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Effects of Bilingual Language Use and Language Proficiency on 24-month-olds' Cognitive Control

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ABSTRACT

Although a bilingual advantage has been reported for various measures of cognitive control, most previous studies have looked at a limited range of cognitive control measures. Furthermore, they typically leave unaddressed whether positive effects of bilingualism hold for all bilinguals or whether these are modulated by differences in bilingual language use and proficiency of children and their parents. This study reports on tasks of selective attention and inhibitory control from 24-month-old bilinguals (n = 37) and monolinguals (n = 58). Their parents completed a Dutch vocabulary checklist assessing receptive and productive vocabulary as well as questionnaires on children's attentional focusing, attention shifting and inhibitory control, and language background. Linear mixed-effect regressions showed no differences on cognitive control between the monolinguals and bilingual groups. However, analyses taking into account differences in children's bilingual language use and proficiency and of their parents revealed a more nuanced picture. Specifically, children's degree of balanced language usage predicted parent-rated cognitive control. Furthermore, bilingual toddlers who had parents were low proficient in one of the home languages showed significantly better performance on a selective attention task than toddlers whose parents were both proficient in both home languages. These findings suggest that both children's active usage of two languages and their experience with switching depending on their interlocutor are related to cognitive control performance in young bilingual children. As such, they add to a growing body of evidence that the bilingual advantage in cognitive control is tied to specific conditions of bilingualism, already at a young age.

Many studies have found that bilinguals may outperform monolinguals on cognitive control (Bialystok, 2001). Cognitive control, often also referred to as executive control, encompasses the set of processes which allows information processing and behavior to vary depending on a person's current goals, and includes, amongst others, inhibitory control, selective attention, and attention switching (Diamond, 2013; Miller, 2000). Positive effects of bilingualism on cognitive control have mainly been reported for school-aged children and adults (see Adesope, Lavin, Thompson, & Ungerleider, 2010; Hilchey & Klein, 2011 for reviews). The evidence for very young children is much more limited, but some studies have found positive effects of bilingualism on cognitive control

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in children as young as two or three years of age (Bialystok, Barac, Blaye, & Poulin-Dubois, 2011; Crivello et al., 2016; Poulin-Dubois, Blaye, Coutya, & Bialystok, 2011), and even in infants (Comishen, Bialystok, & Adler, 2019; Kovács & Mehler, 2009).

Bilinguals' superior performance on cognitive tasks has commonly been attributed to their intensive experience with selectively using one language, while suppressing interference from the other language (Bialystok, 2001, but see Hilchey & Klein, 2011 for alternative proposals). Specifically, since the two languages of a bilingual are both active during language use (Green, 1998), bilinguals constantly need to control attention to two jointly activated (and sometimes conflicting) language systems. Recent proposals hold that bilinguals' enhanced cognitive functioning is modulated by bilingual proficiency (Carlson & Meltzoff, 2008; Poarch & van Hell, 2012), as well as whether a bilingual's languages are spoken in the same context and whether there is frequent language switching (Gathercole et al., 2010; Green & Abutalebi, 2013).

Previous studies on young children have mostly focused on inhibitory control rather than a broader set of cognitive control skills. Moreover, they have often treated bilinguals as a monolithic group, leaving aside potential different within-group differences in bilinguals' language use and proficiency. The aim of the current study is twofold. First, we investigate whether 24-month-old bilingual toddlers outperform monolingual peers on a range of measures of cognitive control, assessing selective attention, inhibitory control, attentional focusing, and attention shifting. Second, we investigate whether performance within the bilingual children differs as a function of their language use and language proficiency, both of the children themselves and of their parents. The overall goal of our study is to see whether, already at toddler age, enhanced cognitive control is specific to certain subgroups of bilinguals, such as those who frequently use their two languages or children who are proficient in both languages.

Previous research on effects of bilingualism on cognitive functioning has almost exclusively looked at school-aged children and adults, and only a handful of studies have examined effects of bilingualism on children aged three or below. Interestingly, the results of these studies indicate that increased cognitive control in bilinguals can be found very early in life, which suggests that effects of bilingualism can arise without extensive periods of active bilingual language use (Brito & Barr, 2014; Poulin-Dubois et al., 2011; Verhagen, Mulder, & Leseman, 2017). In these studies, however, increased performance in bilinguals was found for inhibitory control, but not for other aspects of cognitive control. Poulin-Dubois et al. (2011), for example, found that bilingual 24-month-old children outperformed monolingual peers on a task assessing children's ability to inhibit a prepotent response (i.e., Shape Stroop, cf. Kochanska, Murray, & Harlan, 2000), but not on tasks assessing task switching and delay of gratification. Verhagen et al. (2017) found a small effect of bilingualism on three-year-olds' inhibitory control, but not on measures of selective attention and working memory.

Work on older children and adults shows, however, that bilinguals' enhanced performance may extend to other aspects of cognitive control than inhibition. Specifically, in inhibition tasks, bilingual speakers outperform monolinguals not only on incongruent trials, requiring the inhibition of a dominant response, but also on congruent trials, in which performance does not rely on inhibition (Bialystok, Martin, & Viswanathan, 2005; see also Hilchey & Klein, 2011). This has led to the proposal that effects of bilingualism are wide-spread, and that they are related to executive processing more generally. Further evidence for a more broad effect on executive processing comes from studies showing that bilinguals outperform monolinguals on tasks of working memory and memory flexibility (Blom, Küntay, Messer, Verhagen, & Leseman, 2014; Brito & Barr, 2014), selective attention (Engel de Abreu, Cruz-Santos, Tourinho, Martin, & Bialystok, 2012), and attention switching (Bialystok & Martin, 2004; Vega-Mendoza, West, Sorace, & Bak, 2015). In fact, a recent proposal by Bialystok (2017) is that the locus of the "bilingual advantage" is in "executive attention", a "domain-general resource-limited monitoring system" that incorporates both working memory and attention (Bialystok, 2017, p. 33).

Not all previous studies have found enhanced cognitive skills in bilinguals, however. In some studies, bilinguals and monolinguals performed equally well, even after the two groups were closely matched on a number of background characteristics (Duñabeitia et al., 2014). Furthermore, positive effects of bilingualism have been observed to disappear after specific factors such as socio-economic status were controlled (Morton & Harper, 2007, but see Calvo & Bialystok, 2013 for different results). These mixed findings in earlier work have been attributed to differences in task complexity (Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009; Morales, Calvo, & Bialystok, 2013) and to specific properties of the tasks used (Bialystok & Martin, 2004). In particular, it has been noted that some commonly-used tasks that are assumed to tap inhibitory control (such as Stroop, Simon and flanker tasks) often do not correlate with one another. This suggests that these tasks might not tap into the same underlying ability, not even within the same participant group (cf. Paap & Greenberg, 2013 for a more elaborate discussion).

Another possible source of the mixed findings across studies relates to the variability that characterizes most bilingual samples. Bilinguals often form a heterogeneous population, showing variation in, amongst others, the languages they speak, how often they speak them, to whom, how well they speak them, and how often they switch back and forth between their two languages. Luk and Bialystok (2013) showed that two key factors relating to this variability are language use and language proficiency. These authors analyzed questionnaire and proficiency test data from a heterogeneous group of 110 bilingual adults with the aim of operationalizing the concept of bilingualism. Using factor analyses, they found that bilingualism was best described with two factors, representing bilingual language use and bilingual proficiency. These factors were significantly correlated, and each of the factors correlated significantly with bilinguals' self-rated linguistic proficiency levels. Luk and Bialystok concluded that bilingualism is multi-faceted, and proposed that the different factors characterizing bilinguals should each be taken into account when studying effects of bilingualism.

