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Bilingualism and Social Cognitive Development: the Effect of Dual-Language Acquisition on Nonverbal Communication

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Bilingualism and Social Cognitive Development:
The Effect of Dual-Language Acquisition on Nonverbal Communication

by

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Abstract

Consistent with Piaget and Vygotsky's theories that recognized a close relationship between language and cognitive development, previous studies have consistently found evidence of accelerated cognitive development among children who have operated daily in two languages since birth. Native bilingual children have outperformed their monolingual peers on a range of nonverbal cognitive tasks, including theory of mind (ToM) and other measures of social cognition, and there is evidence that these advantages are maintained throughout the lifespan. However, the social cognitive aspect of bilingualism has been only briefly explored and limited to child populations. Based on previous research, the present study hypothesized that native bilingual adults would continue to display superior social cognition in relation to monolinguals. Furthermore, the possibility that non-native bilinguals could also experience cognitive benefits was explored. Participants were 59 undergraduates ranging from 18 to 23 years of age who were either monolingual, native bilingual, childhood bilingual (early L2), or bilingual since adolescence (late L2). Participants were measured on their accuracy in recognizing emotion from subtle facial expressions before and after watching a training video. Results showed that native bilinguals had significant advantage over monolinguals and a slight advantage over non-native bilinguals in both the pre-test and post-test. It was concluded that, as a direct result of their language experience, native bilingual adults maintained their childhood advantage in social cognition. Further research should focus on individuals with varying degrees of non-native bilingualism to investigate which aspect of dual-language acquisition enhances cognitive development.

Introduction

Decades of research have found that bilingualism accelerates and enhances cognitive development primarily in nonverbal domains, including executive functioning and social cognition (Ben-Zeev, 1977; Bialystok et al., 2005; Carlson & Meltzoff, 2008; Genesee, Tucker, & Lambert, 1975; Ianco-Worrall, 1972). Evidence that bilingualism offers more than merely knowing two different ways to speak has also been demonstrated in a sample of preverbal infants. Bilinguals as young as seven months old, who were simply spoken to in two languages since birth, showed a significant advantage for inhibitory control compared to their monolingual age counterparts (Kovács & Mehler, 2009). Research has shown that these superior cognitive abilities are most salient during early childhood, but recent studies suggest that advantages in executive functions are maintained into adulthood (Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Luk, 2008). These findings have led to the discovery of meaningful, long-term benefits of bilingualism, such as postponing the onset of dementia for several years, and protecting against disorders such as ADHD and autism (Bialystok, Craik, & Freedman, 2007). In order to expand on the clinical implications of bilingualism, researchers have been investigating the mechanism that explains how the unique experience of growing up in a dual-language environment could directly engender accelerated development for cognitive abilities that are unrelated to language, even for individuals too young to speak. Exploring the range of cognitive advantages that are preserved throughout the lifespan could help elucidate this mechanism.

Research has also examined the possibility that immersion in a dual-language environment after birth could still influence an individual’s path of cognitive development. These studies, however, have not shown conclusive evidence of a critical period for second language acquisition with respect to cognitive development. Therefore, for the purposes of this review, bilinguals will refer to those who natively acquired two languages and have continued to exercise both languages daily since birth unless otherwise specified.

Why Bilingualism?

Developmental psychologists have provided a thorough account of how a child progresses through the course of cognitive development with age. While Piaget acknowledged that decreased egocentrism fostered language acquisition, Vygotsky's sociocultural theory recognized that social interaction may be a key mechanism that facilitates a decline in egocentrism. This could explain how no experiential manipulations, such as teaching pretend play or the ability to conserve, have resulted in a significant acceleration of cognitive development (Golomb & Cornelius, 1977).

Vygotsky and Semantic Development. Vygotsky's sociocultural theory recognized the importance of the interaction of language and thought on development. Vygotsky theorized that language and thought are originally independent, but merge, to an extent, when a child begins to participate in social interactions. These social interactions would significantly foster language acquisition, which, in turn, advances cognitive development. Vygotsky emphasized play as essential to cognitive development because it allows the child to separate sound from meaning, and, therefore, develop abstract thought. Studies, such as Ianco-Worrall's (1972), have found bilingualism to have similar, but even stronger, effects than play in fostering the separation of sound and meaning, otherwise known as the achievement of semantic development. Further research has found multiple other ways in which bilingualism influences a child's cognitive development, supporting Vygotsky's theory that language acquisition is more complex than merely understanding its structure and meaning. Instead, language acquisition requires perception of context in order to respond appropriately to the less explicit characteristics of others, such as feeling and thought. Research has examined whether or not bilingualism enhanced a particular underlying cognitive structure that is responsible for these differences.

Because native bilingual children have functioned in two languages every day since birth, they were forced to quickly learn the arbitrariness of a relationship between a word and referent (Ben-Zeev, 1977; Ianco-Worrall, 1972). Researchers proposed that, given such early semantic development, bilinguals could demanticize units, more freely abandon old rules, and, therefore, could achieve the ability to think abstractly more quickly than their monolingual peers. Research with bilingual children ranging from seven months old to seven years old has consistently shown that bilinguals outperformed their monolingual peers on tasks that assessed nonverbal cognitive abilities (Bialystok et al., 2008; Carlson & Meltzoff, 2008; Genesee et al., 1975; Kovács & Mehler, 2009). In fact, bilingual children generally performed at the level of monolinguals who were two to three years older (Bialystok & Shapiro, 2005; Ianco-Worrall, 1972). Developmental psychologists have, therefore, suggested that growing up in a dual-language environment could have significant advantages as a result of accelerated semantic development.

Piaget and Egocentrism. The crucial difference between Piaget and Vygotsky's theories of development is the way in which they address the relationship between language and thought on a child's cognitive development. Piaget explained children's ineffective communication, exemplified by statements such as "he hit me with that", by their lack of linguistic and cognitive skill. His theory emphasized that egocentrism, a characteristic that drove much of preoperational children's behavior, was an indication of low cognitive functioning. He proposed, therefore, that as children aged, their egocentrism declined. A decline in egocentrism then allowed children to gradually understand that people have their own perspective. However, research involving bilingual children has suggested that some experiences apart from age could accelerate cognitive development, and, therefore, decrease egocentrism. This research found that bilingual children, ranging from ages four to six, achieved more effective communication than their monolingual peers despite there being no difference between the groups' linguistic skills (Genesee et al., 1975). This suggests that although Piaget was on the right track, Vygotsky's theory provides a better-suited framework for explaining how the role of bilingual children's unique social interactions result in accelerated cognitive development. Bilingual children learned to pick up cues from social interactions to learn which language is appropriate to use. Through social interaction, the bilingual child learns that people have their own backgrounds and may speak only one language the bilingual knows. They must accurately perceive cues from the social interaction and take the perspective of the person they are talking to in order to select the right language. Because bilinguals' language background requires them to take the perspective of others at an early age, their egocentrism is reduced at an earlier age. As Piaget and Vygotsky agree, this decline in egocentrism is an inverse function of their cognitive development. Another theory focuses on the development of the mechanism used for selecting the appropriate language after the social cues have been perceived.

Parallel activation. Parallel activation, the dominating theory for explaining the foundation of bilingualism's advantages, suggests that bilinguals constantly live in two languages; therefore, they actively interpret the world in two languages and are forced to simultaneously select their attention to one interpretation while inhibiting the other (Ben-Zeev, 1977; Bialystok, 1999; Carlson & Meltzoff, 2008; Ianco-Worrall, 1972). This ability then translates to excelling in tasks that require the participant to recognize multiple interpretations of a single stimulus, selectively attend to one aspect of a stimulus, and inhibit responding to its more salient aspects. In terms of executive functioning, these tasks represent selective attention and inhibitory control, processes that have no relation to verbal domains. Studies have found evidence to support one or more of these theories for how dual-language acquisition could accelerate the cognitive development of non-language domains.

Advantages in Nonverbal Cognitive Abilities

Bilingual children have been found to demonstrate an advantage in a range of nonverbal abilities, including inhibitory control (Kovács & Mehler, 2009), selective attention (Bialystok et al., 2005; Martin-Rhee & Bialystok, 2008), metalinguistic awareness (Ianco-Worrall, 1972), spatial ability (Ben-Zeev, 1977), alternative interpretation of a stimulus (Bialystok & Shapero, 2005), and social cognition (Genesee et al., 1975).

