ABSTRACT

Title of Thesis: DISTRIBUTED AND SELECTIVE ATTENTION IN BILINGUAL AND MONOLINGUAL PRESCHOOL-AGED CHILDREN

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This study investigated the effects of early bilingualism on selective and distributed auditory attention in preschool-aged children. Using an online, asynchronous preferential-looking paradigm, 48 children (24 bilingual, 24 monolingual), aged 2.98-4.89 years, were presented with trials in which two speakers simultaneously named familiar objects. Selective attention was measured by children's fixation on targets named by the primary speaker, while distributed attention was measured by recall of targets previously named by the secondary speaker. Contrary to the hypothesis, no significant effect of language group was observed in either task. While children showed a weak significant effect of looking at target objects vs. distractor objects in selective attention trials, no group differences emerged, and performance in distributed attention tasks was near chance for both groups. Importantly, variability in bilingual participants' language dominance, as reported through measures of children's language experience, suggests group comparisons may obscure individual differences in bilingual experience. The absence of robust bilingual advantages in attention may also reflect limitations in task design, particularly for measuring distributed attention in young children in remote testing environments. These findings highlight the complexity of measuring bilingualism in early childhood and call attention to structural barriers that limit representation of non-English dominant families in developmental research. Future research should employ more refined measures of bilingual experience and address environmental and methodological constraints in remote child language studies.

DISTRIBUTED AND SELECTIVE ATTENTION IN BILINGUAL AND MONOLINGUAL PRESCHOOL-AGED CHILDREN

by

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1. Introduction

Children and adults can have surprisingly different ways of interacting with the world. For example, adults demonstrate a tendency to pay attention to one thing at a time, selectively. Real life instances of this include reading a book while taking public transportation, listening to a phone call while the television is on in the background, or sticking to your shopping list as you walk throughout the grocery store. While the difficulty of these everyday tasks may differ depending on the person and the day, it is generally easier for adults to select and maintain their attention on a specific task than it is for children. Imagine handing a preschooler your weekly grocery list, even a simple list with corresponding pictures, and dropping them off at the store for twenty minutes. It is not likely that they would have accurately completed this task. The shopping cart may have been abandoned, and once you do find it, whatever items are in the cart will likely be unrelated to the items specified on the grocery list.

Children, on the other hand, tend to want to pay attention to everything around them, distributing their focus more broadly (Coch, Sanders, & Neville, 2005; Plude, Enns, & Brodeur, 1994). This difference is largely attributed to the gradual development of selective attention throughout childhood and even into early adulthood, although typically developing children begin to show the ability to pay attention selectively around age 4 (Goldberg, Maurer, & Lewis, 2001; Plude, Enns, & Brodeur, 1994).

While attentional development does follow a natural progression as the brain matures, recent evidence suggests it is possible that children’s tendency toward distributed attention may be less a result of immature selective attention skills and more a cognitive adaptation biased towards broad processing of information in order to prevent children from preemptively filtering out and subsequently missing information streams that may turn out to be relevant to their learning (Blanco, Turner, & Sloutsky, 2023; Blanco & Sloutsky, 2020; Coch, Sanders, & Neville, 2005; Plebanek & Sloutsky, 2017).

One such study by Plebanek and Sloutsky (2017) found that young children not only demonstrate stronger distributive attention skills than selective attention skills, which was expected, but they also observed that the children outperformed adults in change-detection and visual search tasks, designed to measure distributed attention. Participants included 34 4-5 year-olds and 35 adults. In the change detection task, participants were shown a sequence of images of two overlaid outline shapes, one red and one green, in which either the red shape would change, the green shape would change, or neither shape would change. Participants were cued to pay attention to only the red shapes and then asked to make a judgement about 1) whether the red shape had stayed the same or changed (indicating a measure of selective attention), and 2) whether the whole picture had stayed the same or changed (indicating a measure of distributed attention). Both adults and children performed well on detecting changes in the cued red shapes, with adults demonstrating a .94 proportion of correctly identified cued changes and children demonstrating a .87 proportion of correctly identified cued changes. More significantly, children outperformed adults in detecting uncued green shape changes (indicating a measure of distributed attention), with adults demonstrating a .63 proportion of correctly identified uncued changes and children demonstrating a .77 proportion of correctly identified uncued changes.

In the visual search task in the same paper, the same participants were tested on their attention and memory recall for both search-relevant and search-irrelevant information, as well as changes in what parameters were assigned as search-relevant or search-irrelevant (Plebanek & Sloutsky, 2017). Using visual arrays of six drawings each of artificial creatures with unique dimensions, participants were cued for that trial's relevant dimensions and then asked to search for the creature with the relevant dimension. Throughout trials, the artificial creatures were shown with observable dimensions (features such as body color, body shape, hat shape, antennae, etc.) that alternated between different combinations of either relevant or irrelevant in order to create *new* and *old* types of relevant and irrelevant dimensions for participants to attend to. Researchers believed high recognition accuracy for new relevant items but not new irrelevant items suggested selective attention to relevant information, while high memory accuracy for new relevant and new irrelevant items suggested distributed attention across both relevant and irrelevant information.

The results from these experiments suggest that adults and children demonstrated comparable recognition accuracy of relevant target dimensions, thus showing similar selective attention. More specifically, adults and children both demonstrated comparable recognition accuracy of relevant target dimensions, with both adults and children demonstrating a .83 proportion of correctly identified relevant dimensions. Notably, with regard to distributed attention, children outperformed adults in accurately recognizing irrelevant dimensions, with adults demonstrating a .59 proportion of correctly identified irrelevant dimensions and children demonstrating a .72 proportion of correctly identified irrelevant dimensions, thus supporting the results of the previous change detection task and suggesting that children were able to distribute their attention across relevant and irrelevant visual information and recall task-irrelevant information better than adults.

Together, these findings suggest a "rare developmental reversal" in which children demonstrate "a surprising advantage over adults in processing task-irrelevant information" (Plebanek & Sloutsky, 2017, p. 729). While selective attention facilitates processing of task-relevant information, distributed attention facilitates processing of task-irrelevant information, which may support better learning in children over time (Plebanek & Sloutsky, 2017; Chrysikou, Weber, & Thompson-Schill, 2014).

While young children have been shown to demonstrate greater distributed attention skills than selective attention skills in cognitive tasks in general, it is possible that children's use of more distributed vs. selective attention could vary across children. One factor that might affect this, in particular, would be differences in experience. For example, the diverse language environments of bilingual children may create a greater attentional demand than monolingual peers in order to acquire the linguistic information necessary for learning. This is a challenging, but essential, task for all children regardless of their language environment(s).

It would follow logically that bilingual children gain more experience distributing their attention than their monolingual peers because bilinguals are constantly managing two language systems. This constant navigation between and within distinct language systems creates a higher cognitive demand for young bilinguals, requiring greater flexibility and control in order to successfully engage with the world around them which could translate to greater distributed attention abilities in bilingual children that are rapidly developing language skills and attention skills (Adesope, 2010; Barac & Bialystok, 2012; Bialystok et al., 2022; Bialystok & Werker, 2017; Blanco, Turner, & Sloutsky, 2017; Byers-Heinlein & Lew-Williams, 2013; Hernandez, 2013; Kroll et al., 2015). The same cognitive flexibility and control needed to process this auditory information broadly are also essential for choosing what to specifically pay attention to, or selective attention, as well as the ability to switch between distributed and selective attention.

This study aims to investigate the performance of young bilingual children, aged 3-4 years, on auditory selection tasks requiring both selective and distributed attention compared to monolinguals of the same age group. In what follows, we provide a brief overview of developmental attention and consider how bilingualism may impact the cognitive skills that relate to attention in young children.

1.1 Theoretical Models of Attention

Human attention is a complex cognitive process that allows individuals to selectively focus on specific information while simultaneously filtering out information they judge to be irrelevant. Cherry's famous research on the "cocktail party effect" demonstrates this effect, where adults can focus on a single stream of speech in the presence of prominent background noise (Cherry, 1953). One of the earlier theories of how selective attention works, Broadbent's filter model, suggests that attention utilizes a selective filter that prioritizes certain sensory inputs over others based on measurable physical characteristics like pitch and stimuli location (Broadbent, 1958; Driver, 2001).

Soon after, Gray and Wedderburn (1960) argued that selective attention functioned by initially taking in all information, and then boosting or dampening certain signals as deemed relevant by semantic and contextual meaning. Tresiman offered her own expansion of Broadbent's model, in which all words are attended to at different processing levels where individual words have higher or lower thresholds of semantic importance to trigger increased attention (Treisman, 1960; Driver, 2001). The development of selective attention across the lifespan, as observed by Plude, Enns, and Brodeur, indicates that our attentional skills evolve, improving in childhood and becoming more sophisticated as we age, until a certain point of decline in overall cognitive ability (Plude, Enns, & Brodeur, 1994). Although the mechanisms may not be clearly defined and skill level changes over time, human attention is an adaptive cognitive process that helps to determine what is the most relevant information in our language environment.

1.2 Types of Attention

While there are multiple types of attention, for the purposes of this study, the following will be discussed: Selective Attention, Distributed Attention, and Attentional Switching.

Selective Attention

Attentional skills develop in predictable stages for young children. Their ability to focus and engage with their environment changes as they grow. Early attention skills involve simple processes like visual tracking, joint attention, and protoconversations, in which infants learn to sustain and share focus with their communication partners. In 2005, Newman found that infants can demonstrate a limited capacity to selectively attend to their name in a somewhat noisy environment as early as 5 months of age, and that this capacity continues to develop further throughout their development. In a study investigating selective auditory attention in 3- to 5-year-olds, Sanders et al. (2006) found behavioral and electrophysiological evidence that later 3-year-olds were able to successfully focus on a single auditory stimulus with competing auditory information, although the children required verbal cues to redirect their attention. It is not surprising that this capacity is present but limited in childhood, as current research finds that children already demonstrate some ability in selective attention starting around age 4, although the cognitive control required for such a skill is not thought to be fully developed until early adolescence (Blanco, Turner, & Sloutsky, 2023; Hobbiss & Lavie, 2024; Plebanek & Sloutsky, 2017).