Regarding effects of bilingualism on cognitive functioning, evidence is accumulating that both bilingual language use and bilingual proficiency are related to whether effects of bilingualism on cognitive control are found. Poarch and van Hell (2012), for example, observed that bilinguals and trilinguals showed enhanced performance on tasks of inhibitory control over monolinguals, and marginally so over second-language learners. Tse and Altarriba (2014) found that bilingual children's proficiency in the second language predicted children's performance on a working memory task and on a Simon task. Furthermore, in a study by Prior, Goldwasser, Ravet-Hirsch, and Schwartz (2016), Russian-Hebrew school-aged children with balanced proficiency levels outperformed monolingual Hebrew peers on a flanker task, but bilingual children with less balanced profiles did not. Taken together, these findings as well as those from other studies not reviewed in detail here indicate that higher proficiency and/or more balanced bilingual proficiency levels are positively related to cognitive control across age groups, including preschoolers (Blom, Küntay, Messer, Verhagen, & Leseman, 2014; Carlson & Meltzoff, 2008), school-aged children (Goriot, Broersma, McQueen, Unsworth, & van Hout, 2018; Poarch & van Hell, 2012; Vega & Fernandez, 2011), and adults (Luk, De Sa, & Bialystok, 2011; Tao, Marzecova, Taft, Asanowicz, & Wodniecka, 2011; Vega-Mendoza et al., 2015).

Importantly, although these studies provide interesting results, they often do not allow us to disentangle effects of language proficiency, language exposure and language use, as the bilingually proficient speakers showing increased cognitive control are typically the ones whose bilingual exposure started early and who use their two languages often (see Kapa & Colombo, 2013; Tao et al., 2011 for similar arguments). In an attempt to disentangle language proficiency and onset of bilingualism, Kapa and Colombo (2013) compared bilingual children who had started speaking their two languages by age three and bilingual children who had started after age three. Controlling for linguistic proficiency, these authors found that the early-exposed children outperformed the later-exposed children on a flanker task. They conclude that this effect was either due to differential effects of acquiring a second language earlier versus later in development, or to a longer duration of bilingual exposure. Another factor that could explain the effect is bilingual usage, which is yet another factor that has been shown to modulate effects of bilingualism on cognitive control in bilingual children (Guerrero, Smith, & Luk, 2016).

Evidence that specific aspects of language exposure affect whether bilinguals show enhanced cognitive functioning comes from a study by Gathercole et al. (2010). Specifically, these authors found that bilingual children from homes in which both English and Welsh was spoken outperformed three other groups of children on a Stroop task when children were tested in English: bilingual children from Welsh-only homes who learnt English outside of their homes, bilingual children from English-only homes who learnt Welsh outside of their homes, and English monolingual children. In a similar vein, Verhagen et al. (2017) found effects of bilingual language exposure such that increased performance on inhibitory control tasks was found for bilingual three-year-olds who were addressed in two different languages by each of their parents, but not in bilingual three-year-olds who were addressed in the same language by their two parents (and thus learnt their other language outside the home). The authors speculated that these effects reflected the degree to which children experienced switching opportunities at home, such that the bilingual children who were raised in families in which parents spoke two different languages had more practice switching between languages than children whose parents spoke the same language. Indeed, in bilingual adults, a higher frequency of switching between languages has been found to correlate with increased performance on cognitive tasks (Soveri, Rodriguez-Fornells, & Laine, 2011; Woumans, Ceuleers, & Duyck, 2013).

The results of Gathercole et al. (2010) and Verhagen et al. (2017) are in line with the Adaptive Control Hypothesis proposed by Green and Abutalebi (2013). According to this hypothesis, increased cognitive control is most likely to surface in a dual language context in which (1) both languages are used by different speakers, and (2) switching between languages occurs within a conversation, but not within an utterance. Enhanced cognitive control is less likely in bilingual situations in which one language is used in one setting (e.g., home) and the other in another setting (e.g., school), and in which there is no frequent switching between languages. It is also less likely in dense switching contexts in which speakers routinely switch between languages, both across and within utterances. Unlike in the first context, where conflict monitoring and interference suppression are essential for effective interaction, in these two latter contexts, speakers either experience no switching (language separation context) or do not need to monitor potential conflicts or suppress interference from the other language, because both languages can be used with all speakers (dense code-switching context).

To summarize, earlier studies have shown that bilingualism may have a positive effect on cognitive control (see Adesope et al., 2010 for a review) and that such an effect of bilingualism can already be found in young children (Bialystok et al., 2011; Crivello et al., 2016; Poulin-Dubois et al., 2011). While the focus of these earlier studies has been on inhibitory control, there is some evidence from older children that bilinguals may outperform monolinguals in other aspects of cognitive control as well, including selective attention and attention switching (Bialystok & Martin, 2004; Engel de Abreu et al., 2012; Vega-Mendoza et al., 2015). Much of this earlier work has treated bilinguals as a monolithic group, but evidence is emerging that positive effects of bilingualism on cognitive control are stronger for or even confined to specific groups of bilinguals. Specifically, effects seem to be larger for bilinguals with more balanced proficiency in their two languages than for bilinguals with less balanced profiles (Carlson & Meltzoff, 2008; Goriot et al., 2018; Poarch & van Hell, 2012: Prior et al., 2016; Tse & Altarriba, 2014), the former group being more likely to use their languages more often and having more prolonged bilingual exposure. Effects also seem to be larger for bilingual children with an earlier age of onset and/or more intensive bilingual usage (de Leeuw & Bogulski, 2016; Kapa & Colombo, 2013). Finally, effects are larger for bilingual children whose parents each speak a different language than for bilingual children whose parents speak the same language (Gathercole et al., 2010; Verhagen et al., 2017), in line with the Adaptive Control hypothesis (Green & Abutalebi, 2013), according to which enhanced cognitive control is found when both languages are present, but not subject to intensive code-switching. However, on the basis of previous research findings, it is difficult to tease apart effects of children's language proficiency, children's language use, and language exposure, which present separate yet highly correlated factors in most bilingual samples. Regarding language exposure and language use, for example, previous research has shown that both factors are independently, and sometimes in a combined measure, related to language proficiency (e.g., Bedore et al., 2012; Paradis, 2011).

This study

The overall aim of the current study is to see whether bilingual toddlers outperform monolingual toddlers on various aspects of cognitive control rather than just inhibitory control. Data were collected from monolingual and bilingual 24-month-olds who all grew up in the Netherlands and learnt the majority language Dutch, and in the case of the bilingual children, another language. The bilingual children varied in the degree to which they actively spoke their two home languages, and how proficient they were in these languages. Also, there was considerable variation in the bilingual children's parents in whether parents spoke each or both home languages to their children, as well as in their proficiency in these languages. In our study, we focused on the factors that came out as the two main dimensions of bilingualism in Luk and Bialystok (2013) as possible sources of variation in effects of bilingualism on cognitive control: bilingual language use and bilingual proficiency. Unlike in earlier work on effects of bilingualism on cognitive control, in which only one of these factors was investigated – mostly at the child level only, we investigated the effects of each factor separately, at both the child and parental level. Our research questions were the following:

(1) Do bilingual toddlers outperform monolingual peers on a range of measures of cognitive control (inhibitory control, selective attention, attention shifting)?
(2) How do differences in bilingual language use and bilingual proficiency within children and parents relate cognitive control?

