IQ X SES	-0.00440	-2.71	.010
	IQ X Receptive/Expressive Vocabulary Group	-0.00509	-2.13	.038
	Ethnicity X Sex	0.04202	2.15	.036
Slope				
	N/A			

	Predictor Variable	Coefficient	t-ratio	p value
Phonological Processing				
Intercept				
	Age	0.00832	3.51	.001
	Non-verbal IQ	0.00151	0.51	.395
	SES	-0.02084	-1.42	.161
	Ethnicity	0.01151	1.07	.294
	Sex	0.01029	0.77	.444
	Expressive Vocabulary Group	0.04870	2.96	.005
Slope				
	Age	-0.00248	-3.17	.003
	Non-verbal IQ	0.00002	0.04	.972
	SES	0.01270	2.59	.012
	Ethnicity	0.00731	1.59	.117
	Sex	-0.00205	-0.46	.646
	Expressive Vocabulary Group	-0.00356	-0.67	.503

The significant interaction between SES and nonverbal IQ (see Figure 19) showed that children classified as either low or average SES with higher nonverbal IQ scores evidenced higher performance on the SSI task than children classified as low or average SES with lower nonverbal IQ scores. The significant nonverbal IQ by receptive/expressive vocabulary group interaction (see Figure 20) indicated that those students in the B-AREV group who evidenced higher nonverbal IQ scores entered into the study with performance on the SSI task similar to the students in the TREV group who evidenced lower nonverbal IQ scores. The final interaction between ethnicity and sex (see Figure 21) showed that females evidenced better knowledge of grapheme/phoneme correspondences than males; however, this advantage for females was larger for African Americans than for Caucasians.

When PP skills were analyzed as the outcome variable, age and receptive/expressive vocabulary group classification variables were found to significantly predict levels of PP skills at the baseline time point (see Table 11). Older students entered the study with higher levels of PP skills than younger children. In addition, those children in the B-AREV group evidenced significantly lower levels of PP skills than those children in the TREV group.

HLM analyses also indicated that age and SES significantly predicted the rate at which students acquired PP skills (see Table 11). The coefficient associated with age indicated that older children gained PP skills at a slower rate than younger children. With respect to SES, children with an average SES classification acquired PP skills more rapidly than children with a low SES classification.

Listening Comprehension Groups. Analyses conducted with listening comprehension group classification indicated that age, nonverbal IQ, listening comprehension group membership, the IQ by SES interaction, and the IQ by listening comprehension group interaction

Figure 19. SES by Nonverbal IQ Interaction in the Control Group for Receptive/Expressive Vocabulary Classifications

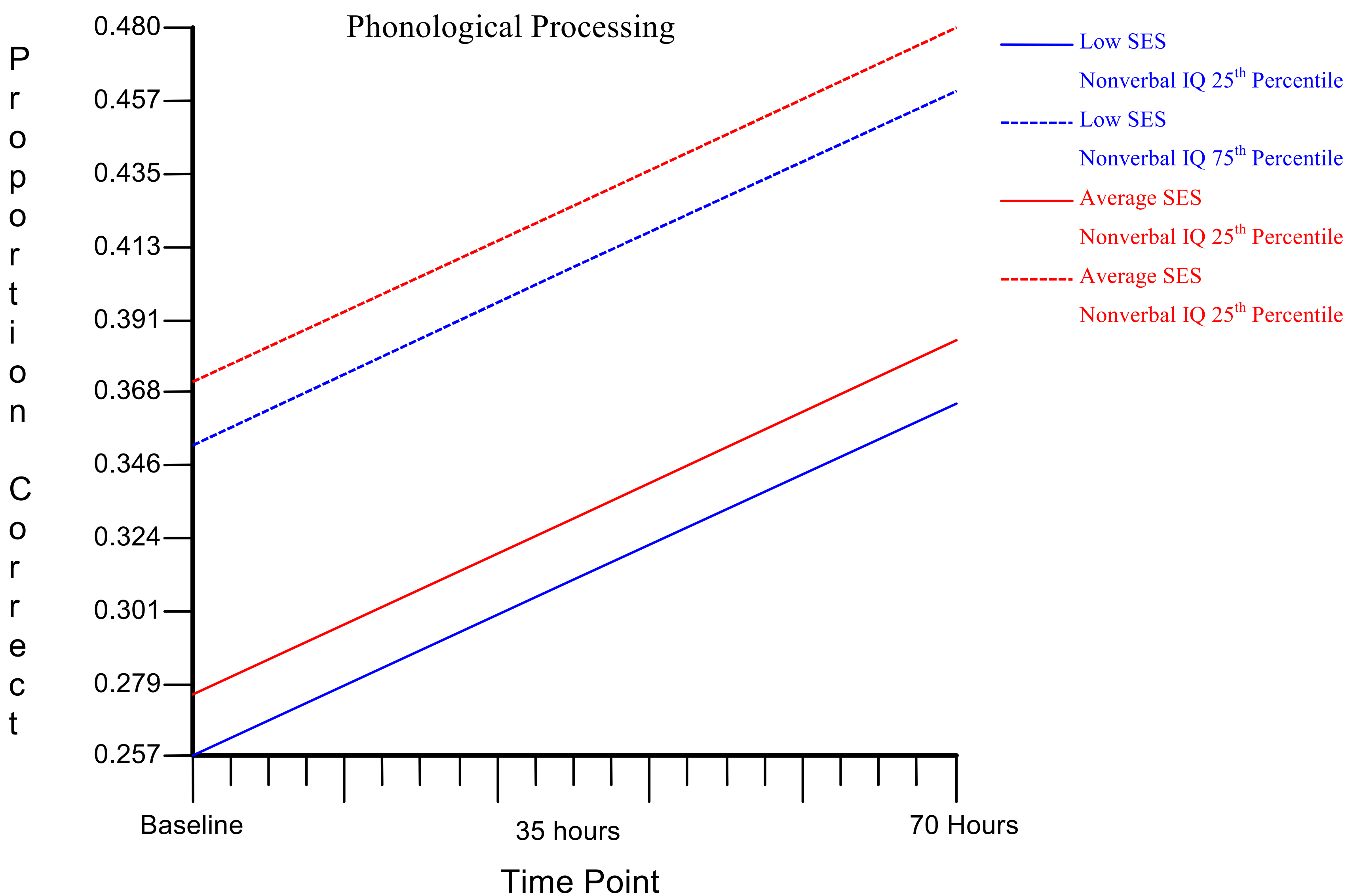


Figure 20. Nonverbal by Receptive/Expressive Vocabulary Group Interaction in the Control Group

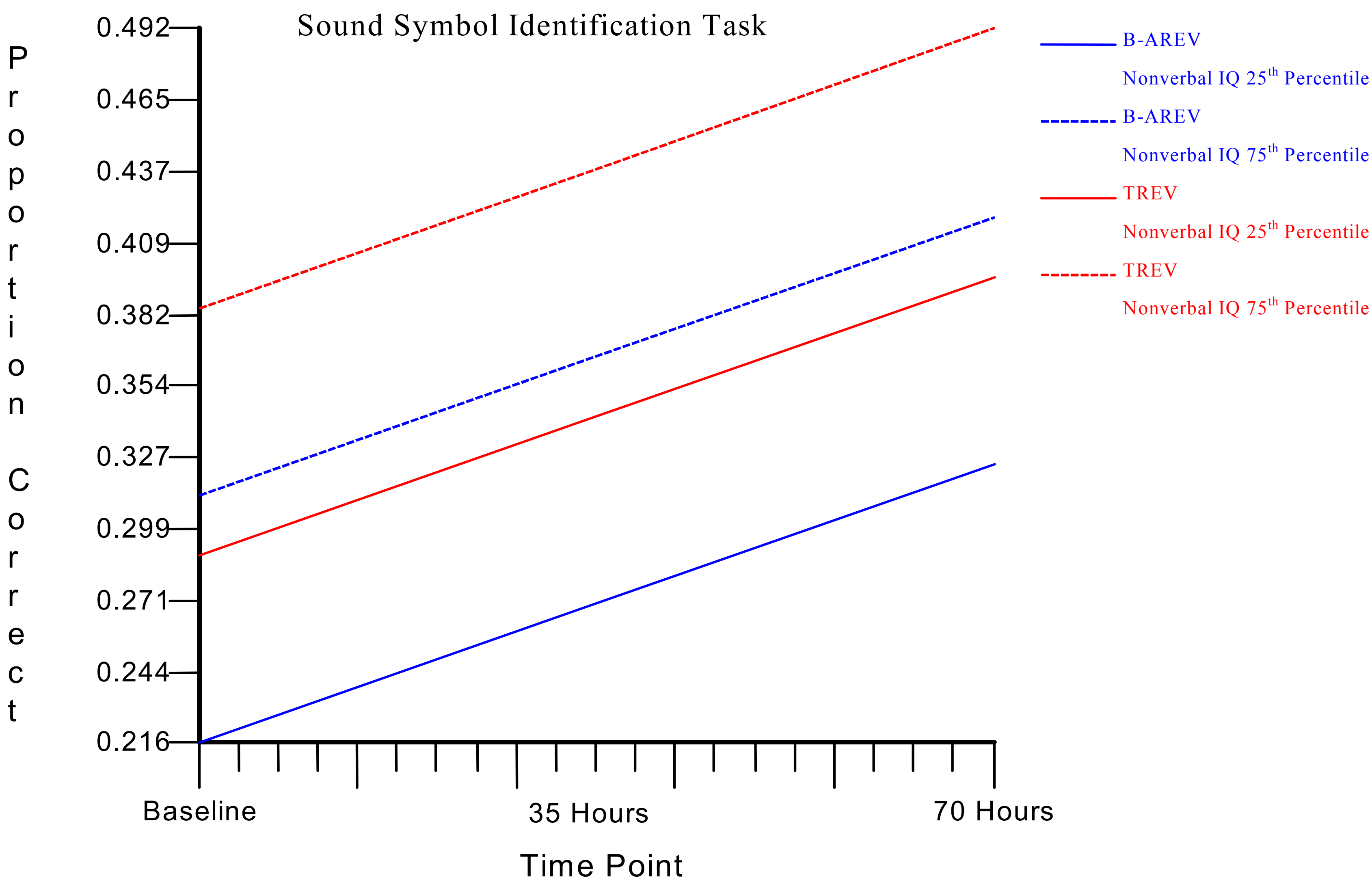
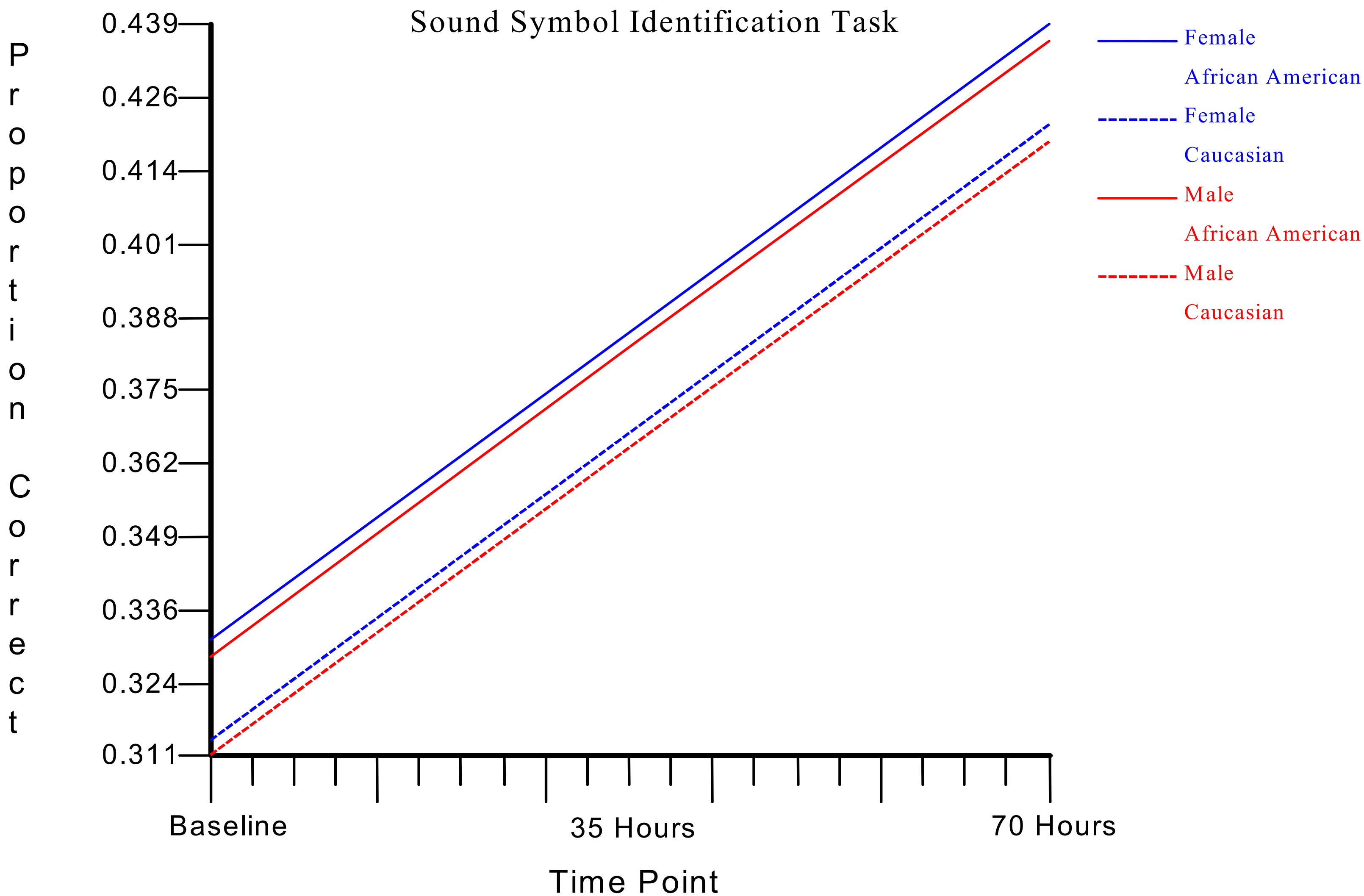


Figure 21. Ethnicity by Sex Interaction in the Control Group for Receptive/Expressive Vocabulary Classifications



significantly predicted performance on the SSI task at the beginning of the study (see Table 12). These results revealed that older students entered the study with higher scores on the SSI task than younger students. Further, students with higher nonverbal IQ scores entered the study with higher scores on the SSI task than students with lower nonverbal IQ scores. The final main effect indicated that those students in the B-ALC group evidenced significantly lower knowledge of grapheme/phoneme correspondences than those students in the TLC group.

The significant nonverbal IQ by SES interaction (see Figure 22) indicated that children classified as low SES with higher nonverbal IQ scores evidenced scores on the SSI task that were similar to children classified as average SES lower nonverbal IQ scores. The significant interaction between nonverbal IQ and listening comprehension group (see Figure 23) showed that children in the B-ALC group who evidenced higher nonverbal IQ scores evidenced knowledge of grapheme/phoneme correspondences that was comparable to children in the TLC group who evidenced lower nonverbal IQ scores.

Analyses conducted in order to examine the growth of PP skills indicated that age and listening comprehension group significantly predicted levels of PP skills at the beginning of the study (see Table 12). Specifically, the older the student was at the beginning of the study, the higher his/her PP skills were at the beginning of the study. Further, students in the B-ALC group evidenced significantly lower PP skills than students in the TLC group.

Analyses also indicated that the variables of age and SES were significant predictors of the rate of acquisition of PP skills (see Table 12). The older the student was upon entering the study, the slower they acquired PP skills. Further, students classified as average SES increased their level of PP skills at a faster rate than those students classified as low SES.

Table 12.
HLM Results for Listening Comprehension Groups Conducted with the Control Group

	Sound Symbol Identification Task			
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.01495	6.91	.000
	Non-verbal IQ	0.00692	4.00	.000
	SES	0.02622	1.54	.129
	Ethnicity	0.01134	0.65	.519
	Sex	-0.00260	-0.15	.884
	Listening Comprehension Group	0.05740	3.27	.002
	IQ X SES	-0.00477	-2.94	.005
	IQ X Listening Comprehension Group	-0.00493	-2.63	.012
Slope				
	N/A			

	Phonological Processing			
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.00863	3.58	.001
	Non-verbal IQ	0.00223	1.34	.185
	SES	-0.01315	-0.96	.341
	Ethnicity	0.01885	1.39	.172
	Sex	0.01159	0.86	.395
	Listening Comprehension Group	0.03684	2.55	.014
Slope				
	Age	-0.00234	-2.86	.006
	Non-verbal IQ	-0.00016	-0.30	.764
	SES	0.01213	2.70	.010
	Ethnicity	0.00701	1.52	.134
	Sex	-0.00198	-0.44	.661
	Listening Comprehension Group	0.00372	0.70	.489

Figure 22. Nonverbal IQ by SES Interaction in the Control Group for Listening Comprehension Classifications

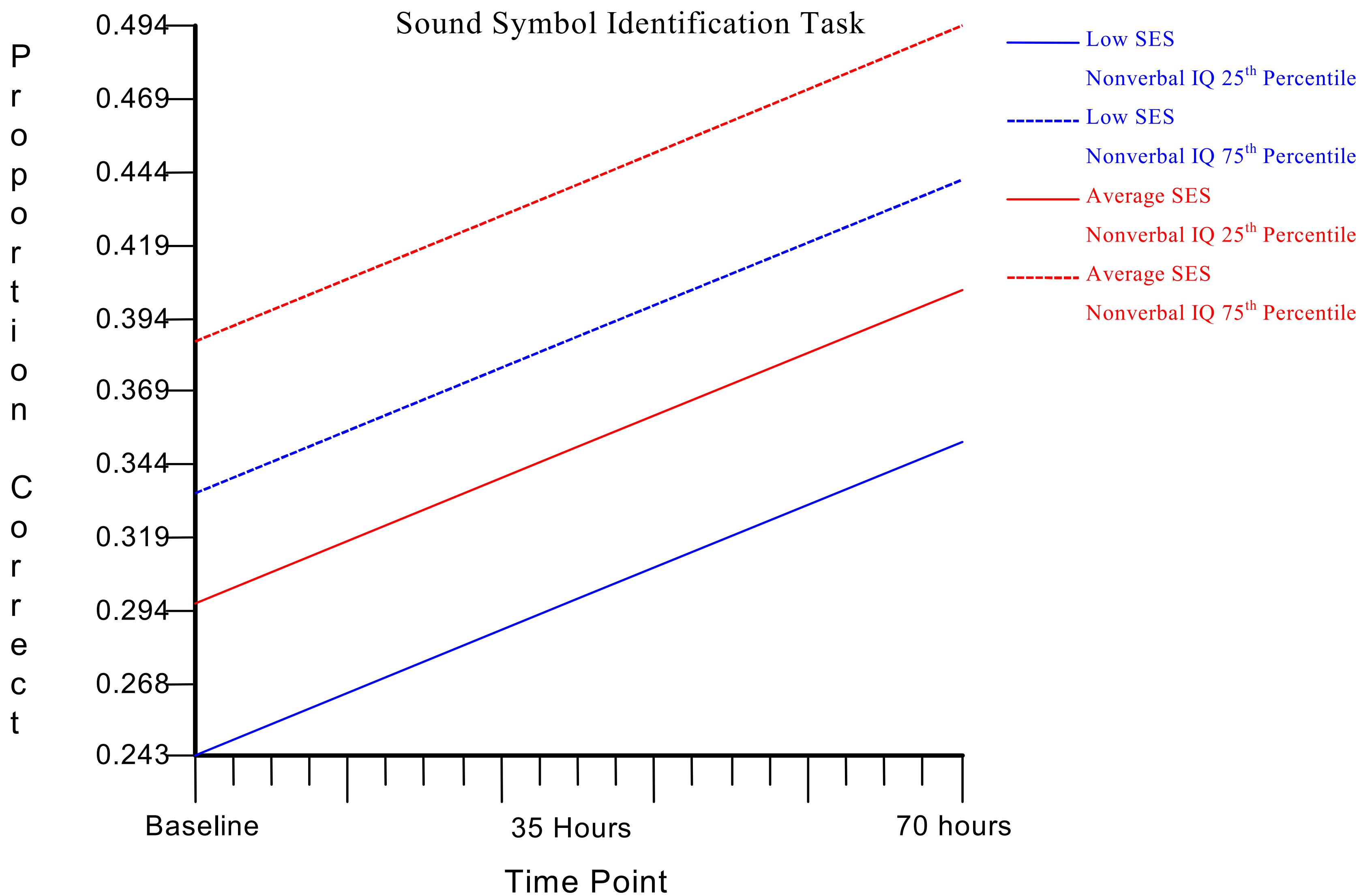
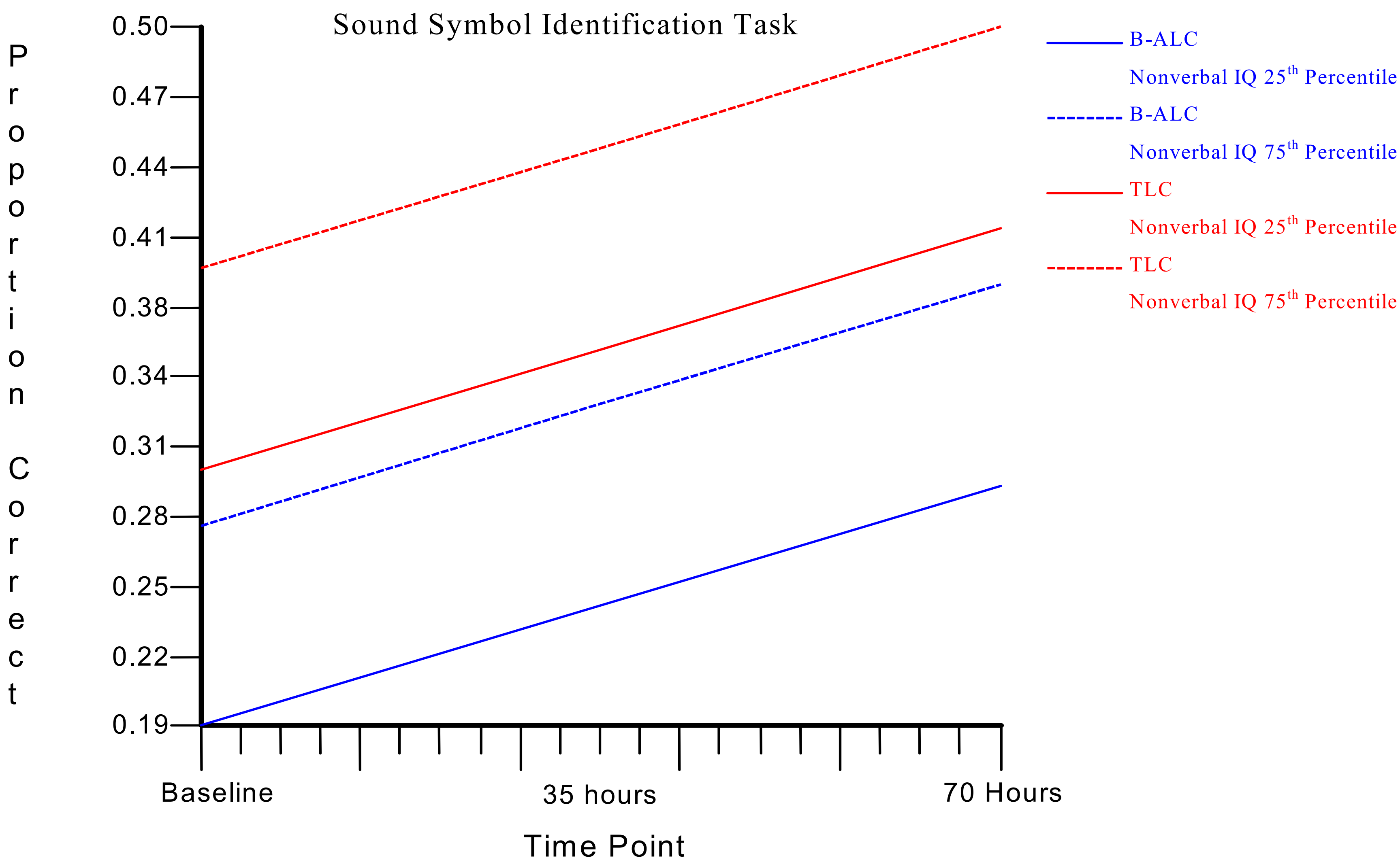


Figure 23. Nonverbal IQ by Listening Comprehension Group Interaction in the Control Group



HLM Analyses Conducted with the First Year Intervention Group

The unconditional model analyzed with the SSI task as the dependent variable indicated that both the level-1 intercept and slope coefficients evidenced enough individual variability to warrant the addition of level-2 predictors. This was seen in the reliability estimates of the two coefficients; r = .84 for the intercept and r = .42 for the slope. In addition, the variance estimates of the intercept and slope parameters indicated that the students in this study varied significantly in the knowledge of letter-sound relationships at entry into the study, χ^2 (192, n = 65) = 1213.50, $p < .001$, and that there were significant differences among students' acquisition of this knowledge over the course of the study, χ^2 (192) = 333.04, $p < .001$.