Distributed Attention

Elliot (2002) found that young children are more easily distracted by task-irrelevant information compared to adults; however, it was observed that the children may remember the task-irrelevant information better than the adults, likely because adults automatically filtered out the distractions in order to focus their attention on the target stimuli, demonstrating what is known as learned inattention, a cognitive process in which task-irrelevant information is thought to be filtered out and unprocessed in order to prioritize the brain's limited cognitive resources to process task-relevant information more efficiently. This filtering of specific information comes at the cost of processing information more broadly, both of which have their own costs and benefits depending on the context.

Elliot's findings illustrate an inadvertent demonstration of how what is perceived to be immature cognitive control may in fact benefit early learning, observed in young children as distributed attention, the ability to attend to multiple streams of information simultaneously, as opposed to selective attention (2002). Our current understanding of how attention skills develop over time is that children are better at distributed attention than selective attention, and adults are better at selective attention than distributed attention, a difference that may not simply be due to maturation over time, but could also serve a functional purpose to facilitate learning. Blanco, Turner, and Sloutsky (2023) and Plebanek and Sloutsky (2017) argue that young children's weak selective attention and skills in distributed attention are an adaptive feature that safeguard children from ignoring the details that adults tend to automatically judge as irrelevant and miss.

Essentially, efficient information processing requires selective attention to filter out task-irrelevant information, but accurate filtering requires experiential knowledge to know what is relevant and what is not relevant to the task. Adults have access to this experiential knowledge, while children do not, hence the tendency of children to learn via exploration and interaction with their environment. Therefore, children are less able to filter out what is task-irrelevant because they do not yet understand what is task relevant, resulting in a broad distribution of information in order to promote early cognitive development (Plebanek & Sloutsky, 2017). While this is a less efficient method of processing information than generally observed in adults, it ensures that nothing important is erroneously filtered out and missed by children developing their experiential knowledge, and, according to the “Matched Filter Hypothesis”, is thought to ultimately result in slower, but better, learning overall (Chrysikou, Weber, & Thompson-Schill, 2014).

Attentional Switching

Both selective and distributed attention skills require certain levels of cognitive control in order for an individual to process and determine which modality of attention is most appropriate for any given task. What happens when there are multiple tasks at once, or the demands of a particular task are variable over a brief period of time? Attention switching depends on cognitive flexibility in order to recognize and adjust how we allocate our attention depending on the most immediate contextual demands. Similarly to selective attention, cognitive flexibility is understood to have a protracted development over time. According to Dick (2014), preschool-aged children demonstrate some capacity to perform tasks requiring attentional shifts, noting a rapid improvement in observed performance between 3 to 4.5 years of age followed by a gradual improvement up to 10 years of age. Hanania & Smith (2011) suggest that poor attention switching seen in preschool-aged children, relative to adults, may also be the result of interference via perseveration due to “weak and partial” selective attention, describing their selective attention as “sticky” and therefore, less flexible in the context of the Dimensional Change Card Sort task where participants are prompted to sort a set of cards according to one rule, e.g., by shape, and then asked to re-sort the cards based on a different rule, e.g. by color. While children of different ages all tend to perform well on the first step, younger children typically perform worse once the rule has been changed due to the perseveration of the initial card sorting rule, indicating young children's budding, but inflexible, ability to attend selectively.

Selective attention and the cognitive flexibility required to switch between modes of attention is understood to improve with both time and experience. While the passing of time, being linear, is a constant parameter in child development, experience is highly variable across individuals. As with many skills, practice tends to enhance performance to some degree - that is, individuals who use a particular skill more often tend to become better at doing so. One group who may have particular practice switching attention between systems are bilinguals, those who identify as having language experience with two language systems, who regularly need to switch between language systems.

1.3 Defining Bilingualism

Bilingualism is not a fixed category, but a dynamic and multifaceted spectrum of language experience. Factors including age of acquisition, frequency of use, context, and language dominance, as well as individual and community identity contribute to what it means to be bilingual (Grosjean, 2010; Luk & Bialystok, 2013). However, these variables are often difficult to quantify or standardize across participants, and sometimes even within participants depending on the context. There is no universally accepted threshold of experience for what qualities for the label of "bilingual", although some researchers have suggested both minimum and maximum thresholds in an attempt to better understand the role of the quantity of language input in bilingual language development; however, there is currently no conclusive evidence supporting such thresholds (Hoff & Core, 2013). Additionally, tools such as parent report questionnaires about children's language experience may not thoroughly or accurately capture the complexity of a child's language environment (Hoff & Core, 2013). This ambiguity presents marked challenges for researchers in both attempting to define and measure bilingualism for the purposes of developmental language research, making study replication and comparisons particularly difficult.

Due to these conceptual and methodological complexities, research on the cognitive effects of bilingualism, especially in young children, has produced mixed and often irreplicable results (Paap et al., 2015; Leivada et al., 2020). In many studies, a lack of meaningful language difference in language dominance between monolingual and bilingual groups makes it difficult to isolate any significant observed outcomes as an effect of bilingualism. If bilingual participants are predominantly English language dominant, as was the case in the current study, any expected bilingual cognitive effects may be minimized or absent. To more effectively examine potential impacts of bilingualism on cognitive domains such as attention, research practices must develop a more nuanced view of bilingualism and ensure broader variation in language experience across participant samples (Surrain & Luk, 2019; Bialystok, 2017). Otherwise, findings may continue to reflect methodological biases rather than underlying effects of bilingualism and cognitive processing.

1.4 Bilingualism and Cognitive Processing

To get a better understanding of how bilingual language experience may influence attentional skills, we will take a step back and consider the cognitive processes that underlie and interact with attention. These cognitive processes fall under the category of executive functions, "a family of top-down mental processes needed when you have to concentrate and pay attention, when … relying on instinct or intuition would be ill-advised, insufficient, or impossible" (Diamond, 2013, p. 136). The three core executive functions are understood to be cognitive flexibility (shifting), working memory (updating/monitoring), and inhibition (control), which serve as the basis for higher order executive functions including problem solving, planning, and decision-making, each of these skills being vital for cognitive, social, and psychological development (Diamond, 2013; Giovannoli et al., 2020; Miyake et al., 2000).

Over the past two decades, a growing body of research has investigated how bilingualism may influence children's executive functioning, particularly within the domains of attention, cognitive flexibility, and inhibitory control. Foundational work by Bialystok and colleagues suggest that managing two language systems may benefit domain-general cognitive processes due to the constant need to select one language while actively inhibiting the other (Bialystok et al., 2012; Bialystok, 1999). This hypothesis has been supported by findings that bilingual children outperform their monolingual peers on tasks requiring attentional control and conflict resolution, likely as a result of greater cognitive demands in order to acquire and manage more than one language system (Carlson & Meltzoff, 2008; Costa et al., 2008; Kapa & Colombo, 2013). However, results across studies are mixed and difficult to replicate, with some suggesting that any observed bilingual advantages may depend on factors such as age of acquisition, proficiency, and language use context (Barac et al., 2014). Additionally, the degree to which bilingualism shapes early cognitive development may vary with the demands of the specific tasks and at which point in a child's development they are measured (Poulin-Dubois et al., 2011). While the evidence for a consistent and specific bilingual advantage remains debated, research continues to explore the role of bilingual experience in shaping early cognitive development.

What are the cognitive demands of language use, and how are they different between bilingual and monolingual children? One of the most essential cognitive domains for facilitating language use is attention, as one must have the capacity to notice and attend to streams of language input in order to perceive, segment, and comprehend meaningful units of language. Monolinguals generally need to focus their attention on one specific system of language input, while bilinguals need to selectively attend to one of two language systems while inhibiting the other, as well as shift between those systems, depending on the particular context of their immediate language environment.

Inhibitory control is necessary for suppressing the irrelevant or competing stimuli that very frequently exist within a child's natural language environment. For example, a child who knows both English and Spanish and is talking about *uno gato* in a Spanish language context needs to suppress the English representation of the same lexical concept, *the cat*. Compared to monolinguals, bilingual children must practice their inhibitory control constantly to suppress any non-target language input within a multilingual environment, which some studies argue may enhance general executive functioning (Bialystok, 1999; Carlson & Meltzoff, 2008; Costa, Hernández, & Sebastián-Gallés, 2008).

It is worth noting that young bilingual children are more likely to demonstrate vocabulary knowledge that is distributed unevenly across their distinct language systems, likely because different language environments require relevant vocabulary terms that are unique to that particular context (Hoff & Core, 2013). For example, a bilingual child that knows the Spanish word, *dientes,* may not know and/or need to know the English equivalent, *teeth*, if they have only experienced oral care routines in a majority Spanish-speaking home and a Spanish-speaking dentist's office. In this case, until bilingual children experience language contexts that require vocabulary knowledge of a word concept in both languages, inhibitory control is less of a factor with respect to cognitive load.

Working memory is critical for temporarily holding and processing linguistic information, and, while employed by both monolingual and bilinguals, the latter may experience an additional cognitive load when resolving which language's set of rules to apply to language input as they are processing in real time.

Previously mentioned, cognitive flexibility enables speakers to shift between cognitive tasks and rule systems. While monolingual children exercise cognitive flexibility across communication contexts, there may be an additional load on bilingual children, as they must actively shift between different language systems and contexts. Finally, the skill of metalinguistic awareness, in which children use language to contemplate language itself, has been observed, albeit inconsistently, earlier in bilingual children than monolingual peers, thought to be due to bilinguals' frequent comparison in representation and rules between two language systems (Barac et al., 2014; Bialystok et al., 2012; Poulin-Dubois et al., 2011). Table 1 below presents a summary of the identified cognitive processes, as well as how demands may be different for monolinguals and bilinguals.