As for the first question, we hypothesized that the bilingual children would outperform the monolingual children on inhibitory control (Poulin-Dubois et al., 2010; Verhagen et al., 2017). Furthermore, we predicted that bilinguals would show enhanced performance on selective attention and attention switching, based on earlier work reporting widespread increased performance on cognitive tasks (Brito & Barr, 2014; Kovács & Mehler, 2009; Singh et al., 2015) as well as increased attentional control in young children (Comishen et al., 2019). Regarding the second question, we had four hypotheses. First, with respect to bilingual *children's language use*, we predicted that bilingual children who used both languages about equally often would outperform bilingual children who mainly used one language. This prediction was based on earlier studies showing that bilingual usage modulates effects of bilingualism on cognitive control, at least in studies where potentially confounding factors such as language proficiency and exposure were left uncontrolled (de Leeuw & Bogulski, 2016; Guerrero et al., 2016). Second, regarding individual differences in *children's language proficiency*, we predicted, following earlier studies showing effects of degree of bilingualism on cognitive control in somewhat older children (Blom et al., 2014; Carlson & Meltzoff, 2008; Prior et al., 2016; Poarch & van Hell, 2012; Tse & Altarriba, 2014), that bilingual children with more balanced levels of bilingual proficiency would outperform bilingual children with less balanced bilingual proficiency. Third, as for *parents' language use*, we hypothesized that children who were addressed in different languages by each of their parents would outperform children who were addressed in the same language by both of their parents, based on previous results for three-year-olds (Verhagen et al., 2017) as well as the Adaptive Control hypothesis, which predicts that cognitive control will be particularly enhanced if both languages are spoken in the same context (Green & Abutalebi, 2013). Finally, regarding *parents' language proficiency*, we hypothesized that bilingual children whose parents were not proficient in one of the languages spoken at home would show enhanced cognitive control as compared to bilingual children whose parents were highly proficient in both home languages. The rationale for this prediction was that, in the former group, children need to switch between languages to be able to understood, while in the latter, they can use either language without running the risk of breakdowns in communication. The degree to which bilingual speakers switch between languages is considered one of the main processes underlying effects of bilingualism on cognitive functioning, at least in adults (Green & Wei, 2014; Soveri et al., 2011).

By zooming in on specific properties of bilingual children's language use and proficiency as well as properties of parents' language use and proficiency, we aimed to identify which factors play a role in effects of bilingualism on cognitive functioning, and as such, contribute to a better understanding of the possible factors explaining the mixed pattern of results in previous research. As is common in studies on very young children, including those investigating effects of language input on children's language development (Hoff et al., 2012; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010), we limited our study to children's parents as the main input providers. Unlike at older ages, when children go to school, sports clubs or music lessons, and teachers and friends become important input providers, the overwhelming majority of infants and toddlers' input typically comes from their parents or other main caregivers within the home.

Method

Participants

Participants were 95 children with a mean age of 24 months. Of these, 58 were monolingual and 37 were bilingual. Children had been recruited through a database of the Utrecht Babylab. All toddlers had normal birth weight, normal hearing and vision, and no known neurological problems, as indicated by their parents in a questionnaire. The monolingual group had a mean age of 24 months and 11 days (*SD* = 36 days) and contained 21 girls (36%). The bilingual group had a mean age of 24 months and 2 days (*SD* = 20 days) and contained 16 girls (43%). Group differences in age and gender were not significant ($t(93) = 0.490$, $p = .625$ for age; $\chi^2(1, N = 95) = 0.470$, $p = .493$ for gender). Parents' mean level of education, as assessed on a 6-point scale ranging from 1 (no education) to 6 ((post-)university degree), was comparably high in both groups (monolinguals: *M* = 5.57, *SD* = 0.38, bilinguals: *M* = 5.58, *SD* = 0.73). The monolingual children were all from monolingual Dutch-speaking families. None of them had been in regular contact with another language, as indicated by parents' responses in a questionnaire. The bilingual children were from families in which a language other than Dutch, the majority language, was spoken in addition to or instead of Dutch. Specifically, they were all exposed to Dutch plus one of the following languages: English (*n* = 16), German (*n* = 7), Italian (*n* = 3), Spanish (*n* = 2), Frisian (*n* = 1), Brazilian Portuguese (*n* = 1), Catalan (*n* = 1), Dari (*n* = 1), Norwegian (*n* = 1), West-Flemish (*n* = 1), Czech (*n* = 1), Chinese (*n* = 1), or Bahasa Indonesia (*n* = 1). The majority (*n* = 34) were exposed to both Dutch and the other language at home by their parents, albeit to varying degrees. Three bilingual children were only exposed to their other language at home and acquired the majority language Dutch outside their homes (i.e., at daycare and through contacts outside the home). Percentages of parental exposure to Dutch in the bilingual group varied from 0% to 88% (*M* = 45.33, *SD* = 23.02). Details of the bilingual children's home language background were collected via an oral structured interview (BiLEC, Unsworth, 2013, see "below"). Regarding daycare attendance, information was available through the BiLEC questionnaire, which was administered to the bilingual children's parents only. These data showed that 33 out of all 37 bilingual children attended daycare, with an average number of 14.49 hours per week (*SD* = 10.29). This average is very close to average in the Netherlands, where children attend daycare two days (ca. 16 hours) per week on average (NCKO, 2011). The BiLEC data showed, moreover, that only Dutch was provided at daycare, in line with Dutch legislation that only allows Dutch to be spoken at daycare for children aged zero to four years.

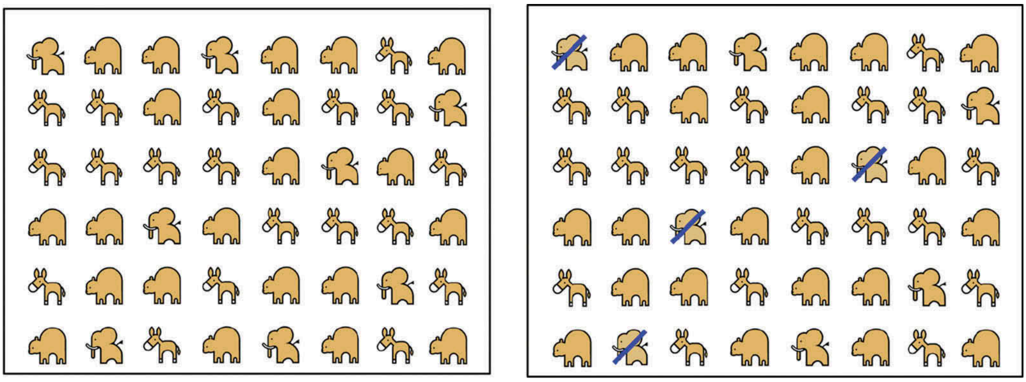

Figure 1. Sample item of the visual search task (left: item as presented to the child; right: item during task performance with some of the targets crossed off, because of being identified).

Materials

Selective attention

A *visual search task* (Mulder, Hoofs, Verhagen, van der Veen, & Leseman, 2014) was used to assess selective attention. In this task, children were presented with a display of 48 animals on a laptop screen. Stimuli were images of elephants, bears, and donkeys that were very similar in color and size (see Figure 1). During test trials, children were asked to find as many targets (elephants) as quickly as possible within 40 seconds while ignoring distractors (bears and donkeys). All test trials contained eight targets and 40 distractors presented in a 6 × 8 grid. To minimize memory demands, the elephants that children had located were crossed off. Prior to the test trials, there were three practice trials in which children were instructed to only search for the elephants and ignore the other animals, and do so as quickly as possible. Stimuli presentation and response recording were controlled via the experimental software E-prime. Scores were calculated as the mean number of correctly located targets per item for children who completed at least two items. The task had good internal consistency (Cronbach's alpha = .80).