Executive functioning. Bilinguals have consistently shown advanced executive functioning in relation to their monolingual peers, which has been most significantly related to nonverbal cognitive domains. The most relevant executive functions in which bilinguals have excelled are those that required an individual to consider a stimulus from multiple perspectives and simultaneously control attention to one of these interpretations while inhibiting the others. These domains of executive functioning include inhibitory control and selective attention, processes that have no relation to verbal domains.

An advantage in selective attention has been an important domain of cognitive functioning in which bilinguals have shown superior abilities compared to their monolingual peers. This has been demonstrated using tasks such as the Children's Embedded Figures Task and Suststained Attention to Response task (Bialystok et al., 2005; Bialystok et al., 2008). A development of attentional control has been used to selectively attend to target cues in conflicting situations, which is more advanced in bilingual children than in comparable monolinguals (Martin-Rhee & Bialystok, 2008).

An advantage in inhibitory control explains bilinguals' superior performance in nonverbal tasks such as the Dimensional Change Card Sort (DCCS), the Opposite Worlds Task, the Stroop Naming task, and the Simons arrows task (Bialystok et al., 2005; Bialystok et al., 1999). Because these tasks presented the child with a conflicting situation, they have been related to tasks that assess a child's theory of mind and reversibility. The DCCS, in particular, required that the child recognized and switched between various rule systems, which would be a common experience for bilingual children (Bialystok, 1999). This advantage in inhibitory control has even been shown in a preverbal population. Researchers found that 7-month old infants who were simply spoken to in two different languages since birth outperformed their monolingual age counterparts on tasks that required inhibitory control (Kovács & Mehler, 2009).

Bilinguals were theorized to excel in these tasks because they present the individual a situation with seemingly conflicting stimuli and constantly changing rule systems (Meristo et al., 2007). Parallel activation theory suggests that these situations are familiar to the bilingual individual because they actively live in an environment of two languages, each with their own rule systems. These advantages in executive functioning have been shown to extend into adulthood and have been related to the reason that bilingual Alzheimer's disease patients do not experience the symptoms of dementia for several years after monolingual patients would.

Metalinguistic awareness and abstract thinking. Consistent with Vygotsky's theory, studies have provided evidence that achieving early semantic development directly promoted advanced cognitive thinking by demonstrating bilingual children's increased metalinguistic awareness. As a result of quickly learning the arbitrariness of a sound and its meaning, bilingual children could more readily substitute one word for another within a fixed sentence (Ben-Zeev, 1977). Similarly, both third and sixth-grade bilinguals have displayed more flexible, abstract thinking in the face of contradictory and tautological statements than their monolingual peers (Cummins, 1978). While bilinguals have shown an earlier ability to analyze linguistic input, research has not found evidence of any bilingual advantages in verbal cognitive domains. In fact, the only difference in verbal abilities is in favor of monolinguals. Studies found that bilinguals not demonstrated inferior lexical retrieval in relation to their monolingual peers, and that these deficits were maintained into adulthood (Carlson & Meltzoff, 2008).

Research suggested that bilinguals' superior metalinguistic ability was a result of their ability to analyze syntax due to exposure to multiple language structures. Their readiness to reorganize reflected mastery of syntax, suggesting that exposure to more than one language accelerated their understanding of the hierarchy of syntax that underlies all spoken languages. Finally, these tasks did not only require demanticizing units, but they also required the individual to inhibit the typical referent of a word and attend to its new meaning that would be assigned. Therefore, bilinguals' advantage in executive functions also contributed to their superior metalinguistic ability. The extent to which bilinguals maintain this advantage is unknown because for the measures to assess metalinguistic awareness in these studies, monolinguals would eventually catch up to bilinguals' performance as their language skills increased with age.

Social cognition. Bilingual children have also been found to have a superior ability to understand others' mental states, otherwise known as the possession of a theory of mind (Piaget, 1962). Demonstrating theory of mind (ToM) has been found to be a significant indicator of social cognition. While four-year old children typically outperformed three-year olds on standard false-belief tasks, bilingual children have displayed superior performance to monolinguals of their respective age groups (Goetz, 2003; Farhadian, 2010). Results indicated that bilinguals did not have an advantage in verbal ability, but rather the number of languages the preschooler spoke was the significant predictor of performance on ToM tasks. Researchers have suggested that bilingualism enhances metalinguistic awareness, which facilitated the abstract thinking required for false-belief tasks. It has also been suggested that advantages in executive function translated into the ability to inhibit one interpretation and attend to another, another key component to succeeding in such tasks. Furthermore, this bilingual advantage has been replicated in a sample of deaf children, a population that has displayed deficits in social cognition, including delayed ToM.

Consistent with hearing children, bilingually instructed native signers possessed a ToM much earlier than the deaf children who learned to sign in a second language later in life (Meristo et al., 2007). According to Vygotsky, deaf and hard-of hearing children live in an impoverished linguistic environment due to their relatively low amount of social interactions. Because Vygotsky theorized that social interactions are driven by language, this advantage in ToM tasks may suggest that bilinguals live in an enriched language environment, which may, in turn, enhance their social interactions. In support of this theory, bilingually instructed signers' performance was comparable to that of monolingual hearing children. One way in which two forms of communication, whether verbal or gestural, could directly affect social interactions is because the child must be consciously aware of other's linguistic knowledge.

Following Vygotsky's theory, studies have suggested that in order to communicate effectively while operating in two languages, a child must incorporate social and responsive needs of the listener. Because they quickly become aware that they speak two separate languages and the conditions under which each are spoken are very specific, bilingual children more urgently require the ability to perceive the characteristics about the listener. When asked to explain the rules of a particular game to either a blindfolded or sighted listener, children enrolled in kindergarten, first grade, and second grade who had been raised bilingual performed significantly better than their monolingual peers (Genesee et al., 1975). Consistent with Goetz (2003) and Farhadian (2010), bilinguals did not show a linguistic advantage by using more complex language skills. Instead, children who were raised speaking two languages mentioned significantly more of rules to the blindfolded listener than did those raised speaking only one language. Monolinguals may have been as perceptive to the blindfolded listener's needs, but the bilinguals demonstrated a superior ability to take the perspective of the listener and apply it to improve the social interaction. This supports the notion that a dual-language environment could enhance social interactions. Furthermore, the age of the children in this sample suggests that the bilingual advantage of understanding others' mental states extends past the emergence of ToM.

Cognitive flexibility. Finally, researchers have also concentrated on working memory and spatial ability as important differences in nonverbal cognitive abilities for bilingual children. Studies that have assessed working memory in bilingual and monolingual children found no significant differences between groups (Bialystok et al., 2005; Bialystok et al., 2008; Martin-Rhee & Bialystok, 2008). This suggested that bilingual children experienced more advanced development without having higher levels of intelligence. Studies that have assessed spatial ability have also not found significant differences in performance between the language groups.

However, a closer look at how the two language groups solved spatial ability tasks showed that bilinguals had a different problem solving strategy, which was to scan the field of possible responses before answering. Bilinguals showed a readiness to reorganize and an ability to pay attention to structure in order to assess the possibility and nature of differences in responses. It is possible that differences in the way in which bilinguals approach problem solving was influenced by their unique path for semantic and cognitive development. In fact, it is this flexible approach to solving any task with changing or unknown rule systems that is most likely the mechanism behind bilinguals' superior performance on all cognitive tasks. A flexible approach to any task with changing or undefined rules would directly aid performance on the executive functions task previously reviewed.

Underlying Mechanism: Flexibility of Rule Systems and the Prefrontal Cortex

While Vygotsky's theory of early semantic development and Piaget's theory of declining egocentrism could explain many of the superior cognitive abilities that bilinguals demonstrate, the current theory of parallel activation both supports and extends previous theories. Parallel activation theory proposes that each language is categorized by a set of rules. Rather than organizing and expressing one's thoughts according to a single rule system, the bilingual must not only acquire two rule systems, but develop the cognitive flexibility and control to switch between the rule systems depending on situational cues. This theory incorporates Vygotsky's notion of a correlation between semantic and cognitive development, because it recognizes the consequences of acquiring multiple rule systems. Furthermore, parallel activation theory includes Vygotsky's concept of child-in-action-in-context as the bilingual must select the appropriate language based on their current environment. Finally, the understanding that choosing which language to speak to achieve effective communication depends entirely on the needs of others reflects the inverse relationship Piaget theorized between declining egocentrism and cognitive development. However, neither Vygotsky nor Piaget proposed a mechanism that could explain how bilingual children's enhanced cognition could be maintained throughout their lifetime, a feature that parallel activation theory does not lack.

