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Effects of developmental language disorder and bilingualism on children's executive functioning: A longitudinal study

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A R T I C L E I N F O

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A B S T R A C T

Background: Children's executive functioning (EF) is often negatively associated with a developmental language disorder (DLD) and positively related to bilingualism. However, both regarding children with DLD and bilingual children, findings are mixed and few studies have investigated the combination of DLD and bilingualism in relation to EF.
Aims: This study investigated the effects of DLD and bilingualism on children's EF development.
Methods: Monolingual and bilingual children with DLD and typical development (TD; $N = 32$ in each group) were tested three times with yearly intervals ($M_{AGE} = 71$ months at time 1). Verbal and visuospatial working memory, selective attention, and inhibition were assessed.
Results: Monolinguals and bilinguals with DLD had weak working memory and inhibition skills at each time point compared to TD peers, which could partly be explained by verbal short-term memory limitations. Positive effects of bilingualism emerged when controlling for Dutch vocabulary and morphology skills, and were most pronounced at time 1.
Conclusions: Monolinguals and bilinguals with DLD have similar and persistent EF deficits, which are partly secondary to verbal short-term memory weaknesses. Bilinguals performed better on EF than monolinguals when Dutch language knowledge was controlled for. This effect was found regardless of DLD and was most prominent at age 5–6 years.

What this paper adds?

An inborn DLD is associated with weaker EF skills, while bilingualism may enhance EF. However, both with respect to DLD and bilingualism, findings in the literature are mixed and previous work has primarily focused on monolingual or typically developing children. The present study provides insight into the effect of DLD on EF in children learning two languages and the effect of bilingualism on EF in children with DLD. Moreover, it is the first study that tracks the effects of DLD and bilingualism on EF over time. Results contribute to our understanding of the cognitive strengths and weaknesses of bilingual children with DLD, thereby informing targeted interventions and therapy.

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1. Introduction

Previous research found differential effects of a developmental language disorder (DLD) and bilingualism on children's executive functioning (EF). While EF may be positively affected by bilingualism (Adesope, Lavin, Thompson, & Ungerleider, 2010; Hilchey & Klein, 2011), it may be negatively associated with DLD (Kapa & Plante, 2015; Vissers, Koolen, Hermans, Scheper, & Knoors, 2015). However, both the positive effect of bilingualism and the negative effect of DLD have been the subject of debate. The bilingual benefit has been questioned due to null results, confounding factors and small effect sizes (see, Paap, Johnson, & Sawi, 2015). Furthermore, it is unclear how extensive and domain-general the EF weaknesses of children with DLD are (e.g., Lukács, Ladányi, Fazekas, & Kemény, 2016).

The present study aimed to further elucidate the effects of DLD and bilingualism on children's EF skills. Previous studies have primarily focused on bilingualism in the context of typical development (TD) (e.g., Adesope et al., 2010; Hilchey & Klein, 2011), or on DLD in the context of monolingualism (e.g., Kapa & Plante, 2015; Vissers et al., 2015). It is, however, unclear which patterns emerge when DLD and bilingualism interact and whether findings from abovementioned studies can be generalized to bilingual children with DLD. The current research therefore used a four-group design which allowed for a systematic investigation of the effects of DLD and bilingualism on EF. The four groups consisted of monolingual Dutch children with and without DLD, and bilingual children with and without DLD, the majority of whom was of Turkish or Moroccan descent and belonged to the largest immigrant groups in the Netherlands. Exploratorily, we furthermore examined the stability of the effects of DLD and bilingualism on EF over a three-year period. We thus adopt a longitudinal approach, which is to our knowledge unique in this field of research.

1.1. *Executive functioning in monolingual children with DLD*

Executive functions are domain-general cognitive processing mechanisms underlying goal-directed behavior, which emerge during early childhood and continue to develop into adolescence (Best & Miller, 2010). These mechanisms enable us to override a dominant response or resist interference from distractors (inhibition), selectively and sustainedly attend to relevant information (selective and sustained attention, respectively), flexibly switch back and forth between tasks (shifting), and retain information in an accessible state allowing further processing (working memory). As such, EF plays a crucial role in learning from the environment and contributes greatly to many aspects in life, such as health, academic achievement, and job success (Diamond, 2013).

DLD has been associated with diminished EF skills (Kapa & Plante, 2015; Vissers et al., 2015). Working memory impairments have often been reported (Henry & Botting, 2017; Vugs, Cuperus, Hendriks, & Verhoeven, 2013), but, in two meta-analyses, negative effects of DLD on inhibition, shifting and sustained attention have also been found (Ebert & Kohnert, 2011; Pauls & Archibald, 2016). This suggests relatively broad EF deficits of children with DLD, but, given many mixed findings in the literature, it remains controversial how general and extensive these deficits are. For example, differences between children with DLD and TD on inhibition (Lukács et al., 2016; Noterdaeme, Amorosa, Mildenberger, Sitter, & Minow, 2001) or shifting (Henry, Messer, & Nash, 2012; Im-Bolter, Johnson, & Pascual-Leone, 2006) have not always been found, and some studies only identified deficits on verbal EF tasks, in contrast to nonverbal measures (Archibald & Gathercole, 2006; Lukács et al., 2016; Spaulding, Plante, & Vance, 2008).