Inhibitory control

A *spatial conflict task* modeled after a task used by Rothbart, Ellis, Rueda, and Posner (2003) was used to assess children's ability to inhibit a pre-potent response. In this task, children were presented with pictures of two houses, located at the lower left and right corners of a laptop screen. These houses served as locations for the child to make a response. During all trials, a third animal appeared above the houses, and children were asked to help this animal find its home, by pointing to its house. Specifically, they were provided with the Dutch equivalent of the sentence 'In which house does [the butterfly] go?" During practice trials, the target animal, which matched one of the animals pictured in the houses, appeared in the upper-center of the screen. During the test trials, the target animal either appeared in the upper-left or in the upper-right corner of the screen, directly above one of the two houses. Crucially, in congruent trials, the target animal matched the animal in the house above which it appeared; in incongruent trials the target animal matched the animal in the other house (see Figure 2). Thus, in incongruent trials, children had to ignore the spatial location

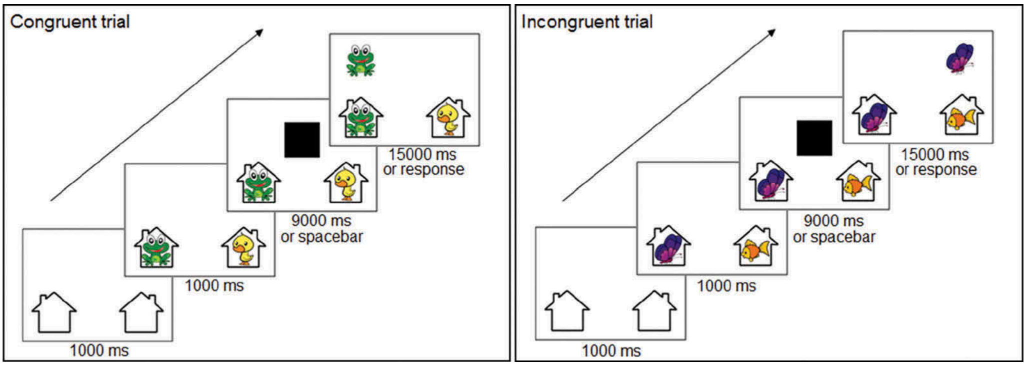

Figure 2. Example items of the congruent and incongruent trials in the spatial conflict task.

of the picture and respond on the basis of picture identity alone. All animal pictures consisted of brightly colored figures, and the stimulus words were high-frequent Dutch words composed of two syllables (*kikker* "frog", *eendje* "duckie", *vlinder* "butterfly", *visje* "little fish") that were assumed to be familiar to Dutch-speaking two-year-olds. Diminutives (e.g., *eendje* "little duck") were used, because these are prevalent in speech to young Dutch children, especially in the case of animal names of otherwise monosyllabic labels. The pictures of the animals used in the stimuli were about the same size and contained different but equally bright colors. The animals used in the practice trials were a pig and a cow. In the first and second blocks, these were a frog and a duck, and a butterfly and a fish, respectively. After the two animals had appeared in the two houses, a square was presented for nine seconds in the center of the screen to capture the child's attention. As soon as the child's attention was directed at the screen, the experimenter touched a computer key, and the target stimulus, matching one of pictures in the houses, appeared. The experimenter then instructed the child to help the target animal (e.g., the "frog") find its home. There were four practice trials, in which the stimulus appeared in a neutral position (central-upper position), followed by two blocks of eight test trials. Half the trials within a block were congruent, while the other half were incongruent. The order of compatible versus incompatible stimulus appearance was randomized within each block, and a different picture pair was used in each block. The target remained visible until the child responded, or for a maximum of 15 seconds. The task was the same as the spatial conflict task used by Rothbart, Ellis, Rueda, and Posner (2003) except that different (but very similar) pictures were used. Outcome measures were also the same, except that no reaction times were recorded. Rothbart et al. (2003) found reaction times to be unreliable in 24- and 25-month-olds, so, in the current study, only accuracy scores were used. As in Rothbart et al., proportion correct scores were calculated for the incongruent and congruent trials separately, and difference scores were computed as children's accuracy scores on the congruent trials minus their scores on the incongruent trials. Cronbach's alpha of the task was .83 for the congruent trials and .77 for the incongruent trials.

Parent-reported attentional focusing, inhibitory control, and attentional shifting

A parental questionnaire – the *Early Childhood Behavior Questionnaire (ECBQ)* (Putnam, Gartstein, & Rothbart, 2006; Dutch translation by Majdandžić & van den Boom, 2007), was used to assess attentional focusing, inhibitory control, and attentional shifting. For all scales, parents were asked to indicate for their child how often a certain behavior had occurred during the past two weeks. Answers were given on a seven-point scale that ranged from "does not apply" to "strongly applies" The inhibitory control scale contained 12 items that assessed children's ability to stop, moderate, or refrain from a certain behavior under instruction. An example item is: "When told NOT to, how often did your child touch an attractive object (such as an ornament) anyway?" The attentional focusing scale contained 12 items that assessed children's ability to sustained orientation toward an object or task of attention. An example item is: "When playing alone, how often did your child play with a set of objects for 5 minutes or longer at a time?" The attentional shifting scale contained 12 items that assessed children's ability to transfer their attentional focus from one activity or task to another. An example item is "After having been interrupted, how often did your child return to a previous activity?" Parents completed the questionnaire in the language of their choice (Dutch or English), with all parents being sufficiently proficient in either one (or both) of these languages, as indicated by the fact that, for each child, the parent who filled out the questionnaire had rated their proficiency no lower than 4 (very fluent: can carry out virtually any kind of conversations) or 5 (native). Reliability of the inhibitory control subscale in our sample was good (Cronbach's alpha .84). Reliability of the attentional focusing scale was poor (alpha .56), but became very good after removing the item "When engaged in play with his/her favorite toy, how often did your child play for 5 minutes or less?" (alpha .88). Reliability of the attentional shifting scale was sufficient (alpha .64), and could not be improved by removing items.

Bilingual language use and bilingual proficiency

The *Bilingual Language Experience Calculator (BiLEC)* (Unsworth, 2013) was used to obtain information about the language background, language use and language proficiency of the bilingual children and their parents. This questionnaire, which is administered as an oral interview, can be used with children aged two to 18 years. Specifically, the questionnaire (which follows Gutiérrez-Clellen & Kreiter, 2003; Paradis, 2011; Thordardottir, 2011, amongst others) assesses which languages parents speak to their children, how often they speak them, and how well they speak and understand each of the languages spoken at home. It also assesses when and where children use their two languages, when they started learning them, and how well they speak and understand each of their languages. Although BiLEC is designed to derive a composite measure of overall language exposure and use, for the current study, raw scores on aspects of language use and language proficiency were analyzed at the child and parent level separately. At the child level, estimates for *children's language use* were collected by asking parents to provide precise estimates of how often a child spoke each language used in the home environment to each parent separately. These scores were converted into percentages. Specifically, parents responded to the following question: "How often does your child speak [language A/language B etc.] to you?" and "How often does your child speak [language A/ language B] to your partner?" Similarly, regarding *children's language proficiency*, the BiLEC assessed how children spoke and understood each language used within the home on a 6-point scale ranging from 0 ("almost no speaking/understanding") to 5 ("native-like speaking/understanding"). Specifically, parents were asked the following question for each of the languages spoken at home separately: "How well does your child speak [language A/language B etc.]?" In answering these questions, parents were instructed to estimate their child's language abilities as compared to those of a typical monolingual child of the same age. At the parent level, estimates for *parents' language use* were obtained by asking parents to provide precise estimates of their relative amount of use of a given home language when speaking to their child for each parent separately (converted to percentages). Similarly, regarding *parents' language proficiency*, the questionnaire assessed for both parents separately how well they spoke and understood each language used within the home on a 6-point scale ranging from 0 ("almost no speaking/understanding") to 5 ("native-like speaking/understanding").

Dutch Mcarthur-Bates communicative development inventory (N-CDI)

The Dutch version of the *McArthur-Bates Communicative Development Inventory* (N-CDI, Zink & Lejaegere, 2002) was used to measure children's vocabulary knowledge in Dutch, the language of testing. In this questionnaire, parents are asked to indicate whether their child "understands" or "understands and says" 702 words from a fixed list. Percentile scores and raw scores (based on monolingual norms) were calculated for receptive and productive vocabulary separately.

