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Effects of short-term music and second-language training on executive control



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ABSTRACT

Separate lines of research have identified enhanced performance on nonverbal executive control (EC) tasks for bilinguals and those with music training, but little is known about the relation between them in terms of the specificity of the effects of each experience or the degree of exposure necessary to induce these changes. Using an intervention design, the current study pseudorandomly assigned 57 4- to 6-year-old children (matched on age, maternal education, and cognitive scores) to a 20-day training program offering instruction in either music or conversational French. The test battery consisted of verbal and nonverbal tasks requiring EC. All children improved on these tasks following training with some training-specific differences. No changes were observed on background or working memory measures after either training, ruling out simple practice effects. Children in both groups had better scores on the most challenging condition of a grammaticality sentence judgment task in which it was necessary to ignore conflict introduced through misleading semantic content. Children in both training groups also showed better accuracy on the easier condition of a nonverbal visual search task at post-test, but children in the French training group also showed significant improvement on the more challenging condition of this task. These results are discussed in terms of emergent EC benefits of language and music training.

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Introduction

Even brief learning experiences can have lasting effects on performance and on the underlying neural mechanisms that support that performance in both humans and other species (Kolb et al., 2012; Kramer, Bherer, Colcombe, Dong, & Greenough, 2004; Reuter-Lorenz, 2002; Steven & Blakemore, 2004). This research has led to growing interest in the potential for training to improve cognitive function and brain development across the lifespan (Green & Bavelier, 2008; Kelly & Garavan, 2005). Evidence for such training-related plasticity in children would be particularly important because it may potentially form the basis for developmental interventions. Two experiences that have received attention in this regard are bilingualism and musical training; children with bilingual experience generally show improved executive control (EC) (for a meta-analysis, see Adesope, Lavin, Thompson, & Ungerleider, 2010; for a review, see Barac, Bialystok, Castro, & Sanchez, 2014), and children with musical training often demonstrate better verbal and spatial abilities (for a meta-analysis, see Hetland, 2000) than their respective counterparts. However, there are two outstanding questions in this research. The first is the problem of selection and direction; did children become bilingual or study music because these abilities were already advanced, or was the experience in fact responsible for the advantageous outcomes? The second is the issue of specificity; although there is some similarity in the outcomes reported for bilingualism and musical training, no research has determined the extent to which the outcomes of these experiences are unique to each experience. In the current study, young children with no experience in either learning another language or studying music were given brief intense training in one of them to determine whether significant early-stage, training-specific cognitive changes could be detected and whether the outcomes for each were common or distinct.

There is little consensus on the mechanism responsible for the effects of bilingualism on EC, especially in children (see Bialystok, 2015, for a discussion), but one view explains those effects in terms of the well-documented coactivation of languages in the bilingual mind even when only one language is required (for a review, see Kroll, Bobb, & Hoshino, 2014). This joint activation requires a control mechanism to select the target and avoid interference from the other language, and this practice with language selection may underlie the more general bilingual advantage in EC. Consistent with this view, most studies show that bilingual children outperform comparable monolinguals on a range of tasks that require attention and control (e.g., Adi-Japha, Berberich-Artzi, & Libnawi, 2010; Carlson & Meltzoff, 2008; Filippi et al., 2015; Kapa & Colombo, 2013), although some studies have not found these effects (Anton et al., 2014; Dunabeitia et al., 2014; but see Kroll & Bialystok, 2013, for a discussion). At the same time, bilingual children on average have a smaller vocabulary in each language than monolingual speakers of that language (Bialystok, Luk, Peets, & Yang, 2010) and often show no advantage over or perform more poorly than monolinguals on EC tasks based on linguistic processing (e.g., Foy & Mann, 2013), leading to interactions between the development of linguistic and nonverbal EC in bilingual children. Moreover, joint activation of languages cannot be the full explanation given that attentional differences have been found between 7-month-old infants who were being raised in monolingual or bilingual homes (Kovacs & Mehler, 2009; Singh et al., 2015). Thus, more research is needed on the emergence of these bilingual effects on EC.

Research is also needed to clarify the types of EC outcomes that may follow from bilingualism. Executive control has been measured in numerous ways, and the outcomes of bilingualism depend on the task. The first evidence for cognitive advantages of bilingualism came from tests of metalinguistic awareness. In a set of studies performed by Bialystok (1986, 1988), children were asked to focus attention on the grammar of sentences and ignore their salient meaning. Bilingual children were more accurate than monolingual children in judging the grammaticality of anomalous sentences with intact grammar but misleading information (e.g., “Apples grow on noses”), a decision that requires EC to ignore the meaning. Thus, in spite of being a linguistic task, the control demands for that condition were substantial.

As with metalinguistic awareness, verbal fluency tasks incorporate both vocabulary knowledge and EC. For adults, category fluency is considered to be a vocabulary measure and letter fluency is considered to involve EC (Grogan, Green, Ali, Crinion, & Price, 2009), but for children even category fluency involves controlled attention (Friesen, Luo, Luk, & Bialystok, 2015). Thus, bilingual adults outperform

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