Parallel activation theory proposes that the constant mental exercise of attending to and inhibiting one of two simultaneously active rule systems has a direct effect on bilinguals' performance on tasks of executive function. Evidence of neurological structures responding to this constant exercise has been found in a population of aging adults and bilinguals diagnosed with Alzheimer’s disease (AD). While elderly monolinguals showed evidence of cognitive decline on a series of executive function tasks, bilinguals of the same age performed comparably to individuals more than 30 years younger, demonstrating no signs of age-related cognitive deficits (Bialystok et al., 2004; Bialystok et al., 2008). Similarly, despite the neurological presence of AD, bilingual adults displayed a profound delay in displaying symptoms of dementia (Bialystok et al., 2007), which is characterized by a gradual decline in executive functions and general cognitive skills, including language, abstract thinking, and social skills. Supporting that this resistance to dementia is a result of bilinguals’ language-switching exercise, the neurodegeneration associated with dementia involves the prefrontal cortex (PFC), which is the same cortical structure implicated in executive function (Grady, Furey, Pietrini, Horwitz, & Rapoport, 2001; Kronhaus et al., 2006). Additionally, studies have suggested that staying mentally healthy by incorporating sufficient mental exercise into one’s lifestyle is a critical factor in averting age-related cognitive decline and experiencing symptoms of AD (Snowdon, 1997). Together this suggests that, as a direct result of parallel activation, a bilingual’s PFC was less vulnerable to the specific course of neurodegeneration that is characteristic of AD patients.

If the bilingual experience structures the brain to be selectively preserved from late-life neuropathology related to deficits in executive functioning, then it is possible that brain regions responsible for executive functions, such as the PFC, are more highly developed in bilinguals. While previous neuroimaging studies have not examined activation of any processes besides those specific to language domains in the bilingual brain, research involving patients with abnormalities in regions of the PFC illustrates its potential contribution to bilinguals’ advantages.

For example, in contrast to bilinguals' superior performance on tasks assessing selective attention such as the Stroop task, individuals with bipolar disorder, characterized by dysfunctioning of the ventral PFC, could not complete the task (Kronhaus et al., 2006). Implicating the PFC not only explains why bilinguals exceeded in executive functioning, but also other cognitive skills that were both preserved in bilingual AD patients and superior in healthy bilingual children. For example, bipolar disorder patients' abnormal PFC activity was also related to deficits in flexible thinking and social cognition (McClure et al., 2005). Furthermore, research has demonstrated that ToM and executive functions shared overlapping areas of activation in the medial PFC (Carlson & Moses, 2001; Perner & Lang, 1999).

Although research has found that superior executive functioning was maintained into old age, no studies to date have examined other ways in which bilingualism can benefit individuals after childhood. This is likely because many previous studies found that monolinguals eventually caught up to the performance of their bilingual peers on a given task. However, it is possible that, when adjusted for age, bilinguals would continue to excel on more advanced tasks that recruit regions of their potentially better developed PFC. Among these are tasks of social cognition, which have also been associated with activity in the PFC.

Implications for social cognition. While studies have attributed bilingual children's superior social responsiveness to their enhanced attention to situational cues required to select the appropriate language, it is possible that a more highly developed PFC indirectly contributed to their advantages in social cognition. In addition to executive functions, neuroimaging studies have demonstrated that the medial PFC is selectively engaged during social-cognitive tasks that require the consideration of the mental states of either oneself or another person, including the self-regulation of expressing emotions and the recognition of others' emotions from facial expressions (Blakemore & Choudhury, 2006; Mitchell, Macrae, & Banaji, 2004). Because the PFC has been implicated in self-awareness and perspective-taking ability, this cortical structure is responsible for developing and maintaining cognitive representations of both the self and of others. This suggests that inhibitory control is necessary for distinguishing between the subjective and external world, as one cannot reliably take the perspective of another without inhibiting their own. Furthermore, individuals with damage to the frontopolar cortex in the anterior PFC displayed excessive egocentrism (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999), demonstrating the relationship between a loss of inhibitory control and impaired perspective-taking ability.

As discussed, bilingual children have shown an advantage in both inhibitory control, among other executive functions and social cognition. Given evidence of superior development of the brain region responsible for executive function, research on other responsibilities of the PFC supports the notion that bilinguals demonstrated higher levels of social cognition as a result of how their unique language experience shaped their brain. Parallel activation theory explains how constant rule switching between languages directly develops executive functioning skills, which contribute to social cognition. However, whether there is direct causation between bilingualism and the development of social cognition is yet to be elucidated. Individuals with autism spectrum disorders are an extensively researched population that are prime examples of how linguistic, cognitive, and social development are, in fact, inextricably linked processes of the PFC.

Autism spectrum disorders are a range of neurodevelopmental disorders characterized by a variety of language disorders, impaired executive functioning, and severe social deficits, all of which are thought to be the result of abnormal functioning of the PFC. In contrast to bilingual children, those diagnosed with a disorder on the autism spectrum have showed difficulty on perspective taking and ToM tasks, such as role taking and false belief tasks (Baron-Cohen, 1989). Therefore, both autistic and bilingual populations demonstrate a clear relationship between language, social cognition, and executive functioning in both behavioral and neurological aspects. This suggests that symptoms of autism and the benefits of bilingualism are not coincidental, but that these processes have more in common than is recognized in current research. While language disorders are merely correlated with other symptoms of autism, the social and cognitive advantages associated with bilingualism are a direct result of their language experience. Considering the evolution of language could shed light on the specific relationship between linguistic and social development.

The Evolution of Communication

The notion that bilingualism could enhance nonverbal domains is initially puzzling. However, despite how complex human linguistic abilities have become since the first spoken language, still two-thirds of the meaning in the sentences we utter is conveyed in the nonverbal signals that accompany speech, such as gestures, postures, and facial expressions (Birdwhistell, 1970). This suggests that it was possible to communicate a majority of thoughts well before the emergence of speech and reminds us that “language” is only the most recently developed form of communicating our internal states. It also underlines that reasons for the evolution of verbal communication include the need to exchange even more complex information about our internal states, which would facilitate social cohesion among our species (Dunbar, 1996). Therefore, tracing the origin of spoken language would only reveal a piece of the puzzle. Instead, a discussion of language should begin with the first form of communication.

Emotional facial expressions, a component of social cognition, were possibly the most primitive form of communication among our evolutionary ancestors. Darwin (1872) was the first to propose that facial expressions originally served a specific adaptive function, rather than being arbitrary muscular configurations for social communication. He theorized that facial expressions originated to alter sensory regulation in response to the environment. Darwin further proposed that these innate facial expressions eventually became associated with their respective internal states. At this point, facial expressions began to serve a secondary purpose of communicating internal states. Because the two functions of facial expressions evolved independently, Darwin suggested that the production of each took place in two separate pathways. Innate facial expressions were produced in reaction to emotional stimuli in an involuntary pathway while communicative facial expressions were produced in a voluntary pathway.

While not all researchers have agreed upon a single theory to explain whether facial expressions are learned or innate, there is significant empirical evidence to support Darwin's theory. This evidence includes Ekman's (1992) cross-cultural research, which found seven universal facial expressions: happiness, sadness, anger, fear, surprise, contempt, and disgust. More recent studies have identified the specific functional role of various facial expressions, specifically for fear and disgust. For example, the widening of the eyes as a characteristic of expressing fear has been found to expand the visual field and allow for faster ocular movement, which would aid an individual in escaping a dangerous situation (Susskind et al., 2008). Furthermore, facial musculature that is characteristic of expressing disgust, including the scrunching of the nose and pursing of the lips, has been found to effectively constrict potentially noxious particles from passing through orifices into the bloodstream. While this research has not been completed for all universal facial expressions, congenitally blind populations could be useful for elucidating the extent to which facial expressions are innate or learned.