Procedure

Children visited the lab with their parents twice to perform the current tasks as well as two artificial language learning experiments that are reported elsewhere (de Bree, Verhagen, Kerkhoff, Doedens, & Unsworth, 2017). During the first visit, they performed the spatial conflict and visual search tasks. Trained research assistants administered the tasks in a fixed order with the visual search task preceding the spatial conflict task. The visual search task was administered first because this task requires less instruction and is more intuitive for children to perform than the spatial conflict task. By doing so, we aimed to keep non-responding children or fussy children to a minimum. Both tasks were administered in Dutch, and lasted no longer than five minutes each. A standardized procedure was followed in which only very simple language was used and non-verbal cues such as pointing were used to support children's understanding. Prior to their first lab visit, parents were sent the N-CDI and ECBQ questionnaires to complete, along with a number of other questionnaires which are not discussed here. Parents returned these questionnaires when they came to visit the lab. The BiLEC was administered as an oral interview by a trained assessor during the second visit, and lasted for approximately 30 minutes. After each session, children received a small gift.

Analyses and variable construction

For all measures, data were normally distributed or deviated only slightly from normality, and showed no skewness or kurtosis values of more than three times the standard error. Prior to the main analyses, the monolingual and bilingual children were compared on Dutch vocabulary. Also, bivariate correlations were calculated among all cognitive control measures as well as with Dutch receptive and productive vocabulary scores. The aim of these correlational analyses was twofold: (1) investigate correlations with Dutch vocabulary to see if performance on the cognitive control tasks was correlated with individual differences in knowledge of Dutch (which would potentially make these tasks more difficult for the bilingual children) and (2) determine whether scores on the cognitive control tasks were strongly interrelated, which would present evidence for these tasks tapping one broad underlying construct rather than separate constructs.

To address our first research question concerning possible differences between monolingual and bilingual toddlers in cognitive control, a series of generalized linear mixed-effect models were run in R (R Core Team, 2015), using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). Dependent variables in these analyses were children's scores on the visual search task, spatial conflict task, and parents' ECBQ ratings. Group (monolingual vs. bilingual) was entered as a fixed effect factor. Subjects and items were added as random-effect factors, and a by-item random slope was added for "group", following common recommendations to keep models as specified as possible (Barr, Levy, Scheepers, & Tily, 2013).

To address our second research question on possible effects within the bilingual group, four variables were created reflecting variation in children's language use and language proficiency as well as in their parents' own language use and proficiency, as collected with the BiLEC questionnaire. These bilingualism-related variables were all continuous variables, and will be described in turn below. Subsequently, the same mixed-effect models as above were run, except that, instead of "group", the four predictor variables were added as fixed-effect factors.

In all models, orthogonal sum-to-zero contrast coding was applied to our binary fixed effect (i.e. group) and all continuous variables were centered around zero (Baguley, 2012). We corrected the alpha level for multiple comparisons by dividing .05 by the number of statistical comparisons made in each model. Effects that were below .05 but above the corrected alpha-level were interpreted as trend effects.

Bilingualism-related variables

On the basis of the BiLEC questionnaire, language use and proficiency variable were created for the bilingual children. First, a variable was created based on parents' estimates of the percentages children spoke each home language to their parents (*children's language use*). This variable was used as an indicator of the extent to which children used both languages at home. A score of 0 for this variable indicated that the child used only one language at home, whereas a score of 100 indicated that the child used both languages in equal amounts. Specifically, if parents indicated that, to parent 1, their child spoke language A (e.g., Dutch) 80% of the time and language B (e.g., English) 20%, and, to parent 2, their child spoke language A and language B each 50% of the time, their "language use" score was calculated as follows: the mean for language A (65%) minus the mean for language B (35%) = 30. Similarly, if children spoke language A 100% of the time to parent 1 and language B 100% to parent 2, their language use score was 50% − 50% = 0. This scale was reverted by subtracting 100 from each value and making all values positive, resulting in a scale ranging from 0 to 100 in which a score of 0 represented a situation where children spoke one language 100% of the time to both parents, and a score of 100 represented situations where children either spoke language A 100% of the time to parent 1 and language B 100% of the time to parent 1, or spoke both languages 50% of the time to both parents (i.e., maximum use of both languages by the child). While its construction may seem complicated, the resulting variable closely reflected children's relative use of both languages within the home, based on their language usage with both parents. Note, however, that additional analyses with children's language use weighted for the actual time children spent with each parent were also run, but not reported, because they yielded very similar results.

Second, a variable was created that reflected *children's language proficiency*, or the extent to which children had balanced proficiency in their two languages. This variable was based on parent's ratings of their children's speaking proficiency for each language on a scale ranging from 0 (virtually no fluency), 1 (limited fluency; only basic words and expressions), 2 (somewhat fluent: can carry out simple conversations), 3 (quite fluent: extended conversations, e.g., at (pre)school), 4 (very fluent: can carry out virtually any kind of conversations), and 5 (native). Specifically, this variable was constructed by calculating the difference between the ratings for each language, with a 0 score reflecting equal proficiency on both languages and a higher score reflecting a larger difference in proficiency between the two languages. For example, a child with a proficiency rating of 5 for Dutch and 1 for English was given a score of 4 (for a similar procedures, see Bedore et al., 2012; Prior et al., 2016). Values were reverted by subtracting 5 from each value, resulting in a scale ranging from 0 to 5, with 0 indicating unbalanced bilingual proficiency (5-point difference in proficiency ratings between languages) and 5 indicating balanced proficiency (same proficiency rating for both languages).

Third, the role of *parents' language use* was investigated using a variable that reflected the degree to which parents each spoke a different language to their child, that is, the degree to which they applied a "one parent, one language" approach. To arrive at this variable, difference scores were calculated between the relative amount of language A spoken by parent 1 and the relative amount of language A spoken by parent 2. For example, if parent 1 spoke English 100% (and 0% Dutch) of the time and parent 2 Dutch 100% of the time (and 0% English), the resulting score was the difference score between 0% Dutch and 100% Dutch (i.e., 100). If parent 1 spoke French 70% of the time and Dutch 30% of the time and parent 2 spoke 10% French and 90% Dutch, the resulting score was the difference between 30% Dutch and 90% Dutch (i.e., 60). In this way, a variable was created with 0 representing a situation where both parents spoke the same language(s) to the same degree (e.g., both 0% Dutch and 100% English) and 100 represented a situation where each parent maximally spoke a different language to their child (e.g., one parent spoke 100% English and the other 100% Dutch).

Finally, a variable was created that represented *parents' language proficiency*, or more specifically, whether parents lacked proficiency in one of the home languages. To this end, parents' ratings of their speaking proficiency in both home languages were taken, and parents were assigned the value of the rating for the language they were least proficient in. This variable ranged between 0 ("virtually no fluency") and 5 ("native"), reflecting the degree to which parents were proficient in the home languages. Note that only their rating for their weakest language was taken, as the scores for the other home language were always high (i.e., 5). Thus, parents (either one or both) who self-rated their proficiency with a score of 5 indicated to be native(-like) in one (and consequently, both home languages), whereas parents having a score of 0 or 1 indicated to have low proficiency in one of the languages spoken at home. When this latter situation occurred, the low rating was always given to the language spoken to the child by the other parent.

Table 1. Descriptive statistics and T-test results for Dutch vocabulary (N-CDI) for the monolinguals and bilinguals.

	Monolinguals		Bilinguals		*t*-test statistics		
	M	(SD)	M	(SD)	*t*	*p*	*d*
Receptive vocabulary							
Raw scores	446.85	(127.69)	345.91	(155.06)	3.36	.001	.71
Percentile scores	56.41	(28.84)	35.91	(29.81)	3.20	.002	.70
Productive vocabulary							
Raw scores	308.07	(155.30)	193.85	(114.05)	3.71	<.001	.84
Percentile scores	59.11	(30.65)	37.03	(25.24)	3.52	.001	.79

N-CDI data were available for 55/58 monolinguals (95%) and 34/37 bilinguals (92%). Percentile scores for this instrument are based on norm data of monolingual Dutch children only.

