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Bilingual effects on deployment of the attention system in linguistically and culturally homogeneous children and adults

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ABSTRACT

We investigated the impact of early childhood and adulthood bilingualism on the attention system in a group of linguistically and culturally homogeneous children (5- and 6-year olds) and young adults. We administered the child Attention Network Test (ANT) to 63 English monolingual and Korean–English bilingual children and administered the adult ANT to 39 language- and culture-matched college students. Advantageous bilingual effects on attention were observed for both children and adults in global processing levels of inverse efficiency, response time, and accuracy at a magnitude more pronounced for children than for adults. Differential bilingualism effects were evident at the local network level of executive control and orienting in favor of the adult bilinguals only. Notably, however, bilingual children achieved an adult level of accuracy in the incongruent flanker condition, implying enhanced attentional skills to cope with interferences. Our findings suggest that although both child and adult bilinguals share cognitive advantages in attentional functioning, age-related cognitive and linguistic maturation differentially shapes the outcomes of attentional processing at a local network level.

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Introduction

Individuals differ in their ability to selectively attend to preferred information and allocate attentional resources while inhibiting interference (see Posner & Rothbart, 2007, for a review). Interestingly, attentional skills seem to be more rigorously honed in bilinguals, whose dual linguistic systems constantly compete for selection at varying levels of representation (e.g., phonology, syntax, lexico-semantics, morphology, orthography, pragmatics; Kroll & Stewart, 1994; Rodriguez-Fornells, De Diego Balaguer, & Münte, 2006). Unlike monolinguals, bilinguals are required to continually alternate between two languages in response to contextual demands and to attentively monitor incoming and outgoing information so that the two languages will not be confused. The literature that supports bilinguals' cognitive advantages asserts that bilinguals' regular use of two language systems is a major contributor to cognitive benefits in general control processing (i.e., executive function skills), as measured by a variety of different behavioral tasks (e.g., Bialystok, 1999; Bialystok, Craik, Klein, & Viswanathan, 2004; Carlson & Meltzoff, 2008).

Along this line, a number of studies have centered on bilingual benefits in executive function skills, particularly inhibitory control, to cope with interferences due to language coactivation (Garbin et al., 2010; Kroll & Bialystok, 2013). However, despite bilinguals' potentially unique capacity to exert attentional control in a manner different from that of monolinguals (e.g., see Friesen, Latman, Calvo, & Bialystok, 2015, for bilinguals' superior performance in the conjunction condition of a visual search task), relatively few studies have investigated how bilinguals deploy their attention system, which refers to a multidimensional construct of attention networks for goal-directed behavior (Posner & Petersen, 1990). To close this gap, we set out to examine bilinguals' attention skills and efficiency in a cross-sectional design that compared two age groups (children aged 5 or 6 years and young adults) at different maturational stages of attention.

Development of the attention system in children and adults

In the field of cognitive neuroscience, attention is commonly described as a multidimensional dynamic model that encompasses three network scores that are employed concurrently to assist the overall attention system in selective processes that guard against distraction (Posner & Fan, 2004; see Diamond, 2013, for a different conceptualization of executive attention as a unitary selective attention or inhibitory control). According to Posner, Sheese, Odludaş, and Tang (2006), the framework for attention as a networked system is based on an integrated "cue-by-flanker" paradigm in a visual field (Eriksen & Eriksen, 1974; Posner, 1980). The attention system in the brain is theorized to include three regulatory components: *alerting* for maintenance of vigilance to increase readiness to respond to impending stimuli; *orienting* for fast target detection, selection of information, and either engagement or disengagement of attention by shifting attentional resources; and *executive control* for conflict resolution when distracting stimuli interfere with the correct choice of response (for reviews, see Mezzacappa, 2004; Posner & Fan, 2004; Posner & Rothbart, 2007; Raz & Buhle, 2006). Although separate anatomical locations in the brain are implicated, suggesting the networks' reasonably independent operation (Fan, McCandliss, Sommer, Raz, & Posner, 2002), interactions among the three networks have been reported elsewhere based on cue-by-flanker interactions (Callejas, Lupiáñez, & Tudela, 2004; Fan et al., 2009; MacLeod et al., 2010; McConnell & Shore, 2011). These three network efficiency scores (alerting, orienting, and executive control) are believed to reflect attentional processing on a local level due to their computational methods. Three local network scores are obtained by contrasting two cue types (e.g., no cue vs. double cue) or flankers (congruent vs. incongruent) to reflect a narrowly defined area of attention. In contrast, global processing efficiency such as overall reaction time (RT), accuracy, and inverse efficiency score—which is a combined measure of both RT and accuracy—is computed by collapsing over all cue and flanker conditions to measure attentional performance from a holistic perspective.

Based on Posner and Petersen's (1990) theory of the attention system, reliable individual differences in attention capacity have been documented as measured by the Attention Network Test (ANT; e.g., see Rueda, Fan, et al., 2004a, for developmental differences; see Mezzacappa, 2004, for