After nearly half a century of studies that compared facial expressions of emotion between congenitally blind and sighted participants, research had not generated conclusive results regarding whether the development of facial expressions was learned or innate. However, a closer look at the methodologies of these studies reveals a trend that congenitally blind participants only had the same facial movements to reproduce the same expressions as sighted people when the study observed spontaneous emotional responses. It was the studies that observed voluntary facial expressions that reported a difference between sighted and blind participants, reporting that the expressions of congenitally blind participants were less evident and that their muscle movements were less accentuated. Research noted this key difference and further studies concluded that facial expressions were in fact innate neural programs that appeared normal when triggered spontaneously, but that voluntary facial expressions required sufficient control over these subcortical centers, which depended on visual learning and feedback (Galati, Sherer, & Ricci-Bitti, 1997). Therefore, the particular deficits in social interaction experienced by blind individuals did not interfere in the first evolutionary adaptation of emotional expressions proposed by Darwin, but did hinder their ability to use the expressions for their secondary purpose of communication. The theory of two separate pathways for expressing emotion has also been supported by research examining fake and genuine smiles. When smiling in response to a joke, individuals produced an involuntary smile that involved activation of particular facial muscles that voluntarily produced fake smiles lacked.

Support for both an innate and communicative pathway raises the question of what mechanisms evolved that allowed for humans to learn the first form of communication. If there was a gap between the evolution of the adaptive and communicative function of these facial expressions, then the emergence of their role as a form of communication could demonstrate the emergence of ToM in our ancestors. Because ToM requires the ability to think about another person's perspective and believe that they have thoughts, beliefs, and intentions different from your own, ToM must be a prerequisite to emotion perception, and, therefore, communication. However, to think about another's perspective requires another ability: imitation.

Mirror neuron system. The facial feedback hypothesis has been a prominent theory of emotion perception and states that recognizing emotion is specifically accomplished by automatically mimicking motor actions of others and using facial feedback to infer their mental states (Buck, 1980). For example, individuals who had received Botox, a cosmetic procedure that reduces muscular feedback from the face, demonstrated significantly impaired emotion perception compared to controls (Neal & Chartrand, 2011). This deficit was likely caused by an interference with what researchers have identified as 'mirror neurons' located in the premotor cortex (PMC), which are automatically activated when an individual observes an action being performed. The mirror neuron hypothesis has proposed that inferring meaning from an action relies on unconsciously mentally mapping a motor representation of the movements (Buccino, Binkofski, & Riggio, 2004). Because imitation is the only way to experience other people's actions, which represent their internal states, automatic mimicry facilitates the understanding of other perspectives. In support of the mirror-neuron system, children with autism showed an inverse relationship between the severity of their symptoms in the social domain and activity of mirror neurons while both imitating and passively observing facial expressions of emotion (Dapretto et al., 2005). While autistic children could imitate on command, they lacked the ability to automatically mimic the behavior. Because automatic mimicking has been shown to activate mirror neurons that are directly involved in the generation and perception of emotionally expressive faces, this deficit in unconscious mimicry has been found to be the key reason autistic individuals demonstrate impaired emotion perception (Leslie, Johnson-Frey, & Grafton, 2004; McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006). Similarly, individuals that are more empathetic show evidence of quicker automatic mimicking (Sonnby-Borgström, 2002). Because autistic children have consistently demonstrated delayed or impaired ToM (Baron-Cohen, 1989), this supports that automatic mimicry was a precursor to ToM.

The mirror neuron system not only allowed for communicative facial expressions and the development of ToM, but also for learning to voluntarily produce other complex sequences of movements, including increasingly abstract forms of communication. Gestural communication could evolve as specific motor movements of the body became associated with an action, from putting your hand to your mouth to signify eating to nodding your head to indicate approval. Verbal communication would be next to emerge as the mirror neuron system was used to learn to associate particular motor movements of the lips and tongue muscles with actions. Studies have found that the PMC was activated when three-month old babies were passively listening to speech, suggesting that they were mapping mouth movements with sounds. In fact, researchers have found evidence that the communicative meaning of gestures was directly transferred to the articulation of sound. Symbolic gestural and verbal communication that represent a single meaning were found to be outputs of a single coding in the PMC (Gentilucci, Bernadis, Crisi, & Volta, 2006; Goldin-Meadow, 1999). This demonstrated that imitation plays a central role in the acquisition of nonverbal and verbal communication. Furthermore, the PMC continues to be key for language processing into adulthood. Adults have shown activation in the PMC when listening to and viewing speech, which transcanial magnetic stimulation studies have found to be associated with motor-evoked potentials from lip and tongue muscles (Fadiga, Craighero, Buccino, & Rizzolatti, 2002; Meister, Wilson, Debelieck, Wu, & Iacoboni, 2007; Watkins, Strafella, & Paus, 2003). This is similar to the role of perspective taking in social cognition because imitation is necessary to understand speech. Therefore, social cognition and language processing are inextricably linked processes of the PMC because both require imitating others' movements from which an individual can infer meaning. This also supports Darwin's (1872) theory because he proposed that the first form of communication was also the first form of social interaction.

Because humans are born bereft of spoken language, it takes a significant amount of sensory input via social interaction to activate the mirror neuron system to acquire just one language. As evidenced by congenitally blind individuals, a lack of visual feedback impaired the ability to master even innately programmed forms of social interaction. This relationship between a lack of sensory input and deficits in social interaction suggests that bilinguals' advantages in social cognition could be attributed to higher levels of sensory input. The importance of sensory input in socio-cognitive development would also explain why deaf children, who typically experience deficits in social cognition, showed superior performance on ToM tasks when they were taught to sign in two different languages (Meristo et al., 2007). Similarly, although autistic children do not have deficits in sensory input, they have shown to have difficulties automatically processing sensory information. Forced imitation therapies have been found to reduce the severity of impaired social cognition in autistic children, suggesting that increasing the amount of sensory input that is processed is correlated with socio-cognitive development. In these cases, sensory input would be the mechanism that enabled more imitative abilities, which facilitated the emergence of ToM. Furthermore, it is possible that executive functions develop as sensory input is organized, suggesting that bilinguals' superior executive functions could be indirectly attributed to the increase in sensory input related to dual-language acquisition. Despite studies such as Meristo et al. (2007) that showed that deaf children who learned to sign in a second language later in life did not show the same benefits as native bilingually instructed signers, there has been an ongoing debate whether non-native bilinguals could share these benefits from second language acquisition.

Non-native Bilingualism

Because bilingual research has presented such profound implications, studies have investigated the specific criteria for non-native bilinguals who could develop superior cognitive abilities as a result of their language experience. With regard to their second language, these studies have identified either an individual's level of proficiency or age of acquisition as the defining variable that could affect whether or not acquiring a second language alters their course of cognitive development. However, it may be that both factors play a key role in determining standards for who should be considered "bilingual" in developmental research.

Proficiency. The threshold theory, which explains how varying degrees of bilingualism could result in a particular level of cognitive functioning, was one of the first widely accepted theories for understanding the effects of bilingualism (Ricciardelli, 1992; Toukomaa & Skutnabb-Kangas, 1977). This theory explains that in order to experience superior or accelerated cognitive development, a person must have attained high levels of proficiency in both languages. Research with children, aged five or six, found consistent evidence that an individual with a high level of proficiency in one language, but a low level of proficiency in their second language, performed comparably to those who had only been exposed to one language (Collier, 1989). Although the threshold theory does not directly address the role of an individual's age of exposure to a second language, previous studies have shown that there is an optimal age for second language acquisition. In other words, an individual's age of exposure could predict their potential proficiency in the language, which, in turn, could predict whether he or she will experience the benefits of bilingualism. This relates to the parallel activation theory because the individual must be highly proficient in both languages to readily switch back and forth between the languages, which is the additional cognitive exercise that researchers believe is the mechanism driving the benefits of bilingualism. In order to view the languages as interchangeable with one another, the individual must have a highly proficient understanding of both languages.