Furthermore, it remains unclear what the origins of the EF deficits of children with DLD are. The mechanisms underlying the association between DLD and EF have not often been studied, but reciprocal relations may be hypothesized (see, Blom & Boerma, 2019). EF deficits could impair children's capacity to process language input efficiently, in turn affecting language outcomes (e.g., Boerma, Leseman, Wijnen, & Blom, 2017). Alternatively, language may also support EF, for example through verbal mediation strategies (e.g., Marcovitch & Zelazo, 2009). Poor language skills, as observed in children with DLD, could in this case hinder the optimal development of EF. EF weaknesses of children with DLD have also been suggested to be secondary to more fundamental deficits in verbal short-term memory. Lukács et al. (2016) showed that differences between children with DLD and TD on verbal EF tasks disappeared when controlling for verbal short-term memory span, which is known to be severely limited in children with DLD (Henry & Botting, 2017). It is unclear whether the role of verbal short-term memory generalizes to other (nonverbal) EF tasks as well.

1.2. *Executive functioning in bilingual TD children*

Unlike DLD, bilingualism has been associated with advanced EF skills (Adesope et al., 2010; Barac & Bialystok, 2011). Some have hypothesized that this advantage stems from a bilingual's need to continuously inhibit interference from the language that is not appropriate for a particular communicative interaction (Green, 1998), predicting that bilingualism mainly influences inhibition (e.g., Engel de Abreu, Cruz-Santos, Tourinho, Martin, & Bialystok, 2012; Poarch & van Hell, 2012). However, this hypothesis does not explain why a bilingual benefit has also been found in task conditions that do not require inhibition (Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009), and in other EF domains, such as working memory (Blom, Küntay, Messer, Verhagen, & Leseman, 2014; Morales, Calvo, & Bialystok, 2013) and shifting (Okanda, Moriguchi, & Itakura, 2010). Others have therefore argued that dual language management also involves the continuous monitoring of two languages and the selection of the right language for each communicative interaction, calling upon domain-general monitoring and goal-orienting abilities (Colzato et al., 2008; Costa et al., 2009).

There is much debate about the hypothesis that bilingualism leads to a cognitive benefit (see, Paap et al., 2015). Next to research supporting the hypothesis, there are also many studies that did not show any EF differences between monolinguals and bilinguals (see, De Bruin, Treccani, & Della Sala, 2014), including studies with large sample sizes (e.g., Duñabeitia et al., 2014; Gathercole et al., 2014). Recently, several studies have investigated factors that are shown to moderate the positive effect of bilingualism on EF, creating a more refined picture (Marton, 2016). For example, a number of studies only found a bilingual advantage when monolingual and bilingual children were matched on language ability (Okanda et al., 2010), or when language skills were controlled for (Blom et al., 2014; Carlson & Meltzoff, 2008). Furthermore, there is research indicating that enhanced EF is limited to bilinguals who are sufficiently proficient in both languages (Blom, Boerma, Bosma, Cornips, & Everaert, 2017, 2014; Carlson & Meltzoff, 2008; Poarch & van Hell, 2012) and that it is related to language use and switching (e.g., Kuzyk, Friend, Severdija, Zesiger, & Poulin-Dubois, 2020; Verhagen, de Bree, & Unsworth, 2020). Next to language variables, factors in a child's social context, such as socio-economic status (SES), may influence the comparison between monolingual and bilingual children (Carlson & Meltzoff, 2008; but see Calvo & Bialystok, 2014), emphasizing the need to carefully control for such factors (Morton & Harper, 2007).

1.3. *Executive functioning in bilingual children with DLD*

Research about the effect of bilingualism on EF in children with DLD (monolingual DLD vs. bilingual DLD) and the effect of DLD on EF in children learning two languages (bilingual TD vs. bilingual DLD) is scarce. More research is necessary, as the interaction between DLD and bilingualism may have different implications for children's EF profile. Given the opposite effects of bilingualism and DLD on EF, it is possible that the two cancel each other out, resulting in similar performance of bilingual children with DLD to monolingual TD peers. On the other hand, it may also be that the positive effect of bilingualism on EF is diminished or non-existent in children with DLD due to their low language proficiency, which has already been mentioned as one of the moderating factors of the bilingual EF advantage (see, Marton, 2016). This, in turn, could lead to bigger EF differences between bilingual children with and without DLD in comparison with monolingual children with and without DLD.

The studies that have included bilingual children with DLD indicate that this group of children performs weaker on verbal working memory, inhibition and sustained attention relative to their bilingual TD peers (Blom & Boerma, 2017; Boerma et al., 2017; Ebert, Rak, Slawny, & Fogg, 2019; Engel de Abreu, Cruz-Santos, & Puglisi, 2014; Laloi, De Jong, & Baker, 2017; Sandgren & Holmström, 2015), while visuospatial working memory and selective attention skills are similar (Engel de Abreu et al., 2014). These findings largely correspond to other work with monolinguals, although some research in a monolingual context did find negative effects of DLD on visuospatial working memory (see, Vugs et al., 2013). Findings with respect to the effect of bilingualism on EF are mixed. Three studies did not find a bilingual EF benefit in a DLD group (Ebert et al., 2019; Laloi et al., 2017; Sandgren & Holmström, 2015), but two other studies do suggest cognitive advantages of bilingual children with DLD (Blom & Boerma, 2017; Engel de Abreu et al., 2014). Blom and Boerma (2017) reported better verbal memory skills of a group of bilinguals with and without DLD compared with a group of monolinguals with and without DLD, but only when children's language abilities were controlled for and when TD and DLD groups were collapsed. In addition, Engel de Abreu et al. (2014) found that bilingual TD children outperformed bilingual children with DLD and monolingual TD children on a measure of inhibition, whereas the latter two groups scored similarly on this measure. According to the authors, these patterns may indicate that a bilingual advantage overrode possible differences in inhibition (due to DLD) between the bilinguals with DLD and the monolinguals with TD (p. 745). Strong conclusions could, however, not be drawn, as no monolingual control group with DLD was included.