Table 1

Suggested Differences in Cognitive Demands Between Monolinguals and Bilinguals

Cognitive Process	Monolinguals	Bilinguals
Attentional Control	Attend to one language input	Shift/select between multiple inputs
Inhibitory Control	Inhibit non-linguistic distractors	Frequently inhibit meaningful non-target language and other distractors
Working Memory	Standard load	May represent and manage more linguistic information across two language systems
Cognitive Flexibility	Switching within one system of linguistic rules and contexts	Regular switching between two systems of linguistic rules and contexts
Metalinguistic Awareness	Develops with literacy	Often develops preliteracy due to language contrast

Note. Adapted from Barac et al. (2014), Bialystok (1999), Bialystok et al. (2012), Carlson & Meltzoff (2008), Costa et al. (2008), Kapa & Colombo (2013), and Poulin-Dubois et al. (2011). This table summarizes proposed differences in cognitive processes between monolingual and bilingual individuals based on current research.

Bilingualism, Attention, and Switching

Specifically in the domain of attention, there is evidence to suggest that early bilingualism may have a positive impact on young children's distributed attention across multiple streams of information due to regular exposure to competing language input, which may result in greater attentional efficiency and flexibility than in monolingual peers (Adesope et al., 2010; Bialystok, 2001; Blanco, Turner, & Sloutsky, 2017; Byers-Heinlein, 2013; Kovács & Mehler, 2009; Kroll et al., 2015). The constant switching between languages and managing both systems simultaneously could boost the cognitive ability to distribute attention across competing stimuli, similar to the demanding task of navigating two simultaneously activated language systems (Grainger & Beauvillain, 1987).

This bilingual advantage may also extend to performance in tasks that require selective attention and, subsequently, cognitive flexibility (Bialystok, 2001). Evidence shows that bilingual children specifically excel over their monolingual peers in conflict tasks, which require efficient management of conflicting attentional demands. Poulin-Dubois et al. (2011) found evidence of such executive benefits, in conflict tasks specifically, as early as 24 months when comparing French-English bilingual toddler to English and French monolingual toddler performance on the Shape Stroop Task, a modified version of the widely used Stroop Task adapted for young children by Kochanska, Murray, and Harlan (2000). In this modified version of the Stroop Task, children are presented with three colored images of fruits (banana, apple, and orange) that each contain a smaller image of a different fruit embedded within the larger image such that each of the three original fruits are represented once in both big and small sizes but never within the same image (e.g. a small orange in a big apple). The children are then asked to identify the smaller fruit within each image, with the monolingual group demonstrating a .31 proportion of correct Stroop trials and the bilingual group demonstrating a .50 proportion of correct Stroop trials (Poulin-Dubois et al., 2011). Although Stroop style tasks were initially developed to assess participants' ability to inhibit cognitive interference of an automated task (naming the larger fruit) on a less-automated task (naming the smaller fruit), its application has been extended as a measure of attention and cognitive flexibility as well (Jensen & Rohwer, 1966; Stroop, 1935).

Chung-Fat-Yim, Calvo, and Grundy (2022) suggest these observed differences in development of selective attention and cognitive flexibility in bilinguals compared to monolinguals may be an adaptive "means of facilitation and promoting language acquisition and discrimination" (p. 10), indicating that the perceived cognitive boost observed in bilingual children is a developmental response to the higher cognitive demand of acquiring and managing more than one language system. In order to differentiate between distinct languages, bilingual children need greater discrimination, and therefore, greater attentional selectivity, as well as the cognitive flexibility to switch between these distinct languages depending on the context of their immediate environment.

Current Study

While these findings suggest possible benefits of early bilingualism on development of cognitive skills, there is not robust enough evidence to fully understand the effects of early bilingualism on attention, as well as how these observed effects may translate from a controlled environment into more natural language environments. Further research is needed to investigate possible generalization across contexts, especially in young children. In this study, we investigated whether bilingual and monolingual children ages 3-4 years differ in their ability to notice and recall words spoken when presented in two different speech streams, with the overall goal of contributing to a growing body of evidence substantiating the cognitive benefits of early bilingualism on children's development.

Using a preferential-looking paradigm with a bi-phase trial design, we examined the possible effects of bilingualism on preschool aged children's attention. Specifically, we presented children with two different speakers talking simultaneously, and assessed their ability to notice and recall words in both of the two streams. Attending to words spoken by a background speaker indicates a child's ability to distribute their attention, while attending to words spoken by a primary speaker indicates a child's ability to attend selectively. We predict that 3–4-year-old bilinguals will demonstrate better performance than monolinguals in mean target looking time for tasks requiring both distributed and selective attention.

2. Methods

Participants

The study included a total of 48 preschool-aged children, evenly divided between English bilingual (n=24) and 24 English monolingual (n=24) according to initial parental report. Participants ranged in age from 2.98 and 4.89 years of age (*M* = 3.78 years). Gender distribution was roughly equal, with 23 females and 25 males overall.

Families identified their child as either bilingual or monolingual when registering for the study prior to participation, and more in-depth analysis of the child's language experience was conducted subsequently via asynchronous language experience questionnaire (see *Analysis* section below for more detail). The bilingual group represented a linguistically and ethnically diverse population. Spanish was the most frequently reported non-English language, present in one-third of the bilingual group (8 out of 24 participants). Other languages included Japanese, French, Yoruba, Twi, Korean, Gujarati, Mandarin, Indonesian, Bengali, Pashto, Cantonese, and Urdu, indicating a broad representation of language families.

Racial and ethnic identities within the bilingual group included White, Hispanic or Latino, Asian, Black or African American, and Middle Eastern or North African backgrounds. The monolingual group was less diverse, predominantly identifying as White, with some participants reporting Asian, Black or African American, Hispanic or Latino, and American Indian or Alaska Native backgrounds. See Table 2 below for participant race and ethnicity by language group.

Table 2

Participant Race/Ethnicity by Language Group

Race/Ethnicity Category	Bilingual (n = 24), n (%)	Monolingual (n = 24), n (%)	Total (N = 48), n (%)
White only	3 (12.5%)	15 (62.5%)	18 (37.5%)
Asian only	8 (33.3%)	2 (8.3%)	10 (20.8%)

Black or African American only	2 (8.3%)	0 (0.0%)	2 (4.2%)
Hispanic/Latino only	1 (4.2%)	0 (0.0%)	1 (2.1%)
White + Asian	1 (4.2%)	3 (12.5%)	4 (8.3%)
White + Black or African American	0 (0.0%)	1 (4.2%)	1 (2.1%)
White + Hispanic/Latino (with or without other)	2 (8.3%)	2 (8.3%)	4 (8.3%)
Hispanic/Latino + Black or African American	2 (8.3%)	0 (0.0%)	2 (4.2%)
Asian + Middle Eastern or North African	1 (4.2%)	0 (0.0%)	1 (2.1%)
White + Hispanic/Latino + American Indian/Alaska Native	0 (0.0%)	1 (4.2%)	1 (2.1%)
White + Hispanic/Latino + Middle Eastern/North African	1 (4.2%)	0 (0.0%)	1 (2.1%)
Total	24 (100%)	24 (100%)	48 (100%)

Note. Categories reflect both single and multiracial/ethnic identities as reported. Participants could identify with more than one group. Categories are based on U.S. Census racial/ethnic classifications.

Household income levels varied across participants, with bilingual families reporting incomes ranging from below $40,000 to over $200,000, and monolingual families reporting a similarly broad range. Maternal education levels were generally high across both groups, with many reporting professional or graduate-level education, followed by bachelor's degrees. See Table 3 below for household income and maternal education level by language group.

Table 3

Household Income and Maternal Education Level by Language Group

Variable	Bilingual (n = 24)	Monolingual (n = 24)	Total (N = 48)
Household Income			
$0–$24,999	1	4	5
$25,000–$49,999	1	2	3
$50,000–$74,999	6	2	8
$75,000–$99,999	2	1	3
$100,000–$149,999	4	4	8
$150,000–$199,999	2	3	5
$200,000+	4	7	11
Not Available / Missing	4	1	5
Mother's Education Level			
Associate's Degree	0	1	1
Bachelor's Degree	6	7	13
Graduate Degree (MA/PhD)	2	2	4
Professional Degree (e.g., JD, MD)	14	14	28
Not Available / Missing	2	0	2

Note. Income values grouped into standard U.S. income brackets. "Professional degree" includes degrees such as JD, MD, DDS.

Geographically, participants were distributed across multiple U.S. states. The bilingual group had a greater concentration in states such as California and Illinois, with other participants spread across

states including Massachusetts, Maryland, Louisiana, and Hawai'i. Monolingual participants were similarly distributed, with clusters in states like Texas, North Carolina, and New York. Regarding population density, most participants resided in suburban or urban areas, with a small number from rural locations.
See Table 4 below for participant location and population density by language group.

Table 4

Participant Location and Population Density by Language Group

Population Density	Bilingual (n = 24)	Monolingual (n = 24)	Total (N = 48)
Urban	10	7	17
Suburban	13	16	29
Rural	1	1	2

State	Bilingual (n)	Monolingual (n)	Total (N)
CA	**6**	**4**	**10**
IL	**5**	**2**	**7**
MA	**2**	**1**	**3**
AL	**2**	**0**	**2**
Other States	**9**	**17**	**26**

Note. "Other States" include all states represented by fewer than 2 participants per group. Population density categorization based on reported urban, suburban, and rural locations.