On the other hand, one study has found evidence of the widely observed disadvantage of bilingualism in a sample of non-native bilinguals. Many studies have found that native bilinguals experienced inferior lexical access in relation to their monolingual peers. Recently, this relationship has been found in bilinguals with varying degrees of proficiency in a second language population (Linck, Kroll, & Sunderman, 2009). If the disadvantages of bilingualism are related to its advantages, then these findings could provide further support for the theory that individuals experience the benefits of bilingualism based on the specific task, rather than the individual's level mastery for both languages.

Age of acquisition. The critical period hypothesis, popularized by Lenneberg (1979), proposed that there are maturational constraints on the time of first language acquisition. Due to the loss of neuroplasticity experienced during puberty, the critical period hypothesis emphasized puberty as the end of the critical period for acquiring a first language. Therefore, there must be similar constraints on the critical period for second language acquisition. Research has been less conclusive as it is more difficult, but certainly not impossible to learn a second language after puberty. Studies have suggested a broad range of critical periods for experiencing the benefits of non-native bilingualism, but a majority of current research maintains that learning a second language during the first year of life is essential for experiencing accelerated cognitive development.

One study that assessed the critical period hypothesis for second language acquisition examined the effects of second language immersion programs for six year olds who were raised monolingual. Results showed that kindergarten students who had been immersed a second language for half of the school day for six months prior to testing performed comparably to their monolingual peers, rather than to their native bilingual peers, on verbal and nonverbal cognition tasks. It was concluded that six years old was too late for second language immersion programs to alter an individual’s course of cognitive development. However, research suggests that this finding is only temporary because the immersion sample was only exposed to the second language for six months. Previous studies have found that, before puberty, only children who had been immersed in a second language for two to three years achieved equivalent proficiency as those who had been immersed in two languages since birth (Collier, 1989). The aforementioned study, therefore, may have made premature conclusions.

In light of the theories that provide an explanation for the cognitive advantages of bilingualism, it makes sense that bilingualism must be achieved early in life because the benefits arise from making realizations that are eventually made. For example, monolinguals achieved metalinguistic awareness once they started to learn enough of their first language, at approximately eight years old, but this does not mean that educated monolingual adults are equally matched at analyzing the properties of language without the knowledge of a second. However, research has not measured the extent of metalinguistic awareness in adults. On the other hand, studies have demonstrated neuroplasticity in the frontal cortex until early adolescence, including the medial PFC, which was implicated in both executive function and social cognition tasks (Blakemore & Choudhury, 2006; Nemati & Kolb, 2011).

The Present Study

Previous research has found that native bilingual children demonstrated superior performance in tasks requiring theory of mind and nonverbal communication effectiveness during social interactions, suggesting that bilinguals had an advantage in social cognition. Past studies have also shown that bilingual children had advantages in executive functions that were maintained through adulthood and extended into old age. Based on this research and studies suggesting that social cognition and executive functions are overlapping processes, the present study hypothesized that bilinguals' advantage in social cognition would also be preserved into adulthood. Specifically, in relation to monolinguals, bilingual adults were expected to more accurately detect emotion from subtle facial expressions during a simulated social interaction.

All individuals would approach the task with an inherent, concrete set of rules for categorizing facial expressions. However, research has shown that these subtle facial expressions are normally too quick to recognize without proper training, which defines a specific set of rules that is most effective for recognizing emotion. Based on studies that demonstrated bilinguals' flexible rule systems, it was further hypothesized that, after receiving brief training, bilinguals would show greater improvement in relation to monolinguals. In other words, if an individual used a rule set that is shown to be ineffective in the pre-test, then we expected that bilinguals would more readily incorporate the rules defined in the training videos and obtain a higher improvement score on the post-test. Furthermore, the present study controlled for the age at which bilinguals acquired their second language.

Previous studies have shown inconclusive evidence regarding the minimum age of second language acquisition required to experience accelerated cognitive development. While many studies have suggested that changes in cognitive development could begin as early as the prenatal period, others have suggested that advantages could extend to individuals who obtained high proficiency in a second language any time before adolescence. Therefore, the present study also examined whether these advantages in social cognition could be observed for bilinguals with varying degrees of second language acquisition. Based on studies supporting parallel activation theory, native bilingual adults were hypothesized to demonstrate a greater advantage in social cognition than non-native bilinguals. Among non-native bilinguals, those who spoke two languages interchangeably in a single environment were expected to demonstrate superior social cognition.

Method

Participants

Participants were 59 undergraduates ranging from 18 to 23 years of age who were either monolingual or bilingual. Monolinguals (10 females) had no experience learning a second language. Bilinguals were subdivided into six groups (native bilingual, early L2A, early L2B, late L2-L, late L2-M, and late L2-H) depending on what age they acquired their additional language(s), whether both languages were spoken at home, and proficiency in their second language. Native bilinguals (4 females and 6 males) acquired two languages from birth and spoke both interchangeably at home. Early L2s acquired high proficiency in a second language before age twelve and were further divided into two groups: early L2As and early L2Bs. Early L2As (7 females and 3 males) spoke both languages at home. Early L2Bs (3 females and 1 male) spoke one language exclusively at home and spoke the other in school. Late L2s acquired a second language after age twelve and were further divided into three groups based on their degree of proficiency for each language. Late L2-Ls (9 females and 3 males), late L2-Ms (8 females and 1 male), and late L2-Hs (3 females and 1 male) had low, moderate, and high proficiency in their second language, respectively.

Materials and Procedure

Each participant completed a social competence task followed by a language background survey that indicated bilingual participants' age of second language acquisition and level of second language proficiency.

Micro-expression Training Tool- Original (METT). This software was originally developed to train individuals to detect facial affects that are only expressed for an average of 40 ms. These brief facial expressions, also referred to as micro-expressions, have shown to be valuable information for recognizing an individual's emotions that he or she is trying to conceal when, for example, telling a lie. The task comprised a pre-test and a post-test, which were separated by four training sessions. In both the pre-test and the post-test, each stimulus was a neutral face that was displayed on the screen for two to five seconds. The face flashed a micro-expression for 40 ms and returned to a neutral expression until the micro-expression was categorized as one of seven emotions. The expressions used were the seven universal emotions identified by Ekman, which included anger, happiness, sadness, contempt, surprise, fear, and disgust (see Appendix A).

The pre-test included ten micro-expressions that the individual identified as one of the seven emotions. The individual categorized the emotion after only one presentation of the stimulus and no feedback was given until all ten stimuli were presented and categorized. A pre-test score ranging *0* to *100* represented the percentage of the ten micro-expressions that were accurately identified.

Following the pre-test, the individual was presented with four 30-second training sessions that described how to easily distinguish between each of the seven micro-expressions. The individual was then administered a post-test, which consisted of twenty micro-expressions displayed on faces that had not yet been presented. Again, each stimulus was only presented once before the individual categorized it as one of the seven emotions and no feedback was given until all twenty stimuli were presented and categorized. A post-test score ranging from *0* to *100* represented the percentage of the twenty micro-expressions that were accurately identified. Furthermore, seven emotion breakdown scores, also ranging from *0* to *100*, represented the percentage that each emotion was accurately identified in the post-test.

Language background survey. The language background survey consisted of ten items and provided details regarding the participant's prior language experience (see Appendix B). Included in the survey were questions that asked participants to list the language(s) they spoke, the age at which each language was acquired, and their self-reported level of proficiency (*low*, *moderate*, or *high*) in each language. Other items on the survey applied only to bilinguals. For example, participants were asked to report whether two languages were spoken in their house daily. Bilingual participants were also asked to agree or disagree to a series of statements concerning the contexts each language was spoken. Examples of these statements include "More than one language was normally spoken at the dinner table", "Only one parent spoke more than one language", and "I spoke a different language at school than I did at home." Participants were assigned to a language group based on their answers to the survey.

Results

Bilinguals were hypothesized to perform better than monolinguals on a task of social cognition. We expected that bilinguals would be more accurate in detecting subtle facial expressions before and after viewing a training video that explained how to distinguish them. Specifically, it was predicted that native bilinguals who were raised speaking two languages interchangeably in their home would perform the best compared to bilinguals who acquired a second language later in life. Our second hypothesis stated that bilinguals would benefit more from the training and improve their score in the post-test more than the monolinguals.