1.4. *The present study*

Previous research found negative effects of DLD and positive effects of bilingualism on children's EF, but findings are not uniform across studies and both effects have been the subject of debate. Moreover, it is unclear how the interaction of DLD and bilingualism is associated with children's EF skills. Providing insight into this association is of theoretical interest, but also has great clinical value due to the increasing number of bilingual children on clinical caseloads. The few studies that included bilingual children with DLD mostly used small sample sizes ($N \leq 15$), and varied in terms of the ages of the participants, the use of control variables, and the EF domains and tasks that were tested. Aiming to further elucidate the (interaction of the) effects of DLD and bilingualism on EF, the present study used a four-group design, included a sufficiently large sample size, and adopted a longitudinal approach. Moreover, we examined EF across different domains (verbal and visuospatial working memory, selective attention, and inhibition) with commonly-used tasks. Finally, we conducted the analyses with and without verbal short-term memory and language ability as covariates to better understand the origin of the EF deficit in children with DLD and the moderating factors of EF benefits in bilinguals, respectively.

As EF mechanisms develop from early childhood to adolescence (Best & Miller, 2010), we anticipated EF performance to improve over time in all four groups of 5-to-8-year-old children. Effects of DLD on EF were predicted to be similar in monolingual and bilingual learning contexts, in line with previous work (Blom & Boerma, 2017; Laloi et al., 2017; Sandgren & Holmström, 2015), although we also reckoned with the possibility that the effect of DLD on EF would be bigger in the bilingual group. Verbal working memory deficits of children with DLD were expected to be most severe given the unequivocal evidence in this domain (Blom & Boerma, 2017; Henry & Botting, 2017), but we also anticipated subtle limitations in visuospatial working memory (Vugs et al., 2013). Moreover, we hypothesized that inhibition was negatively related to DLD (Pauls & Archibald, 2016; Sandgren & Holmström, 2015), in contrast to visual selective attention (Engel de Abreu et al., 2014; Noterdaeme et al., 2001; Spaulding et al., 2008). Finally, following Lukács et al. (2016), we predicted that EF deficits of children with DLD could, at least to some extent, be attributed to verbal short-term memory limitations.

In accordance with the limited number of studies that investigated bilingualism and EF in the context of both TD and DLD (Blom & Boerma, 2017; Laloi et al., 2017; Sandgren & Holmström, 2015), we expected that effects of bilingualism would not differ across TD and DLD groups. We also consider the possibility that the effect of bilingualism is smaller in the DLD group due to the effect of low language proficiency. Research using the same tasks as the ones included in the present study showed similar scores of monolingual and bilingual children on working memory tasks when children's language ability was not entered as a covariate (Blom & Boerma, 2017; Blom et al., 2014; Engel de Abreu et al., 2012, 2014). This contrasts with selective attention and inhibition, for which positive effects of bilingualism were found despite lower language abilities of the bilinguals in the majority language (Engel de Abreu et al., 2012, 2014). We therefore tentatively predicted that a bilingual benefit was most likely to emerge on selective attention and inhibition. Finally, in line with previous work (Blom & Boerma, 2017; Blom et al., 2014; Carlson & Meltzoff, 2008), we hypothesized that a positive effect of bilingualism on EF was more likely to emerge when children's language knowledge in Dutch was controlled for.

2. Methods

2.1. Participants

This study used the same participant sample as Boerma et al. (2017). A total of 32 monolingual TD children (MOTD), 32 monolingual children with DLD (MODLD), 32 bilingual TD children (BITD) and 32 bilingual children with DLD (BIDLD) participated. All children were tested three times with yearly intervals, starting around 5 and 6 years old. The four groups were matched on age in months, nonverbal intelligence (NVIQ, measured with the short version of the *Wechsler Nonverbal-NL*; Wechsler & Naglieri, 2008), SES (indexed by the average education level of the child's parents, using a scale from 1 to 9), and, for the bilinguals, exposure to Dutch (assessed with the *Questionnaire for Parents of Bilingual Children* (PaBiQ); Tuller et al., 2015). Group characteristics and comparisons are presented in Table 1, showing no significant differences between the groups. In line with expectations based on the prevalence of DLD (Tomblin et al., 1997), there were relatively many boys in the DLD groups.