Data from 48 total participants was included in analysis, while an additional 14 were collected as possible replacements if needed for bilingual (n=3) and monolingual (n=11). A total of 10 additional participants were dropped for fussiness (n=5), too many environmental distractors (n=3), and poor video recording quality (n=2). Any individual trial phases that had no observed looks at either target or distractor objects, or a total looking time of 0 frames, were excluded from analysis. Out of 48 participants, 17 participants had dropped trial phases, with a range of 1 to 16 trial phases (*M* = 2.82) dropped from a total of 32 trial phases per participant. Across all 48 participants, 56 out of 1536 total trial phases, or 0.04%, were dropped.

Participants were recruited using the online study platform, Children Helping Science. Participants were assigned to either the monolingual or bilingual group according to their reported language experience upon registration for Children Helping Science. Families were compensated for their time with a $5 digital gift card.

Stimuli

Participants saw colored pictures of familiar objects presented in pairs over a white background, one target (named) object and one distractor object, on either side of the screen (e.g., a *baby* and a *cow*). Simultaneously, they heard speech stimuli of two sentences instructing participants to look at the picture of the target (named) object, which appeared in the sentence-final position. Sentences were presented in two different carrier phases within each trial. For each visual target and distractor pair, participant looking time at the target (named) object is considered correct looking time. Participant looking time at the distractor object is considered incorrect looking time.

During the first phase of each trial, participants were shown a pair of familiar objects while simultaneously presented with two auditory speech stimuli at a 0 dB signal-to-noise ratio (SNR), a primary female speaker using child-directed speech to direct the children's attention to a target (named) object on the screen while a secondary male speaker using adult-directed speech spoke about an object not shown on the screen. The speech stimuli spoken by the primary female speaker directed children to attend to one of the objects shown on the screen (e.g., Look at the *baby*! Do you see the *baby*?), while the speech stimuli spoken by the secondary male speaker directed children to attend to an unseen object (e.g., It's a *fish*. Look. Right there, it's a *fish*.). Greater looking time at the visual target (named) object that correlates with the auditory target presented by the primary speech stream in the first phase of each trial indicates that the child attended to the primary speech stream. By analyzing the mean looking time at phase one target (named) objects, we can obtain a measure of the child's selective attention to that speech stream.

During the second phase of each trial, participants were presented with a different visual target/distractor pair of familiar objects (e.g., a *frog* and a *fish*) while a singular speech stream spoken by the primary female speaker using infant-directed speech directed children to attend to an unspecified object shown on the screen. The second phase differed in that the speech stimuli contained no target words (e.g., Look! There it is. It's right there.) and the visual target (named) object was previously named by the secondary male speaker in the preceding phase one trial (e.g., *fish*). Greater correct looking time at the target (named) object previously mentioned by the male speaker, compared to incorrect looking time at the distractor object, indicates distributed attention to both the female speaker and the male speaker in the previous phase. By analyzing the mean looking time at phase two target (named) objects, we can obtain a measure of the child's distributive attention to both speech streams.

Speech stimuli were created in English and recorded by the same female (Spanish-English bilingual) and male (English monolingual) speakers. To help reduce differences in recording across orders, the speakers were instructed to produce speech stimuli with similar prosodic patterns, with the primary female speaker using infant-directed speech with a consistent intonation pattern and the secondary male speaker using adult-directed speech with a consistent intonation pattern. Mono signal recordings were made using Adobe Audition software with a Shure SM51 microphone at a 44.1 kHz sampling rate and 32 bits of precision.

Target words were selected using the Stanford Word Bank, using words that ranked above the 3rd quartile in familiarity for typically developing children by age 30 months. Auditory targets ranged from one to four syllables. Target and distractor pairs were matched for approximate size, animacy, and, when possible, color into one set of 16 phase one target/distractor pairs and two sets of 16 phase two distractor/target pairs. Refer to Tables 5-6 in the Appendix for detailed word lists.

Which object appeared on the left vs. right side of the screen was counterbalanced across participants. Audiovisual stimuli were arranged into four possible orders consisting of different sequences of all 16 phase one target/distractor pairs, as well as varying between the first or second set of 16 phase two target word pairs. These variations in stimuli presentation were made in order to account for possible differences in participant object preference, familiarity, and visual looking preference between left and right sides of the screen. See Table 7 below for an example of the first four trials in Order 1. Refer to Table 7 in the Appendix for detailed lists of Orders 1-4.

Table 7 (Abbreviated)

Order 1 Target and Distractor Trial Pairings

Trial	**Phase**	**Visual Target** (Shown on either left or right side of screen)	**Visual Distractor** (Shown on either left or right side of screen)	**Primary Auditory Target** (Female Speaker)	**Secondary Auditory Target** (Male Speaker)
Trial 1	Phase 1	Ice Cream (L)	Lollipop (R)	Ice Cream	Pillow
	Phase 2	Pillow (R)	Box (L)	–	–
Trial 2	Phase 1	Elephant (L)	Lion (R)	Elephant	Horse
	Phase 2	Horse (R)	Dog (L)	–	–
Trial 3	Phase 1	Baby (L)	Cow (R)	Baby	Fish
	Phase 2	Fish (R)	Frog (L)	–	–
Trial 4	Phase 1	Bunny (L)	Zebra (R)	Bunny	Bird
	Phase 2	Bird (L)	Bear (R)	–	–

Note. With each trial phase, visual targets were shown on either left or right side of screen, while visual distractors were shown on the opposite side of the screen as the visual target. Different trial orders presented the same set of visual stimuli in different target/distractor pairings and left/right screen locations, in order to control for any participant biases of left/right screen preference and object preference.

Visual stimuli were edited using Google Slides. Auditory stimuli were recorded and edited in a sound booth using Adobe Audition. Both phase one and phase 2 of each trial were edited to be 5500 milliseconds in length. Between each trial phase a short attention-getter (a colorful swirling ball) appeared on the screen for approximately 3000 milliseconds to provide participants with a break from the stimulus and to direct their attention to the center of the screen, followed by a brief red screen with a simultaneous click sound (used to calibrate videos for later analysis) consisting of 400 milliseconds. Including an attention getter, red click, phase one, an attention getter, red click, and phase two, each trial consisted of a total of approximately 17.8 seconds.

Four blocks of four trials were presented, consisting of 16 total trials. Between blocks, a short attention-getter (a peeking monkey) appeared on the screen to provide participants with a break from the stimulus.

Procedure

Study design was an online asynchronous preferential looking study. The independent variable was children's language condition (monolingual vs. bilingual), and the dependent variable was participant fixation times (how long children looked at phase one and phase two target ((named)) objects). Using the online data collection platform, Children Helping Science, participants completed the study asynchronously online on a home computer while the internal webcam recorded their eye movement. Families were provided a brief overview of how to set up their room (adjusting background noise, lighting, camera angle, volume, etc.) and what to expect during the approximately 5-minute study and subsequent language exposure survey. Caregivers were asked to position their child alone in front of the computer screen or, if placing their child in their lap for the study, to close their eyes in order to prevent caregivers from inadvertently influencing the children's looking behavior.

Following two optional preview trials, participants were randomly assigned and presented with one of four possible testing orders of 16 two-phase testing trials. An attention getter was presented before each trial phase in order to reorient the participant to the center of the computer screen. While each of the four testing orders were randomly assigned and counterbalanced across participants, the order of phases within each trial was fixed so that the first phase was always a test of selective attention and the second phase was always a test of distributed attention. Due to the nature of attentional allocation, this fixing was deemed necessary in order to present both phase one and phase two auditory target (named) objects within two competing speech streams. In order to test a child's ability to notice and recall information from the preceding secondary speech stimulus, the phase two auditory target (named) object must be presented with the primary speech stimulus simultaneously such that participants' immediate attention to the primary speech stimulus is measured first and then distributed attention, by means of target (named) object recall, to the secondary speech stimulus is measured second.

Following the testing phase, families were asked to fill out an adapted version of the Multilingual Approach to Parent Language Estimates (MAPLE), which is a structured interview intended to gather information about a child's language background and provide demographic information regarding whether their bilingual children were frequently exposed to both languages within the home or in other environments (Byers-Heinlein et al., 2020). The MAPLE is typically conducted synchronously by a live interviewer so they may prompt the child's caregiver and answer any clarifying questions the caregiver may have in order to gain more detailed information, and may take up to forty minutes to complete. Because the current study was asynchronous, the format of the traditional interview was modified into a remote survey that caregivers could complete on their own via the online Children Helping Science platform in about fifteen to twenty minutes. Without a live interviewer to guide caregivers through this adapted asynchronous version of the MAPLE, there is the possibility that the information provided may be less detailed or accurate than if the interview was conducted in its original format. That being said, we decided that maintaining the asynchronous format of the study at the risk of less detailed or accurate MAPLE data was worth taking in order to keep the overall study as accessible as possible for families to sign up for and complete at their convenience. While the MAPLE data may not be as thorough in this asynchronous format, it does provide a valuable approximation of participants' language exposure and as well as meaningful context in confirming whether participants are truly monolingual or bilingual.

Measures

Outcome measures included mean looking time in frames at the visual target (named) objects during phase one trials, as well as mean looking time in frames at visual target (named) objects during phase two trials. Mean looking time in frames at phase one trial target (named) objects may be an indicator of a child's demonstrated ability in selective attention. Mean looking time in frames at phase two trial target (named) objects may be an indicator of a child's demonstrated ability in distributed attention.