Results generated by the unconditional model with PP skills as a dependent variable produced a reliability estimate of the intercept parameter of, r =.86, and a reliability estimate of the slope parameter of, r = .47. The students evidenced significant variability in PP skills at the beginning of the study, χ^2 (192) = 1339.52, $p < .001$ and significant variability in the rate at which they acquired PP skills, χ^2 (192) = 360.26 $p < .001$. Based on these findings, person-level variables were entered as predictors of the intercept and slope parameters.

Receptive Vocabulary Groups. HLM analyses that utilized scores from the SSI task as the level-1 outcome variable indicated that age, nonverbal IQ, SES, the nonverbal IQ by sex interaction, the SES by sex interaction, and the sex by receptive vocabulary group interaction were significant predictors of initial performance (see Table 13). These results indicated that the older children were when they entered the program, the higher their performance on the SSI task. It also was shown that the higher a student's nonverbal IQ when he or she entered the study the better he or she performed on the SSI task. In terms of between group variables, analyses indicated that students in the average SES group demonstrated significantly better knowledge of

Table 13.
HLM Results for Receptive Vocabulary Groups Conducted with the Reading Intervention Group

	Predictor Variable	Coefficient	t-ratio	p value
Sound Symbol Identification Task				
Intercept				
	Age	0.01361	8.02	.000
	Non-verbal IQ	0.00622	4.83	.000
	SES	0.02928	2.65	.008
	Ethnicity	0.01642	1.41	.159
	Sex	-0.01704	-1.52	.128
	Receptive Vocabulary Group	0.02265	1.87	.062
	IQ X Sex	-0.00248	-2.25	.024
	SES X Sex	-0.02261	-2.32	.020
	Sex X Receptive Vocabulary Group	0.02931	2.93	.004
Slope				
	Age	-0.00199	-2.24	.025
	Non-verbal IQ	-0.00049	-0.90	.371
	SES	0.00234	0.43	.669
	Ethnicity	0.00442	0.74	.457
	Sex	-0.00344	-0.57	.568
	Receptive Vocabulary Group	-0.00354	-0.56	.574
Phonological Processing				
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.00777	5.86	.000
	Non-verbal IQ	0.00343	4.08	.000
	SES	0.01055	1.29	.199
	Ethnicity	0.02829	3.11	.002
	Sex	0.00022	0.03	.979
	Receptive Vocabulary Group	0.03317	3.56	.001
	Age X Ethnicity	0.00272	2.04	.041
Slope				
	Age	-0.00171	-2.33	.020
	Non-verbal IQ	-0.00032	-0.87	.385
	SES	0.00418	1.02	.307
	Ethnicity	0.00206	0.48	.630
	Sex	-0.00366	-0.89	.376
	Receptive Vocabulary Group	-0.00212	-0.48	.630

grapheme/phoneme correspondences than students in the low SES group. Further, Caucasian students entered the program with significantly better letter/sound knowledge than African American students.

The significant nonverbal IQ by sex interaction (see Figure 24) showed that male students evidencing high nonverbal IQ scores entered the study with scores on SSI task that were more similar to females evidencing low nonverbal IQ scores than males evidencing low nonverbal scores. In addition, female students evidencing high nonverbal IQ scores entered the study with the highest scores on the SSI task. The finding of a significant interaction between SES and Sex (see Figure 25) showed that males who received an average SES classification performed similarly to females who received a low SES classification on the SSI task at the beginning of the study, while males who received a low SES classification evidenced scores that were substantially lower than females with an average SES classification. The final significant interaction between sex and receptive vocabulary group (see Figure 26) indicated that male students in the TRV entered the study with scores on the SSI task that were essentially the same as females in the B-ARV group. Further, females in the TRV entered the study with SSI scores that were considerably higher than males in the B-ARV group.

When person-level variables were entered as predictors of the slope parameter, only one variable was found to be a significant predictor. Analyses indicated that older children evidenced significantly slower acquisition of knowledge of grapheme/phoneme correspondences than younger children (see Table 13).

When PP skills were utilized as the outcome variable, HLM analyses indicated that age, nonverbal IQ, ethnicity, receptive vocabulary group, and the age by ethnicity interaction were significant predictors of the intercept parameter (see Table 13). Results indicated that upon

Figure 24. Nonverbal IQ by Sex Interaction in the Intervention Group for Receptive Vocabulary Classifications

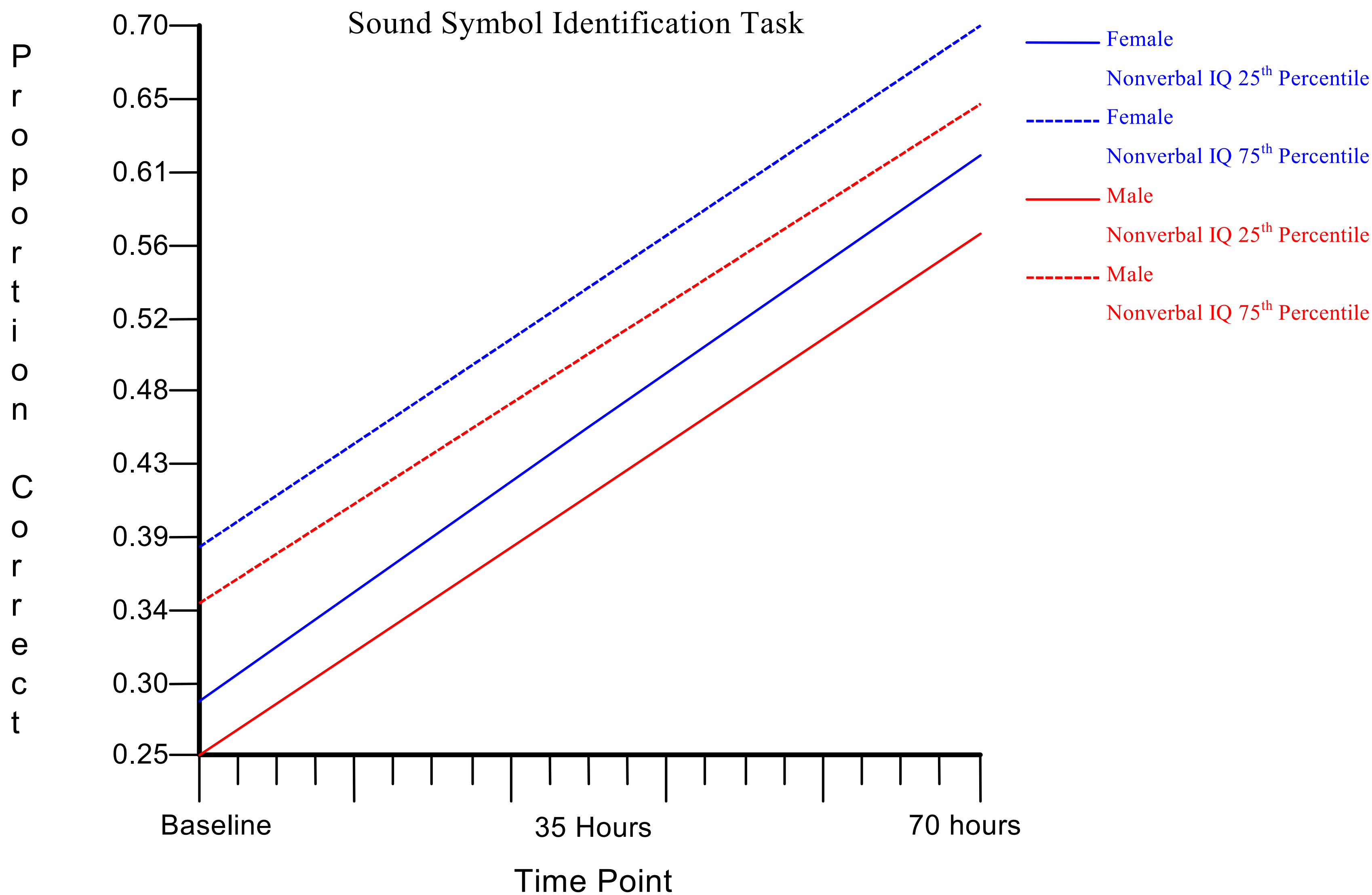


Figure 25. SES by Sex Interaction in the Intervention Group for Receptive Vocabulary Classifications

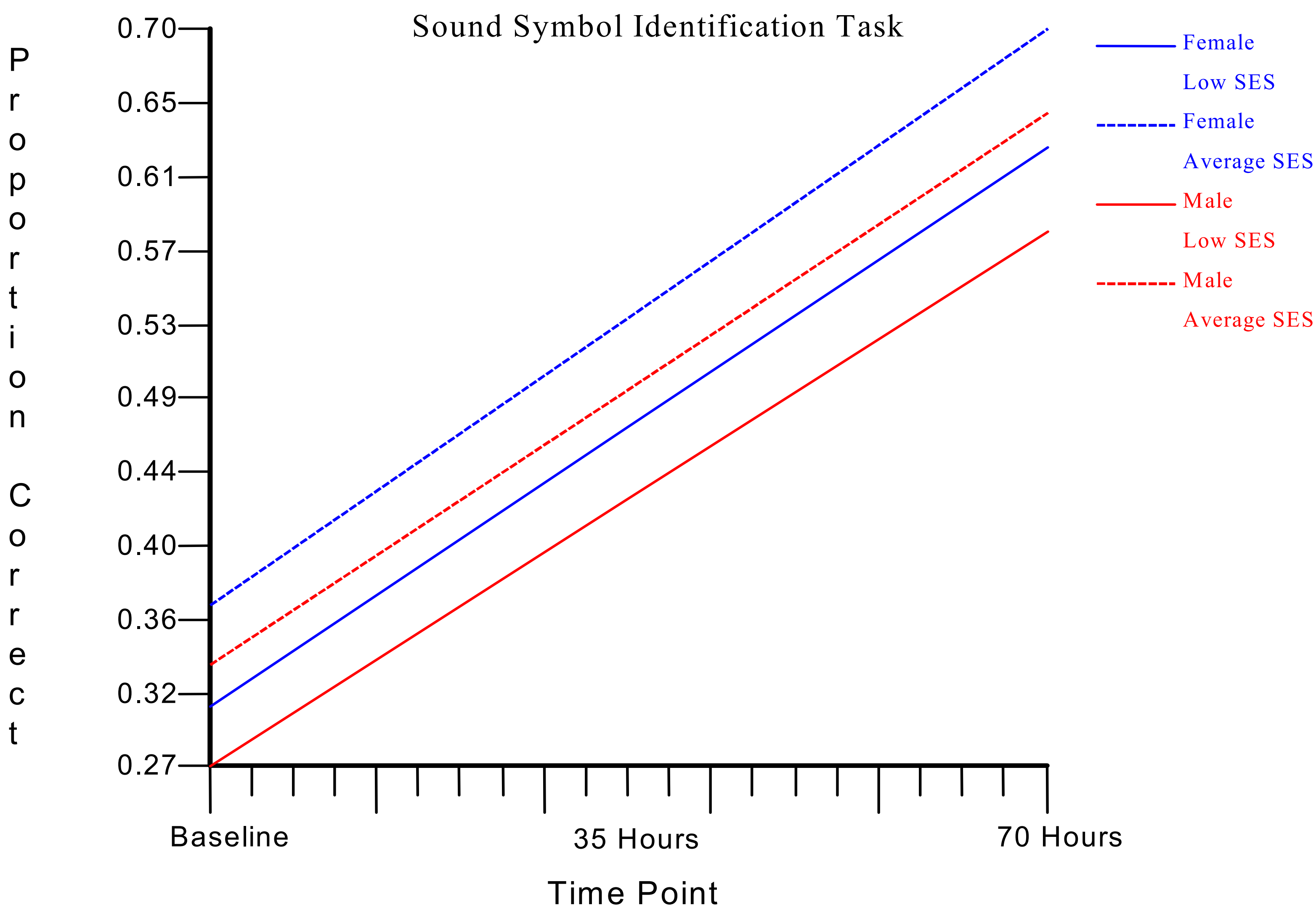
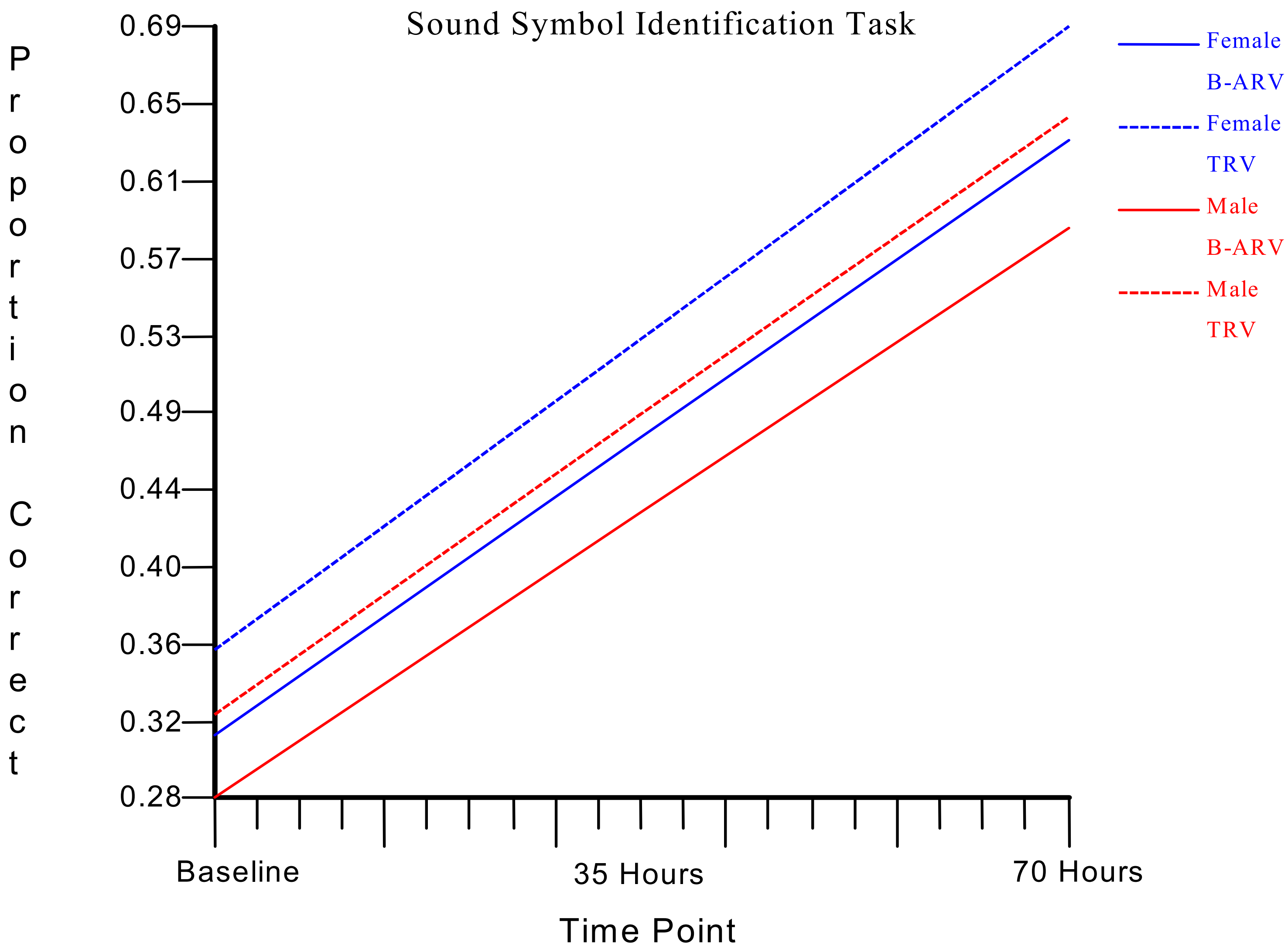


Figure 26. Sex by Receptive Vocabulary Group Interaction in the Intervention Group



entering the study, older students and students with higher nonverbal IQ demonstrated higher levels of PP. Results also indicated that Caucasian students entered the study with significantly higher level of PP than African American students. With respect to receptive vocabulary groups, students in the B-ARV group demonstrated significantly worse PP skills that students in the TRV group.

The only significant interaction present in these analyses indicated younger Caucasian students and older African American students entered the study with similar scores on the SSI task (see Figure 27). Older Caucasian children evidenced the highest scores, while younger African American students evidenced the lowest scores.

Only age was shown to be a significant predictor of the rate of acquisition of PP skills (see table 13). Results indicated that younger children gained PP skills faster than older children.

Expressive Vocabulary Groups. When the SSI task was analyzed as the outcome variable, analyses indicated that age, nonverbal IQ, ethnicity, expressive vocabulary group, and the SES by sex interaction were significant predictors of entry-level knowledge of grapheme/phoneme correspondences (see Table 14). Results indicated that the older a child was at the beginning of the study, the better his/her understanding of grapheme/phoneme correspondences. Similarly, the higher a student's nonverbal IQ at entry into the study, the higher his/her SSI scores were. The significant main effect of ethnicity showed that Caucasian children evidenced significantly higher scores on the SSI task than African American children. Finally, results indicated that children in the B-AEV group entered the study with significantly lower SSI scores than children in the TEV group. The significant SES by sex interaction (see Figure 28) indicated that males from an average SES home environment entered the study with

Figure 27. Ethnicity by Age Interaction in the Intervention Group for Receptive Vocabulary Classifications