The PaBiQ also gave information about the language background of the children. Children were considered bilingual when at least one of their parents was a native speaker of another language than Dutch and consistently spoke their native tongue with the child. Children were considered monolingual when both parents were native speakers of Dutch and did not speak a language other than Dutch with the child. As elementary school in the Netherlands starts at age 4, all children had received on average one or two years of Dutch schooling before the first time of testing. The majority of the bilingual children (80 %) was of Turkish or Moroccan descent and spoke Turkish (N = 24), Moroccan Arabic (N = 15), or Tarifit Berber (N = 12) at home. Their degree of exposure to Dutch at home and before the start of school varied from child to child, which is representative for the diverse groups of immigrants in the Netherlands (Centraal Bureau Voor De Statistiek (CBS; Statistics Netherlands), 2016)

The children with DLD were independently diagnosed by licensed clinicians before the start of the present study. They obtained a score of at least 2 standard deviations (SD) below the mean on an overall score of a standardized language assessment test battery or a score of at least 1.5 SD below the mean on two out of four subscales of this standardized language assessment (Stichting Siméa, 2014). In the Netherlands, bilingual children are diagnosed with DLD through use of a bilingual anamnesis and the evaluation of the first and second language (following the guideline of Stichting Siméa, 2016). If one of the languages of a bilingual child could not be evaluated, due to a lack of instruments or skilled native speakers, diagnosis is based on the anamnesis and assessment in one language. At wave 1 and 2, all children with DLD met the inclusion criteria specified above, indicating that none of the children quickly caught up (even though their exposure to Dutch was high due to schooling) and that the diagnosis was reliable. There were four bilingual children with DLD and four (matched) monolingual children with DLD who did not meet the criteria anymore at wave 3. We did not exclude these children, given their history of DLD and the long-term persistence of language difficulties (Scarborough & Dobrich, 1990). The TD participants did not have documented language problems. Moreover, both the children with DLD and TD had a NVIQ above 70, normal hearing, no attention deficit or autism spectrum disorder, and no severe speech impairment.

A receptive vocabulary task (*Peabody Picture Vocabulary Test*; Schlichting, 2005) and a grammatical morphology task (subtest of the *Taaltoets Alle Kinderen*; Verhoeven & Vermeer, 2001) gave background information on the Dutch language knowledge of the children (see Table 2 for raw scores). The group comparisons are presented in Table 2 and show clear group distinctions. At each wave and on both measures, the MOTD group outperformed the MODLD group, and the BITD group outperformed the BIDLD group. In addition, the BITD group had weaker vocabulary and morphology skills than the MOTD group at wave 1 and 2, but caught up at wave 3 (only

Table 1
Characteristics of the participants.

	MOTD ($N = 32$)	MODLD ($N = 32$)	BITD ($N = 32$)	BIDLD ($N = 32$)	Statistic
	$N_{\text{GIRLS/BOYS}}$ (%)	$N_{\text{GIRLS/BOYS}}$ (%)	$N_{\text{GIRLS/BOYS}}$ (%)	$N_{\text{GIRLS/BOYS}}$ (%)	
Gender	14/18 (44 %/56 %)	8/24 (25 %/75 %)	17/15 (53 %/47 %)	10/22 (31 %/69 %)	$\chi^2(3, N = 128) = 6.4, p = .09$
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	
Age (months) Wave 1	70.9 (7.0)	71.4 (6.3)	71.3 (7.3)	72.4 (8.6)	$F(3,124) = .25, p = .86, \eta_p^2 < .01$
Age (months) Wave 2	82.5 (6.9)	82.8 (6.5)	83.0 (7.1)	83.0 (8.9)	$F(3,124) = .03, p = .99, \eta_p^2 < .01$
Age (months) Wave 3	94.1 (6.9)	94.6 (6.6)	94.8 (7.1)	94.7 (8.8)	$F(3,124) = .07, p = .98, \eta_p^2 < .01$
Nonverbal intelligence	100.4 (11.9)	97.5 (12.9)	95.8 (15.0)	94.7 (15.3)	$F(3,124) = 1.02, p = .39, \eta_p^2 = .02$
Socio-Economic Status	6.3 (2.0)	5.2 (1.8)	5.3 (2.4)	5.7 (2.2)	$H(3) = 5.5, p = .14$
Exposure to Dutch before age 4 (%)	n/a	n/a	43.0 (8.3)	40.9 (11.1)	$F(1,61) = .68, p = .41, \eta_p^2 = .01$
Exposure to Dutch at Wave 1 (%)	n/a	n/a	50.9 (12.0)	45.2 (16.5)	$F(1,62) = 2.5, p = .12, \eta_p^2 = .04$

Note: MOTD = monolingual typically developing; MODLD = monolingual language disorder; BITD = bilingual typically developing; BIDLD = bilingual language disorder.

Table 2
Vocabulary, morphology and verbal short-term memory skills of the participants (raw scores).

	MOTD (*N* = 32) Mean (*SD*)	MODLD (*N* = 32) Mean (*SD*)	BITD (*N* = 32) Mean (*SD*)	BIDLD (*N* = 32) Mean (*SD*)	Statistic
Vocabulary Wave 1	86.6 (10.4)	76.5 (9.2)	75.8 (10.5)	62.9 (13.3)	$F(1,122) = 24.7, p<.001, \eta_p^2 = .38$
Vocabulary Wave 2	98.5 (9.6)	86.6 (11.9)	87.8 (11.5)	77.8 (15.5)	$F(1,123) = 15.1, p<.001, \eta_p^2 = .27$
Vocabulary Wave 3	103.8 (8.9)	95.9 (10.1)	96.2 (12.4)	86.3 (14.0)	$F(1,124) = 12.4, p<.001, \eta_p^2 = .23$
Morphology Wave 1	15.3 (3.8)	10.0 (3.7)	11.7 (5.1)	6.5 (4.7)	$F(1,123) = 22.3, p<.001, \eta_p^2 = .35$
Morphology Wave 2	18.6 (3.5)	12.3 (4.1)	15.3 (4.3)	11.0 (3.8)	$F(1,124) = 23.6, p<.001, \eta_p^2 = .36$
Morphology Wave 3	20.5 (3.6)	15.5 (3.9)	18.1 (3.9)	12.7 (5.1)	$F(1,124) = 20.4, p<.001, \eta_p^2 = .33$
Verbal STM Wave 1	20.5 (3.7)	14.9 (3.5)	19.3 (3.4)	15.2 (3.9)	$F(1,123) = 19.5, p<.001, \eta_p^2 = .32$
Verbal STM Wave 2	23.0 (4.1)	17.8 (3.0)	22.0 (2.7)	18.0 (3.6)	$F(1,124) = 19.9, p<.001, \eta_p^2 = .33$
Verbal STM Wave 3	24.3 (3.7)	19.6 (3.3)	23.7 (2.8)	19.8 (4.4)	$F(1,124) = 15.4, p<.001, \eta_p^2 = .27$