Scores from the METT included a score out of 100 for both the pre-test and the post-test. Table 1 presents the mean scores for the pre-test and the post-test. A difference score for each individual was also calculated by subtracting their post-test score from their pre-test score. Finally, scores from the METT also included a score out of 100 for each of the seven emotions. These scores represented mean accuracy for identifying each emotion in the post-test only. A series of one-way ANOVAs were conducted to examine differences in pre-test and post-test accuracy scores, difference scores, and accuracy scores for each emotion across all seven language groups. Post-hoc comparisons were analyzed using the Tukey HSD test.

Table 1

Mean Accuracy Scores and Standard Deviations for the METT Pre-test and Post-test

Condition	Pre-Test (%)		Post-Test (%)		Improvement (%)	
	M	SD	M	SD	M	SD
Mono	58.00	13.98	65.00	18.56	7.00	11.83
Native	78.00	11.35	84.00	8.43	8.00	11.35
Early L2A	63.00	13.37	71.00	9.94	8.00	16.87
Early L2B	47.50	9.57	65.00	4.08	17.50	13.23
Late L2-L	57.50	12.88	67.92	16.16	10.42	15.14
Late L2-M	65.55	16.67	67.78	10.93	2.22	10.34
Late L2-H	55.00	5.77	67.50	16.58	12.50	19.36
Total (N = 59)	62.37	15.01	70.42	14.24	8.39	13.66

Note. The mean score represents the percent of facial expressions correctly identified on the METT pre-test and post-test. Mono: Monolingual; Native: Native bilingual; Early L2A: second language acquisition (SLA) between ages 2-12 and spoke both in the home; Early L2B: SLA between ages 2-12 and spoke each in a separate context; Late L2-L: SLA in adolescence with low proficiency; Late L2-M: SLA in adolescence with moderate proficiency; Late L2-H: SLA in adolescence with high proficiency.

A one-way between subjects ANOVA was conducted to compare the effect of language group on pre-test accuracy scores on the METT (see Table 1). Results showed a significant difference for percent of facial micro-expressions correctly identified across the language groups, F (6, 52) = 3.98, $p < .01$. Post-hoc comparisons using the Tukey HSD test indicated that the mean pre-test score for native bilinguals (M = 78.00, SD = 11.35) was significantly different than that of the monolinguals (M = 58.00, SD = 13.98), p = .02, early L2Bs (M = 47.50, SD = 9.57), p = .004, and late L2-Ls (M = 57.50, SD = 12.88), p = .01 (see Figure 1). There were no other significant differences between the pre-test scores across the language groups ($p > .05$).

A second one-way between subjects ANOVA was conducted to compare the effect of language group on post-test accuracy scores on the METT (see Table 1). Results showed a difference that approached significance, F (6, 52) = 2.26, p = .052. Post-hoc comparisons using the Tukey HSD test revealed that the mean post-test score for native bilinguals (M = 84.00, SD = 8.43) was significantly higher than for the monolinguals (M = 65.00, SD = 18.56), p = .038 (see Figure 1). No other differences were significant between post-test scores across the language groups. Another one-way between subjects ANOVA showed that there was no significant effect of language group on mean difference scores (p > .05).

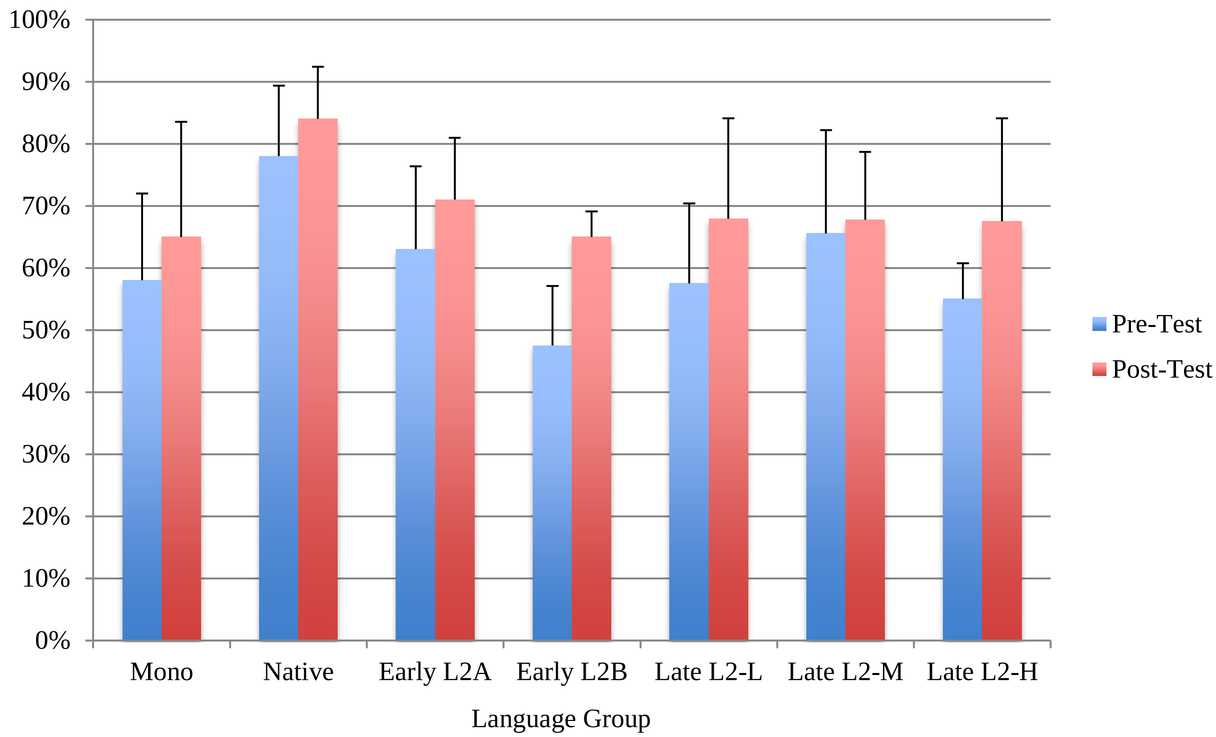

Figure 1. Mean Accuracy Scores and Standard Deviations on METT Pre-test and Post-test. Native bilinguals significantly outperformed monolinguals, early L2Bs, and late L2-Ls on the pre-test. After training, native bilinguals still performed significantly better than monolinguals on the post-test.

A series of one-way ANOVAs were conducted to examine differences in accuracy of identifying each of the seven emotions across language groups. Table 2 represents mean scores for recognizing each emotion. Results showed that there was a significant difference for identifying happiness, F (6, 51) = 5.74, $p < .001$. Post-hoc analyses using the Tukey HSD test indicated that monolinguals' mean score for identifying happiness in the post-test (M = 70.20, SD = 18.95) was significantly different from the mean score for the early L2Bs (M = 100.00, SD = 0.00), p = .014, late L2-Ms (M = 96.33, SD = 11.00), p = .004, native bilinguals (M = 100.00, SD = 0.00), p = .000, and the early L2As (M = 100.00, SD = 0.00), p = .000. Results also revealed a significant difference for identifying anger, F (6, 51) = 3.77, $p < .005$. Post-hoc analyses indicated that mean scores for late L2-Ms (M = 27.78, SD = 44.09) was significantly different than mean scores for native bilinguals (M = 90.00, SD = 21.08), p = .001, and early L2As (M = 75.00, SD = 26.35), p = .024, when identifying anger. Results of one-way ANOVAs conducted to compare the effect of language group on identifying sadness, surprise, fear, disgust, and contempt in the post-test were not significant, $p > .05$. Results of one-way ANOVAs showed no significant effect of biological sex on any of these measures, $p > .05$.