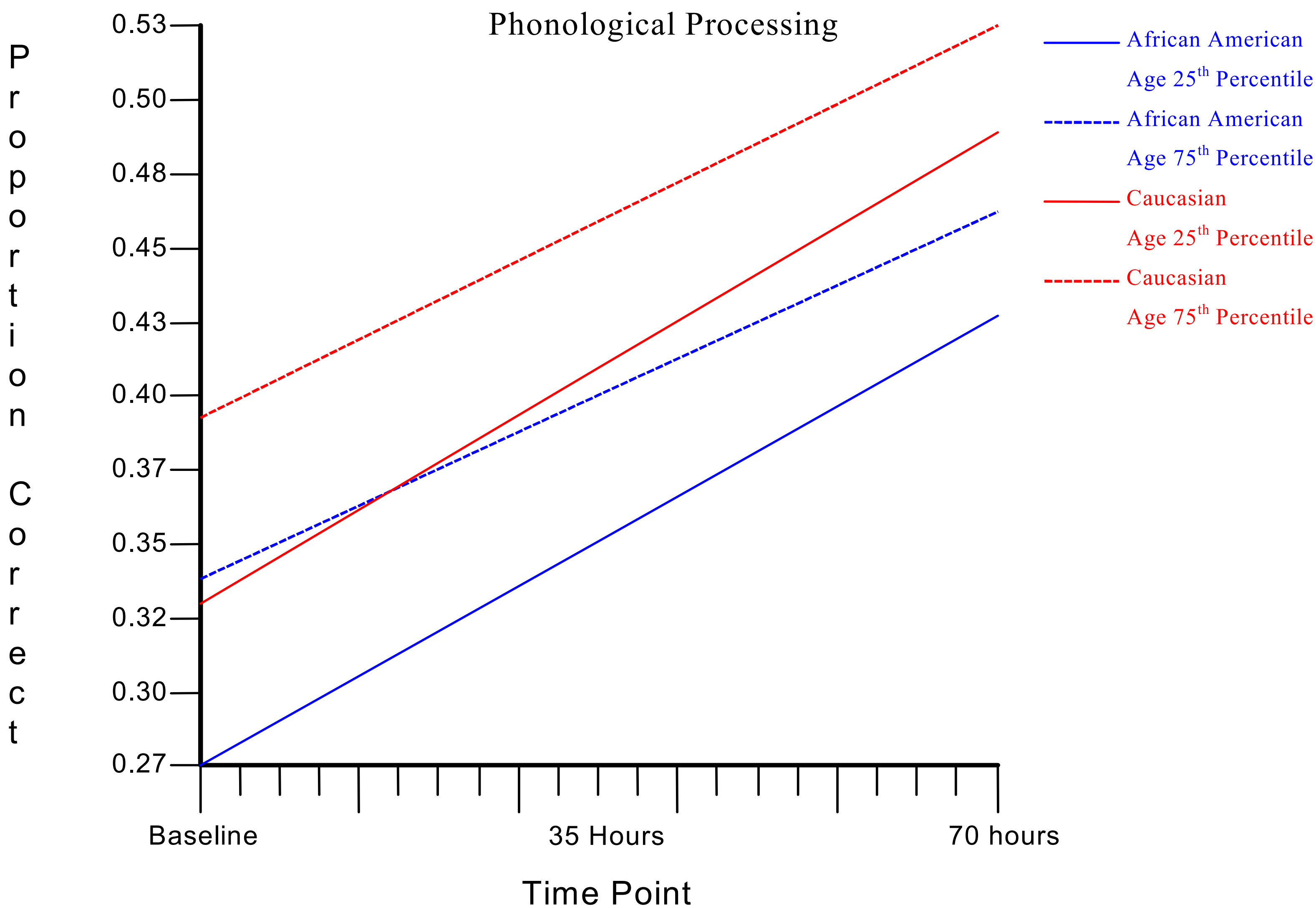
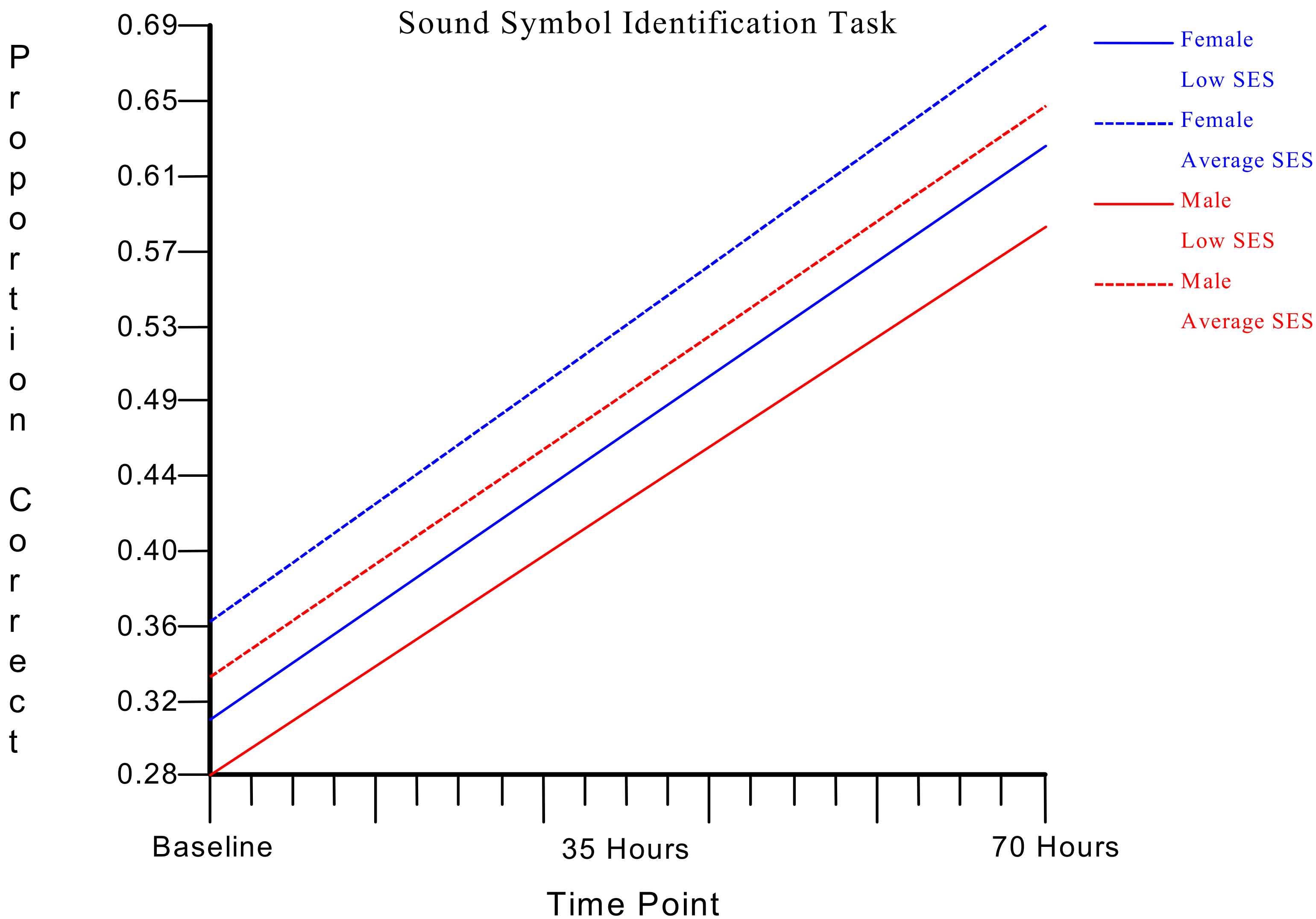


Table 14.
HLM Results for Expressive Vocabulary Groups Conducted with the Reading Intervention Group

	Sound Symbol Identification Task			
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.01362	8.05	.000
	Non-verbal IQ	0.00573	4.83	.000
	SES	0.02757	2.41	.016
	Ethnicity	0.02396	2.18	.029
	Sex	-0.01563	-1.30	.193
	Expressive Vocabulary Group	0.03412	3.05	.003
	SES X Sex	-0.01886	-1.95	.051
Slope				
	Age	-0.00120	-1.34	.180
	Non-verbal IQ	-0.00060	-1.18	.240
	SES	0.00294	0.55	.585
	Ethnicity	0.00493	0.89	.376
	Sex	-0.03204	-0.55	.579
	Expressive Vocabulary Group	0.01086	1.93	.053
	Age X Expressive Vocabulary Group	-0.00222	2.72	.007
	SES X Expressive Vocabulary Group	-0.01218	2.73	.007
	Phonological Processing			
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.00797	6.23	.000
	Non-verbal IQ	0.00364	4.17	.000
	SES	0.01036	1.29	.197
	Ethnicity	0.03518	4.34	.000
	Sex	0.00083	0.10	.919
	Expressive Vocabulary Group	0.03206	3.99	.000
	Age X Ethnicity	0.00306	2.47	.014
Slope				
	Age	-0.00155	-2.11	.035
	Non-verbal IQ	-0.00073	-2.01	.044
	SES	0.00326	0.83	.408
	Ethnicity	0.00105	0.26	.793
	Sex	-0.00339	-0.84	.401
	Expressive Vocabulary Group	-0.00201	0.51	.613
	IQ X Expressive Vocabulary Group	-0.00095	2.65	.008

Figure 28. SES by Sex Interaction in the Intervention Group for Expressive Vocabulary Classifications



similar knowledge of grapheme/phoneme correspondences as females from a low SES home environment.

With regard to the rate at which students' scores on the SSI task increased, the predictor of expressive vocabulary group approached significance (see Table 14). Those students in the B-AEV group evidenced slower acquisition of knowledge of grapheme/phoneme correspondences that students in the TEV group. Analyses also revealed two significant interactions. The age by expressive vocabulary group interaction (see Figure 29) indicated that younger students in the TEV group entered the study with lower SSI scores than older children in the B-AEV group. The younger children in the TEV group, however, gained knowledge of grapheme/phoneme correspondences at a faster rate than the older children in the B-AEV group. Consequently, by the end of the study, these two groups of students performed similarly on the SSI task. The SES by expressive vocabulary interaction (see Figure 30) indicated that children in the TEV group with average and low SES classifications entered the study with essentially the same performance on the SSI task; however, by the children who met average SES criteria evidenced an increase in performance at a faster rate than the children who met low SES criteria. Further, this same pattern was seen in the B-AEV group.

Analyses that included PP skills as the individual-level variable revealed that age, nonverbal IQ, ethnicity, expressive vocabulary group, and the age by ethnicity interaction were significant predictors of beginning levels of PP. Older students and students with higher nonverbal IQ scores entered the study with higher level of PP. Further, Caucasians evidenced significantly higher levels of PP than African Americans. With respect to expressive vocabulary group, those students in the B-AEV group demonstrated significantly lower levels of PP than those students in the TEV group. The significant age by ethnicity interaction (see Figure 31)

Figure 29. Age by Expressive Vocabulary Group Interaction in the Intervention Group

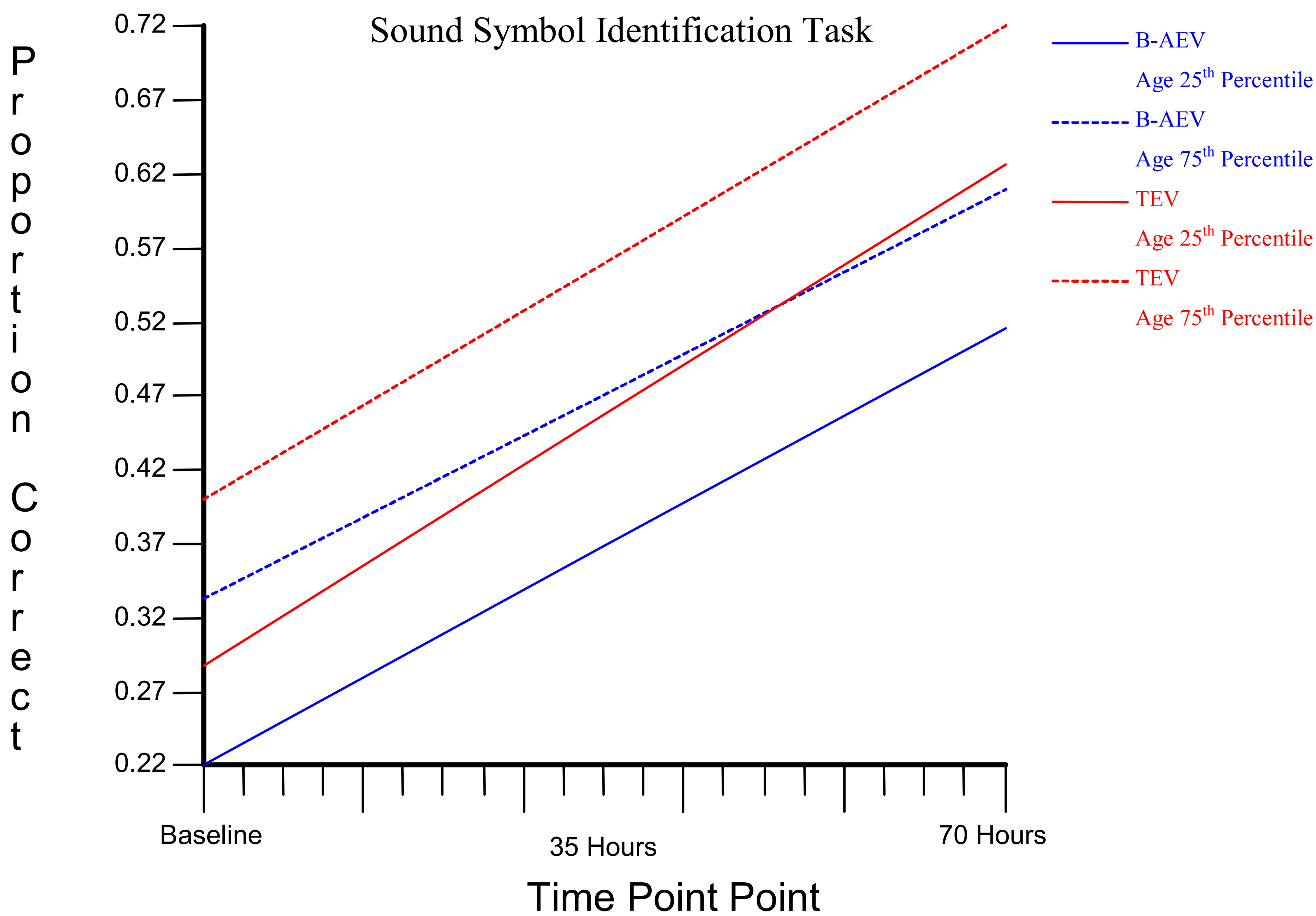


Figure 30. SES by Expressive Vocabulary Group Interaction in the Intervention Group

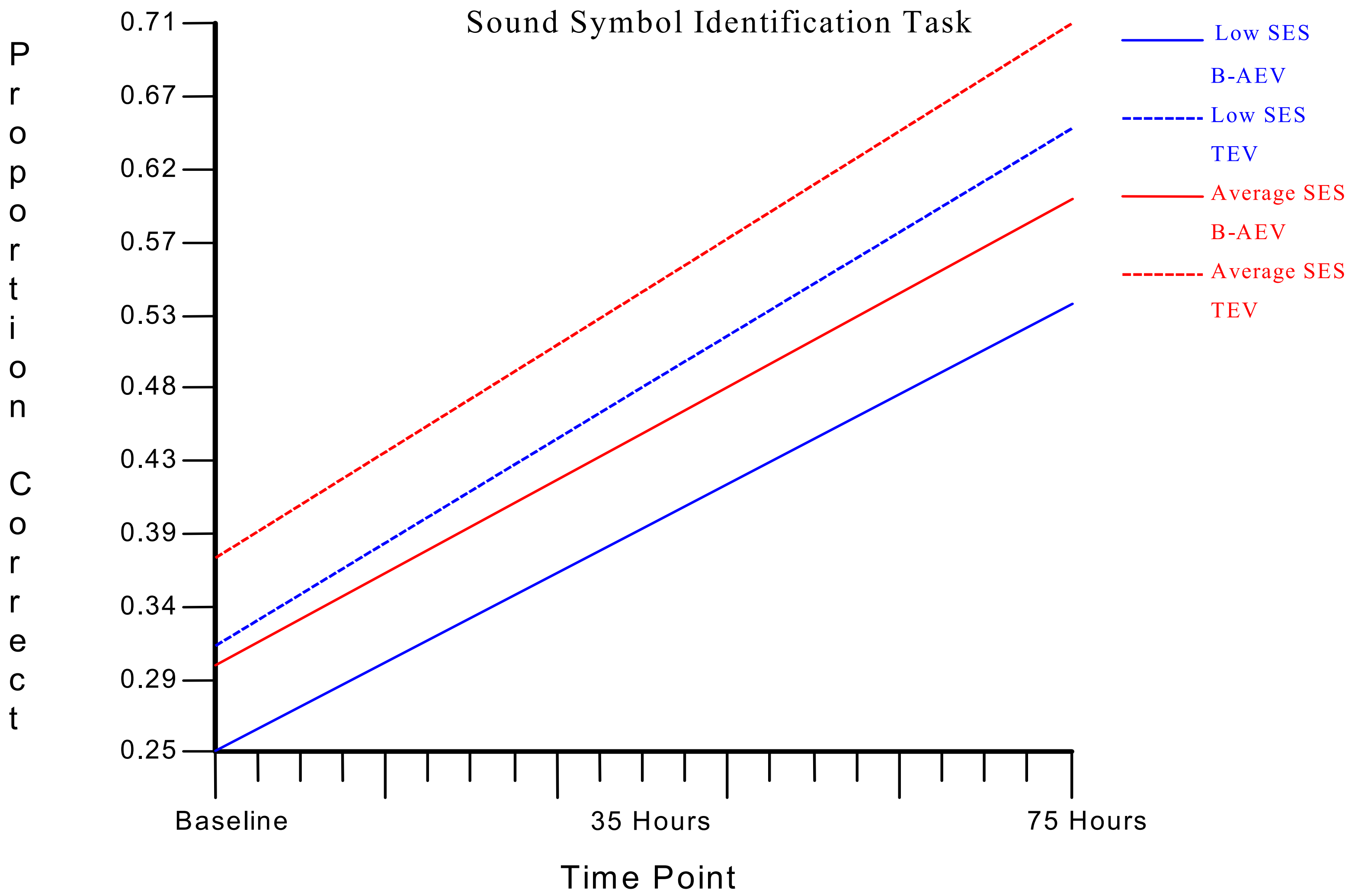
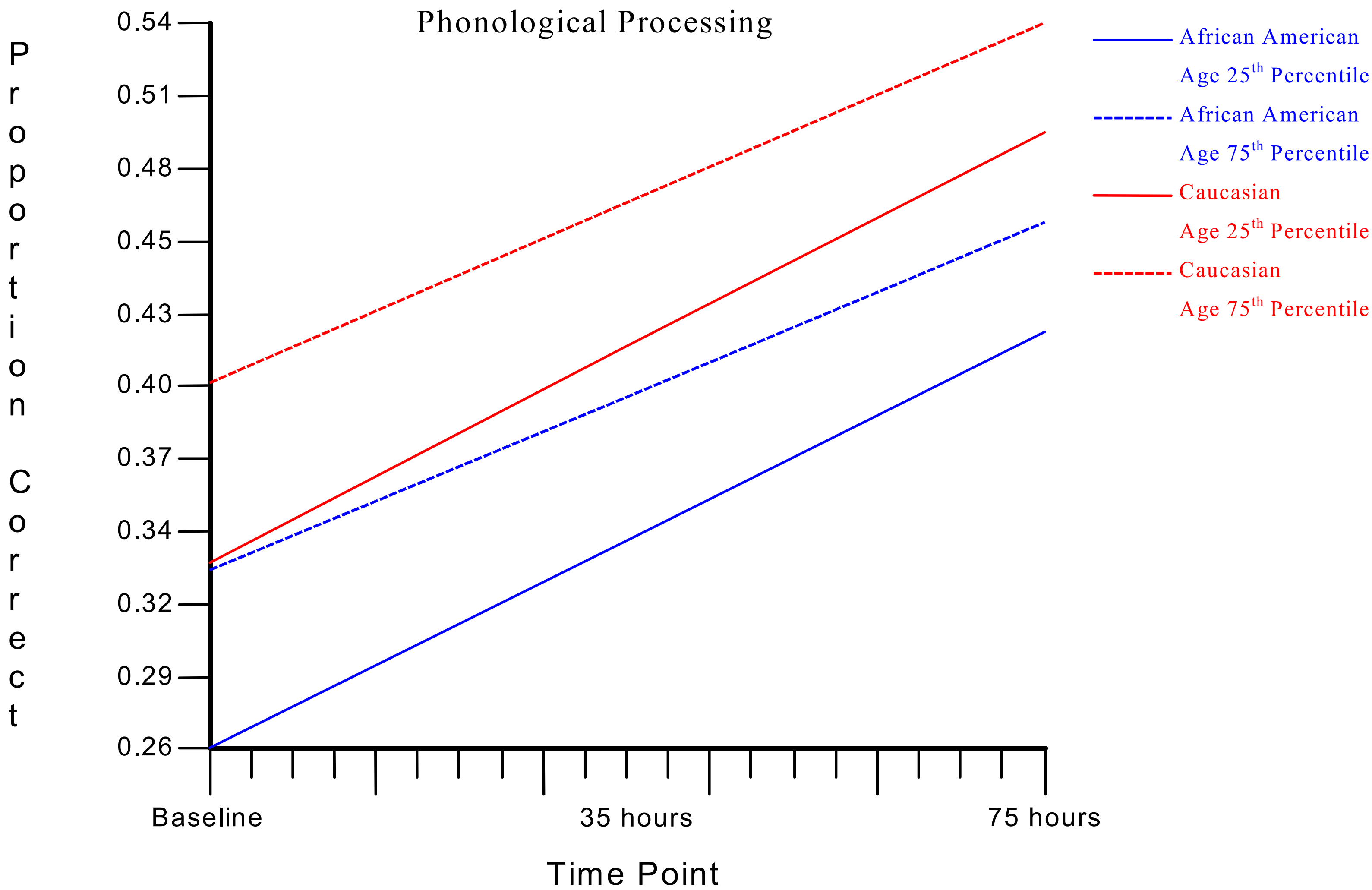


Figure 31. Age by Ethnicity Interaction in the Intervention Group for Expressive Vocabulary Classifications



indicated that younger Caucasian students and older African American students evidenced similar PP scores at the beginning of the study. Older Caucasian students evidenced the highest PP scores while younger African American students evidenced the lowest PP scores.

Significant predictors of the slope intercept included age, nonverbal IQ, and the interaction between nonverbal IQ and expressive vocabulary group. Results indicated that the older a child was at the beginning of the study, the slower they acquired PP skills. In addition, the higher a child's nonverbal IQ at the baseline time point, the slower they acquired PP skills. The nonverbal IQ by expressive vocabulary group interaction (see Figure 32) showed that at the beginning of the study, younger children in the TEV group evidenced similar PP skills to older children in the B-AEV. By the 70 hour intervention time point, however, the younger children in the TEV group evidenced PP skill higher than the older children in the B-AEV group. Further the PP levels of the younger children in the TEV group became more similar to the older children in the TEV group.