Note: MOTD = monolingual typically developing; MODLD = monolingual language disorder; BITD = bilingual typically developing; BIDLD = bilingual language disorder; STM = short-term memory.

leaving a marginal difference on vocabulary). The language abilities of the BIDLD group were also weaker than those of the MODLD group, although their morphology scores were similar at wave 2 and only marginally lower at wave 3.

Finally, a verbal short-term memory task (*Digit Span Forward*; from the Alloway Working Memory Assessment (AWMA); Alloway, 2007) gave insight into the children's ability to store verbal information for a short period of time, which is consistently found to be weak in children with DLD (see, Henry & Botting, 2017). Group comparisons (see Table 2) correspond to previous research. The MOTD group outperformed the MODLD group, and the BITD group outperformed the BIDLD group. There were no differences between the MOTD and BITD groups nor were there any differences between the MODLD and BIDLD groups.

2.2. *Measures and procedures*

This project was approved by The Standing Ethical Assessment Committee of the Faculty of Social and Behavioral Sciences at Utrecht University. Informed consent forms were signed by parents of participants. Children were individually tested by a native speaker of Dutch in two sessions that each lasted approximately one hour. All tasks were thus administered in Dutch. Testing took place in a quiet room at school. Similar procedures were used for each wave. All EF tasks, except for the selective attention task which was a paper-and-pencil task, were administered on a laptop screen using the experimental software E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2002).

2.2.1. *Verbal working memory*

Verbal working memory was assessed with the Digit Span Backward, from the Alloway Working Memory Assessment (AWMA; Alloway, 2007). In this task, children heard a sequence of digits and were asked to repeat this sequence in the reverse order as was presented to them (Backward condition). The task started with a block of six trials in which one digit was presented and continued with sequences of increasing length, up to a maximum of seven digits. The AWMA procedure was applied for scoring, which meant that one point was given for each correct trial (maximum score of 42). If the first four trials of a block were correct, children automatically continued to a subsequent block and were awarded the maximum of six points. The task stopped when children responded incorrectly to three trials within the same block.

2.2.2. *Visuospatial working memory*

Visuospatial working memory was tested with the Dot Matrix Backward, from the AWMA (Alloway, 2007). In this task, children were presented with a four-by-four matrix in which sequences of dots appeared. Children were asked to point out the position of the dots in the reversed order as was presented to them, after the last dot disappeared. In the first block, one dot appeared, but the number of dots increased in subsequent blocks. Each block had six trials and there was a maximum of six blocks. The AWMA procedure was applied for scoring (see verbal working memory). A child could obtain a maximum score of 36 points.

2.2.3. *Selective attention*

Selective attention was evaluated with the Visual Sky Search, a subtest of the Test of Everyday Attention for Children (Manly, Robertson, Anderson, & Nimmo-Smith, 1999). In the first part of the task, children had to encircle identical pairs of spaceships on an A3 sheet of paper. Twenty identical pairs were the targets and 108 non-identical pairs were the distractors. Children were instructed to encircle the targets as fast as possible while ignoring the distractors, and were asked to say stop when they thought that they were done. To control for drawing speed and children's motor abilities, a second A3 sheet of paper was given to the children after they had completed the first part of the task. On this motor-control sheet, only the 20 identical spaceships were displayed and children were again asked to encircle them as fast as possible. Children's selective attention score was calculated by subtracting the mean time per target of the motor-control sheet from the mean time per target of the sheet on which both targets and distractors were displayed.

Table 3
Verbal working memory skills (accuracy on the Digit Span task) of the four groups of children.

		Digit Span Backward Wave 1		Digit Span Backward Wave 2		Digit Span Backward Wave 3	
	N	Mean (*SD*)	Range	Mean (*SD*)	Range	Mean (*SD*)	Range
MOTD	32	12.0 (3.3)	6–18	14.9 (2.5)	9–20	16.1 (3.1)	12–24
MODLD	32	8.0 (2.9)	5–14	12.3 (3.0)	6–20	13.9 (3.2)	8–22
BITD[a]	32	12.1 (3.1)	6–18	14.1 (2.2)	8–18	15.5 (2.3)	11–20
BIDLD	32	8.3 (3.3)	5–18	12.3 (3.4)	6–18	14.2 (2.3)	10–21

Note: MOTD = monolingual typically developing; MODLD = monolingual language disorder; BITD = bilingual typically developing; BIDLD = bilingual language disorder.

[a] One child was excluded due to a refusal to cooperate (BITD – wave 1).