Results

Dutch vocabulary and correlations with cognitive control

Receptive and productive Dutch vocabulary knowledge of the bilingual children was significantly lower than that of the monolingual children, as shown in Table 1. An additional analysis excluding the three bilingual children whose parents both spoke another language than Dutch and for whom parental estimates of Dutch vocabulary size were likely to be unreliable showed the same pattern. In this additional analysis, too, receptive and productive vocabulary scores were higher in the monolingual group than in the bilingual group (all *p*s < .01).

To see whether individual differences in vocabulary were correlated with cognitive control performance, correlations were calculated between children's vocabulary (raw scores) and cognitive control scores. Results on cognitive control outcomes are presented in Table 3 and are discussed below. Table 2 presents these correlations, as well as correlations among the cognitive control measures, for the two groups separately.

Table 2. Bivariate correlations for all variables for the monolingual (upper right triangle) and bilingual (lower left triangle) children.

	1	2	3	4	5	6	7	8	9	10.
Vocabulary										
1. CDI, receptive vocab.	-	**.84*****	.10	.20	.03	.23	.18	−.01	.03	.09
2. CDI, productive vocab.	**.77*****	-	.20	.08	−.07	.20	.22	−.01	−.10	.06
Cognitive control										
3. Visual search	−.01	.06	-	**.40****	**.44****	.01	.23	−.07	−.01	.07
4. Spatial conflict (congr.)	.30	**.37***	.05	-	**.72*****	**.50*****	**.31***	.01	.16	.20
5. Spatial conflict (incongr.)	.17	**.36***	.09	**.85*****	-	−.24	.22	.01	.13	.15
6. Spatial conflict (difference)	.24	.05	−.07	**.38***	−.17	-	.16	.01	.06	−.10
7. ECBQ, inhibitory control	.01	.17	.18	**.41***	**.50****	−.11	-	.23	**.44****	**.75*****
8. ECBQ, attentional focusing	−.23	−.02	.05	−.03	.04	−.12	**.44****	-	**.28***	**.74*****
9. ECBQ, attentional shifting	.21	.27	−.03	−.11	.03	−.23	.27	**.47****	-	**.71*****
10. ECBQ, composite score	−.10	.14	.09	.13	.25	.18	**.75*****	**.88*****	**.67*****	-

*** $p < .001$, ** $p < .01$, * $p < .05$. Sample size ranges between 48 and 55 for the monolinguals and between 31 and 35 for the bilinguals.

Table 3. Descriptive statistics for the cognitive control measures for the monolinguals and bilinguals.

	Monolinguals			Bilinguals		
	M	(SD)	N	M	(SD)	N
Visual search	3.26	(1.51)	58	3.80	(1.39)	37
Spatial conflict (congruent)	0.58	(0.35)	50	0.55	(0.35)	35
Spatial conflict (incongruent)	0.54	(0.31)	50	0.54	(0.32)	35
ECBQ – effortful control	4.27	(0.62)	55	4.18	(0.59)	34

Except for two positive and moderate correlations between productive vocabulary and spatial conflict scores in the bilingual group, there were no significant correlations between Dutch vocabulary and cognitive control. For the cognitive control measures, some significant cross-task correlations were found, which differed across the two groups. First, performance on the visual search task correlated positively and significantly with performance on both the congruent and incongruent trials in the spatial conflict task in the monolinguals, but not in the bilinguals. Second, performance on the congruent and incongruent trials of the spatial conflict task showed positive, significant correlations with parents' ratings of inhibitory control in the bilinguals, while such a correlation was only found for the congruent trials in the monolinguals. In both groups, ECBQ ratings were significantly correlated, except for the correlation between inhibitory control and attentional focusing in the monolingual group and the correlation between inhibitory control and attentional shifting in the bilingual group. Children's difference scores on the spatial conflict task did not correlate significantly with any of the other measures. This result resembles findings by Rothbart et al. (2003), who found that even though 24- to 25-month-olds' differences scores correlated moderately and significantly with parent ratings of effortful control, such correlations were not found in 30-month-olds, suggesting that these relationships were not stable over time. Given the current lack of significant correlations between the spatial conflict difference scores as well as the mixed findings reported in Rothbart et al. (2003), we did not use the difference scores on the spatial conflict task in subsequent analyses. Also, a factor analysis showed that the three ECBQ subscales did not represent separate factors (i.e., a scree plot showed that 10 items had eigenvalues greater than 1), in line with previous results of the developers of the ECBQ showing that these three subscales loaded onto a single latent factor in young children, termed "effortful control" (Putnam et al., 2006). Hence, a composite score (i.e., mean score) of all ECBQ items was used in further analyses (Cronbach's alpha of the combined scales was .82).

Comparing cognitive control between the monolingual and bilingual children

Table 3 provides descriptive statistics for the cognitive control measures for the monolinguals and bilinguals.

Linear mixed-effect models with "group" (monolinguals vs. bilinguals) as a fixed-effect factor and random effects for subjects and items for each measure separately were conducted. For the visual search task, scores in the bilingual group were not significantly higher than in the monolingual group ($\beta = -0.543$, SE = 0.313, $t = -1.738$, $p = .088$). For the spatial conflict task, a model with trial type (congruent vs. incongruent) as an additional fixed-effect factor showed no effect of group ($\beta = 0.038$, SE = 0.434, $z = 0.089$, $p = .929$), no effect of trial type ($\beta = -0.204$, SE = 0.161, $z = -1.269$,

p = .204) and no interaction effect between group and trial type (β = −0.175, SE = 0.320, z = −0.549, p = .583). Finally, although the monolinguals obtained higher scores overall for parental ratings of cognitive control on the ECBQ, a model with parents' ratings as the dependent variable, a fixed-effect factor for group, and random factors for subjects and items as well as a by-item random slope for group showed no effect of group (β = 0.123, SE = 0.142, t = 0.866, p = .390). Thus, the analyses did not show differences between bilingual and monolingual children on any of the cognitive control measures.

Effects of bilingual language use and language proficiency within the bilinguals

Before turning to the effects of bilingual language use and proficiency on bilingual children's cognitive control, we present descriptive statistics for these bilingualism variables in Table 4. These data show that there was considerable variation for each variable. Bivariate correlations across these variables showed two significant correlations. First, there was a correlation between children's language use and their children's bilingual proficiency ($r(37)$ = .40, p = .013), indicating that children who used their two languages often were generally rated as more balanced in these languages. Second, there was a significant correlation between children's language use and parents' language use ($r(37)$ = .49, p = .002), which indicated that children whose parents each spoke a different language used two languages (rather than one language) more often than children whose parents both spoke the same language. Correlations among the parent-based variables were very weak, indicating no clear associations between whether parents both spoke the same or different languages and how proficient they were in their weakest language (rs between −05 and .19, all ps > .1).

Results of the linear mixed-effect regression models testing for the effects of the bilingualism-related variables on children's responses in the visual search task showed an effect of parents' language proficiency, indicating that children whose parents reported low proficiency in one of the home languages performed significantly better than children whose parents reported high proficiency in both languages spoken at home" (β = −0.476, SE = 0.168, t = −2.826, p = .009). A trend effect was found for parents' language use, which was negative (β = −0.014, SE = 0.006, t = −2.215, p = .034), such that children whose parents often spoke the same language performed better on the task than children whose parents each spoke a different

Table 4. Descriptive statistics for the bilingualism-related variables (n = 37).