Receptive/Expressive Vocabulary. Analyses utilizing scores from the SSI task as the individual-level variable indicated that age, nonverbal IQ, SES, receptive/expressive vocabulary group, the age by ethnicity interaction, and the ethnicity by sex interaction were significant predictors of the intercept parameter (see Table 15). These results showed that the older a student was a time of entry into the study, the higher his/her scores were on the SSI task. It also was shown that children with higher nonverbal IQ evidenced higher scores on the SSI task. The between group variable contrasting low versus average classifications of SES suggested that children from an average SES home environment possessed a significantly better understanding of grapheme/phoneme correspondences than children from a low SES home environment. Results also showed that Caucasian students performed significantly better on the SSI task than

Figure 32. Nonverbal IQ by Expressive Vocabulary Group Interaction in the Intervention Group

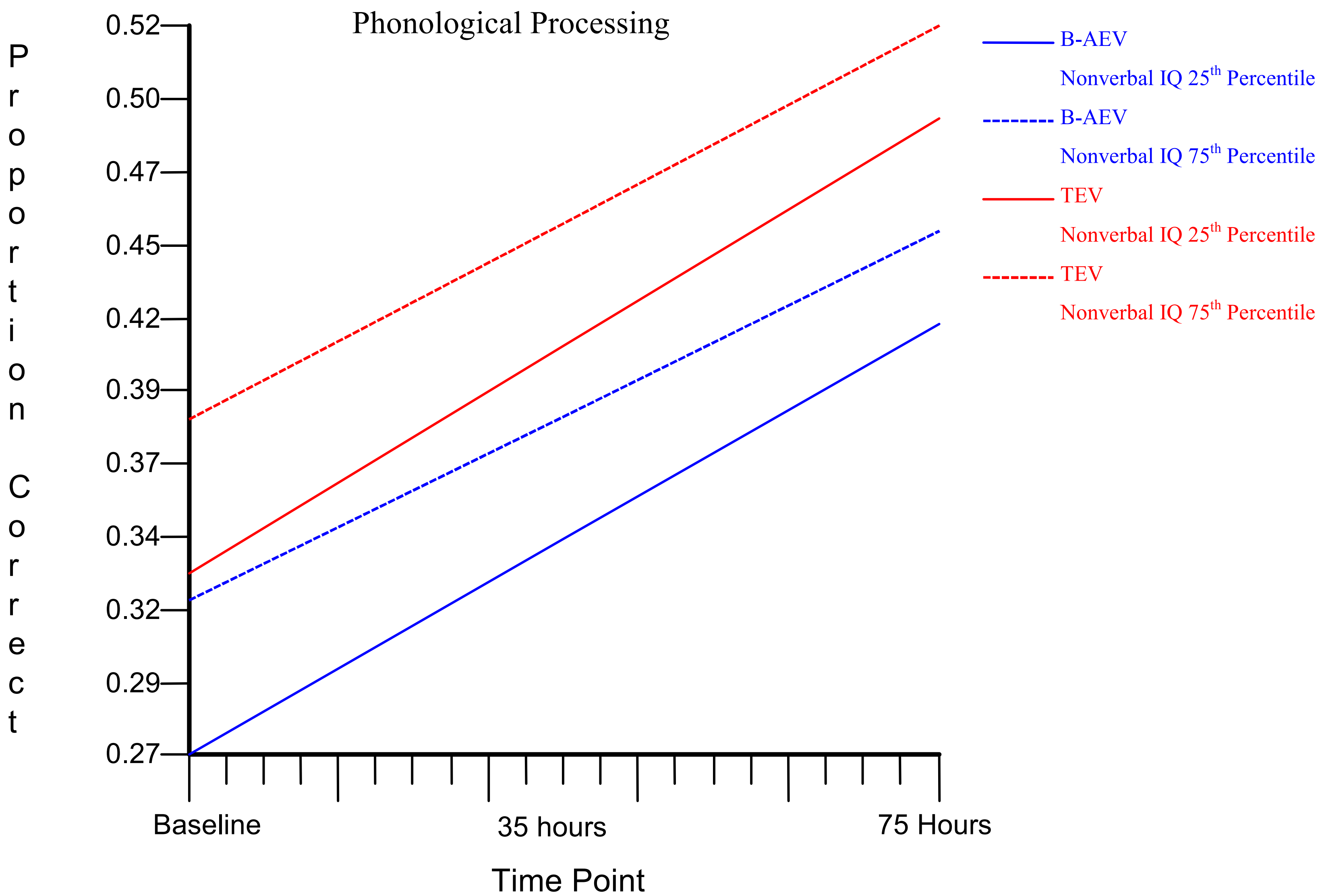


Table 15.
HLM Results for Receptive/Expressive Vocabulary Groups Conducted with the Reading Intervention Group

	Sound Symbol Identification Task			
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.01351	7.79	.000
	Non-verbal IQ	0.00575	4.74	.000
	SES	0.02518	2.22	.026
	Ethnicity	0.01754	1.48	.140
	Sex	-0.01087	-0.91	.366
	Receptive/Expressive Vocabulary Group	0.02976	2.36	.018
	Age X Ethnicity	0.00357	2.20	.028
	Ethnicity X Sex	0.02028	2.08	.037
Slope				
	Age	-0.00205	-2.40	.016
	Non-verbal IQ	-0.00048	-0.94	.350
	SES	0.00827	1.39	.165
	Ethnicity	0.00224	0.39	.699
	Sex	-0.00341	-0.59	.554
	Receptive/Expressive Vocabulary Group	0.01159	1.80	.072
	SES X Receptive/Expressive Vocabulary Group	-0.01552	-2.96	.004

	Phonological Processing			
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.00765	5.94	.000
	Non-verbal IQ	0.00361	4.36	.000
	SES	0.00985	1.22	.224
	Ethnicity	0.03100	3.63	.001
	Sex	0.00169	0.21	.836
	Receptive/Expressive Vocabulary Group	0.03514	4.14	.000
	IQ X Sex	0.00261	2.06	.039
Slope				
	Age	-0.00166	-2.26	.024
	Non-verbal IQ	-0.00107	-2.50	.013
	SES	0.00309	0.77	.441
	Ethnicity	0.00160	0.39	.699
	Sex	-0.00358	-0.89	.375
	Receptive/Expressive Vocabulary Group	0.00196	0.44	.657
	Receptive/Expressive Vocabulary Group	0.00169	2.60	.010

African American students. The final significant main effect of receptive/expressive vocabulary group indicated that the B-AEV group entered the study with significantly lower SSI scores than the TEV group.

A significant interaction between age and ethnicity was found (see Figure 33). Substantial overlap between ethnic groups was seen such that older African American students performance on the SSI task was better than the performance of younger Caucasian students at the beginning of the study. The significant ethnicity by sex interaction (see Figure 34) indicated that Caucasian males and African American females evidenced similar scores on the SSI task at the beginning of the study, while Caucasian females evidenced the highest scores and African American males evidenced the lowest scores.

Age was found to significantly predict the rate at which students gained knowledge of grapheme/phoneme correspondences (see Table 15). The older the student was at the beginning of the study, the slower they acquired this knowledge.

Results also revealed a significant SES by receptive/expressive vocabulary group interaction (see Figure 35). Children in the B-AREV group from an average SES home environment entered the study with scores on the SSI task that were similar to students in the TREV group from a low SES home environment. Students in the TREV group from a low SES home environment, however, increased their scores at a faster rate than students in the B-AREV group who were from an average SES home environment.

When PP skills were analyzed as the outcome variable, age, nonverbal IQ, ethnicity, receptive/expressive vocabulary group, and the age by ethnicity interaction were found to be significant predictors (see Table 15). The older a child was at the beginning of the study, the better his/her PP skills were. Similarly, the higher a child's nonverbal IQ at the baseline time

Figure 33. Age by Ethnicity Intervention in the Intervention Group for Receptive/Expressive Vocabulary Classifications

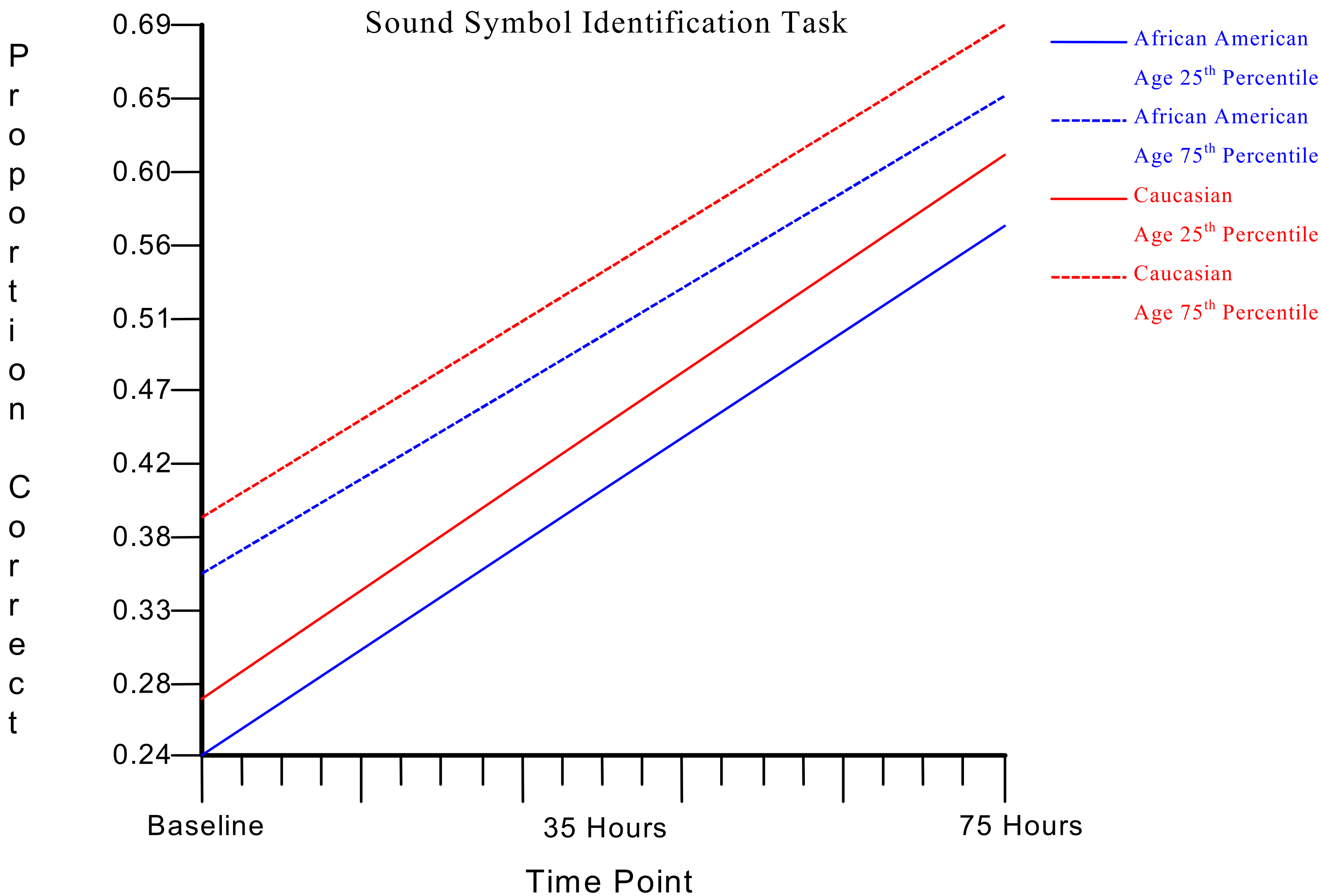


Figure 34. Ethnicity by Sex Interaction in the Intervention Group for Receptive/Expressive Vocabulary Classifications

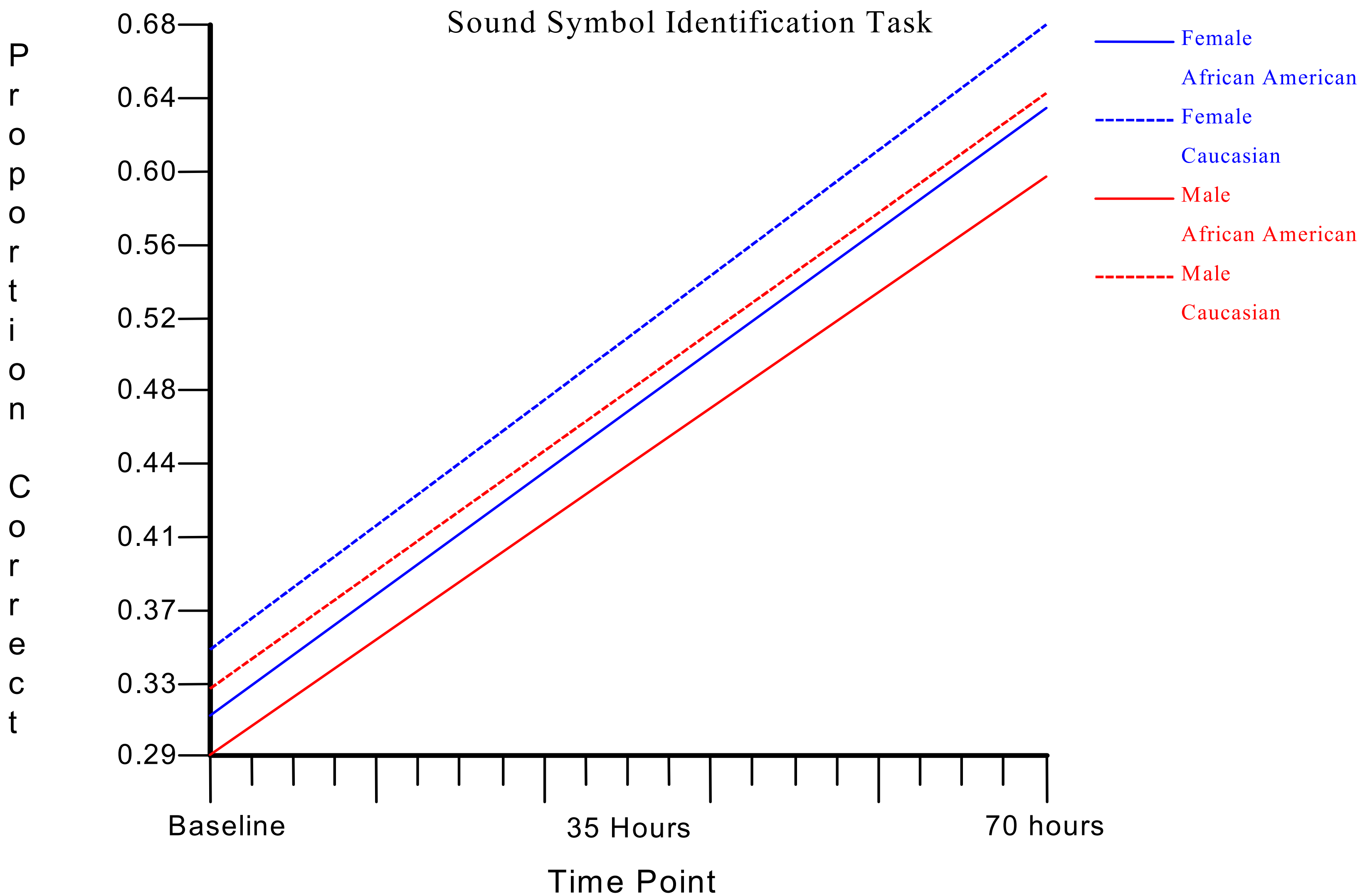
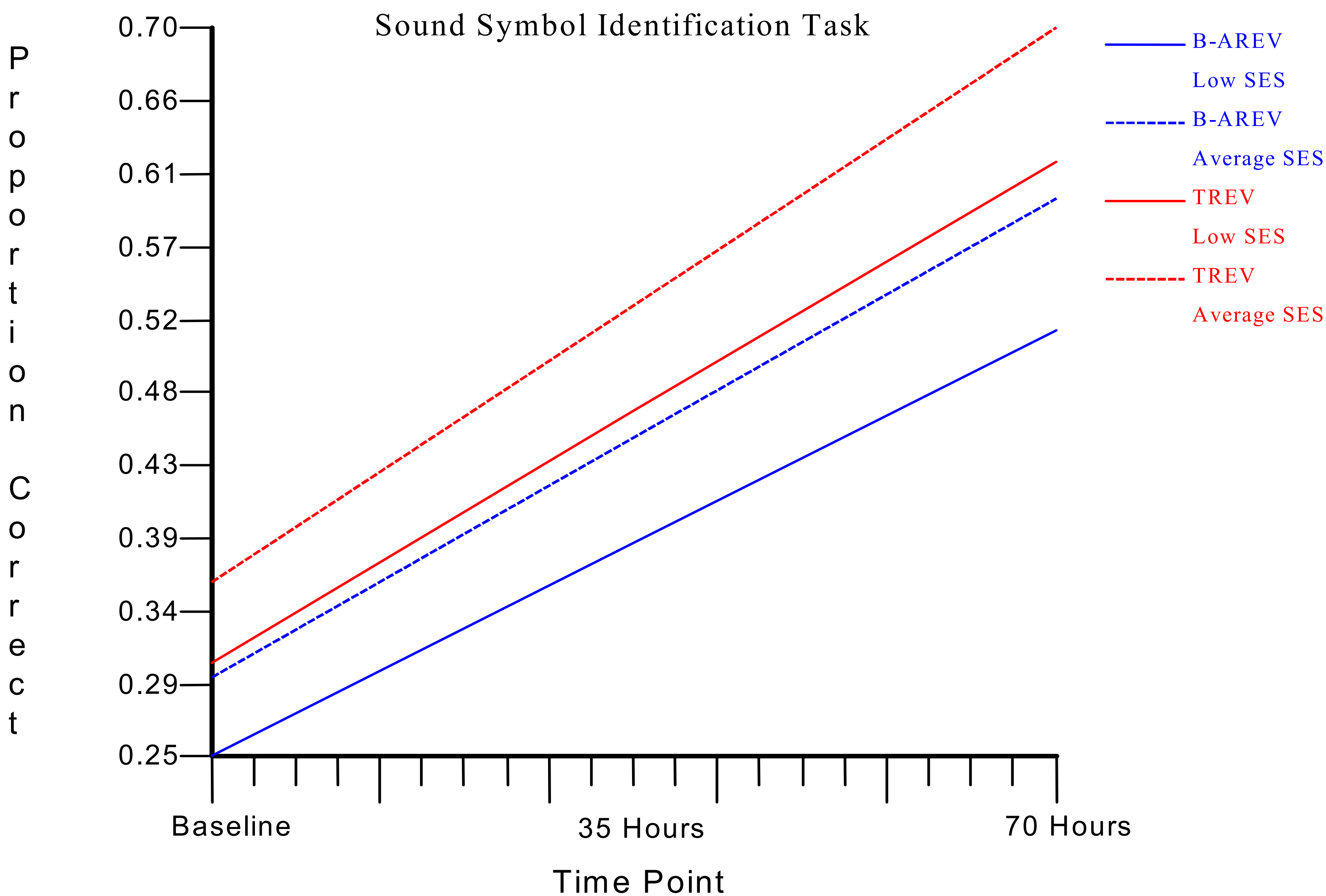


Figure 35. SES by Receptive/Expressive Vocabulary Group Interaction in the Intervention Group



point, the higher his/her PP levels were at the baseline time point. Caucasian students demonstrated significantly higher levels of PP than African American students. Students in the B-AREV group evidenced significantly lower levels of PP than students in the TREV group. The significant interaction between age and ethnicity (see Figure 36) revealed that younger Caucasian students and older African American students evidenced similar PP skills at the baseline time point, while older Caucasian children evidenced the highest PP skills and younger African American students evidenced the lowest PP skills.

When person-level predictors were entered as predictors of the rate of acquisition of PP skills, age, nonverbal IQ, and the interaction between nonverbal IQ and receptive/expressive vocabulary group were significant (see Table 15). Younger students evidenced a faster rate of acquisition of PP skills than older children. In addition, children with lower nonverbal IQ scores acquired PP skills faster than children with higher nonverbal IQ scores.

The significant interaction between nonverbal IQ and receptive/expressive vocabulary group (see Figure 37) indicated that younger children in the TREV group evidenced similar levels of PP when compared to older children in the B-AREV group at the baseline time point. The younger children in the TREV acquired PP skills at a faster rate than the older children in the B-AREV group, however, and evidenced PP skills that were similar to older students in the TEV by the 70 hour intervention time point.

Listening Comprehension Groups. HLM analyses including the SSI task as the outcome variable revealed that age, nonverbal IQ, SES, listening comprehension group classification, the age by ethnicity interaction, and the ethnicity by sex interaction were significant predictors of the intercept parameter (see Table 16). In addition, the predictor of ethnicity approached the $p < .05$ level of significance (i.e., $p = .054$). The older a student was at the time of entry into the study,

Figure 36. Age by Ethnicity Interaction in the Intervention Group for Receptive/Expressive Vocabulary Classifications

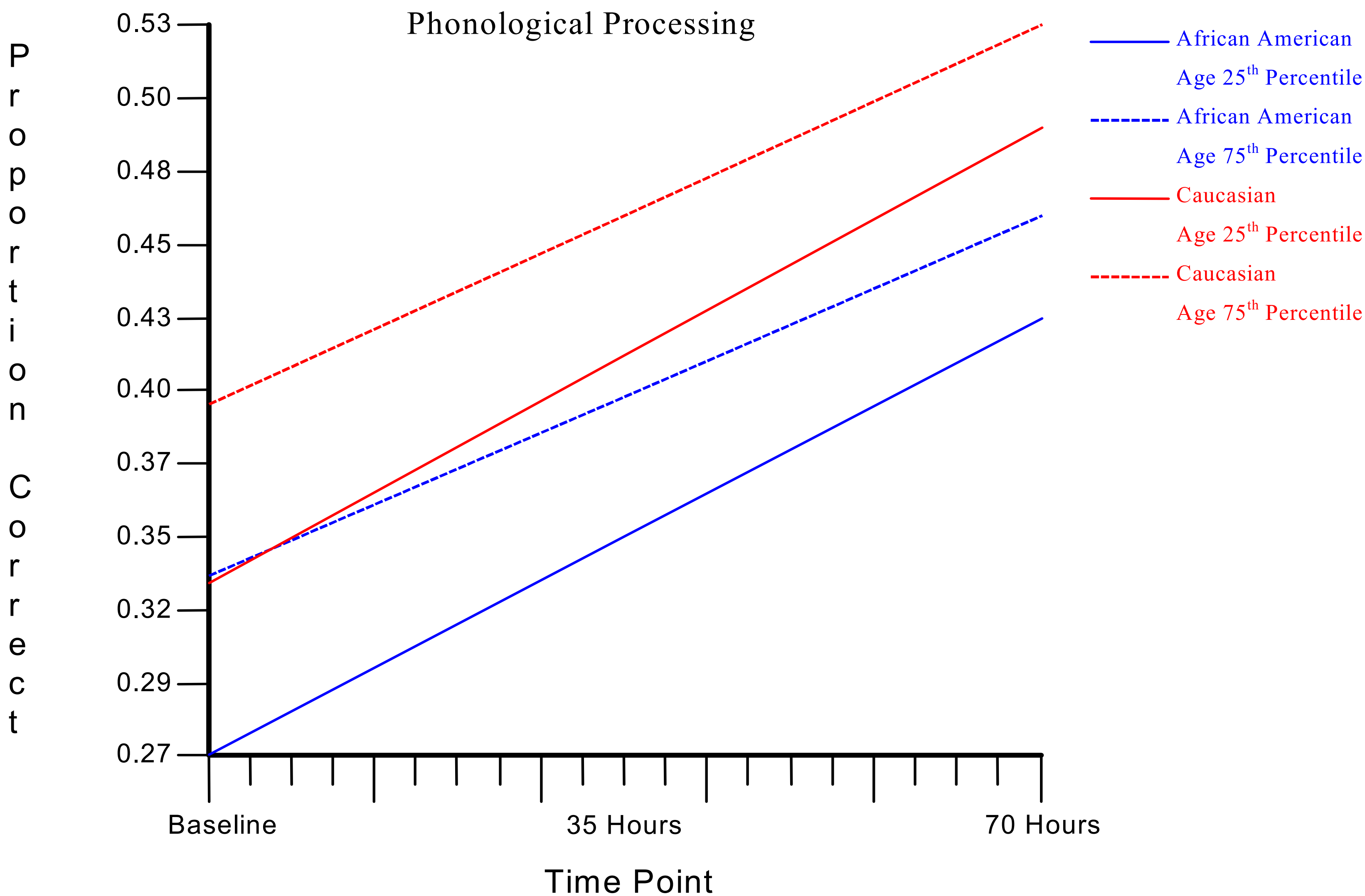


Figure 37. Nonverbal IQ by Receptive/Expressive Vocabulary Group Interaction in the Intervention Group