2.2.4. Inhibition

Inhibition was measured with the Flanker task from Engel de Abreu et al. (2012, 2014), who adapted the task from Rueda et al. (2004). A horizontal row of five equally spaced yellow fish was presented to the children, who were asked to indicate the direction of the central fish by pressing the corresponding left or right response button as quickly as possible. On congruent trials (50 %), the flanking fish pointed in the same direction as the central target fish, and on incongruent trials (50 %), the flanking distractors pointed in the opposite direction. Each trial started with a fixation cross in the middle of the screen (1000 milliseconds (ms)), followed by the presentation of the five fish. A response had to be made within 5000 ms and was otherwise considered incorrect. All children completed two blocks of 20 trials in which congruent and incongruent trials were randomized.

Accuracy and reaction times (RTs) were documented, but we focused on RTs, as accuracy was generally high (>80 % correct). Mean RTs on the incongruent and congruent condition were calculated, as well as the Flanker effect (i.e., RTs incongruent minus RTs congruent). All three variables had a skewed distribution. After transformation of the data, the distribution of the mean RTs of the congruent and incongruent trials were acceptable, whereas the distribution of the Flanker effect remained skewed. RTs in the incongruent condition were strongly correlated with the Flanker effect at all three time points (time 1: $r_s(127) = .69, p < .001$; time 2: $r_s(128) = .63, p < .001$; time 3: $r_s(128) = .55, p < .001$), in contrast with RTs in the congruent condition which were only weakly correlated with the Flanker effect at time 1 (time 1: $r_s(127) = .18, p = .04$) and not significantly correlated with the Flanker effect at time 2 and 3 (time 2: $r_s(128) = .13, p = .15$; time 3: $r_s(128) = .10, p = .28$). Due to the strong correlation with the Flanker effect and the mean RTs on the incongruent trials (both requiring children to resist interference), mean RTs on the incongruent trials were used as dependent variable, in line with Engel de Abreu et al. (2012, 2014). Following the procedure of these studies, mean RTs were calculated excluding incorrect responses, RTs below 200 ms and RTs above three standard deviations of children's individual means (~10 % of all incongruent trials).

2.3. Data-analysis

Exploration of skewness and kurtosis values indicated that a normal distribution could be assumed for the verbal and visuospatial working memory measures at each time point. One extreme outlier on the verbal working memory measure at wave 1 (with scores of 0) was excluded, because the experimenter had noted that the child refused to cooperate. The data of both the selective attention and (as mentioned before) inhibition task showed a skewed distribution, which was improved by a logtransformation. Logtransformed variables were therefore used in the analyses. The effects of DLD and bilingualism on each EF task were investigated with a 3 × 2 × 2 mixed-design analysis of covariance (ANCOVA). Time (1, 2, 3) was included as a within-subjects variable, and Impairment Status (TD, DLD) and Language Group (monolingual, bilingual) as between-subjects variables. NVIQ and SES were entered as time-independent covariates.

We furthermore explored whether the effects of DLD and bilingualism changed when verbal short-term memory and Dutch language knowledge was controlled for, respectively. To be able to include these time-varying covariates, we used linear mixed models to run the repeated measures analyses. Linear mixed modelling without the time-varying covariates produced the same results as the mixed ANCOVA and we therefore only reported the results from the mixed ANCOVA for these analyses. If significant effects of Impairment Status were found, a subsequent analysis was conducted with verbal short-term memory as a time-varying covariate to examine whether EF deficits of children with DLD could be attributed to verbal short-term memory limitations (see Table 2). Verbal short-term memory skills were not found to be influenced by bilingualism, so analyses were only done in monolingual and bilingual groups separately if significant effects of bilingualism emerged on the outcome measures (EF performance). In addition, Dutch language knowledge was included as a time-varying covariate to further investigate the effects of bilingualism on EF. In line with previous research (Blom & Boerma, 2017), we used Dutch receptive vocabulary and grammatical morphology as measures for children's Dutch language knowledge (see Table 2). As DLD was shown to influence children's language knowledge, we decided to treat the TD and DLD groups as distinct populations and thus conducted the analyses with vocabulary and morphology as covariates in separate groups.

3. Results

3.1. Verbal working memory

Table 3 presents children's performance on the Digit Span Backward, measuring verbal working memory. Results revealed a significant main effect of Time ($F(2,242) = 151.3$, $p < .001$, $\eta_p^2 = .56$), indicating that verbal working memory capacity increased significantly across all three waves ($p < .001$). Furthermore, a significant main effect of Impairment Status ($F(1,121) = 47.8$, $p < .001$, $\eta_p^2 = .28$) was found, while there was no main effect of Language Group. Children with DLD scored weaker on verbal working memory than TD peers. A significant interaction effect of Time × Impairment Status also emerged ($F(2,242) = 7.3$, $p = .001$, $\eta_p^2 = .06$). NVIQ was a significant covariate ($F(1,121) = 23.6$, $p < .001$, $\eta_p^2 = .16$), while SES was not. Post-hoc analyses, which unpacked the interaction between Time × Impairment Status, showed a significant effect of Impairment Status at each wave. The magnitude of the effect decreased, being large at wave 1 ($\eta_p^2 = .30$) and medium at waves 2 ($\eta_p^2 = .13$) and 3 ($\eta_p^2 = .09$). Thus, the difference in verbal working memory capacity between the children with and without DLD became smaller over time, but the gap was not fully closed.