Table 2

Means and Standard Deviations for Emotion Breakdown Scores on the Post-test

Condition	Sad		Happy		Surprise		Fear		Disgust		Contempt		Anger	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Mono	53.30	32.34	70.20	18.95	87.50	21.25	50.00	13.39	49.90	39.36	80.00	34.96	60.00	21.08
Native	65.20	16.67	100.00	00.00	89.20	14.13	86.80	17.04	62.60	25.95	98.00	6.32	90.00	21.08
Early L2A	38.30	25.06	100.00	00.00	81.70	12.87	70.20	29.16	49.20	18.91	93.00	16.36	75.00	26.35
Early L2B	33.00	00.00	100.00	00.00	100.00	00.00	41.75	32.11	41.50	17.00	75.00	28.87	75.00	28.87
Late L2-L	36.00	30.09	84.91	22.91	86.36	20.50	51.55	40.52	60.73	20.31	86.3	23.35	58.33	35.89
Late L2-M	44.56	29.06	96.33	11.00	86.11	13.18	51.78	41.27	63.00	26.22	94.44	16.67	27.78	44.09
Late L2-H	33.25	27.35	91.75	16.50	75.00	14.43	50.00	43.11	58.25	32.11	100.00	00.00	75.00	28.87
Total (*N* = 58)	45.19	27.49	90.86	17.37	86.36	17.28	59.83	36.87	56.05	26.37	89.83	21.88	64.41	34.80

Note. The mean score represents the percent of each emotion correctly identified on the METT post-test. Mono: Monolingual; Native: Native bilingual; Early L2A: second language acquisition (SLA) between ages 2-12 and spoke both in the home; Early L2B: SLA between ages 2-12 and spoke each in a separate context; Late L2-L: SLA in adolescence with low proficiency; Late L2-M: SLA in adolescence with moderate proficiency; Late L2-H: SLA in adolescence with high proficiency.

Discussion

Based on previous research, the present study assessed differences between monolingual and bilinguals' social cognition. Past research has demonstrated that native dual-language acquisition could accelerate a child's development of nonverbal cognitive abilities, including executive functions, metalinguistic awareness, and social cognition. Furthermore, studies have found evidence that bilinguals' superior executive functioning was maintained into old age when compared to monolinguals. The goal of the present study was to determine whether advantages in social cognition were also preserved with age. Results supported our first hypothesis that, in comparison to monolingual adults, native bilingual adults would display superior performance on a task of social cognition, which required participants to detect emotion from facial expressions. These results were consistent with previous research that native bilingual children displayed a superior ability to understand others' mental states compared to monolingual peers (Farhadian, 2010; Genesee et al., 1975; Goetz, 2003). Previous research has suggested that bilinguals' superior executive functioning was maintained throughout adulthood due to the mental exercise of switching between two languages. Therefore, results of the present study could suggest a relationship between the mechanism that drives bilinguals' superior executive functioning and social cognition. It is also possible that dual-language acquisition required individuals to organize more sensory input than monolinguals language experience required. In contrast to bilinguals, studies have shown that a lack of sensory input negatively affects the development of both executive functions and social cognition.

A second goal of the present study was to determine whether bilinguals would demonstrate more cognitive flexibility than monolinguals. Previous research found that switching between two languages contributed to bilinguals' ability to update their rule systems.

Results did not support our second hypothesis that bilinguals would improve more than monolinguals between their pre-test and post-test performance. However, this may not reflect contradicting evidence against parallel activation theory because native bilinguals' obtained such a high pre-test score, this task did not allow for significant improvement on the post-test.

Finally, the present study examined whether advantages in social cognition were apparent for individuals with varying degrees of non-native bilingualism. A majority of previous research has focused on comparisons between samples of strictly monolingual and native bilingual populations. However, researchers have debated, in theory, whether age of acquisition, proficiency, or parallel activation would be the most significant predictor for non-native bilinguals experiencing cognitive advantages. Results suggested that all three aspects of bilingualism were important and provided the most support for parallel activation. This was particularly evident in the analyses of the emotion breakdown scores. Across language groups, there was a significant difference for recognizing only two emotions, happiness and anger. For both these emotions, native bilinguals were joined by early L2As in showing a significant advantage. This suggested that parallel activation was related to the ability to imitate. Overall, we concluded that, in addition to nonverbal abilities such as executive functioning, the experience of acquiring two languages from birth and speaking both daily within a single context also enhances the development of an individual's social cognition, which is maintained into adulthood. It was further concluded that non-native bilingualism could still have a positive effect on cognitive development.

Bilingual Advantage in Social Cognition: Imitation or Cognitive Control?

Support for our first hypothesis that bilingual adults would perform better than monolinguals on a task of social cognition was consistent with previous studies that found evidence that bilingual children outperformed monolingual peers on tasks of ToM and social responsiveness (Farhadian, 2010; Genesee et al., 1975; Goetz, 2003). Native bilinguals scored significantly higher than the monolinguals on the pre-test and their higher score on the post-test was marginally significant. Analyses of pre-test scores demonstrated that native bilinguals' natural ability to detect emotion from facial expressions was superior to that of other language groups, while analyses of the post-test scores showed that native bilinguals maintained this advantage in social cognition even after all language groups were trained for the task. Previous research suggested that bilinguals' superior performance on ToM tasks could be attributed to superior executive functioning, a bilingual advantage found in previous studies (Bialystok, 1999; Bialystok et al., 2005; Bialystok et al., 2008), because this facilitated attending to one mental representation and inhibiting the other conflicting representation. Research provided another explanation for bilinguals' superior social responsiveness, suggesting that bilinguals could more easily take the perspective of others experiencing communicational difficulties. However, because these studies assessed social cognition in sociolinguistic contexts, neither of these explanations is sufficient to explain why bilinguals in the present study demonstrated an advantage in strictly nonverbal tasks of social cognition.

In order to succeed in a task of recognizing emotion from facial expressions, one must first imitate a person's muscular configurations and then identify, first-person, the emotion associated with that particular expression (Buck, 1980; Neal & Chartrand, 2011). Specifically, given the brief exposure times of emotionally expressive faces, this task required automatic mimicry rather than a controlled cognitive process (Sonnby-Borgström, 2002). Therefore, bilingual children's superior social responsiveness (Genesee et al., 1975) was not a direct result of being able to relate to others' communicational difficulties. Instead, success on the METT pre-test suggests bilinguals had a generalized deeper understanding of others' mental states because they could more readily and accurately imitate another person. Because language acquisition is an exercise in perspective taking, it is possible that increased sensory input during dual-language acquisition improved imitative ability. This would support the notion that bilingual environments are coupled with enriched social interactions because imitation, which is a prerequisite to ToM, relies on sufficient sensory input. Therefore, bilinguals' enhanced imitation could have contributed to achieving ToM at an earlier stage in development. On the other hand, it is also possible that the ability to acquire two languages reflects an innate advantage in automatic mimicry. One limitation of bilingual research is that it can only assess people who had the capacity to acquire two languages. A third possibility is that bilinguals' superior executive functioning facilitated imitation.

Unlike previous studies, the present study demonstrated that bilinguals' maintain superior social skills past childhood. Previous research has not examined whether superior metalinguistic awareness extends into adulthood, but studies have found evidence that bilingual children's advantage in executive functions was maintained into old age (Bialystok et al., 2004; Bialystok et al., 2007; Bialystok et al., 2008). Because inhibition is thought to play an important role in discriminating between self-other representations, the mechanism by which superior executive functions were preserved could have indirectly maintained the observed advantage in social cognition. Specifically, superior cognitive control could have allowed bilinguals to more quickly activate the voluntary pathway proposed by Darwin (1872). Voluntary pathway relies on imitation/learning from social interaction. This would support the notion that executive functions and social cognition are overlapping processes (Blakemore & Choudhury, 2006; Mitchell et al., 2004). If the advantages found in the present study are related to the superior executive functioning as research involving the PFC suggests (Carlson & Moses, 2001; Perner & Lang, 1999), it is possible that bilinguals' social skills may also be preserved in age or disease-related cognitive decline. Finally, due to the novelty of the task, it is possible that bilinguals' superior attentional control could have contributed to their superior performance on the METT pre-test. Evidence that attentional control played a role in this task was marked by native bilinguals' unwavering upward trend when moving from the pre-test to the post-test, whereas ten to twenty-five percent of individuals in all other language groups performed worse in the post-test, indicating distractions or fatigue.