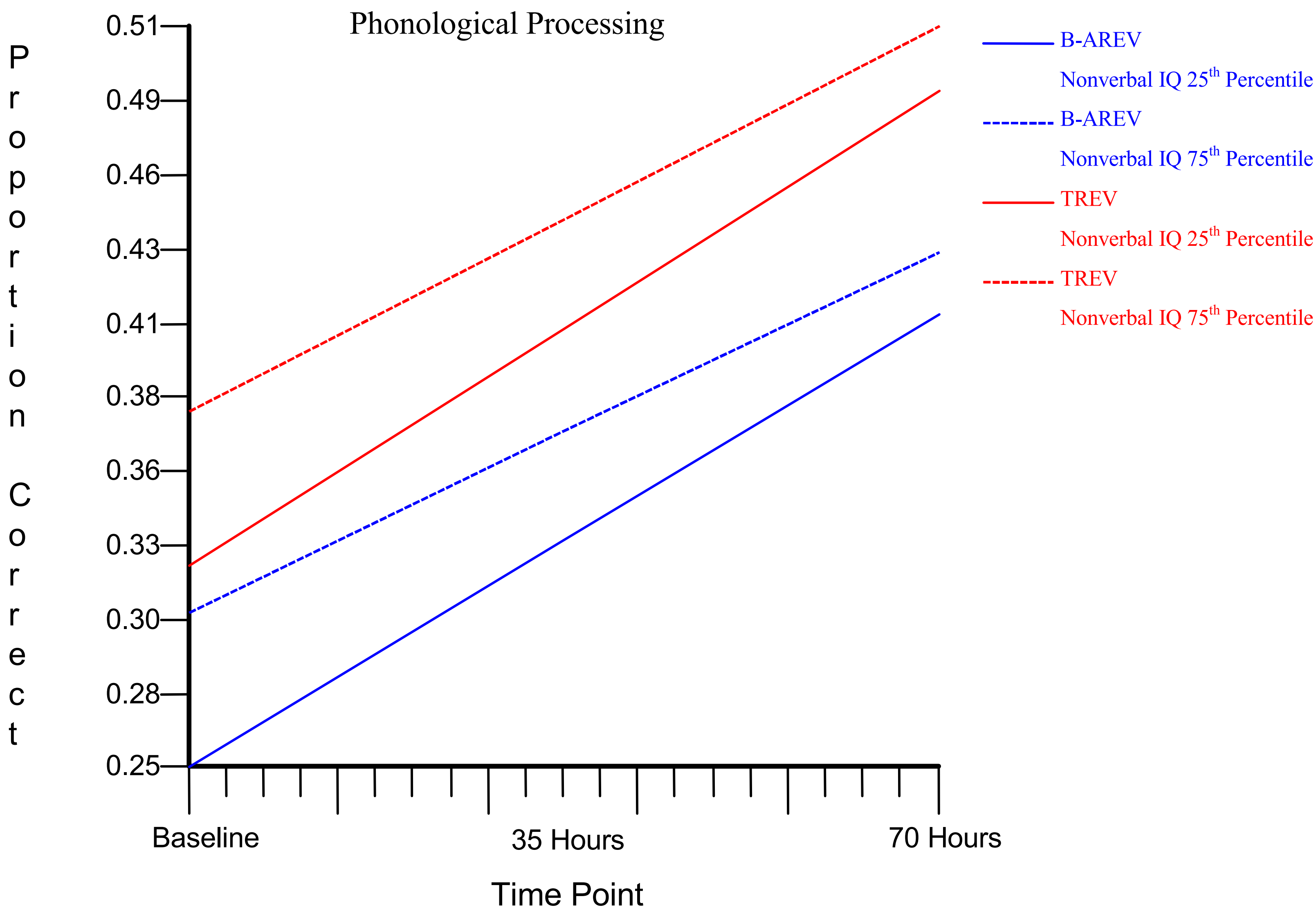


Table 16.
HLM Results for Listening Comprehension Groups Conducted with the Reading Intervention Group

Sound Symbol Identification Task				
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.01318	7.64	.000
	Non-verbal IQ	0.00566	4.66	.000
	SES	0.02842	2.53	.012
	Ethnicity	0.02192	1.93	.054
	Sex	-0.00930	-0.78	.435
	Listening Comprehension Group	0.02883	2.53	.024
	Age X Ethnicity	0.00472	2.95	.004
	Ethnicity X Sex	0.01953	1.97	.049
Slope				
	Age	-0.00056	-0.53	.597
	Non-verbal IQ	-0.0059	-1.09	.276
	SES	0.00078	0.14	.887
	Ethnicity	0.00548	1.02	.310
	Sex	-0.00270	-0.45	.649
	Listening Comprehension Group	0.00567	0.85	.395
	Age X Listening Comprehension Group	-0.00262	-2.66	.008

Phonological Processing				
	Predictor Variable	**Coefficient**	**t-ratio**	**p value**
Intercept				
	Age	0.00728	5.77	.000
	Non-verbal IQ	0.00338	4.18	.000
	SES	0.01642	2.08	.037
	Ethnicity	0.03482	4.45	.000
	Sex	0.00218	0.28	.783
	Listening Comprehension Group	0.02913	3.02	.003
	Age X Ethnicity	0.00268	2.17	.030
Slope				
	Age	-0.00171	-2.55	.011
	Non-verbal IQ	-0.00095	-2.17	.034
	SES	0.00211	0.54	.586
	Ethnicity	0.00063	0.17	.869
	Sex	-0.00308	-0.79	.428
	Listening Comprehension Group	0.00213	0.45	.655
	Non-Verbal IQ Listening Comprehension Group	0.00088	2.08	.038

the higher he/she scored on the SSI task. Similar results were seen with respect to nonverbal IQ. The higher a student's nonverbal IQ at the beginning of the study, the higher his/her performance on the SSI task. Results also indicated that students with an average SES classification evidenced significantly higher scores than students with a low SES classification. The final significant main effect indicated that student in the B-ALC group demonstrated significantly lower knowledge of grapheme/phoneme correspondences than students in the TLC group. With respect to ethnicity, Caucasians entered the study with higher scores than African Americans.

The interaction between age and ethnicity (see Figure 38) showed that older Caucasian students entered the study with higher scores on the SSI task than African American students. Younger Caucasian students, however, entered the study with lower SSI scores than older African American students. The significant ethnicity by sex interaction (see Figure 39) indicated that older African American students entered the study with similar scores on the SSI task compared to younger Caucasian students. Older Caucasian students evidenced the highest scores while younger African American students evidenced the lowest scores.

When predicting the slope intercept, a significant age by listening comprehension group interaction was found (see figure 40). This result indicated that younger students in the TLC group started the study with lower SSI scores than older students in the B-ALC group. By the 70 hour intervention time point, however, these two groups of students demonstrated comparable SSI scores.

Analyses in which PP skills were utilized as the individual level variable indicated that age, nonverbal IQ, SES, ethnicity, listening comprehension group, the age by ethnicity interaction were significant predictors of the intercept parameter (see Table 16). Results indicated that older children and children with higher nonverbal IQ scores entered the study with

Figure 38. Age by Ethnicity Interaction in the Intervention Group for Listening Comprehension Classifications

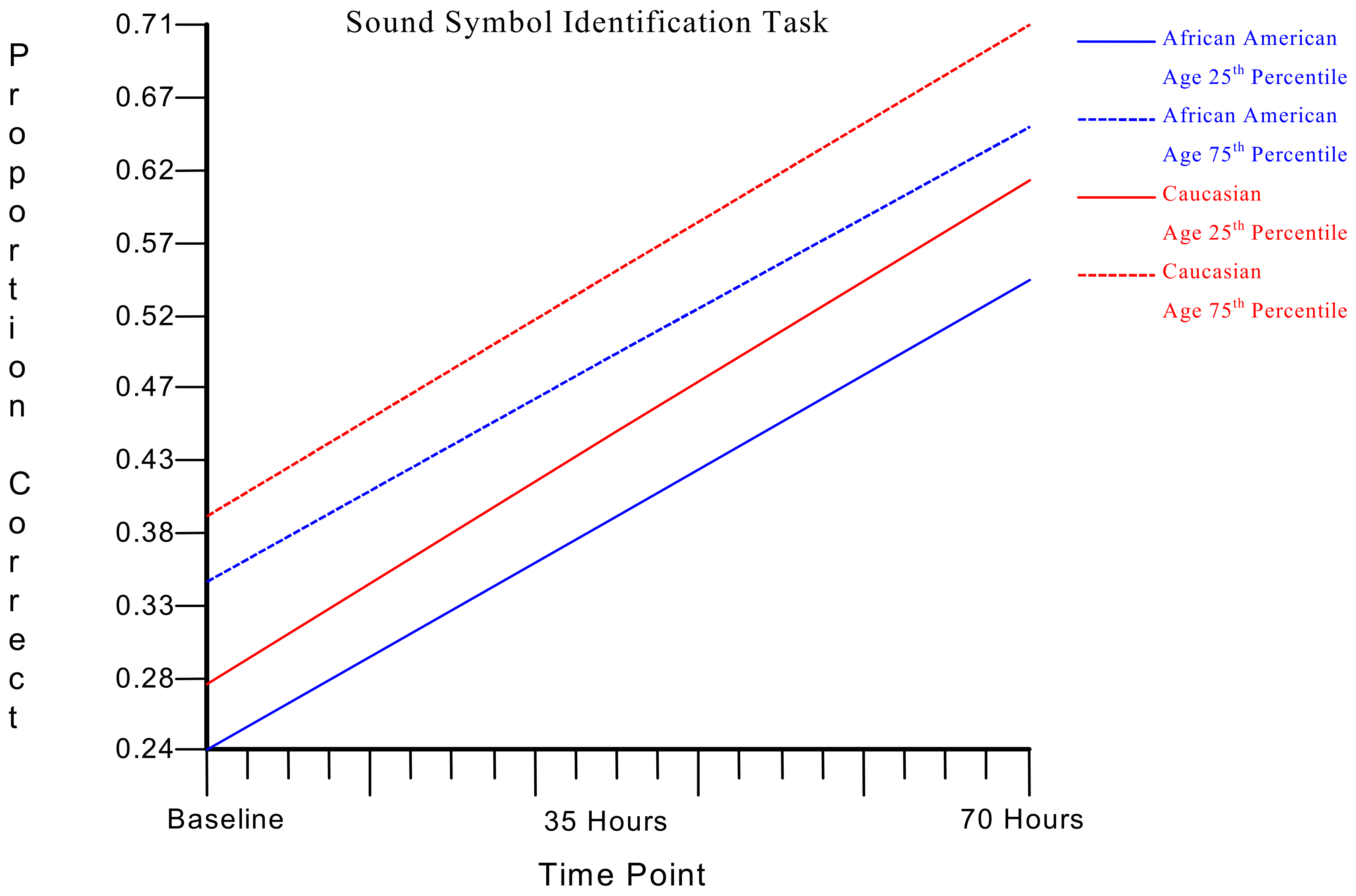


Figure 39. Ethnicity by Sex Interaction in the Intervention Group for Listening Comprehension Classifications

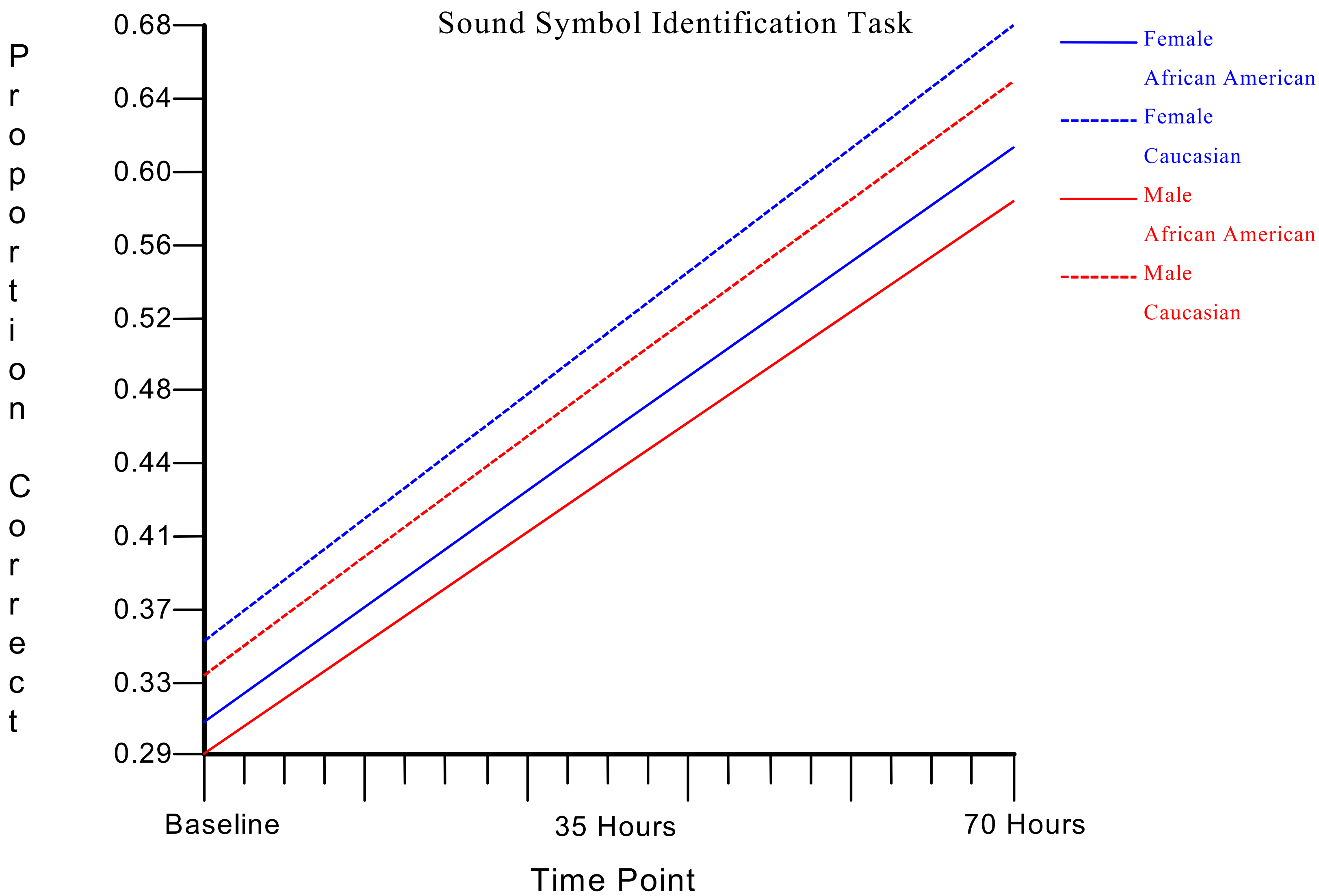
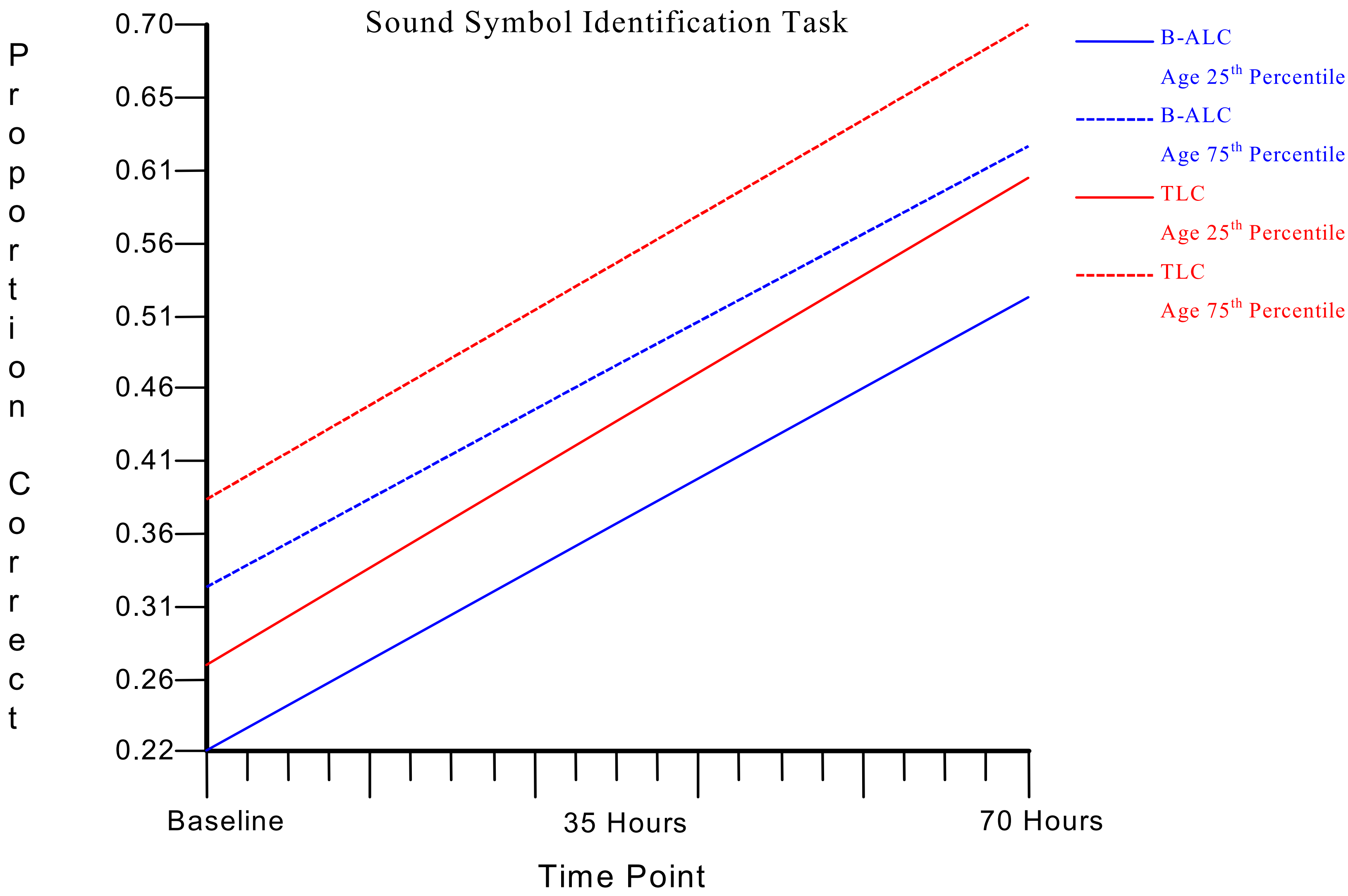


Figure 40. Age by Listening Comprehension Group Interaction in the Intervention Group



higher levels of PP skills. In addition, it was shown that children from a low SES home environment began the study with significantly lower levels of PP than children from an average SES home environment. Analyses also showed that African American children demonstrated significantly lower levels of PP than Caucasian children and that the children in the B-ALC group also demonstrated significantly lower levels of PP than children in the TLC group at the beginning of the study.

The significant age by ethnicity interaction (see Figure 41) suggested that younger Caucasian children and older African American children entered the study with similar levels of PP skills, while older Caucasian children evidenced the highest PP skills and younger African American children evidenced the lowest PP skills.

The only significant person-level predictors of the slope intercept were age and the nonverbal IQ by listening comprehension interaction. Results indicated that the older a child was upon entering the study, the slower they acquired PP skills (see Table 16).

The significant nonverbal IQ by listening comprehension group interaction (see Figure 42) indicated that students in the TLC with lower nonverbal IQ scores entered the study with PP skills similar to those evidenced by students in the B-ALC groups with higher nonverbal IQ scores. The students in the TLC group with lower nonverbal IQ scores, however, increased their levels of PP skills at a faster rate than students in the B-ALC group with higher nonverbal IQ scores. In addition, the students in the B-ALC group with lower nonverbal IQ scores increased their PP skills at a faster rate than students in the B-ALC group with higher nonverbal IQ scores.