	M	SD	min-max
Children's language use [a]	50.76	36.16	0–100
Children's language proficiency [b]	3.51	1.24	1–5
Parents' language use [c]	64.68	35.81	0–100
Parents' language proficiency [d]	2.97	1.38	1–5

[a] maximum score is 100, reflecting a child's balanced (relative) use of both languages; minimum score is 0, reflecting children's use of one language only; [b] maximum score is 5, reflecting equal proficiency in both languages; minimum score is 0, reflecting highly unbalanced proficiency in both languages; [c] maximum score is 100, reflecting a situation where each parent consistently spoke a different language to the child; minimum score is 0, reflecting a situation where parents each spoke both languages to the same extent; [d] maximum score is 5, indicating native (-like) proficiency in their "weakest" language (and thus, native-like proficiency in both home languages); minimum score is 0, indicating "virtually no fluency" in parents' weakest language out of the two languages spoken at home.

language. There were no effects of children's language use (β = 0.006, SE = 0.010, t = 0.599, p = .554) or children's language proficiency (β = 0.324, SE = 0.175, t = 1.857, p = .073).

In the model with children's spatial conflict scores as the dependent variable, no effects of the bilingualism-related variables were found (i.e., children's language use: β = 0.013, SE = 0.022, z = 0.609, p = .542; children's language proficiency: β = 0.143, SE = 0.295, z = 0.485, p = .627; parents' language use: β = 0.011, SE = 0.010, z = 1.077, p = .282; parents' language proficiency: β = −0.162, SE = 0.282, z = −0.574, p = .566). "Trial type" did not show an effect either, indicating that the children did not perform differently depending on whether or not the trials were spatially incongruent (β = −0.129, SE = 0.225, z = −0.574, p = .566).

Finally, a model with parental ratings of children's cognitive control (ECBQ ratings) as the dependent variable showed an effect of children's language use: Children who were reported to regularly use two languages when speaking to their parents obtained higher effortful control ratings than children who were reported to use two languages less often, or used only one language (β = 0.014, SE = 0.005, t = 2.711, p = .011). The other bilingualism-related variables did not yield effects for this measure (children's language proficiency: β = 0.060, SE = 0.093, t = 0.647, p = .523; parents' language use: β = −0.003, SE = 0.004, t = −0.807, p = .426; parents' language proficiency: β = −0.033, SE = 0.086, t = −0.387, p = .702).

One possible explanation for the lack of an effect of children's bilingual proficiency is that parents' estimates of children's proficiency were not reliable. To the extent that we could check this, there was no indication that this was the case: rather, there was a positive moderate correlation between children's Dutch speaking proficiency ratings and their productive vocabulary scores on the Dutch CDI ($r(34)$ = .44, p = .009). Note, however, that even though the proficiency ratings and vocabulary scores involved very different measures (i.e., oral questions about children's general language proficiency (BiLEC) versus a long written checklist containing concrete words and phrases (CDI), both were based on parent report. While there is evidence that the CDI is a valid assessment of children's language skills at two years of age (Dale, 1991; Feldman et al., 2006), we cannot rule out that more objective measure of children's language proficiency would have yielded different results.

Discussion

In this study, we investigated whether bilingual toddlers outperformed monolingual toddlers on a set of cognitive control measures. Specifically, we assessed whether bilingual 24-month-olds outperformed monolingual peers on measures of inhibitory control, selective attention, and a parent-based composite measure based on inhibitory control, attentional focusing and attention shifting. We then analyzed the bilingual children's data further to see how within-group differences in terms of bilingual language use and bilingual proficiency of both the children themselves and of their parents related to cognitive control performance.

When the entire group of bilingual children was considered, the results showed no differences between the monolinguals and bilinguals on any of the measures. The difference for the visual search task was most prominent, but did not reach significance. This lack of a robust effect of bilingualism in the current study is in line with earlier work showing no broad effects in young children, such that effects on cognitive control were either very small and only detectable because of a very large sample size (Verhagen et al.,

2017) or attested for only one task out of a whole battery of tasks (Poulin-Dubois et al., 2011). In work on older children, null results have also been reported (Duñabeitia et al., 2014; Morton & Harper, 2007).

Other studies, however, demonstrated effects of bilingualism on cognitive control in a number of different populations (see Adesope et al., 2010). Besides to properties of the tasks used, such mixed effects may have been at least partially due to differences in the characteristics, such as language proficiency and use. In the current study, individual variation in bilingual children's home language background and proficiency levels was investigated along each of the following four dimensions: (1) *children's language use* – the degree to which children actively used the two home languages versus mainly or only one language, (2) *children's language proficiency* – the degree to which they were equally proficient (balanced) in their two home languages, (3) *parents' language use* – the degree to which parents each spoke the same language(s) to their child rather than adopted a one-parent-one-language approach, and (4) *parents' language proficiency* – the degree to which parents were proficient in their "weakest" language (if any) out of the two home languages, thus reflecting the degree to which parent had speaking proficiency in the home language that was spoken by the other parent. We found that children's language use and parents' language proficiency were related to children's performance on our measures of cognitive control. Bilingual children who displayed a more balanced use of both languages obtained significantly higher ratings on parent-reported cognitive control than bilingual children who mainly used one language. The finding that bilingual children with more balanced usage outperformed bilingual children with less balanced usage is in line with our prediction, based on earlier work, that higher degrees of bilingual language use are associated with stronger effects of bilingualism (Carlson & Meltzoff, 2008; Poarch & van Hell, 2011; Prior et al., 2016).

In previous work, however, effects of bilingual language use and bilingual proficiency could not be teased apart, since separate measures of language use and proficiency were not included. The current findings suggest that it is children's use of two languages rather than their proficiency in these languages that drives enhancements in cognitive control. As such, the current results add to earlier work in showing that language use is another factor modulating effects of bilingualism on cognitive control, besides bilingual proficiency and bilingual exposure, which have been shown to be of influence in earlier work (Carlson & Meltzoff, 2008; Kapa & Colombo, 2013; Poarch & van Hell, 2012; Vega & Fernandez, 2011). Since bilinguals' use of two languages is typically correlated with more fine-grained factors such as the frequency of language switching – a factor related to cognitive control in adults (Hofweber, Marinis, & Treffers-Daller, 2016; Soveri et al., 2011), further research is needed to disentangle the effects.

Children's language proficiency did not predict cognitive control, even though a slight trend effect was found for visual search (p = .073). This finding is at odds with the results of a recent study by Crivello et al. (2016), who found that an increase in the number of translation equivalents in two-year-old toddlers' vocabularies over the course of seven months positively predicted children's scores in inhibition tasks. A possible explanation of why bilingual proficiency, which is likely associated with the number of translation equivalents in children's lexicons, was not a significant predictor in our study is that the current measure was based on (parents' estimates of) children's relative proficiency in the two languages. A shortcoming of these data is that they may not reliably reflect children's actual language abilities. Furthermore, the way in which children's proficiency scores were calculated in the present study made it impossible to disentangle absolute and relative proficiency: children with the same score may not have had the same absolute vocabulary scores and might have been more or less proficient overall. Consequently, the results of the current study are uninformative as to whether absolute dual language proficiency or language balance is associated with higher cognitive control scores. Recent work on early second language learners suggests, however, that language balance rather than absolute proficiency predicts switching costs in cognitive control tasks (Goriot et al., 2018).

The second bilingualism-related factor that affected cognitive control scores was parents' language proficiency. Specifically, our results showed that bilingual children with one or two parent(s) with a low proficiency level in one of the home languages showed enhanced performance on a selective attention task (i.e., visual search) as compared to bilingual children whose parents were proficient in both languages. This finding is in line with our prediction that children whose parents were not (very) proficient in one of the child's two languages needed to switch between languages to be able to understood, while children whose parents were proficient in both languages could use either language without running the risk of communication breakdown. The degree to which bilingual speakers switch between languages is considered one of the main processes underlying bilinguals' increased cognitive control, at least in adults (Green & Wei, 2014; Soveri et al., 2011; Woumans et al., 2013), and our results suggest that this also holds for children. Not all types of switching appear to be equal, however: switching between languages in order to avoid communication breakdown (such as when a parent does not understand a given language) may foster the more effortful attentional control or suppression mechanisms also tested in cognitive control tasks, whereas abundant switching between languages in situations where all communication partners are fluent in the languages of communication may not foster such mechanisms. The finding that children whose parents had limited proficiency in one of the home languages had higher selective attention scores than children whose parents were proficient in both home languages is seemingly at odds with the trend effect observed that children who were mainly addressed in the same language by both parents had higher selective attention scores than children whose parents each spoke a different language ($p = .034$). What might be at stake is that children whose parents often used the same language (e.g., 80% of the time) but who indicated to be low-proficient in the language they each spoke less often (e.g., 20% of the time, and mostly the majority language (Dutch)) were the ones who needed to switch between their two languages and monitor their language use. Specifically, in such situations, there is a clear need to switch between languages for the child to be understood, but since parents use the language that they are low-proficient in sometimes themselves, this places a high burden on the child's language switching and monitoring, perhaps even more so than in a one-parent-one-language situation where there is a clear one-to-one relationship between "parent" and "language".