Analysis

Children's eye movements (left vs. right) were coded by hand offline, on a frame-by-frame basis using Datavyu coding software (Datavyu Team, 2014). All videos were single-coded by coders reliability-trained in Datavyu and blind to the visual target (named) object location per trial, including researcher (n=32 participant videos) and 8 undergraduate research assistants (n=16 participant videos). Data on the overall time course of eye movements was linked to the auditory stimuli in order to calculate fixation duration and shifts in gaze between the images on screen. Data was analyzed for total looking time in frames at correct and incorrect objects after the onset of the target (named) object presentation for different trial phases. In phase one trials, the onset of auditory target (named) object presentation occurred 42 frames, or approximately 1.4 seconds, after trial onset. In phase two trials, total looking time in frames at correct and incorrect objects was measured beginning at trial onset because the auditory target (named) object had already been presented in the previous trial. Looking patterns for phase one trial target (named) objects and phase two trial target (named) objects were compared to each other, as well as between bilingual and monolingual participant groups.

3. Results

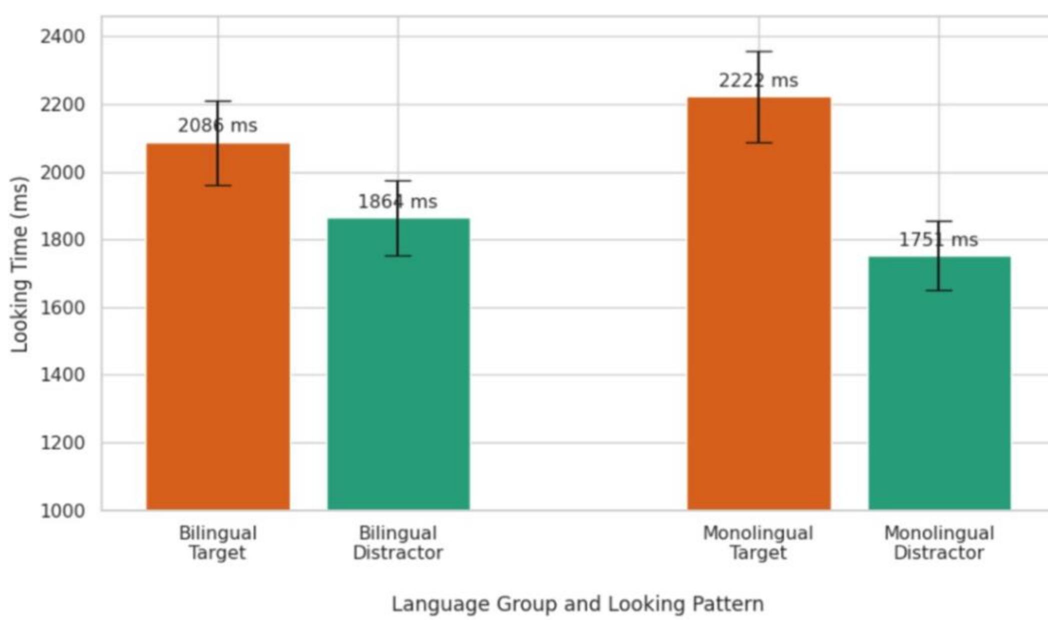
In this study, we investigated whether bilingual and monolingual children ages 3-4 years differ in their ability to notice and recall words spoken when presented in two different speech streams. Is there a difference in observed performance of young bilingual children, aged 3-4 years, on auditory selection tasks requiring both selective and distributed attention compared to monolinguals of the same age group? We hypothesized that bilingual preschoolers would outperform monolingual peers in measures of distributed attention, as well as, selective attention. Across both task types, selective and distributed attention, looking patterns revealed subtle differences between language groups, but none that reached statistical significance.

Selective Attention

Both bilinguals and monolinguals looked at correct objects more than incorrect objects during selective attention tasks, with correct objects being the visual target (named) objects named by the primary female speaker and incorrect objects being the simultaneously presented visual distractors. Although monolinguals showed slightly greater target (named) object looking time and slightly less distractor looking time than bilinguals, these differences were quite small, as can be seen in Figure 1 below.

Figure 1

Total Looking Time (in Milliseconds) During Selective Attention Tasks by Language Group and Accuracy



Note. Looking time measured in milliseconds during selective attention trials. Target (named) object looking indicates correct looking time. Distractor object looking indicates incorrect looking time. Higher values indicate greater visual attention to objects on screen. Error bars represent Standard Error of the Mean (SEM).

A two-way ANOVA examining selective attention found a significant main effect of looking patterns, F(1,48) = 5.034, p = .030, with preschoolers looking significantly longer at correct than incorrect objects. Critically, there was no main effect of language group, F(1,48) = 0.032, p = .859, and no interaction between language group and looking patterns, F(1,48) = 0.648, p = .425, suggesting that participants demonstrated similar looking patterns, attending more to named objects despite competing meaningful speech regardless of language group. See Table 8 below for more details.

Table 8

Two-Way Mixed ANOVA Results for Selective Attention Looking Time

Source	df	F	p
Looking Pattern (Target vs. Distractor)	1, 48	5.034	.030
Language Group (Mono vs. Bi)	1, 48	0.032	.859
Looking Pattern × Language Group	1, 48	0.648	.425

Note. Looking pattern refers to total looking time (in MS) to target (named) vs. distractor objects. Language group refers to monolingual vs. bilingual participants.

Initial analyses showed a main effect of looking pattern, such that children looked longer at correct than incorrect objects, but no effect of language group. Adapted MAPLE questionnaire data later revealed that the bilingual sample was highly English-dominant and heterogeneous: 1 non-English-dominant child, 4 balanced, 14 English-dominant, and 5 reported as English-only. Four of those cases yielded inconsistent language histories compared to parent reports on their child's language status prior to study participation, and the fifth child was reported as having prior experience to two languages until age two, after which they only heard and spoke English. That being said, it is important to remember that bilingualism exists on a spectrum and varies over time within individual experience. Re-analyzing the data with parent-reported percentage of estimated English use as a continuous covariate ($n = 44$) removed the looking-pattern effect and produced no main or interaction effects (all $ps \geq .75$), as seen in Table 9 below. In this largely English-dominant cohort (mean estimated English use = 77 % based on adapted MAPLE data), language experience did not predict looking patterns during selective attention tasks. Stronger effects may require a sample with a more balanced distribution of bilingual experience.

Table 9

GLM Results for Selective Attention Looking Time with English Language Experience as a Covariate

Source	df	F	p
Looking Pattern (Correct vs. Incorrect)	1, 44	0.098	.756
English Language Experience (Covariate)	1, 44	0.039	.845
Looking Pattern × English Language Experience	1, 44	0.010	.920

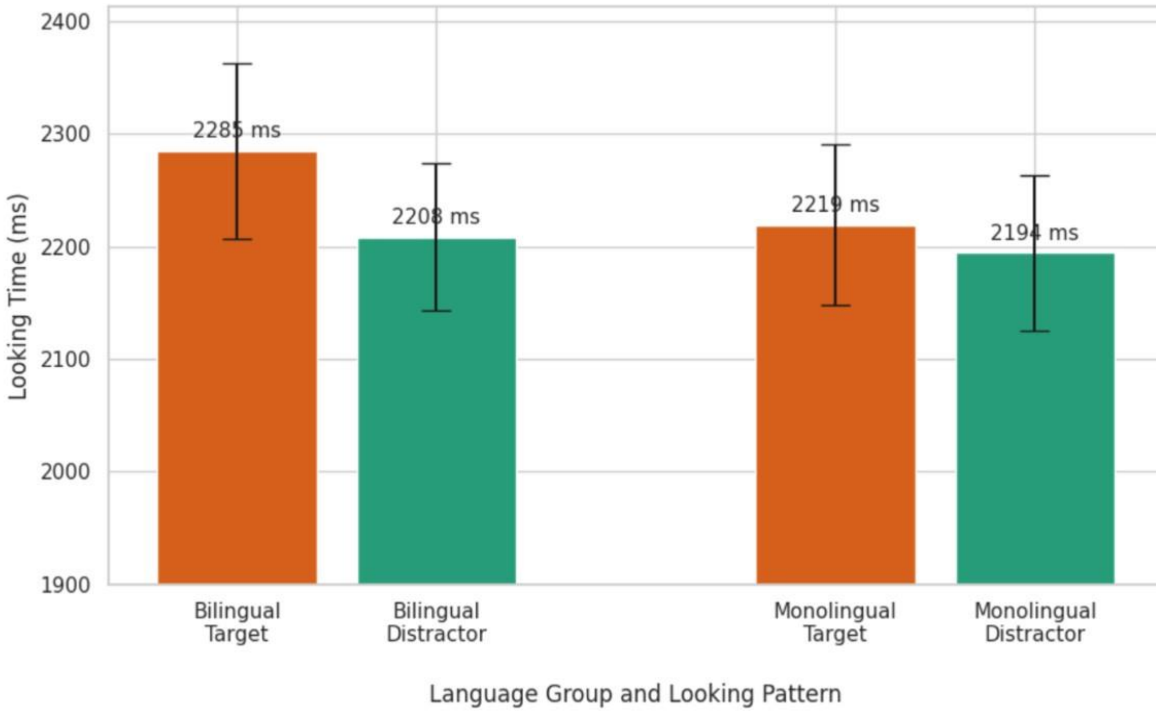
Note. Looking pattern refers to total looking time (in ms) to correct vs. incorrect objects during selective attention tasks. English language experience reflects parent-reported current percentage of English language use from adapted MAPLE questionnaire.

Distributed Attention

Distributed attention tasks revealed near chance performance accuracy across both language groups (bilingual: $X = 0.51$, monolingual: $X = 0.49$), with correct objects being the visual target named by the secondary male speaker in the preceding selective attention trial phase, and incorrect objects being the simultaneously presented visual distractor. Minimal differences in looking patterns at correct vs. incorrect objects, particularly in the monolingual group, suggest that participants had difficulty noticing and recalling the previously named target object from the secondary male speaker during selective attention task trials in order to successfully complete the more demanding distributed attention task trials, as seen in Figure 2 below.