Structural Equation Modeling

In order to examine the relationships that exist between different linguistic domains and different measures of reading achievement, Structural Equation Modeling (SEM) techniques

Figure 41. Age by Ethnicity Interaction in the Intervention Group for Listening Comprehension Classifications

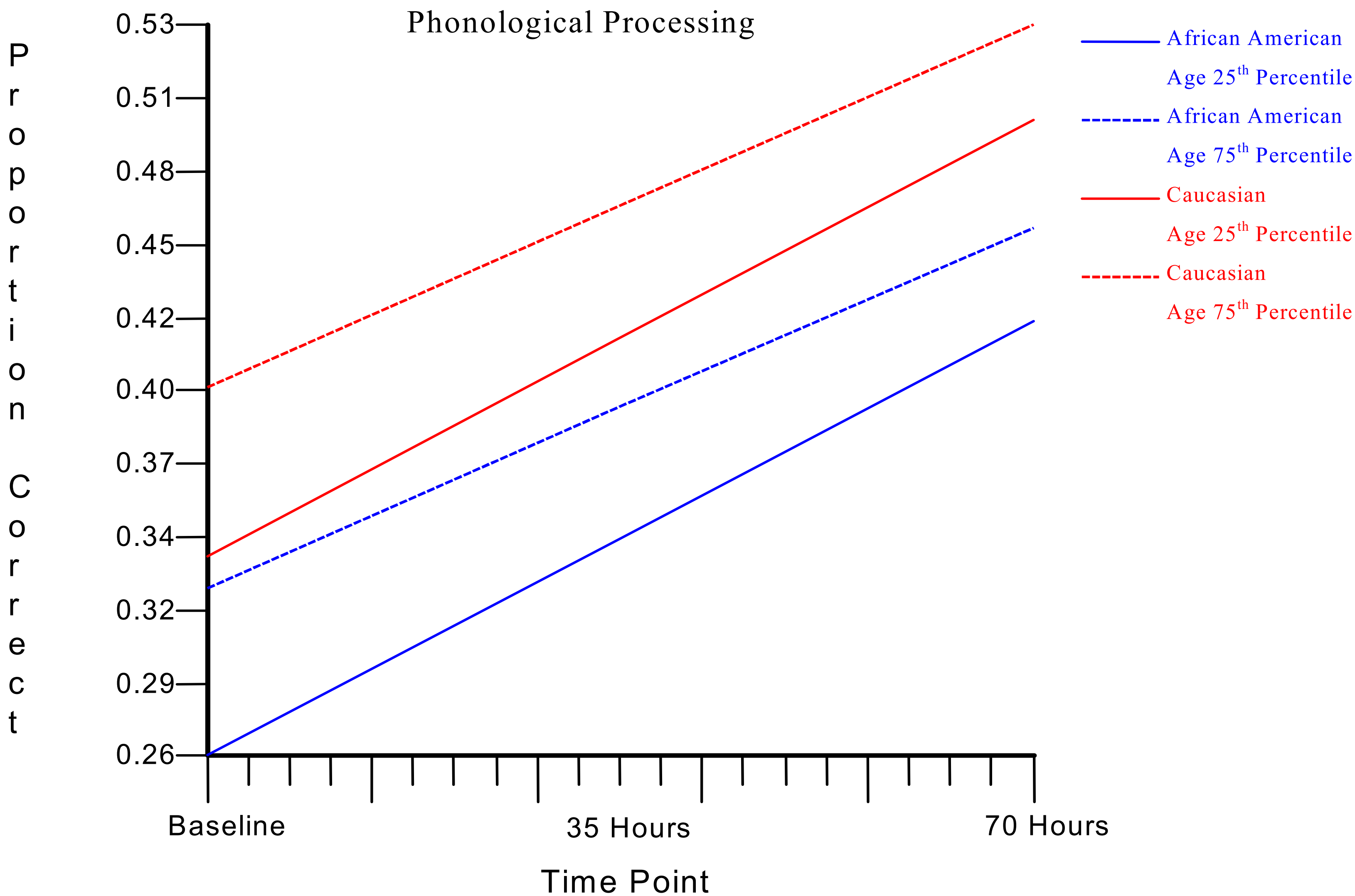
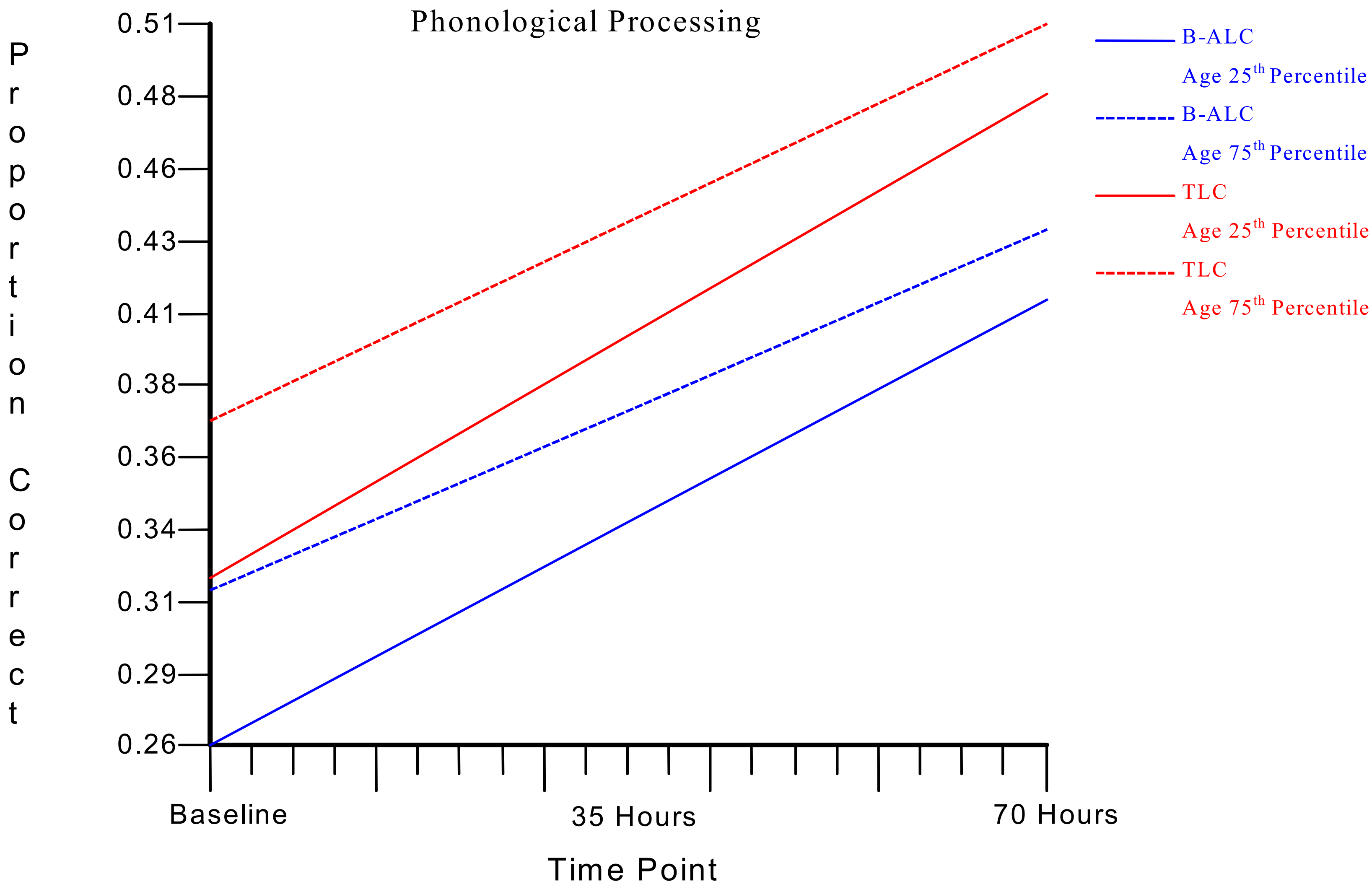


Figure 42. Nonverbal IQ by Listening Comprehension Group Interaction in the Intervention Group



were used. It was of interest to examine these relationships at both baseline and 70 hour intervention time points to determine whether these relationships change as children develop decoding skills. SEM analysis allows for the testing of proposed causal relationships among latent and observed variables through the use of hybrid models, which combine measurement models and path analysis models. Measurement models depict latent variables as represented by observed variables and path analysis models allow the specification of direct and indirect relationships among variables.

Guidelines put forth by Kline (1998) indicate that a minimum sample size of 100 is required to conduct path analyses and that a sample size greater than 200 is considered large. Complex models with large numbers of parameters, however, may require larger samples. Kline suggests the number of participants to parameter ratio should be 10:1 and should not fall below a ratio of 5:1. These restrictions allowed for the testing of a longitudinal model that assessed the relationship between linguistic measures and reading related skills at the baseline time point and after 70 hours of reading intervention efforts.

The longitudinal model was analyzed with the 211 students who participated in a reading intervention program during their first year of participation in the study. It was decided that the below average and typical linguistic groups should be collapsed into one group for the SEM analyses. This decision to combine the typical language group and below-average language group for the SEM analyses was based on two reasons. First, while the strength of the proposed relationships among language measures and reading measures may be weaker in the below-average language groups, the overall pattern of the relationships was not expected to differ from the typical language groups. Second, examining the hypothesized relationships among the different linguistic domains and aspects of reading achievement separately for the two language

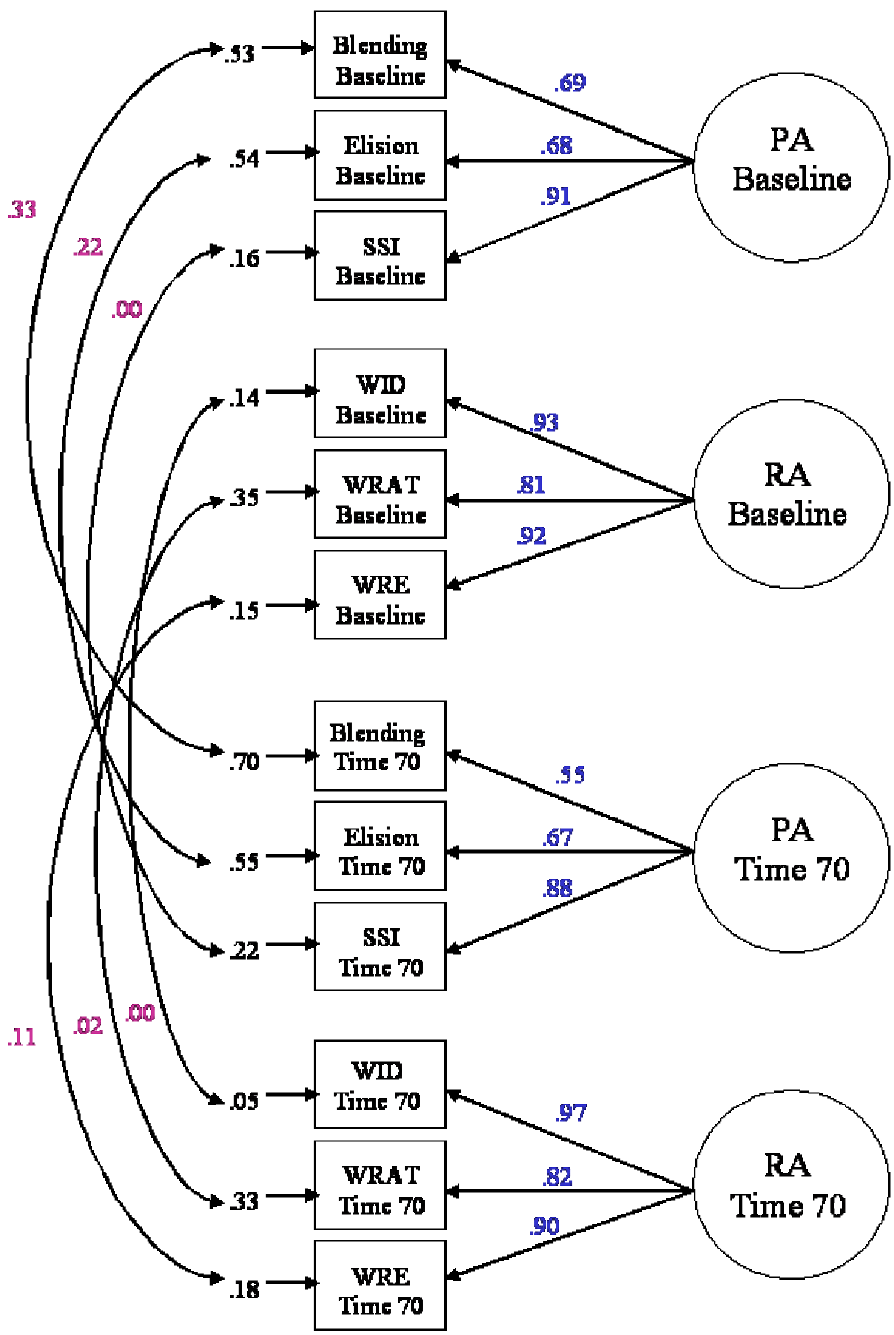
groups resulted in a participant to parameter ratio too low to warrant SEM analyses. SEM analyses were conducted using LISREL 8 Structural Equation Modeling software.

Measurement Models

The first step in the SEM analyses involved assessing the fit of a measurement model that included the latent variables of PA and reading accuracy (RA) at the baseline and 70 hour instruction time points (see Figure 43). The latent variable PA was represented by the Blending and Elision subtests of the CTRRPP and a composite score of the four subtests comprising the SSI task. A composite score of the SSI task was utilized because this increased statistical power by reducing the parameter to participant ratio. In addition, it was thought that a composite measure would be a more reliable indicator of a student's knowledge of grapheme/phoneme relationships. Because previous analyses conducted with the intervention group did not indicate that the SSI task and subtests of the CTRRP were differentially related to linguistic skill, it was decided that these assessment measures could be used to represent the same underlying construct of PA. In addition, adding a third indicator of PA made the measurement model more reliable.

The Word Reading Efficiency subtest of the CTRRPP, the Reading subtest of the WRAT-3, and the Word Identification subtest of the WRMT-R served as the indicators of RA. This measurement model fit the data well, χ^2 (42, n = 185) = 117.98, $p < .05$, NFI of .94, NNFI of .94, CFI of .96, and SRMR of .062. According to Kline (1998), because the Chi-square statistic is sensitive to sample size, an alternative fit index, the Chi-square/degree of freedom ratio, may be used instead of the Chi-square statistic itself. A Chi-square/degrees of freedom ratio below three is generally considered acceptable. Therefore, although the Chi-square value for the measurement model was significant, the Chi-square/degrees of freedom ratio was less than three ($\chi^2/df = 2.81$) and indicated a good fit for the data.

Figure 43.
Measurement Model 1

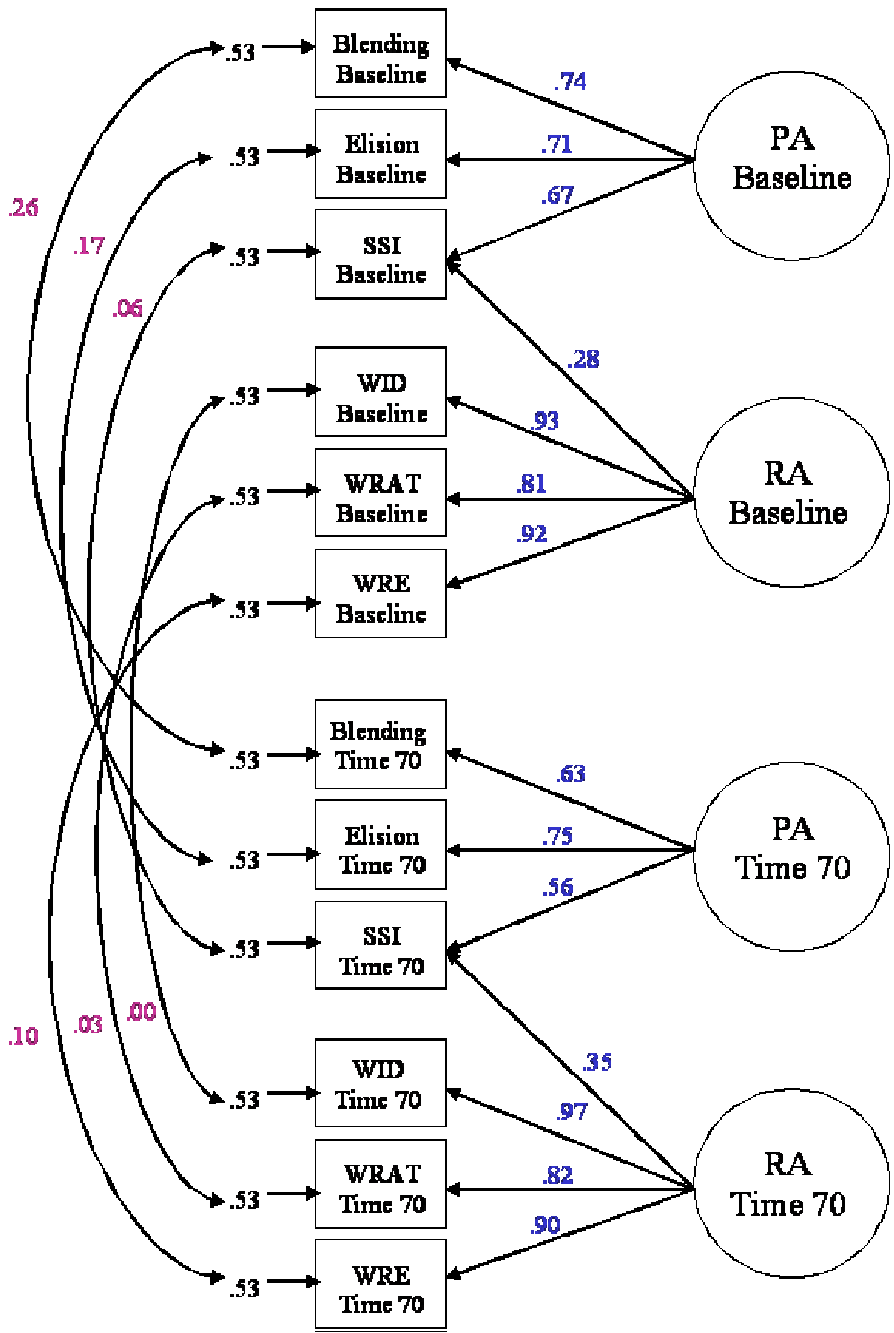


Although this model fit the data well, an alternative measurement model was tested (see Figure 44). For this measurement model a complex loading was tested in which the SSI task was an indicator of both PA and RA latent variables. This model was proposed in part because the original measurement model indicated that the SSI task was the most reliable indicator of PA ($r^2 = .83$) while at the same time indicating that the Blending and Elision variables were only moderate indicators of PA ($r^2 = .47$ and $r^2 = .46$, respectively). In addition, the Blending and Elision tasks are purely auditory in nature, while the SSI task possesses an orthographic component. Thus, it was hypothesized that the SSI task would load on both PA and RA latent variables. This alternative measurement model also fit the data well, χ^2 (40, n = 185) = 100.18, $p < .05$, $\chi^2/df = 2.50$, NFI of .95, NNFI of .95, CFI of .97, and SRMR of .057. In addition, this measurement model fit significantly better than the original measurement model, $\chi^2_{difference}$ (2, n = 185) = 17.80, $p < .05$. Therefore, based on theory and model fit indices, it was decided that the alternative measurement model would be used for all subsequent SEM analyses assessing the relationships that exist between linguistic skill, PA, and reading achievement.

Hybrid Models

A number of longitudinal models were tested that depicted the hypothesized relationships thought to exist between working memory, linguistic skill (i.e., receptive vocabulary, expressive vocabulary, and listening compression skills), PA, and reading achievement. Models which included paths from measures of linguistic skill to measures of reading comprehension did not fit the data well and did not produce significant paths as assessed by t-values ($p > .05$). Based on these findings, more simplistic models assessing the relationships that existed between measures of semantic knowledge, PA, and RA were tested. Not only did this produce more parsimonious

Figure 44.
Measurement Model 2



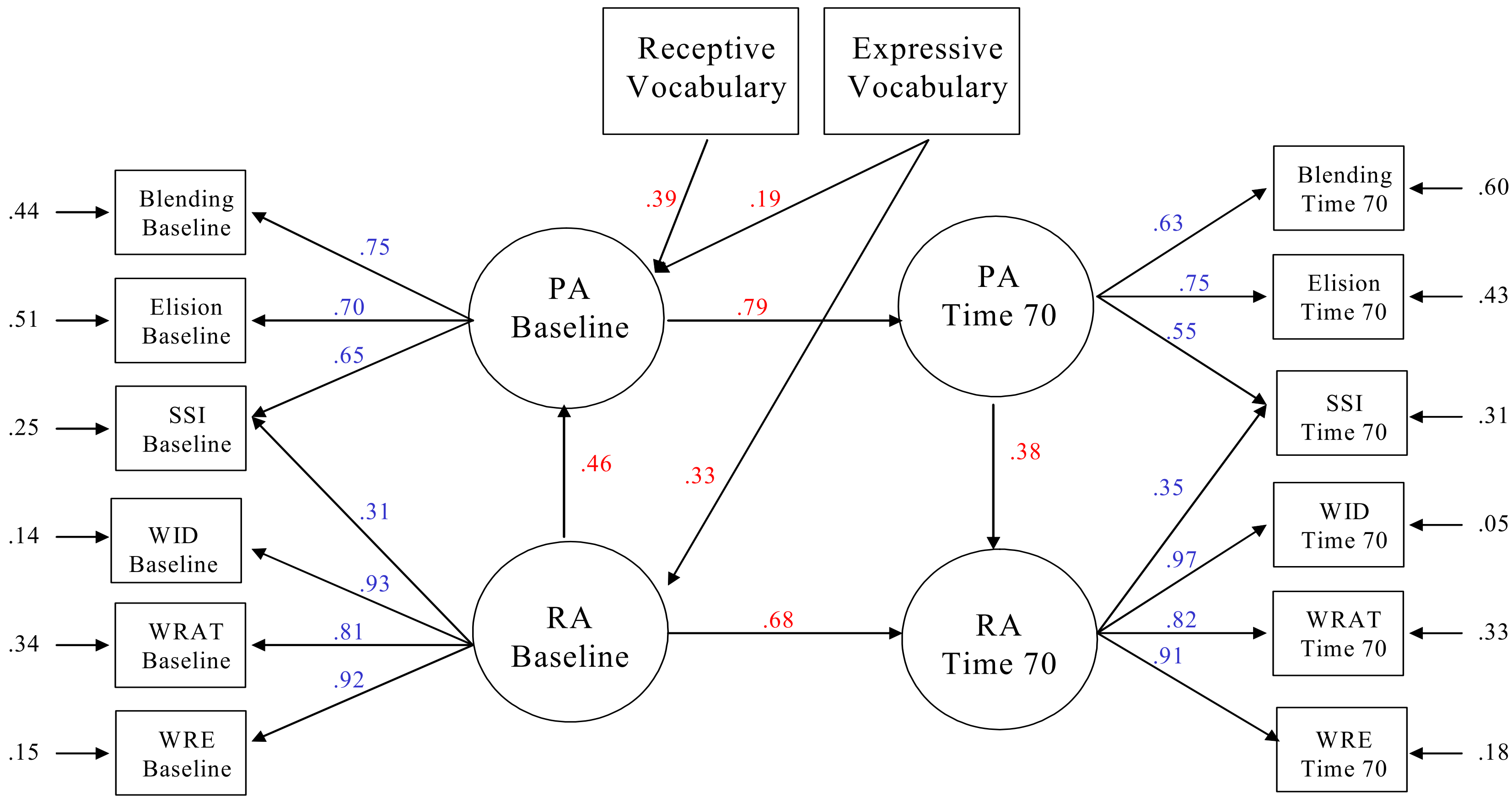
models, but also it served to increase statistical power by reducing the parameter to participant ratio.

A number of models were tested that depicted the potential relationships that exist between semantic knowledge and PA and word RA, however, only three theoretically meaningful models will be discussed. The selection of these models was based on theory, SEM fit indices, Chi-square difference analyses between competing nested models, and the rule of parsimony. All path coefficients reported are standardized values. In addition, all reported significant paths were assessed by t-values ($p < .05$).

The first model (see Figure 45), was a good fit for the data, χ^2 (63, n = 185) = 134.36, $p < .05$, $\chi^2/df = 2.13$, NFI of .94, NNFI of .95, CFI of .96, and SRMR of .056. Not surprisingly, the path between PA skill at the baseline time point and PA skill at the 70 hour intervention time point (.79) was strong and significant. Similarly, the path between RA skill at the baseline time point and RA skill at the 70 hour intervention time point (.68) was strong and significant. The nature of the relationship between PA skills and RA, however, appeared to change over time. Specifically, at the baseline time point, a path from RA to PA skill was strong and significant (.46). At the 70 hour intervention time point, however, a reverse relationship was seen with a path from PA skill to RA (.38) being strong and significant. The results suggest that at the baseline time point, RA was influencing PA skill, while at the 70 hour intervention time point, PA skill was influencing RA.