Taken together, the results of the current study suggest that, already in young children, the existence of positive effects of bilingualism on cognitive control is related to switching frequency or perhaps the necessity to switch. This fits well with the predictions made by the Adaptive Control hypothesis, which assumes that enhanced cognitive control in bilinguals is most likely in dual language contexts in which both languages are used in one setting (e.g., home) and in which there is some switching between languages, but not to the extent that switching occurs freely and abundantly both across and within utterances (i.e., dense code-switching). The finding that, in the current study, the clearest results were obtained for the visual search task aligns with the recent proposal that the locus of effects of bilingualism is in attentional control (Bialystok, 2017).

To the best of our knowledge, the current study is the first to consider parents' proficiency in the home languages as a proxy for bilingual children's necessity to switch between languages. Further research is needed to test this proposal further. Observational studies could be conducted, for example, to check whether bilingual children indeed switch between languages more often in families in which one or both parents are low proficient in one of the home languages than in families in which both parents are high-proficient in both languages, and whether, frequency of such switching, in turn, is related to enhancements in cognitive control. Furthermore, rather than seeing differences between monolinguals and bilinguals in terms of advantages, future research could investigate how differences in children's developmental trajectories toward attentional control relate to specific properties of the dual language environments they grow up in, and examine under which circumstances heightened attentional control is or is not beneficial.

Our data showed that cognitive control performance was only weakly related to children's Dutch vocabulary knowledge. Except for the inhibitory control measure (i.e., spatial conflict task), which showed moderate positive correlations with vocabulary, correlations were weak and non-significant. In our study, we tried to minimize the role of language in the cognitive control tasks by using standardized instructions that contained very simple language and supported children's understanding through gestures (e.g., pointing). Earlier work reporting stronger correlations between cognitive control and language, albeit for somewhat older children (Fuhs & Day, 2011; Gooch, Thompson, Nash, Snowling, & Hulme, 2016; Okanda, Moriguchi, & Itakura, 2010) have typically used more language-dependent measures of cognitive control (e.g., verbal working memory tasks), which might explain the stronger associations with children's language skills in those studies. In our study, the finding that the cognitive control measures generally correlated weakly with Dutch vocabulary suggests that the lack of positive effects of bilingualism on cognitive control was not due to the bilingual children's lower Dutch proficiency levels.

The current findings constitute a first step toward unraveling which properties of bilingual children's experiences are associated with enhanced cognitive control and, as such, contribute to a better understanding of the mixed results in earlier work. Future research could explore whether the current findings are unique for young children for whom parents are typically the main input providers by far, or whether they generalize to older children, whose language input is provided in settings other than the home to a greater extent (i.e., school, contacts with friends, siblings). Another open issue that could be investigated is how siblings' language use and proficiency level relate to bilingual children's cognitive control, as well as take into account children's language exposure outside of the home, especially at daycare.

There are a number of potential limitations to the present study. First, questionnaire data rather than direct assessments were used as indicators of both children's and parents' language use and proficiency. Observational data would have provided more fine-grained, and perhaps more reliable, measures of children's and parents' language use and proficiency. However, there is evidence from three sources supporting the reliability and validity of the current parent-based estimates. First, in our own study, we found a positive and significant correlation with scores on the Dutch version of the CDI, providing at least some support that parents' estimates were valid. Second, previous work has shown that parents can reliably estimate the amount of input per language in bilingual families (Marchman, Martinez, Hurtado, Grüter, & Fernald, 2017) as well as children's bilingual proficiency (Bedore, Peňa, Joyner, & Macken, 2011). Finally, in a recent study, a strong, positive correlation was found between parents' (self-)reported proficiency data of the BiLEC questionnaire and ratings of these same parents film-retell production data by native-speaker judges (i.e., $r(33) = .69$, $p < .001$, cf. high correlations were found between parents' self-ratings in the BiLEC questionnaire and independent raters' evaluations of these same parents' production data (Unsworth, Brouwer, de Bree, & Verhagen, 2019). A second limitation of the study is that a mixture of child assessments and parent ratings was used to assess cognitive control. The reason for this is that age-appropriate tasks were available for use with two-year-olds for selective attention (Mulder et al., 2014) and inhibitory control (Rothbart et al., 2003). Due to the lack of such tasks for attention switching, another important component of cognitive control, we used the attentional shifting subscale of the ECBQ. However, this scale may not have measured the type of switching abilities, as tapped by the switching tasks (e.g., the Dimensional Change Card Sort) on which (older) bilingual participants have often been found to show advanced performance (Bialystok & Martin, 2004). A third possible limitation of our study is the unclear status of the spatial conflict task as a measure of inhibitory control, because it did not show the expected interference effect in neither of the groups. This finding is surprising and in contrast with the results of earlier work in which highly similar tasks were used (Gerardi-Caulton, 2000; Rothbart et al., 2003). A possible explanation for this discrepancy in findings is that, in our study, the task tapped – to some degree at least – into children's language skills. This idea receives support from the positive correlations with vocabulary in both groups, which were weak to moderate in both groups, and reached significance in the bilingual group (rs = .36/.37). These correlations with vocabulary raise the question whether the task was valid, especially in the bilingual group, in which task performance may partly reflect children's language skills (vocabulary knowledge of butterfly, frog etc.). Previous studies using this task did not include vocabulary measures (Rothbart et al., 2003) or do not report correlations with vocabulary (Gerardi-Caulton, 2000). Perhaps, the fact that differences in children's language skills caused part of the variance in children's spatial conflict – together with the secondary processes known to affect performance in EF tasks, such as motor skills, ability to follow instructions, attention span – might have attenuated the interference effect. Importantly, however, in our study, correlations between the spatial conflict task and the EF measures were found in both groups, and these correlations were higher than those with vocabulary: in the bilinguals, there were significant and moderate correlations with ECBQ inhibitory control (r = .41) and attentional focusing; in the monolinguals, there were significant correlations with ECBQ inhibitory control (r = .31) and with visual search (r = .44). Especially the correlation with ECBQ inhibitory control is important, given that one of the measures involved a task for the child and the other a questionnaire for parents, such that shared variance is unlikely due to shared demands of both instruments. Finally, our sample was relatively small, even though it contained larger numbers of monolingual and bilingual children than some of the previous studies investigating effects of bilingualism on cognitive control in very young children (Brito & Barr, 2014; Comishen et al., 2019; Kovács & Mehler, 2009). Also, the finding that effects were found even in the analyses involving the bilingual children only indicates that the relatively small sample size did not play a major role. Perhaps a clearer limitation of the current sample, then, is that it was biased in terms of parental education, such that children were from families in which parents were highly-educated. Future work is needed to establish whether the current results generalize to larger samples and samples that are more representative of the bilingual population at large.

Notwithstanding these limitations, the current study provides evidence that both children's language use and their parents' language proficiency are related to cognitive control performance in very young bilingual children. As such, it adds to a growing body of evidence that effects of bilingualism on cognitive control are tied to specific conditions of bilingualism (Carlson & Meltzoff; Poarch & van Hell, 2012; Verhagen et al., 2017), already at a very young age.

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