Figure 2

Total Looking Time (in Milliseconds) During Distributed Attention Tasks by Language Group and Accuracy



Note. Looking time measured in video frames during distributed attention trials. Target (named) object looking indicates correct looking time. Distractor object looking indicates incorrect looking time. Similar values across conditions suggest performance near chance level. Error bars represent Standard Error of the Mean (SEM).

A two-way ANOVA for distributed attention revealed no significant effects of looking pattern, language group, or their interaction (all ps > .49). Participants did not show a difference in looking time toward correct vs. incorrect objects during phase two trials, regardless of language background, suggesting unsuccessful attention to target (named) objects in this condition, as seen in Table 10 below.

Table 10

Two-Way ANOVA Results for Distributed Attention Looking Time by Language Group

Source	df	F	p
Looking Pattern (Target vs. Distracted)	1, 48	0.474	.494

Language Group (Monolingual vs. Bilingual)	1, 48	0.328	.569
Looking Pattern × Language Group	1, 48	0.122	.729

Note. Looking pattern refers to total looking time (in frames) to correct (named) vs. incorrect objects during distributed attention tasks. Language group includes monolingual English and bilingual English-speaking participants.

Adapted MAPLE Questionnaire

Although language backgrounds were diverse, non-English dominance was low, as described earlier and as seen in Table 11 below. Parent-reported English use among bilingual participants ranged from 40% to 100%, with a few balanced bilinguals and 19 of 24 identified as currently English dominant. This highlights the variability within the bilingual group in terms of language exposure, dominance, and pairings, as seen in Table 12 below.

Table 11

Reported Home Language Use Among Bilingual Participants (N = 24)

Language(s) Reported	Count	Estimated English Use (%)	Notes
English only	4	100	No additional language reported
English & Spanish	8	40–95	Most frequent non-English language
English & French	1	50	Balanced bilingual
English & Yoruba	1	50	Balanced bilingual
English & Japanese	1	60	Moderate use of Japanese
English, Korean & Gujarati	1	90	Minimal use of other two languages
English, Spanish & Twi	1	50	25% Spanish, 25% Twi
English & Mandarin	1	95	Mandarin minimally reported

English & Indonesian	2	90, 90	Minor Indonesian use
English & Bengali	1	99	Minimal Bengali use
English & Pashto	1	95	Minimal Pashto use
English & Cantonese	1	98	Minimal Cantonese use
English & Urdu	1	60	Moderate use of Urdu
Totals	24	Range: 40–100	13 languages other than English reported

Note. Estimated English Use (%) based on parental estimates from the adapted MAPLE questionnaire.

Table 12

Language Dominance Breakdown of Bilingual Participants (N = 24)

Dominance Type	Number of Participants	Percentage of Group (%)
Non-English Dominant	1	4.2
Balanced (50% English)	4	16.7
English Dominant (>51%)	19	79.2

Note. Estimated Dominance Type based on parental estimates from the adapted MAPLE questionnaire.

4. Discussion

Language Experience

Across both selective and distributed attention tasks, language experience did not predict looking pattern: Children with bilingual language experience showed no advantage over monolingual peers, and the hypothesized bilingual advantage was not observed. Parent reports revealed that the bilingual sample was overwhelmingly English-dominant: only 1 of 24 spoke English <50% of the time and 4 were balanced bilinguals, while the remaining 19 were English-dominant. With just 21% of bilingual participants truly balanced or non-English-dominant, the study was underpowered to detect effects of language experience.

This sampling issue illustrates a broader challenge. Assignment to language groups was based on initial parental report regarding their child's bilingual status, but more in-depth analysis of data from the adapted MAPLE suggests that the bilingual sample did not include the target bilingual children who may have demonstrated a difference in performance.

The shifting and individual nature of the bilingual experience makes it challenging to quantify for a study participant and distill in a way that fits neatly into the boxes we like to use for scientific measurement. From a sociolinguistic perspective, if a bilingual parent identifies their child as a bilingual speaker, then that choice is valid, and there is no "magic number" their child needs to reach in order to qualify as bilingual. No matter where an individual's language experience falls on the spectrum of proficiency from 1-100, this identity is something to be claimed by members within that particular language community. Bilingual experience is fluid and personal, yet experimental work often requires clear contrasts in language experience and dominance.

Considering more developmental cognitive linguistic perspectives, although there is no such thing as needing to be "bilingual enough", current evidence of bilingual language effects has been substantially difficult to reproduce and confirm, indicating a need for more pronounced differences in language experience of comparison groups regarding participants' language dominance. Robust bilingual effects are most likely when comparison groups differ sharply in language balance, enabling researchers to attribute cognitive differences to bilingualism rather than to individual variability.

Recruitment constraints magnified the imbalance in the bilingual group. The study ran remotely, in English, on the Children Helping Science virtual platform, conditions favoring families with reliable internet, English proficiency, and the time and incentive to voluntarily participate in research. As a result, nearly every bilingual child in this sample was English-dominant. Despite the need for minority language representation in developmental research, this gap in recruitment helps illustrate the fact that it is generally less easy and more inconvenient for non-English dominant families to participate in these studies than for families that speak the social majority language, especially when the study is conducted via channels that require sufficient English experience to access participation. Future work should narrow the linguistic focus of language groups (e.g., English and Spanish), prescreen for language dominance, and use multilingual recruitment materials and platforms to reach non-English dominant families.

Why does researching possible effects of bilingualism on cognitive processes beyond the domain of language matter? Even if the “phantom-like” advantages cannot yet be reliably confirmed or replicated, it is important to contribute to growing literature that developmental bilingualism is, if not beneficial, at the very least not harmful to children (Leivada et al., 2020). Challenging the historically pervasive stigma and misinformation against non-English languages and how they may negatively impact a child’s ability to learn is crucial for developmental researchers and educators in order to provide the most accurate information and recommendations to bilingual and non-English language dominant families so they may best support their children’s growth in home and at school.

This study was originally intended to compare monolingual English and bilingual Spanish/English children. Study materials and recruitment advertisements were developed in both English and Spanish by Vanessa Schorr Guerrero, who designed the study, in order to increase accessibility for bilingual Spanish dominant families. Researchers made the decision to broaden study participation for this initial pilot to any bilingual English families, with the intention to narrow bilingual groups to more specific languages in the future. The result of this study’s broader non-English language criteria for study participants resulted in an interesting and diverse representation of languages overall; however, this approach ultimately limited our ability to isolate the possible factors contributing to findings due to high language variation across bilingual participants. Narrowing language groups down to two languages, English and Spanish, would allow for greater specificity in both study design and interpretation of findings. An ideal population for future research would include English monolinguals, Spanish monolinguals, and English/Spanish balanced bilinguals with testing conditions in both English and Spanish in order to achieve a testing environment closer to participants' natural language environment.

In order to represent a higher number of non-English language dominant participants, more specific participation criteria, as well as alternative recruitment methods and study design, would need to be considered by researchers. Specifying children's language dominance with families prior to language group assignment is one strategy that could help increase the number of non-English language dominant participants so researchers could control for differences in English language dominance and subsequently balance the language experience of participants in the bilingual group more effectively.

With a large enough sample, researchers could compare multiple language dominance profiles, e.g., English monolinguals, non-English monolinguals, balanced bilinguals, and English-dominant bilinguals, to clarify how varying bilingual experience may modulate attention, memory, and learning in young children.

Selective Attention

A modest but significant main effect of looking pattern emerged in the selective attention task: children in both language groups spent more time fixating on the target (named) object than the distractor object, indicating they could follow the primary speech stream despite competing meaningful speech. However, the effect disappeared when parent-reported English experience was entered as a covariate, showing that individual variability in language dominance outweighed the group level contrast. In other words, selective attention was present, but weak and highly inconsistent across participants.

This fragility is not surprising. It is important to consider children's general ability to attend to one auditory signal in the presence of background noise, as well as the type of auditory stimuli competing with the primary female speaker. Current evidence suggests that young children are able to select a single speech stream in the presence of background noise, and that their performance differs depending on whether the background noise is a single meaningful speech stream, nonspeech background noise, or multitalker babble, as well as the signal-to-noise ratio (SNR). Electroencephalography work shows that three-year-olds can selectively attend to one of two stories only when clear cues, such as spatial separation and distinct speaker voices, are provided (Coch, Sanders, & Neville, 2005). Preschoolers' auditory selective attention skills are only beginning to develop, and performance declines sharply when the competing stream is linguistically meaningful, delivered at a 0 dB signal-to-noise ratio, and acoustically similar to the target input stream (Blanco et al., 2023; Hobbiss & Lavie, 2024; Newman, 2009).

For example, Newman (2009) found that infants aged 5- and 8.5-months were able to recognize their own name in the presence of background multitalker babble with a 10dB signal-to-noise ratio, but not in the presence a background single talker with either meaningful speech or nonspeech with a 10dB signal-to-noise ratio. This finding suggests that while infants demonstrate an ability to attend selectively to meaningful speech in competing background noise, it may be more difficult for infants to differentiate between streams that are more similar acoustically (Newman, 2009). It is also possible that infants are drawn to single talker speech over multitalker babble, making it difficult to actively select between two single speech streams (Newman, 2009).

Even adults identify speech less accurately under comparable conditions, especially when a single competing talker must be inhibited. Simpson & Cooke (2005) explored how different conditions of background multitalker babble affect adults' ability to identify English consonants in noise. In natural babble conditions, using real recordings with different numbers of speakers, performance accuracy was poorest with 6-128 talkers, the worst of which being 6-8 background speakers, but accuracy slightly improved as more talkers were added background, likely because the background babble became more noisy and less linguistically meaningful as speakers were added (Simpson & Cooke, 2005). In babble-modulated noise, where individual talkers were added gradually, performance accuracy became gradually worse in a more predictable pattern, suggesting that the type of background noise affects adults' ability to attend to speech sounds. It is possible that meaningful background noise may be more "distracting" because the brain wants to process individual speech streams, whereas non-meaningful background noise that still mimics temporal patterns of speech masks the primary speech sound physically, but may be less distracting than natural babble because the brain is not also trying to understand any linguistic content (Simpson & Cooke, 2005).