Of particular interest in this model is the fact that both receptive and expressive language domains were shown to have independent and significant paths to PA skill at the baseline time point (.39 and .19, respectively). Only expressive vocabulary, however, was shown to have a significant relationship with RA at the baseline time point (.33).

Figure 45.
Hybrid Model 1



A second model (see Figure 46) that eliminated the path between expressive vocabulary and the latent variable of RA at the baseline time point also was assessed for goodness of fit. This model provided a good fit for the data, χ^2 (64, n = 185) = 142.71, p < .05, χ^2/df = 2.23, NFI of .93, NNFI of .95, CFI of .96, and SRMR of .061. The model, however, fit significantly worse than the first model, $\chi^2_{difference}$ (1, n = 185) = 8.35, p <. 05, and was therefore not chosen for interpretation over the first model.

The third model (see Figure 47) eliminated the path from expressive vocabulary to PA skill at the baseline time point, but preserved the path from expressive vocabulary to RA at the baseline time point. The model fit the data well, χ^2 (64, n = 185) = 142.71, p < .05, χ^2/df = 2.23, NFI of .93, NNFI of .95, CFI of .96, and SRMR of .061. As with the second model, however, the paths proposed in this model reduced model fit significantly when compared to the original model, $\chi^2_{difference}$ (1, n = 185) = 8.86, p <. 05. This model also was rejected for interpretation because of this significant reduction in fit.

The final model discussed (see Figure 48), added a path from receptive vocabulary to RA at the baseline time point. This model evidenced good fit indices, χ^2 (62, n = 185) = 134.76, p < .05, χ^2/df = 2.17, NFI of .94, NNFI of .95, CFI of .96, and SRMR of .056. The added path from receptive vocabulary to RA at the baseline time point was essentially zero (.03). Therefore, this model did not differ significantly from the original model, $\chi^2_{difference}$ (1, n = 185) = 0.40, p >. 05, and the original model was retained for interpretation based on the rule of parsimony.

Figure 46.
Hybrid Model 2

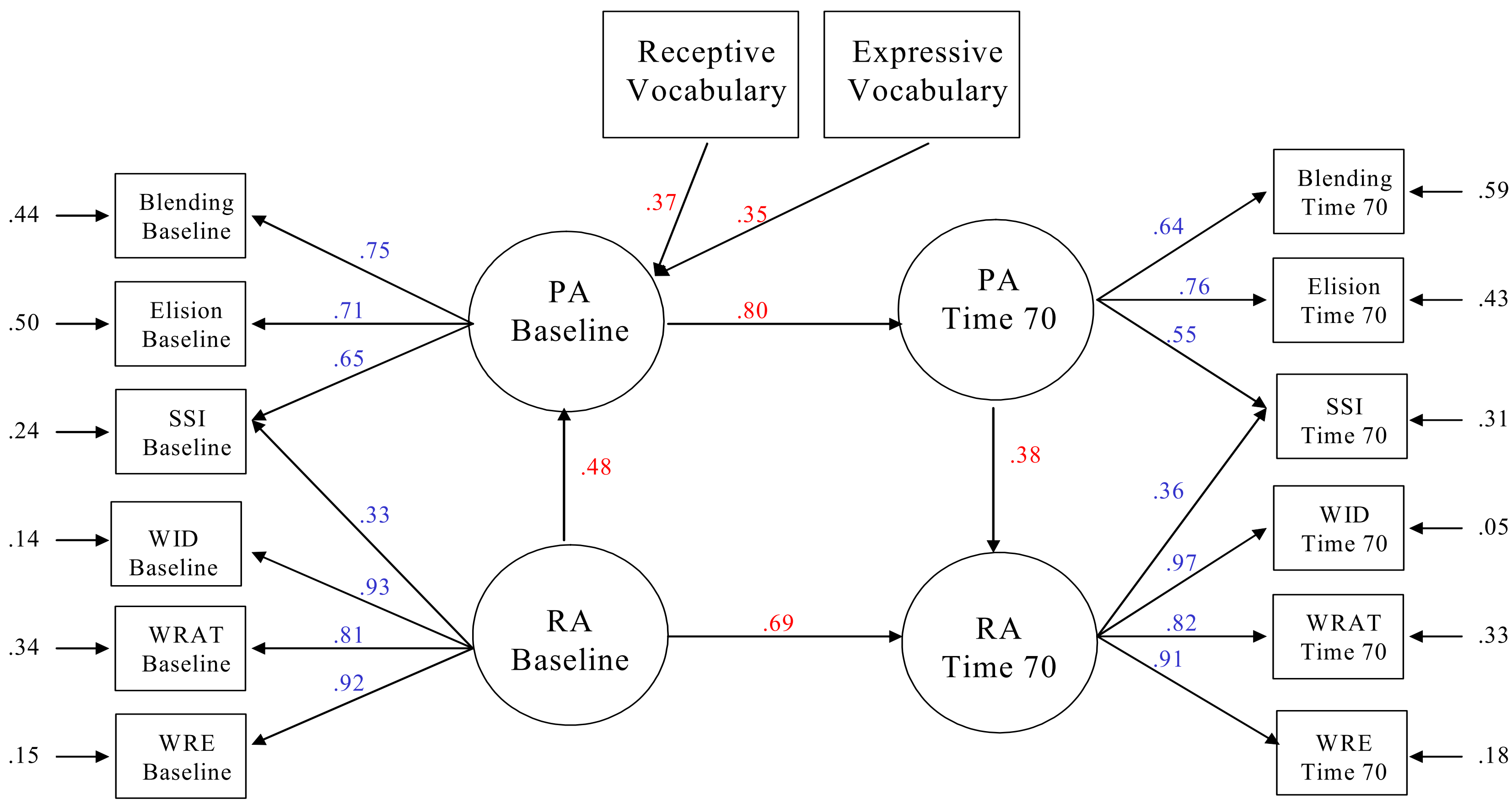


Figure 47.
Hybrid Model 3

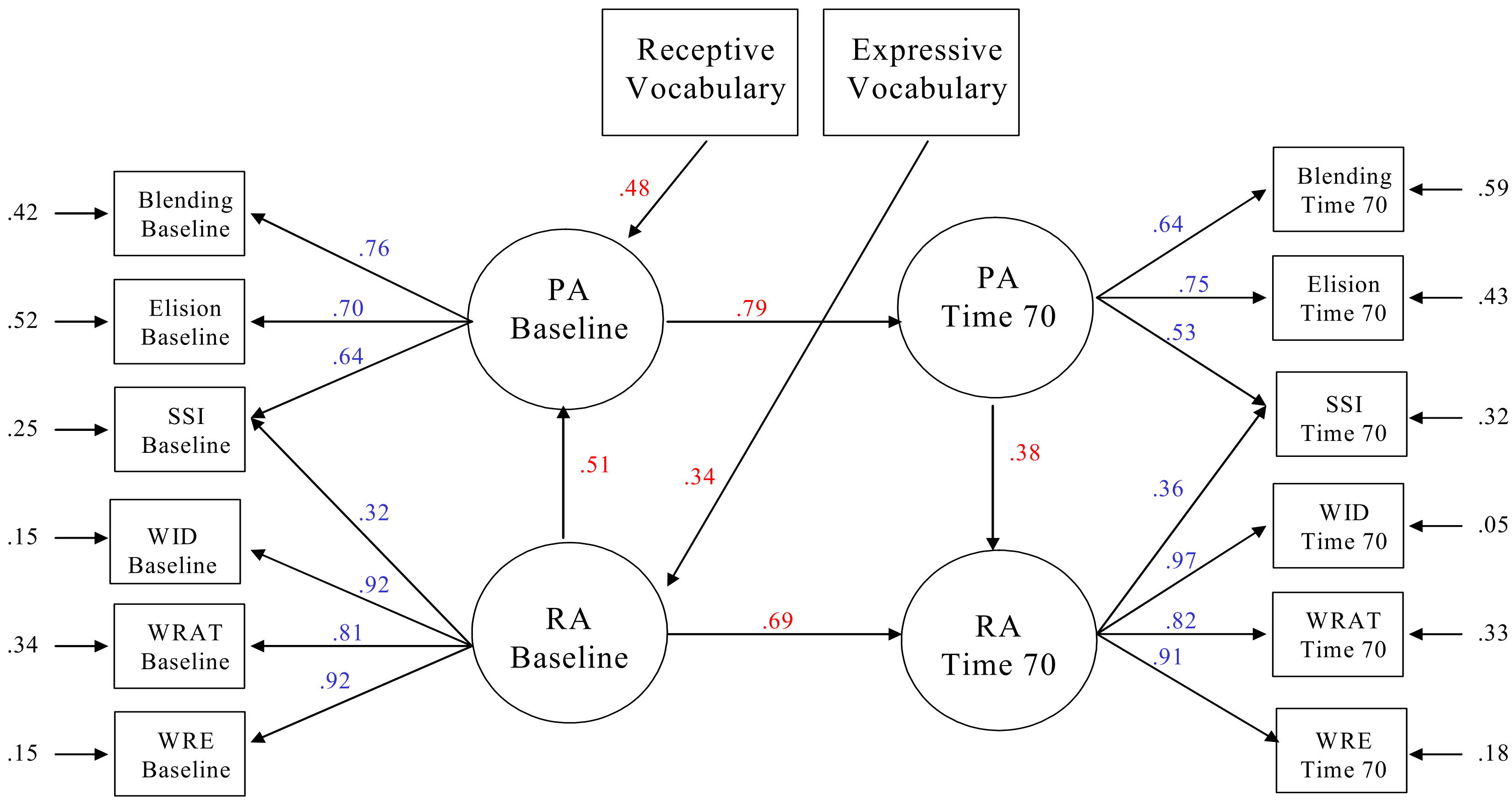
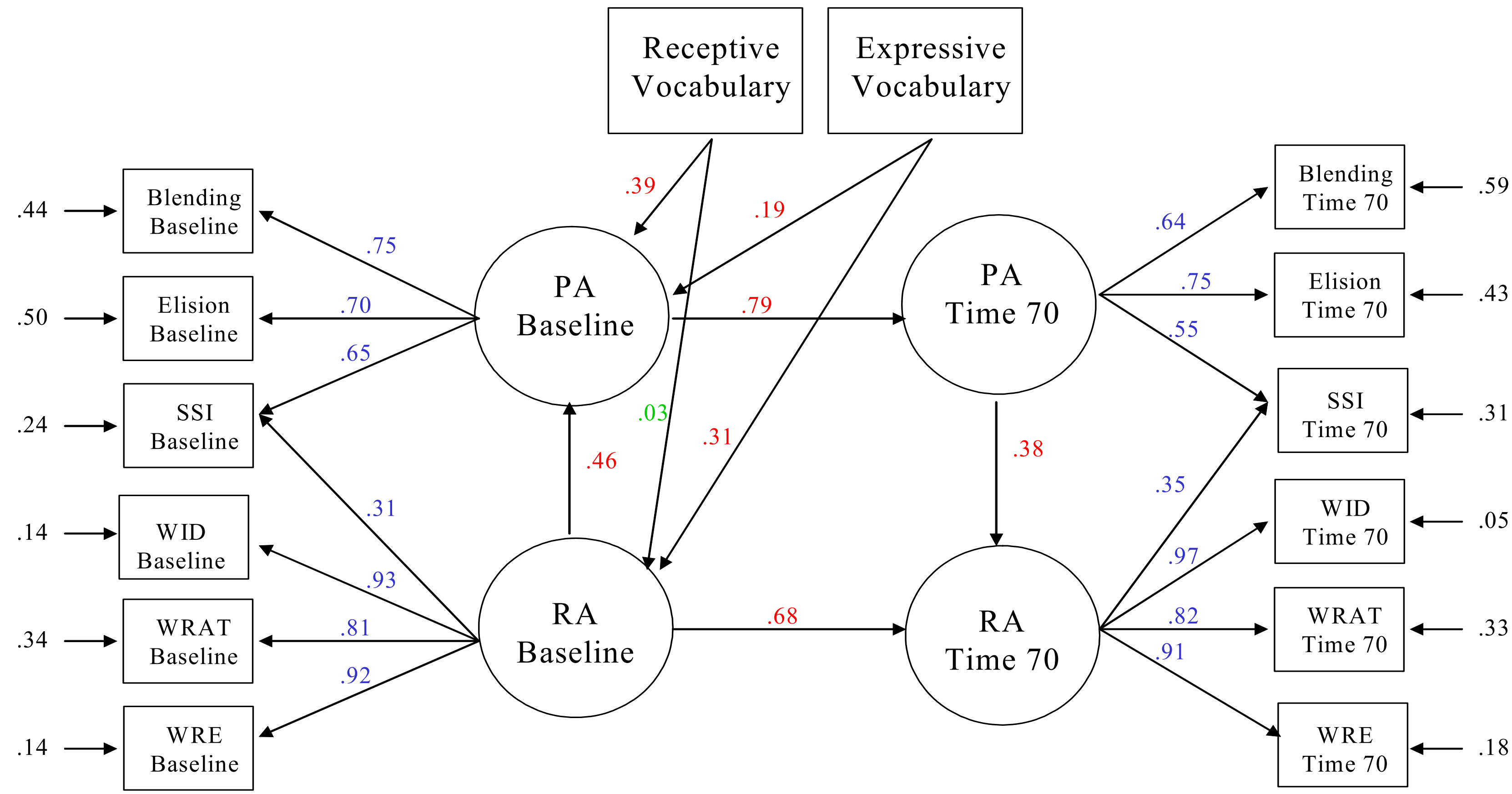


Figure 48.
Hybrid Model 4



Discussion

Results of the study will be discussed in three sections. Each section addresses one of the study's purposes and the hypotheses associated with each. For a summary of results, see Table 17.

Growth of PA Skills and Linguistic Ability

The primary purpose of this study was to examine the growth of PA skills in response to reading intervention by children with RD who evidence discrepant language abilities. According to the LRM proposed by Metsala and Walley (1998), children move from holistic representations of words, to syllabic representations, and finally to phonemic representations through a restructuring process that is driven by their lexical base. The LRM, therefore, provided for the generation of a number of hypotheses concerning the relationship between linguistic ability and the acquisition of PA.

Receptive vocabulary skills were considered to be most closely associated with the lexical base proposed by the LRM and to drive the development of PA skills. It was hypothesized, therefore, that children with below-average receptive vocabulary skills would evidence significantly lower levels of PA than children with typical receptive vocabulary skills. Further, it was hypothesized that below-average linguistic classifications created with expressive vocabulary and listening comprehension criteria also would be associated with significantly lower PA skills than typical linguistic classifications created with expressive vocabulary and

Table 17.
Summary of Results

Relationship Between Linguistic Ability and PA

Repeated Measures Analysis of Co-variance (ANCOVA)

- For both the control and intervention groups, the B-AL group evidenced significantly lower PA skills than the TL group across all linguistic classifications
- Analyses did not reveal a significant linguistic group X time point interaction

Hierarchical Linear Modeling (HLM)

- For both the control and intervention groups, the B-AL group evidenced significantly lower PA skills than the TL group across all linguistic classifications
- Analyses did not indicate that either linguistic classification was a significant predictor of the rate of growth of PA skills

Grapheme/phoneme correspondence knowledge versus phonological processing skills

- With one exception, ANCOVA and HLM analyses indicated the relationship between oral language skills and PA skills remains consistent across different conceptualizations of PA
    - In the control group, knowledge of grapheme/phoneme correspondences did not increase significantly over time; however, phonological processing skills did increase significantly over time

Relationship Between Different Domains of Language and Different Aspects of Reading Achievement

Structural Equation Modeling (SEM)

- Receptive vocabulary and expressive vocabulary knowledge showed independent contributions to PA skills
- Only expressive vocabulary knowledge was shown to enter into a relationship with word identification skills
- No evidence was found to indicate that listening comprehension skills were related to reading comprehension at either baseline or 70 hour intervention time points

listening comprehension criteria. This hypothesis was based on the fact that expressive vocabulary and listening comprehension skills are heavily dependent on receptive vocabulary skills.

Results were largely consistent across control and intervention groups and supported the study's hypotheses. It was found that children classified with below-average receptive language skills exhibited significantly lower levels of knowledge of grapheme/phoneme correspondences and PP than children with typical receptive language skills; however, these results also were seen when linguistic classifications were made using measures of expressive vocabulary and listening comprehension skills. These results can be explained, in part, by the fact that the majority of children classified into below-average linguistic groups based on measures of expressive vocabulary or listening comprehension skills also evidenced below-average receptive vocabulary skills. In addition, because expressive vocabulary skills and listening comprehension skills are heavily reliant on receptive vocabulary knowledge, the significant differences found between linguistic groups based on these measures may have been driven by the inclusion of children with below-average receptive vocabulary skills.

Some exceptions to this pattern of results were evidenced in the analyses. In the control group, ANCOVA analyses indicated that when time points were collapsed, expressive vocabulary groups did not differ significantly with respect to letter/sound knowledge or levels of PP. In contrast, significant differences were found between expressive vocabulary groups for both measures of PA skills in analyses conducted with the intervention group. Why differential findings between the control and intervention groups emerged is not clear. It can be speculated, however, to be a result of the large variability in PA skills evidenced by the two vocabulary

groups. Because a large degree of overlap in performance was seen between the vocabulary groups, there may not have been sufficient power to detect significant differences.

The HLM analyses conducted with the control group were relatively consistent with ANCOVA analyses and indicated that the expressive vocabulary groups did not differ significantly in their performance on the SSI task, but did differ significantly with respect to PP skills. This lack of significant differences between linguistic groups' performance on the SSI task also was seen with receptive/expressive vocabulary classifications. A significant nonverbal IQ by linguistic group interaction (discussed in more detail below), however, was evidenced that could account for the inability to detect significant differences between vocabulary groups.

Despite failing to find significant results between linguistic groups in some analyses, overall, results supported the study's hypotheses and were largely consistent with previous research that has indicated that oral language skills are related to reading ability, and in particular with PA (e.g. Cooper, Roth, Speece, and Schatschneider, 2002; Dickinson, et al., 2003; Olofsson and Niedersoe, 1999; Scarborough, 1990; Storch and Whitehurst, 2002).

One finding that has not been reported in the literature was the interaction between linguistic classification and nonverbal IQ with respect to knowledge of grapheme/phoneme correspondences in the control group. This interaction was present among all linguistic classifications and indicated that students evidencing higher nonverbal IQ scores with a below-average linguistic classification entered the study with SSI scores that were similar to those children with lower nonverbal IQ scores with a typical linguistic classification. Children with higher nonverbal IQ scores with a typical linguistic classification entered the study with the highest scores on the SSI task and children with lower nonverbal IQ scores with a below-average linguistic classification entered the study with the lowest scores.

One conclusion suggested by these results is that children with higher nonverbal IQ scores are better at establishing grapheme/phoneme correspondences. A student with a linguistic deficit who has a higher nonverbal IQ, therefore, would be able compensate for their linguistic disadvantage in creating grapheme/phoneme correspondences with an increased ability to make conceptual links between phonetic elements of speech and arbitrary written symbols.

Interestingly, however, this interaction between entering levels of nonverbal IQ and linguistic ability was not seen in the sample of children who received a reading intervention. In addition, a linguistic classification by nonverbal IQ interaction was not found for PP skills for either the control group or intervention group. These findings tend to suggest that the interaction between nonverbal IQ and linguistic classification evidenced with the control group on the SSI task is confined to this relatively small group of students and may not accurately represent children with RD as a whole. In addition, these findings are not consistent with the extant literature that indicates IQ is unrelated to decoding skills (e.g., Francis, et al., 1994; Stanovich, 1988; Stuebing et al., 2002). Most studies however, have looked at the relationship between decoding skills and a composite measure of IQ that assesses both verbal and nonverbal skills. The finding that nonverbal IQ is influential in creating grapheme/phoneme correspondences, therefore, cannot be completely discounted.

Associated with the primary purpose of this study, based on the LRM (Metsala & Walley, 1998), it also was hypothesized that children with below-average receptive vocabulary skills would acquire PA skills at a slower rate than children with typical receptive vocabulary skills. Both ANCOVA and HLM analyses provided little support for this hypothesis. There was one exception to these findings. In the ANCOVA analyses conducted with the control group, students classified into the B-ARV group were shown to increase their knowledge of

grapheme/phoneme relationships at a slower rate than children in the TRV. This finding suggests that a student's receptive vocabulary skill positively influenced the development of PA skills. This single finding, however, is in contrast with a number of other findings and should be interpreted with caution.

Analyses concerning differences in the rate of acquisition of PA skills with respect to the other linguistic classifications were more exploratory in nature and thus, were not associated with any firm hypotheses. ANCOVA and HLM analyses conducted with the other linguistic classifications failed to reveal a significant linguistic group by time interaction for both control and intervention groups. The only exception in these analyses was the finding that with the intervention group, students in the B-AEV vocabulary group evidenced slower acquisition of grapheme/phoneme correspondences than students in the TEV group. This finding, however, did not reach conventional levels of significance ($p < .05$) and was in contrast to a number of other findings.

Overall, results concerning the relationship between linguistic classification and development of PA skills indicated that students with a below-average linguistic classification acquired PA skills at a similar rate as these students with a typical linguistic classification. This study, therefore, found little support to indicate that a child's lexical base influences the development of PA skills.

Findings concerning levels of PA skills and rate of acquisition of PA skills with respect to linguistic ability supported previous research that has suggested oral language skills are related to PA skills. Results provided little support, however, for the idea that elevated linguistic skills will foster more rapid acquisition of PA skills.

These results, however, do not completely discount the validity of the LRM. Research has indicated that children with RD represent the lower end of a normal distribution of reading ability and are not a distinct group (Shaywitz, Escobar, Shaywitz, Fletcher, & Maruch, 1992). Thus, if a linear relationship exists between linguistic skill and PA skills, it would be possible to find significant differences between typical and below-average linguistic skills groups without also finding that linguistic skill differentially affects the rate of development of PA skills with respect to discrepant language groups.

It must remain at the forefront of this discussion, however, that all children in this study were classified with RD and some children in the typical linguistic groups evidenced poor PA skills. It is possible, therefore, for children to possess average or even above average linguistic skill and still evidence a deficit in PA. In addition, there was substantial overlap in performance on PA tasks between below-average and typical linguistic group classification. Subsequently, a number of students with a below-average linguistic classification evidenced PA skills comparable to students with a typical linguistic classification. In addition, a number of students with a typical linguistic classification evidenced levels of PA that were similar to students with a below-average linguistic classification. Taken together, these two points suggest that something other than, or in addition to, linguistic skill may be driving the development of PA skills.