The effect of Impairment Status on verbal working memory remained significant when controlling for verbal short-term memory ($F(1,152) = 18.0$, $p < .001$), as did the interaction of Time and Impairment Status ($F(2,249) = 6.9$, $p = .001$). Verbal short-term memory was a significant covariate ($F(1,293) = 26.4$, $p < .001$). Post-hoc analyses showed that significant verbal working memory differences between children with TD and DLD emerged at wave 1 ($p < .001$; $\eta_p^2 = .10$) and wave 3 ($p = .049$; $\eta_p^2 = .03$), but this did not reach significance anymore at wave 2. Effect sizes decreased due the inclusion of the covariate (wave 1: $\eta_p^2 = .30$ vs. $\eta_p^2 = .10$; wave 2: $\eta_p^2 = .13$ vs. $\eta_p^2 = .02$; wave 3: $\eta_p^2 = .09$ vs. $\eta_p^2 = .03$). When controlling for children's Dutch language knowledge, the bilingual children with DLD outperformed the monolingual children with DLD ($F(1,69) = 4.8$, $p = .03$). Morphology was a significant covariate ($F(1,190) = 16.8$, $p < .001$), but vocabulary was not. No differences between monolingual and bilingual TD children were found when controlling for Dutch language knowledge.

3.2. Visuospatial working memory

Table 4 presents children's performance on the Dot Matrix Backward, measuring visuospatial working memory. Results revealed a significant main effect of Time ($F(2,242) = 158.3$, $p < .001$, $\eta_p^2 = .57$), indicating that visuospatial working memory capacity increased across all three waves ($p < .001$). Furthermore, a significant main effect of Impairment Status ($F(1,121) = 4.3$, $p = .04$, $\eta_p^2 = .04$) was found, while there was no main effect of Language Group. DLD negatively affected visuospatial working memory scores. The interaction of Time × Language Group was marginally significant ($F(2,242) = 2.7$, $p = .07$, $\eta_p^2 = .02$). NVIQ was a significant covariate ($F(1,121) = 33.3$, $p < .001$, $\eta_p^2 = .22$), while SES was not. Post-hoc analyses, unpacking the marginally significant interaction between Time × Language Group, did not show significant effects of Language Group at any wave. However, the interaction indicated that the bilinguals scored higher (though not significantly) than the monolinguals at wave 1, while the reverse pattern was seen at waves 2 and 3.

Visuospatial working memory differences between children with TD and DLD disappeared when controlling for verbal short-term memory ($F(1,155) = .05$, $p = .83$), which was a significant covariate ($F(1,345) = 23.5$, $p < .001$). Main effects of Language Group remained insignificant when controlling for children's Dutch language knowledge. However, the interaction of Time and Language Group did reach significance in the DLD group ($F(2,126) = 3.3$, $p = .04$). Morphology was a significant covariate ($F(1,187) = 5.4$, $p = .02$), while vocabulary was not. Post-hoc analyses indicated that bilinguals with DLD outperformed monolinguals with DLD at wave 1 when Dutch language knowledge was entered as a covariate ($p = .005$; $\eta_p^2 = .13$), whereas no differences were found at waves 2 and 3.

3.3. Selective attention

Table 5 presents children's performance on the Visual Sky Search, measuring selective attention. Results revealed a significant main effect of Time ($F(2,242) = 169.5$, $p < .001$, $\eta_p^2 = .58$), indicating that children's selective attention skills increased across all three waves ($p < .001$). No significant main or interaction effects were found. NVIQ was a significant covariate ($F(1,121) = 24.5$, $p < .001$, $\eta_p^2 = .17$), while SES was not. When controlling for children's Dutch language knowledge, a bilingual benefit on selective attention

Table 4
Visuospatial working memory skills (accuracy on the Dot Matrix task) of the four groups of children.

		Dot Matrix Backward Wave 1		Dot Matrix Backward Wave 2		Dot Matrix Backward Wave 3	
	N	Mean (*SD*)	Range	Mean (*SD*)	Range	Mean (*SD*)	Range
MOTD	32	11.8 (4.5)	6–23	17.3 (4.7)	10–27	19.4 (4.7)	12–29
MODLD[a]	32	9.8 (4.3)	5–20	14.0 (5.3)	6–26	18.3 (5.0)	9–28
BITD	32	11.4 (3.5)	6–21	15.0 (4.7)	6–24	18.7 (5.1)	6–29
BIDLD	32	10.9 (5.5)	5–24	13.0 (6.4)	5–25	17.3 (5.7)	6–26

Note: MOTD = monolingual typically developing; MODLD = monolingual language disorder; BITD = bilingual typically developing; BIDLD = bilingual language disorder.

[a] Data was missing for one child (MODLD – wave 1).

Table 5
Selective attention skills (selective attention score on the Sky Search task) of the four groups of children.[a].

		Visual Sky Search Wave 1		Visual Sky Search Wave 2		Visual Sky Search Wave 3	
	N	Mean (*SD*)	Range	Mean (*SD*)	Range	Mean (*SD*)	Range
MOTD	32	10.4 (5.6)	4–34	5.9 (2.3)	3–13	4.8 (1.4)	3–9
MODLD	32	13.2 (12.6)	4–73	7.0 (5.2)	3–32	5.0 (2.1)	3–12
BITD	32	9.8 (6.4)	4–29	5.7 (2.6)	−1–11	4.8 (2.2)	2–12
BIDLD	32	13.9 (13.2)	5–64	7.0 (4.1)	3–23	4.9 (1.6)	2–9

Note: MOTD = monolingual typically developing; MODLD = monolingual language disorder; BITD = bilingual typically developing; BIDLD = bilingual language disorder.