These findings briefly highlight our current understanding of how humans are able to selectively attend to meaningful speech within competing listening environments across the lifespan. Current evidence suggests that linguistic interference is more challenging to ignore than physical interference and that greater signal-to-noise ratios aid listeners' ability to selectively attend to competing language inputs

(Coch, Sanders, & Neville, 2005; Newman, 2009; Simpson & Cooke, 2005). Essentially, fewer speakers in a listening environment equate to more meaningful input that the brain wants to process, while more speakers equate to more noise-like, and therefore less linguistically meaningful, input that requires less inhibitory control to ignore. Thus, the current study task posed a demanding combination of low SNR and two meaningful, acoustically similar streams.

Although language group differences did not reach significance, monolinguals looked 136 ms longer at target (named) object and 113 ms less at distractor objects than bilinguals. Given the sample's strong English dominance overall, a more balanced bilingual sample may reveal a clearer effect of bilingual language experience, possibly supporting current evidence that bilingual toddlers and young children generally perform equal or worse than monolinguals in listening-in-noise tasks, especially when the tested language is not strongly dominant (Morini & Newman, 2021; Poulin -Dubois et al., 2011).

Finally, auditory selective attention to a dynamic information stream is understood to be more challenging than visual selective attention to static input because its "intrinsic temporality" creates additional demands on working memory and "object-based perceptual organization of the sensory inputs both over time and across different peripheral sensory channels" in order to notice, select, process, integrate, and scan for the correct object during selective attention tasks (Noyce et al., 2023, p. 1). Developmental attention research has focused largely on the visual domain; our findings highlight the need for further work on auditory attention, where temporal demands and linguistic interference create distinct challenges for young listeners.

Distributed Attention

Across distributed attention trials, children's looking times toward correct versus incorrect objects did not differ, and overall accuracy remained at chance. These null effects held for both monolingual and bilingual participants, indicating that children generally failed to identify the object named by the secondary speaker and therefore, did not attend to the correct visual object shown on the screen during distractor trials. The chance-level performance possibly reflects the need for methodological refinement rather than an inability of preschoolers to distribute their attention. Several features of the stimulus design may have contributed to children's chance-level performance on distributed attention tasks.

First, both speech streams were presented in the same language, Mainstream American English, in order to control for differences in language experience across participants. However, this may have reduced ecological validity for bilingual children, whose natural language environments often include variable exposure to multiple languages. While using the same language for simultaneous auditory stimuli allowed for comparison with monolingual peers, it is possible that presenting competing speech stimuli in two different languages may yield different results in future research, e.g., a primary female speaker using infant-directed speech in English and a secondary female speaker using infant-directed speech in Spanish. Another possible testing condition to consider could be a primary female speaker using infant-directed speech in English and a secondary male speaker using adult-directed speech in Spanish. Introducing two-language speech streams could better capture bilingual children’s attention and more accurately reflect real-world listening contexts.

Second, the competing speech streams were differentiated by speaker gender and intonation pattern. The primary stream featured a female speaker using child-directed speech, while the secondary stream featured a male speaker using adult-directed speech. While this contrast was intended to make streams perceptually distinct and to encourage them to treat the female speaker as the primary speech stream, it may have biased children’s attention such that they did not attend to the secondary male speech stream that contained the target (named) object for the subsequent distributed attention trial phase. Prior research has shown that young children prefer higher-pitched voices and more varied intonation patterns (Fernald & Kuhl, 1987; Nencheva et al., 2021), suggesting they may have been more engaged by the female speaker and more likely to ignore the monotone male speaker.

Finally, the roles of the speakers shifted across task phases. In Phase 1 (selective attention), the primary female speaker consistently named the visual target (named) objects shown, while in Phase 2 (distributed attention), the female speaker used similar language without naming either of the visually presented objects. This shift may have led children to rely on the female voice as the primary source of information, diminishing their attention to the secondary male speech stream during selective attention trials. Together, these factors suggest that the structure of the auditory stimuli may have inadvertently limited children's ability to demonstrate distributed attention.

Additionally, variability in room layout, lighting, device placement, and presence of family members introduced uncontrolled distractions in remote testing environments. Although selective-attention trials still produced above-chance accuracy, such environmental noise may have further reduced attention to the already less-salient secondary speech stream.

To better capture bilingual children's distributed attention abilities, future research should consider several methodological refinements. First, using more naturalistic auditory stimuli may improve task sensitivity. Presenting competing speech streams in two different languages and manipulating the signal-to-noise ratio could more closely reflect the natural listening environments of bilingual children, who often encounter overlapping multilingual input.

Second, researchers should aim to use matched prosody across speakers. For example, using two equally engaging voices, such as female speakers employing child-directed speech, or counterbalancing speaker roles across trials can help avoid unintentional biases, such as children attending primarily to a single speaker. In order to distinguish between primary and secondary speech streams, greater signal-to-noise ratios and/or simultaneous English and Spanish stimuli should be considered.

Third, adopting a within-subject bilingual design, in which bilingual children are compared across language conditions rather than against monolingual peers, may provide a clearer picture of how language dominance affects attentional processes.

Finally, whenever possible, researchers should strive for a controlled testing environment. This could involve in-lab data collection or standardized remote testing protocols that ensure consistent camera positioning, lighting, and background activity. Together, these refinements can enhance the validity and interpretability of future studies examining auditory attention in bilingual children.

5. Implications, Limitations, and Conclusion

This study investigates the relationship between developmental bilingualism and auditory attention, specifically selective and distributed attention, in preschool-aged children. Contrary to the initial hypothesis, bilingual participants did not demonstrate significantly greater looking accuracy than their monolingual peers in either task type, suggesting that the relatively low levels of non-English language dominance among bilingual participants may have contributed to the absence of observable effects. The weak but significant effect observed in selective attention tasks, which did not hold when overall language experience was considered as a covariate across all participants, reflects emerging attentional capacities typical of preschool-aged children. In contrast, the absence of an effect in distributed attention tasks, in addition to chance-level accuracy across all participants, suggests limitations in the current task design rather than a lack of underlying ability. This finding reflects the methodological challenge of capturing distributed auditory attention in young children, particularly in remote and uncontrolled testing environments.

Despite these limitations, this study contributes meaningfully to a growing body of research challenging outdated assumptions about bilingualism's impact on cognitive development. While current study findings do not provide evidence of a bilingual advantage in attentional skills, they support the broader consensus that bilingualism is not detrimental to young children's cognitive outcomes. Crucially, the study also exposes structural limitations in research design and recruitment that disproportionately exclude non-English dominant families. These systemic barriers must be addressed by researchers to ensure linguistic diversity is adequately represented in developmental literature.

Future research should utilize more refined participant selection criteria, prioritize methodological designs that minimize environmental variability, and make use of more inclusive multilingual recruitment strategies. Additionally, comparative work across varying degrees of language dominance may help shed light on the nuanced effects of bilingualism on attentional processes. Doing so will enable researchers to more accurately assess how language experience intersects with early cognitive development and help challenge persistent misconceptions about bilingualism in early childhood.

6. Appendix

Table 5

Selective Attention Tasks: Phase 1 Trial Target Words and Distractors

Target Words	**Distractor Words**
Baby	Cow
Bunny	Zebra
Elephant	Lion
Ice Cream	Lollipop
Bicycle	Hamburger
Butterfly	Ladybug
Cookie	Apple
Monkey	Alligator
Airplane	Scissors
Pizza	Corn
Strawberry	Water Bottle
Table	Candy
Balloon	Cupcake
Banana	Chair
Flower	Sandwich
Orange	Basket

Table 6

Distributed Attention Tasks: Phase 2 Trial Target Words and Distractors

Target Words	Distractor Words
Fish	Frog
Bird	Bear
Horse	Dog
Pillow	Box
Hat	Bowl
Duck	Bee
Bed	Truck
Pig	Cat
Bus	Cheese
Car	Brush
Tree	Toothbrush
Shirt	Key
Clock	Button
Ball	Book
Bug	Mouse
Carrot	Toy
Frog	Fish
Bear	Bird
Dog	Horse
Box	Pillow
Bowl	Hat

Bee	Duck
Truck	Bed
Cat	Pig
Cheese	Bus
Brush	Car
Toothbrush	Tree
Key	Shirt
Button	Clock
Book	Ball
Mouse	Bug
Toy	Carrot

Table 7

Order 1 Target and Distractor Trial Pairings

Trial	**Phase**	**Visual Target** (Shown on either left or right side of screen)	**Visual Distractor** (Shown on either left or right side of screen)	**Primary Auditory Target** (Female Speaker)	**Secondary Auditory Target** (Male Speaker)
Trial 1	Phase 1	Ice Cream (L)	Lollipop (R)	Ice Cream	Pillow
	Phase 2	Pillow (R)	Box (L)	–	–
Trial 2	Phase 1	Elephant (L)	Lion (R)	Elephant	Horse
	Phase 2	Horse (R)	Dog (L)	–	–
Trial 3	Phase 1	Baby (L)	Cow (R)	Baby	Fish
	Phase 2	Fish (R)	Frog (L)	–	–
Trial 4	Phase 1	Bunny (L)	Zebra (R)	Bunny	Bird
	Phase 2	Bird (L)	Bear (R)	–	–
Trial 5	Phase 1	Butterfly (R)	Ladybug (L)	Butterfly	Duck
	Phase 2	Duck (R)	Bee (L)	–	–
Trial 6	Phase 1	Bicycle (L)	Hamburger (R)	Bicycle	Hat
	Phase 2	Hat (R)	Bowl (L)	–	–
Trial 7	Phase 1	Monkey (R)	Alligator (L)	Monkey	Pig
	Phase 2	Pig (L)	Cat (R)	–	–
Trial 8	Phase 1	Cookie (L)	Apple (R)	Cookie	Bed
	Phase 2	Bed (L)	Truck (R)	–	–