An alternative explanation for why the presence of a linguistic deficit is associated with a classification of RD is that poor linguistic ability serves as a risk factor for developing poor PA skills. This is consistent with research conducted with children with SLI that has indicated linguistic deficits increase a child's risk of being classified with RD when compared to children who possess typical linguistic skills (e.g., Aram, Ekelman, & Nation, 1984; Bishop & Adams, 1990; Goulandris et al., 2000). This idea is in line with McArthur et al.'s (2000) suggestion that

that a language impaired-reading impaired RD subtype should be considered for classification. Following from this, an implication of these findings is that early linguistic ability may help to identify children at-risk for developing RD at a time before children begin to read or are able to perform PA tasks. Thus, children evidencing early linguistic difficulties can be identified and measures can be taken to address potential reading difficulties before the child falls behind in the school setting.

Specific factors that drive the development of PA remain unclear. One possibility not examined in this study, is that PA is based a child's ability to effectively and efficiently perceive speech. Previous studies have shown that a child's ability to make discriminations between phonemic elements of speech is related to his/her reading ability (e.g., Tallal, 1980).

Many researchers believe there is an experiential basis for speech perception and argue that exposure to speech stimuli will subsequently influence the development of representations of the phonological categories defined by a particular language (e.g., Best, 1994; Kuhl, 1992). A number of studies have supported this argument (e.g., Best, 1994; Jusczyk et al., 1993; Kuhl and Miller, 1978; Mehler et al. 1988; Werker & Desjardins, 1995) and results from these studies suggest that the structural patterns found in the distributions of sounds in words are available to humans at birth. It is not until later in development that the human speech perception system begins to integrate and process the phonetic elements of speech that map onto the statistical properties of speech. Children who are able to develop well-defined phonological representations will, as a result, be able to manipulate the speech stream more effectively than children with poorly defined phonological representations. In addition, these children will be able to develop grapheme/phoneme correspondences with more ease than children with poorly

defined phonological representations. Both of these advantages would lead to successful reading achievement.

In support of this, a recent longitudinal study by Tsao, Liu, and Kuhl, (2004), found that infants ability to discriminate between computer-synthesized vowels at 6 months of age predicted language abilities at 13, 16, and 24 months. These results support the contention that early speech perception abilities will dictate the integrity of the phonological representations created by an individual. Further, these representations importantly will influence later language development and development of PA skills. Tsao et al. (2004) argue that these findings suggest that it is a child's acoustic system that is governing their early speech perception abilities. Results such as these, however, are correlational in nature and do not provide causal evidence that acoustic perceptual abilities are responsible for the formation of phonological representations and later language abilities.

It also can be argued that the formation of phonological representations is not dictated by acoustic perceptual abilities per se. Instead, the formation of phonological representations may be psychological in nature and are not due to the processing of the speech steam by the auditory system (Best, 1994; Kuhl, 1992). The creation of these phonological representations, therefore, is influenced by exposure to, and experience with, the surrounding environment. It is the interaction, however, of this experience with the constraints of the developing system that will determine the acquisition of a particular skill or behavior (Elman et al., 1997).

In support of an interaction between genes and environment, research has indicated that both environmental and genetic factors are implicated in the origins of developmental RD (e.g., Vellutino et al., 1996; Whitehurst & Lonnigan, 1998). This interaction of genetic and environmental factors makes it difficult to discern the true nature of the development of PA

skills. It also provides for the potential that an impoverished speech or literacy environment can exacerbate an impairment that is organic in nature.

For example, previous research has reported that children from low SES backgrounds are at risk for developing RD when compared to children from average or above-average SES households (Whitehurst & Lonigan, 1998). Further, children from impoverished backgrounds have been found to demonstrate linguistic deficits when compared to children who come from financially stable households (Whitehurst, 1997). Subsequently, PA and linguistic deficits seen in children with RD may be a result of common environmental factors. Associations between linguistic and PA skills, therefore, may arise because the same risk factors for developing RD also impact the development of oral language skills. Thus, increased linguistic ability may help to establish PA by providing anchors onto which phonological representations map. In addition, increased PA may facilitate the acquisition and production of language because of increased automaticity and fluency of encoding and retrieval of linguistic elements.

Support for environmental influences on the acquisition of PA skills was evidenced in the HLM analyses conducted with the intervention group. Analyses indicated that students from a low SES household entered the study with lower knowledge of grapheme/phoneme correspondences than students from an average SES household. In addition, HLM analyses conducted with the control group indicated that students from a low SES household acquired PP skills at a slower rate than students from an average SES household. This finding indicates that without intervention efforts, low SES students with RD will continue to fall farther behind their peers at a faster rate than average SES students with RD.

A somewhat surprising finding concerning the influence of environmental factors was the SES by nonverbal IQ interaction evidenced by the control group that indicated nonverbal IQ may

serve as a protective factor for low SES students. Specifically, this interaction showed that upon entering the study, low SES students with higher nonverbal IQ scores were more similar in their knowledge of grapheme/phoneme correspondences to average SES students with higher nonverbal IQ scores than low SES students with lower nonverbal IQ scores. These results suggest that students with higher nonverbal IQ scores were more proficient at making a symbolic pairing of a speech sound with an orthographic pattern. Again, however, these results are not consistent with the majority of research conducted with children with RD that has indicated IQ is unrelated to core reading-related skills such as PA. In addition, this interaction was not replicated with students in the intervention group and may be a function of the make-up of the relatively small control group.

Grapheme/Phoneme Correspondence Knowledge Versus Phonological Processing Skills

The second purpose of the study was concerned with examining whether differing conceptualizations of PA would produce different results with respect to linguistic skill and the acquisition of PA skills. In both the ANCOVA ad HLM analyses, a number of consistent findings were evidenced between conceptualizations of PA. For example, ANCOVA analyses conducted with the intervention group indicated that the African American students evidenced significantly lower scores on both conceptualizations of PA than Caucasian students. These findings are consistent with previous research that has shown African Americans are at a greater risk for developing RD than Caucasian students (e.g., Donahue, Danne, & Grigg, 2003).

Previous differences found between the reading achievement of Caucasian students and African American students often have been attributed to the overrepresentation of African Americans in poverty situations (Whitehurst, 1997). In this study, however, significant

differences were found between African Americans and Caucasians even after controlling for SES.

Recently, it has been suggested that contributing to this overrepresentation is a mismatch between an African American child's home speech environment and their school speech environment. For example, Charity, Scarborough, and Griffin (2004) examined the relation between familiarity with School English (SE; i.e., the dialect predominantly taught in the classroom) and early reading achievement by African American children ages 5-8 Results indicated that African American children who were less familiar with SE evidenced lower reading achievement than African American children demonstrating higher familiarity with SE (Charity, Scarborough, & Griffin, 2004).

An explanation offered for these findings is that children raised in environments in which African American Vernacular English (AAVE) is spoken provides opportunity for frequent mismatches between a child's dialect and what is taught in the classroom. This mismatch is suggested to negatively affect the formation of grapheme-phoneme correspondences and the ability to decode orthographic patterns into familiar speech sounds. Because some research has suggested that most African American children begin their formal school years speaking AAVE (Craig & Washington, 2002), these findings have important implications and suggest that African American children's increased risk for developing RD is, at least in part, due to disparity between the dialect used at home and the dialect taught within the classroom. Further, these findings call into question the validity of using standardized phonological instruments to assess PA skills in African American children. For example, Thomas-Tate, Washington, and Edwards (2004) found that a sample of African American first graders evidenced standardized PA scores that were below expected norms while evidencing reading skills within typical ranges.

Another consistent finding that occurred in the HLM analyses across measures of PA was that age significantly predicted both entering levels of PA skills and the rate of acquisition of PA skills. This finding was evidenced in both the control and intervention groups. Older children entered the study with higher levels of letter/sound knowledge and PP; however, younger children increased their acquisition of these skills more rapidly than older children. These results suggest that intervention efforts should be targeted towards younger children with the intention of raising their PA skills to those evidenced by typical readers before they fall behind their classmates to an important degree.

Nonverbal IQ also was consistently found to predict entering levels of PA in the HLM analyses. Students with higher nonverbal IQ scores entered the study with higher levels of PA skills. Because this variable was frequently found to interact with other predictors, however, reliable interpretations cannot be made.

With respect to ANCOVA analyses, only one inconsistency was found in the pattern of results between the dependent variables of grapheme/phoneme knowledge and PP skills. Analyses conducted with the control group did not indicate that students' knowledge of grapheme/phoneme correspondences increased significantly over time. In contrast, students' PP skills were shown to increase significantly over time, even without intervention attempts. This discrepancy between measures of PA also was seen in the HLM analyses. With the control group, students did not evidence sufficient variability in the rate at which they gained knowledge of grapheme/phoneme correspondences to warrant the addition of person-level predictors. In contrast, sufficient variability was seen in the rate of acquisition of PP skills to justify the addition of personal level predictors. These findings suggest that in the absence of specific intervention attempts, children with RD develop PP skills at a faster rate than knowledge of

grapheme/phoneme correspondences. Because children have experience with the speech stream daily, their PP skills may continue to develop at a significant rate despite still evidencing levels below those of students without RD. In contrast, because students are exposed to grapheme/phoneme correspondences with far less frequency, they have fewer opportunities to increase their knowledge base of grapheme/phoneme correspondences. These opportunities are especially limited in children with RD who are exposed to these correspondences primarily in the classroom setting for a limited time during the school day.

Apart from this discrepancy in findings, ANCOVA analyses did not indicate that a conceptualization of PA as a purely linguistic ability resulted in differential results when compared to a conceptualization of PA as an ability to recognize that arbitrary orthographic patterns represent specific sounds of speech. In addition, little difference was seen between measures of PA in the effect sizes reported for the significant effects evidenced in the analyses.

In contrast to ANCOVA analyses, HLM analyses provided more than one instance that different conceptualizations of PA can result in differential findings with respect to some demographic and linguistic variables. As already reported, a significant nonverbal IQ by SES interaction and a nonverbal IQ by linguistic classification were found with the control group concerning entering levels of grapheme/phoneme correspondence knowledge. These interactions were not found for PP skills. In addition these interactions were not replicated in the analyses conducted with the intervention group. These findings, therefore, appear to be related more to the dynamics of the students comprising the control group rather than a result of differing conceptualizations of PA.

An additional discrepant finding between conceptualizations of PA was a significant interaction between nonverbal IQ and linguistic classification with respect to the rate of

acquisition of PP skills. Results indicated that students in the below-average linguistic group with higher nonverbal IQ scores evidenced PP skills that were similar to students in the typical linguistic group with lower nonverbal IQ scores. The students in the typical linguistic group with lower nonverbal IQ scores, however, increased their PP skills at a faster rate than students in the below-average linguistic group with higher nonverbal IQ scores. This accelerated rate of acquisition also was seen in students in the below-average linguistic group with lower nonverbal IQ scores. This difference in acquisition rates resulted in the PP skills of students' with discrepant nonverbal IQ scores within the two linguistic groups becoming more similar by the end of the study.

This interaction was found only in the intervention group and only with regard to PP skills; however, this interaction was found across all linguistic classifications with the exception of classifications based on receptive vocabulary levels. Intervention attempts, therefore, appeared to be most advantageous in increasing PP skills for students who entered the study with lower nonverbal IQ scores. At first glance, these results seem counter intuitive; however, given greater consideration, they suggest that there is an upper limit in PA skills that could be attained by these students. Whether this limitation in skill attainment was due to an organic constraint, a result of the intervention offered, or a combination of these factors is not clear. Despite the reason for this limitation, because students with lower nonverbal IQ scores entered the study with lower PA skills, they had a greater discrepancy between this upper limit and beginning levels of PA skills. Subsequently, intervention attempts were more effective for these students.

Other discrepancies did exist in the HLM analyses; however, no other findings occurred consistently across analyses. The discrepancies that did occur could have resulted from the total

number of analyses that were conducted and may be spurious in nature. These discrepancies, therefore, will not be discussed in detail.

Overall, ANCOVA and HLM analyses indicated that the relationship between oral language skills and PA skills appears to remain consistent whether PA is conceptualized as an ability to manipulate sounds of speech or as an ability to identify the sounds of speech specific orthographic patterns represent. Specifically, analyses indicated that students with a below-average linguistic classification evidenced significantly lower levels of grapheme/phoneme correspondence knowledge and PP skills than students with a typical linguistic classification. In addition, oral language skills were shown to have little effect on the rate at which these PA skills were acquired. Further, these findings were consistent across control and intervention groups.

Relationships Among Linguistic Domains and Aspects of Reading Achievement

The final purpose of this study was to examine the relationships that exist among different linguistic domains and different measures of reading achievement. It was hypothesized that at the beginning of the study, strong relationships would be evidenced between semantic knowledge and PA skills and between semantic knowledge and word identification abilities. With respect to listening comprehension skills, it was hypothesized that this linguistic skill would be most strongly related to reading comprehension abilities.

It was hypothesized that the relationships between semantic knowledge and PA skills and between semantic knowledge and reading achievement would change from the onset of the intervention study; i.e., that the relationship between semantic knowledge and word identification ability would be fully mediated through PA skills. It also was hypothesized that semantic knowledge would enter into a relationship with reading comprehension abilities because of its reliance on vocabulary knowledge.

At the baseline time point, consistent with the study's hypothesis, SEM analyses indicated that both receptive and expressive vocabulary skills were significantly related to PA skills. In addition, expressive vocabulary skills were significantly related to real word identification abilities. Neither receptive nor expressive skills, however, were related to reading comprehension. These results are consistent with previous research that has suggested semantic knowledge has a unique relationship with decoding skills (e.g., Catts, 1993; Dickenson, et al., 2003; Purvis & Tanock, 1997).

The hypothesis that listening comprehension skills would be related to reading comprehension at the beginning of the study was not supported in the SEM analyses. In fact, reading comprehension was not found to enter into a significant relationship with any linguistic ability and was subsequently was excluded from the analyses.

No direct support was found for the hypothesis that the relationship between semantic knowledge and real word identification would be completely mediated through PA skills because linguistic ability was not significantly related to PA skills at the end of the study. Indirect support for this hypothesis was obtained, however, by analyses that indicated the relationship between PA skills and reading accuracy remained strong and significant across intervention time points. Thus, any influence semantic knowledge had on PA reading accuracy at the beginning of the study was absent by the end of the study because PA skills appeared to have become more automatized.

Evidence for this automatization of PA skills resides in the nature of the relationship between PA skills and reading accuracy and how it changed over time points. At the baseline time point, reading accuracy was shown to influence PA skills, while after 70 hours of reading intervention efforts, PA skills were shown to influence reading accuracy.

These findings suggest that early decoding skills are shaped by early reading experience and are heavily dependent on semantic knowledge. Further, these findings indicated that students were using sight word vocabulary as the primary means of word identification at the beginning of the study. This finding supports the theory that children's early reading is dictated by a process of associating a word visually, either in part or whole, with the name of the word (see Rayner et al., 2001). During this phase of the reading process, children rely on memorizing the visual images of words without understanding the rules of grapheme/phoneme relationships. Later in the development of the reading process, when PA skills become more sophisticated, they do not rely on a semantic store and become important in the word identification process. Thus, experience with written material and exposure to orthographic patterns should lead to gains in letter/sound knowledge and PP by cultivating well-defined grapheme/phoneme correspondences and phonological representations.

Support for this developmental progression of the reading process was evidenced by finding that PA skills influenced reading accuracy at the end of the study. These results are consitent with suggestions that decoding skills enter into a bi-directional relationship with reading (Foorman, 1995) and support previous research demonstrating this relationship (e.g., Stahl & Murray, 1998). This bi-directional influence provides an explanation of why semantic knowledge was not related to PA skills at the end of the study.

Initially, students exhibited a deficit in PA skills. In the absence of well-developed word-decoding skills, students may have relied on associating an internalized vocabulary set with familiar letter patterns and sounds of speech to guide their performance on the PA tasks. In this sense, the student's semantic store provides representational anchors onto which a child maps phonological elements of speech. Subsequently, students were using an internalized vocabulary

set to guide their performance on the PA task rather than demonstrating true decoding skills represented by well-developed PA skills. As participants gained phonological abilities, however, they were able to shift to a skills approach to reading and relied less on vocabulary knowledge.

This shift in word identification strategy also may explain why only expressive vocabulary skills were found to significantly influence word reading accuracy. This finding may be related to the nature of the expressive vocabulary measure used and the developmental nature of the reading process. The expressive vocabulary measure used in this study required participants to generate definitional knowledge of a word. Because vocabulary knowledge of this nature includes usage in addition to meaning, these vocabulary words should be more thoroughly represented than a child's receptive vocabulary store. Language is a symbolic system and a well-defined symbolic representation would facilitate a child's memory of a word by sight alone. Thus, students with better expressive vocabulary skills would have an advantage when using sight word vocabulary as the primary strategy for word identification purposes.

Finally, this shift in word identification may also explain why analyses did not indicate that semantic knowledge was related to PA at the end of the study. These results suggest that once students begin to establish decoding skills, any influence semantic knowledge had on word identification was completely mediated through decoding skills.

Related to this, is an explanation for why semantic knowledge did not enter into a relationship with reading comprehension at the end of the study. Results suggested that the decoding skills of these children had not become automatized to the degree that would allow for fluent reading of connected text. Thus, these children were still devoting much of their attentional resources to decoding words rather than reading for meaning. This explanation is in line with the idea that reading is a developmental process that shifts from one focused on

decoding to a fluent, automatized process focused on reading for meaning (Adams. 1990). This explanation also is supported by previous research that has indicated that semantic knowledge does not enter into a relationship with reading comprehension until the later elementary school grades (e.g., Cooper et al., 2002; Roth et al., 2002). Therefore, although chronologically these children should be making this shift, their reading skills are developmentally similar to those of younger children and are still focused on decoding.

Limitations and Future Directions

A limitation of the current study was that the language measures used were administered only one time during the study and that the language measures could have been administered at any time during the school year. When designing the study, it was reasoned that these abilities would not be affected by intervention attempts. Additionally, because standardized scores could be derived for these measures, resultant scores should have remained stable throughout the duration of the study. For these reasons, language measures were not administered at a specific time point or at multiple time points during the study.

This limitation is especially important when considering the SEM analyses. For these analyses, the linguistic variables were only related to decoding and reading abilities at the beginning of the study. Without knowing exactly when the linguistic variables were administered, it is difficult to determine the validity of these relationships. Inspection of the dates of administration, however, indicated that the linguistic ability assessments were distributed relatively evenly over the course of the study. It does not appear then, that one or more of the linguistic measures were administered more often towards the beginning of the study or administered more often towards the end of the study. It can be assumed, therefore, that any

influence of a specific test administration time point should have been minimized due to the relatively even distribution of test administration sessions.

This "averaging" effect of assessment time points, however, may have reduced the magnitude of relationships evidenced in the analyses. Additionally, weaker relationships that exist among these variables could have been masked by this "averaging" effect. Future studies interested in the relationship between oral language skills and reading-related abilities should assert more control over the assessment of linguistic abilities and outline precise time points for when these abilities should be measured.

Another limitation of the study concerns the age of the children who participated. A potential explanation for failing to find an influence of linguistic ability on the rate of acquisition of PA skills is that the children in this study had surpassed the age at which this important relationship could be evidenced. Typically developing children have acquired the basic phonology, grammar, semantics, and pragmatic domains of language by the age of four (Gleason, 2001). Because the students in this sample have an established linguistic system, any influence that this developing system may have had on the development of PA skills could have already occurred. This possibility, however, is associated with a conceptual and methodological difficulty.

Students enter the school system evidencing only basic PA skills such as the ability to discriminate onset versus rime and it is not until children begin to engage in the reading process that more complex PA tasks can be completed (Stahl & Murray, 1998). These facts pose a challenge for researchers wanting to measure PA skills before entry into school. The ability to detect rhyme, however, has previously been found to be a significant predictor of later reading achievement (Adams, 1990). There do appear to be ways of tapping this early construct,

therefore, for researchers interested examining the early development of PA skills. Developing tasks that build upon this skill, such as matching words with similar sounds or detecting onset versus rime, can provide insight into the development of PA skills.

Because the participants in this study were all classified with RD, this study is limited in the generalizations that can be made to other populations of children. Conclusions concerning typically developing children, therefore, may be unwarranted. Future studies examining the relationship between oral language skills and the development of PA skills may want to include a group of typically developing children as a comparison group.

Future studies also should take into consideration the existence of subtypes of RD. Although research has consistently indicated that the primary deficit in children with developmental RD is a deficit in PA (e.g., Catts, Fey, Zhang, & Tomblin, 2001; Morris et al., 1998; Olson et al., 1989; Simos, 2002; Stanovich, 1988; Vellutino et al., 1996), children classified with RD represent a very heterogeneous group and exhibit different patterns of deficits of reading-related processes in addition to deficits of PA.

This heterogeneity could greatly influence results concerning the relationship between oral language skills and the development of PA. For example, some researchers (e.g., Wolf & Bowers, 1998)) have suggested, and have received empirical support for (Morris et al., 1998), a subtype of RD that is characterized by a visual naming speed deficit without an associated deficit in PA. The inclusion of a subtype of RD that does not involve a deficit in PA could mask the true nature of the relationship between oral skills and the development of PA. Further, considering the large number of studies that have indicated children with linguistic deficits are at a greater risk for developing RD than children with typical linguistic skills, an RD subtype may exist that has a deficit principally due to impaired oral language skills.

Keeping the study's limitations in consideration, the findings from this study were largely consistent with a large body of research that has indicated oral language skills are related to reading achievement. Findings from this study, however, did not provide direct support that oral language skills drive the development of PA skills. Additionally, results did not differ importantly when PA skills were conceptualized as either the ability to recognize and manipulate phonetic elements of speech or as the ability to understand that arbitrary written symbols represent specific sounds of speech. Finally, this study provided evidence that receptive vocabulary skills and expressive vocabulary skills were independently related to entering levels of PA while only expressive vocabulary skills were related to entering levels of word identification ability. In contrast, none of the language abilities assessed in this study were related to levels PA or word identification ability following participation in an intervention focused on improving reading and reading-related skills. These results suggest that any influence oral language skills have on reading achievement occurs when children possess rudimentary word identification skills. In the absence of fluent and automatized decoding skills, therefore, children must rely on oral language skills as a compensatory strategy for performing reading and reading-related tasks.

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