Cognitive Flexibility in Non-native Bilinguals

The parallel activation theory also suggests that constant rule switching allows bilinguals to incorporate new rules throughout a given task (Bialystok, 1999; Carlson & Meltzoff, 2008). However, results did not support our second hypothesis that bilinguals would benefit more from the training than monolinguals due to their superior flexibility of rule systems. Although the mean difference between the native bilingual's pre-test and post-test score was comparable to the improvement scores of all other language groups, this may not reflect evidence against the parallel activation theory as the native bilinguals obtained significantly higher pre-test scores and had less room to improve on the post-test. Because native bilinguals showed a natural propensity to detect emotion from facial expressions, it is possible that this task did not require them to update their rule systems after training, which explained the pattern of muscle movements associated with each emotion presented on the METT. In this case, the task used in the present study would not be appropriate for observing their cognitive flexibility.

However, there is one key difference between analyses of pre-test and post-test scores. While native bilinguals scored significantly higher than monolinguals and two other language groups on the pre-test, native bilinguals' post-test performance was only significantly higher than the monolinguals. It is possible that the non-native bilinguals who performed more similarly to the monolinguals in the pre-test had some advantage in cognitive flexibility. After training, all subgroups of non-native bilingualism updated their rule systems, but monolinguals continued to lag behind. These slight differences between monolinguals and non-native bilinguals could suggest that the cognitive benefits of bilingualism are not all-or-nothing.

Native v. Non-native Bilingualism

Results showed a specific advantage in social cognition for native bilinguals, who were raised from birth in an environment that spoke two languages daily. On the pre-test, native bilinguals scored significantly higher than the monolinguals, early L2Bs, and late L2-Ls. The comparable performance between monolinguals and late L2-Ls was consistent with previous research that found that bilingual children who only obtained a low level of proficiency in their second language performed no different from monolinguals (Collier, 1989). However, despite acquiring two languages fluently in early childhood, early L2Bs also demonstrated comparable social cognition to monolinguals who had no prior experience learning a foreign language. Similarly, early L2Bs did not score significantly different from late L2-Ls. While these results provided partial support for the threshold theory (Ricciardelli, 1992; Toukomaa & Skutnabb-Kangas, 1977), it is clear that proficiency in both languages is not the most important factor in predicting the nonverbal cognitive advantages of bilingualism. Analyses of pre-test scores demonstrated that age of second language acquisition was a more significant predictor of an individual's natural ability to detect emotion from facial expressions as native bilinguals' performance was superior to that of other language groups.

These findings were consistent with research showing that bilingually instructed native signers showed advantages in ToM earlier than those who acquired a second language later in life (Meristo et al., 2007). Other previous studies have not examined varying degrees of second language acquisition, but parallel activation theory suggests that native bilingualism is important for predicting whether an individual will experience superior executive functioning. Because this study suggests the same pattern for predicting advantages in social cognition, this provides further support that the effect of bilingualism on both executive functions and social cognition is driven by a related mechanism. Evidence for an early critical period also supported Vygotsky's theory of semantic development, which emphasizes the role of learning the arbitrary relationship between a sound and its meaning as a cornerstone for cognitive development. As a result of native bilinguals demonstrating superior metalinguistic abilities, acquiring two languages simultaneously from birth has been suggested to accelerate the ability to demanticize units (Ben-Zeev, 1977; Ianco-Worrall, 1972). Results of the emotion breakdown scores also showed age of acquisition to be particularly important. With the exception of late L2-Ms, the advantage in recognizing happiness was in favor of the three bilingual groups who acquired a second language before adolescence. Furthermore, the only two groups that showed an advantage in anger were native bilinguals and early L2As.

While native bilingual's mean pre-test score was higher than that of all language groups, it was not significantly higher than those who introduced a second language into their home during childhood or those who obtained moderate to high proficiency in a second language during adolescence. Although neither of these groups achieved a pre-test score significantly higher than monolinguals or late L2-Ls, it is possible that the benefits of bilingualism are not all-or-nothing. This is consistent with previous research that has found that non-native bilingualism can negatively affect lexical retrieval to varying degrees (Carlson & Meltzoff, 2008). According to the studies supporting the threshold theory, it is possible for anyone who achieves a certain level of proficiency in a second language to experience somewhat enhanced cognitive development. However, this would not explain why there was a difference between the early L2As who spoke both languages interchangeably at home and the early L2Bs who were also fluent in both languages, but delegated one language for one context (e.g., school) and the second for home.

While native bilinguals' showed a clear advantage on every measure that was significant, early L2As displayed more similar performance to native bilinguals than any other language group. For example, native bilinguals scored higher than both early L2 groups, but only displayed significantly superior social cognition to early L2Bs. Because both groups were highly proficient in each language, this difference in performance provided support for the theory of parallel activation. Similarly, early L2As, but not early L2Bs shared native bilinguals' advantage in recognizing anger. Previous research showed that bilingual mental exercise recruits activity in medial PFC (mPFC), which is activated in tasks of both executive functions and social cognition (Carlson & Moses, 2001; Perner & Lang, 1999). It is possible that early L2As experienced a portion of the cognitive benefits as native bilinguals did because their environment required the parallel activation of two languages after the second language was acquired. Because the mPFC maintains its neuroplasticity into early adolescence (Nemati & Kolb, 2011), parallel activation could still have shaped the mPFC. The path of cognitive development for an early L2B, on the other hand, followed similarly to a monolingual's because only one language was activated at a time.

These results suggest that age of second language acquisition is not the sole predictor of bilinguals' nonverbal cognitive advantages because parallel activation is the mechanism that drives superior development of the mPFC. Due to the plasticity of the mPFC and because parallel activation requires being highly proficient in both languages, results suggest that age of acquisition, proficiency, and parallel activation each play an important role in whether a non-native bilingual may experience advantages in nonverbal cognitive abilities. This supports findings that consistently show advantages for native bilinguals because all three aspects of bilingualism apply to those born and raised in an environment in which two languages are spoken interchangeably.

Limitations and Future Directions

While the present study clearly demonstrated native bilinguals' advantage in social cognition, evidence of non-native bilingualism was inconclusive. There were no significant differences between groups of non-native bilinguals with varying degrees of second language acquisition, but results did show evidence of a trend in favor of parallel activation. A particularly small sample size for early L2Bs and late L2-Hs restricted our ability to reliably assess the differences in performance among non-native bilinguals. However, due to the pattern in performance demonstrated by the early L2As, further research should include samples of non-native bilinguals of multiple different language backgrounds. If there are differences between groups of non-native bilinguals on tasks of either social cognition or executive function, this could significantly contribute to elucidating the mechanism the drives bilinguals' cognitive development. For example, if early L2As continue to perform more similar to native bilinguals than to early L2Bs, this would provide further support for parallel activation as the key mechanism that accelerates and permanently enhances bilinguals' cognitive development.

Similarly, due to the neuroplasticity of the PFC, it is possible that increased sensory input could accelerate the development of executive functions and social cognition at any age before adolescence. If organizing an increased amount of sensory input has a direct effect on cognitive development, bilingualism could have clinical implications for reducing cognitive impairments associated with disorders that are characterized by sensory input deficits, such as deafness and autism. Finally, the methods of the present study were also limited in terms of demonstrating the extent to which dual-language acquisition could have enhanced bilinguals' social cognition. Because recognizing facial expressions is only the most primitive form of social cognition, future research should investigate more complex applications of advanced social cognition. As the population of bilinguals continues to increase as a function of globalization, it is important that research strives to understand and capitalize on the range of bilinguals' cognitive benefits.

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Appendix A

Universal Facial Expressions

Appendix B

Language Background Survey

1. Are you male or female?

   M F

2. Where were you born (city, state/province, country)? If you were born outside of the United States, at what age did you move to the United States?

3. Which language(s) do you speak? List each language according to when the language was acquired and your fluency in each language (low, medium, high).

Native language(s):

Language(s) acquired between ages 1 and 6:

Language(s) acquired between ages 6 and 12:

Language(s) acquired after age 12:

4. Circle whether you were raised in a household that functioned in two or more languages daily?

   Yes No

5. Which language(s) do each of your parents speak fluently? Which of these language(s) do you use to communicate with your parents?

6. Check all that apply.

   __ More than one language was normally spoken at the dinner table.
   __ I have received formal education in more than one language. (Ages ____)
   __ Only one parent spoke more than one language.
   __ I spoke a second language more when certain family members were around.
   __ I spoke a different language at school than I did at home.