Trial 9	Phase 1	Balloon (L)	Cupcake (R)	Balloon	Clock
	Phase 2	Clock (L)	Button (R)	–	–
Trial 10	Phase 1	Banana (R)	Chair (L)	Banana	Ball
	Phase 2	Ball (L)	Book (R)	–	–
Trial 11	Phase 1	Flower (R)	Sandwich (L)	Flower	Bug
	Phase 2	Bug (R)	Mouse (L)	–	–
Trial 12	Phase 1	Orange (R)	Basket (L)	Orange	Carrot
	Phase 2	Carrot (L)	Toy (R)	–	–
Trial 13	Phase 1	Strawberry (R)	Water Bottle (L)	Strawberry	Tree
	Phase 2	Tree (L)	Toothbrush (R)	–	–
Trial 14	Phase 1	Pizza (L)	Corn (R)	Pizza	Car
	Phase 2	Car (L)	Brush (R)	–	–
Trial 15	Phase 1	Airplane (R)	Scissors (L)	Airplane	Bus
	Phase 2	Bus (R)	Cheese (L)	–	–
Trial 16	Phase 1	Table (R)	Candy (L)	Table	Shirt
	Phase 2	Shirt (R)	Key (L)	–	–

Order 2 Target and Distractor Trial Pairings

Trial	**Phase**	**Visual Target** (Shown on either left or right side of screen)	**Visual Distractor** (Shown on either left or right side of screen)	**Primary Auditory Target** (Female Speaker)	**Secondary Auditory Target** (Male Speaker)
Trial 1	Phase 1	Butterfly (R)	Ladybug (L)	Butterfly	Duck
	Phase 2	Duck (R)	Bee (L)	–	–
Trial 2	Phase 1	Bicycle (L)	Hamburger (R)	Bicycle	Hat
	Phase 2	Hat (R)	Bowl (L)	–	–
Trial 3	Phase 1	Monkey (R)	Alligator (L)	Monkey	Pig
	Phase 2	Pig (L)	Cat (R)	–	–
Trial 4	Phase 1	Cookie (L)	Apple (R)	Cookie	Bed
	Phase 2	Bed (L)	Truck (R)	–	–
Trial 5	Phase 1	Strawberry (R)	Water Bottle (L)	Strawberry	Tree
	Phase 2	Tree (L)	Toothbrush (R)	–	–
Trial 6	Phase 1	Pizza (L)	Corn (R)	Pizza	Car
	Phase 2	Car (L)	Brush (R)	–	–
Trial 7	Phase 1	Airplane (R)	Scissors (L)	Airplane	Bus
	Phase 2	Bus (R)	Cheese (L)	–	–
Trial 8	Phase 1	Table (R)	Candy (L)	Table	Shirt
	Phase 2	Shirt (R)	Key (L)	–	–

Trial 9	Phase 1	Ice Cream (L)	Lollipop (R)	Ice Cream	Pillow
	Phase 2	Pillow (R)	Box (L)	–	–
Trial 10	Phase 1	Elephant (L)	Lion (R)	Elephant	Horse
	Phase 2	Horse (R)	Dog (L)	–	–
Trial 11	Phase 1	Baby (L)	Cow (R)	Baby	Fish
	Phase 2	Fish (R)	Frog (L)	–	–
Trial 12	Phase 1	Bunny (L)	Zebra (R)	Bunny	Bird
	Phase 2	Bird (L)	Bear (R)	–	–
Trial 13	Phase 1	Balloon (L)	Cupcake (R)	Balloon	Clock
	Phase 2	Clock (L)	Button (R)	–	–
Trial 14	Phase 1	Banana (R)	Chair (L)	Banana	Ball
	Phase 2	Ball (L)	Book (R)	–	–
Trial 15	Phase 1	Flower (R)	Sandwich (L)	Flower	Bug
	Phase 2	Bug (R)	Mouse (L)	–	–
Trial 16	Phase 1	Orange (R)	Basket (L)	Orange	Carrot
	Phase 2	Carrot (L)	Toy (R)	–	–

Order 3 Target and Distractor Trial Pairings

Trial	**Phase**	**Visual Target** (Shown on either left or right side of screen)	**Visual Distractor** (Shown on either left or right side of screen)	**Primary Auditory Target** (Female Speaker)	**Secondary Auditory Target** (Male Speaker)
Trial 1	Phase 1	Strawberry (L)	Water Bottle (R)	Strawberry	Toothbrush
	Phase 2	Toothbrush (L)	Tree (R)	–	–
Trial 2	Phase 1	Pizza (R)	Corn (L)	Pizza	Brush
	Phase 2	Brush (L)	Car (R)	–	–
Trial 3	Phase 1	Airplane (R)	Scissors (L)	Airplane	Cheese
	Phase 2	Cheese (R)	Bus (L)	–	–
Trial 4	Phase 1	Table (L)	Candy (R)	Table	Key
	Phase 2	Key (R)	Shirt (L)	–	–
Trial 5	Phase 1	Balloon (L)	Cupcake (R)	Balloon	Button
	Phase 2	Button (R)	Clock (L)	–	–
Trial 6	Phase 1	Banana (R)	Chair (L)	Banana	Book
	Phase 2	Book (R)	Ball (L)	–	–
Trial 7	Phase 1	Flower (L)	Sandwich (R)	Flower	Mouse
	Phase 2	Mouse (L)	Bug (R)	–	–
Trial 8	Phase 1	Orange (L)	Basket (R)	Orange	Toy
	Phase 2	Toy (L)	Carrot (R)	–	–
Trial 9	Phase 1	Butterfly (R)	Ladybug (L)	Butterfly	Bee

	Phase 2	Bee (R)	Duck (L)	–	–
Trial 10	Phase 1	Bicycle (R)	Hamburger (L)	Bicycle	Bowl
	Phase 2	Bowl (L)	Hat (R)	–	–
Trial 11	Phase 1	Monkey (L)	Alligator (R)	Monkey	Cat
	Phase 2	Cat (R)	Pig (L)	–	–
Trial 12	Phase 1	Cookie (R)	Apple (L)	Cookie	Truck
	Phase 2	Truck (L)	Bed (R)	–	–
Trial 13	Phase 1	Ice Cream (L)	Lollipop (R)	Ice Cream	Box
	Phase 2	Box (L)	Pillow (R)	–	–
Trial 14	Phase 1	Elephant (L)	Lion (R)	Elephant	Dog
	Phase 2	Dog (L)	Horse (R)	–	–
Trial 15	Phase 1	Baby (R)	Cow (L)	Baby	Frog
	Phase 2	Frog (R)	Fish (L)	–	–
Trial 16	Phase 1	Bunny (R)	Zebra (L)	Bunny	Bear
	Phase 2	Bear (R)	Bird (L)	–	–

Order 4 Target and Distractor Trial Pairings

Trial	**Phase**	**Visual Target** (Shown on either left or right side of screen)	**Visual Distractor** (Shown on either left or right side of screen)	**Primary Auditory Target** (Female Speaker)	**Secondary Auditory Target** (Male Speaker)
Trial 1	Phase 1	Balloon (L)	Cupcake (R)	Balloon	Button
	Phase 2	Button (R)	Clock (L)	–	–
Trial 2	Phase 1	Banana (R)	Chair (L)	Banana	Book
	Phase 2	Book (R)	Ball (L)	–	–
Trial 3	Phase 1	Flower (L)	Sandwich (R)	Flower	Mouse
	Phase 2	Mouse (L)	Bug (R)	–	–
Trial 4	Phase 1	Orange (L)	Basket (R)	Orange	Toy
	Phase 2	Toy (L)	Carrot (R)	–	–
Trial 5	Phase 1	Ice Cream (L)	Lollipop (R)	Ice Cream	Box
	Phase 2	Box (L)	Pillow (R)	–	–
Trial 6	Phase 1	Elephant (L)	Lion (R)	Elephant	Dog
	Phase 2	Dog (L)	Horse (R)	–	–
Trial 7	Phase 1	Baby (R)	Cow (L)	Baby	Frog
	Phase 2	Frog (R)	Fish (L)	–	–
Trial 8	Phase 1	Bunny (R)	Zebra (L)	Bunny	Bear
	Phase 2	Bear (R)	Bird (L)	–	–
Trial 9	Phase 1	Strawberry (L)	Water Bottle (R)	Strawberry	Toothbrush

	Phase 2	Toothbrush (L)	Tree (R)	–	–
Trial 10	Phase 1	Pizza (R)	Corn (L)	Pizza	Brush
	Phase 2	Brush (L)	Car (R)	–	–
Trial 11	Phase 1	Airplane (R)	Scissors (L)	Airplane	Cheese
	Phase 2	Cheese (R)	Bus (L)	–	–
Trial 12	Phase 1	Table (L)	Candy (R)	Table	Key
	Phase 2	Key (R)	Shirt (L)	–	–
Trial 13	Phase 1	Butterfly (R)	Ladybug (L)	Butterfly	Bee
	Phase 2	Bee (R)	Duck (L)	–	–
Trial 14	Phase 1	Bicycle (R)	Hamburger (L)	Bicycle	Bowl
	Phase 2	Bowl (L)	Hat (R)	–	–
Trial 15	Phase 1	Monkey (L)	Alligator (R)	Monkey	Cat
	Phase 2	Cat (R)	Pig (L)	–	–
Trial 16	Phase 1	Cookie (R)	Apple (L)	Cookie	Truck
	Phase 2	Truck (L)	Bed (R)	–	–

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