[a] Note that the means of the raw data are presented here, including a number of extreme outliers at waves 1 and 2. In the analyses, logtransformed data were used which prevented the necessity to exclude data.

emerged in the TD group ($F(1,68) = 4.3$, $p = .04$), but not in the DLD group. The covariates vocabulary and morphology did not reach significance.

3.4. *Inhibition*

Table 6 presents children's performance on the Flanker task, measuring inhibition. Results revealed a significant main effect of Time ($F(2,242) = 123.2$, $p < .001$, $\eta_p^2 = .51$), indicating that children's RTs on the incongruent trials of the Flanker task became faster across all three waves ($p < .001$). In addition, a significant main effect of Impairment Status ($F(1,121) = 15.3$, $p < .001$, $\eta_p^2 = .11$) emerged, while no main effect of Language Group was found. DLD negatively affected children's ability to resist distracting information. In addition, a significant interaction of Time × Language Group emerged ($F(2,242) = 4.5$, $p = .01$, $\eta_p^2 = .04$). NVIQ was a significant covariate ($F(1,21) = 10.2$, $p = .002$, $\eta_p^2 = .08$), while SES was not. Post-hoc analyses, unpacking the significant interaction between Time × Language Group, did not show significant effects of Language Group at any wave. However, the interaction indicated that the bilinguals scored higher (though not significantly) than the monolinguals at wave 1, while the reverse pattern was seen at wave 2.

The effect of Impairment Status on inhibition remained significant when verbal short-term memory was entered as a control variable ($F(1,159) = 9.9$, $p = .002$). The covariate did not reach significance. In addition, main effects of Language Group remained insignificant when controlling for children's Dutch language knowledge. However, the interaction of Time and Language Group did reach significance in the group of TD children ($F(2,128) = 3.2$, $p = .045$), although the covariates were not significant. Post-hoc analyses showed a marginally significant bilingual benefit at wave 1 ($p = .066$; $\eta_p^2 = .06$) when Dutch language knowledge was entered as a covariate, whereas no differences between monolingual and bilingual TD children were found at waves 2 and 3.

4. Discussion

An inborn developmental language disorder (DLD) is associated with weaker executive functioning (EF), while bilingualism may enhance EF. However, previous work on DLD or bilingualism in relation to EF has produced mixed findings and primarily focused on bilingualism in children with a typical development (TD), or on DLD in monolingual children. The present study aimed to further elucidate the effects of DLD and bilingualism on EF, also in the context of dual language learning and in the context of DLD, respectively. We used a four-group design and adopted a longitudinal approach to evaluate children's verbal and visuospatial working memory, selective attention, and inhibition skills.

The results demonstrated that children's EF skills improved over time on all four domains, in line with previous work which showed that EF mechanisms develop from early childhood to adolescence (Best & Miller, 2010). Significant negative effects of DLD emerged on verbal and visuospatial working memory, and inhibition, whereas children with DLD did not score significantly different from TD

Table 6
Inhibition skills (reaction times on the Flanker task) of the four groups of children.[a].

		Flanker Wave 1		Flanker Wave 2		Flanker Wave 3	
	N	Mean (*SD*)	Range	Mean (*SD*)	Range	Mean (*SD*)	Range
MOTD	32	1,619 (578)	830–3,684	1,143 (374)	727–2,281	933 (293)	544–1,723
MODLD	32	1,924 (667)	812–3,621	1,411 (385)	665–2,206	1,180 (369)	690–2,412
BITD	32	1,514 (554)	678–2,497	1,289 (395)	664–2,122	956 (266)	540–1,653
BIDLD[b]	32	1,781 (691)	832–3,365	1,555 (575)	714–3,445	1,190 (374)	559–2,250

Note: MOTD = monolingual typically developing; MODLD = monolingual language disorder; BITD = bilingual typically developing; BIDLD = bilingual language disorder.

[a] Note that the means of the raw data are presented here. Logtransformed data were used in the analyses.

[b] Data was missing for one child (BIDLD – wave 1).

controls on selective attention. Together with the larger effect of DLD on verbal compared with visuospatial working memory, these findings correspond to our predictions based on previous research (Henry & Botting, 2017; Noterdaeme et al., 2001; Pauls & Archibald, 2016; Vugs et al., 2013). The absence of interactions between Impairment Status and Language Group indicated that DLD was not differently associated with the EF skills of monolingual and bilingual children (in line with Blom & Boerma, 2017; Laloi et al., 2017). While stable effects of DLD emerged on visuospatial working memory and inhibition, verbal working memory differences between children with DLD and TD decreased over time, although remaining significant. This decrease may have been the result of the near floor performance of the children with DLD on our verbal working memory task at wave 1, when most children with DLD still had severe difficulties with reversing a minimal sequence of two digits.

We furthermore investigated whether the EF deficits of children with DLD could be attributed to more fundamental limitations in verbal short-term memory, as suggested by Lukács et al. (2016). The results from the present study partly support this hypothesis. The small but significant effect of DLD on visuospatial working memory disappeared when verbal short-term memory capacity was taken into account. Moreover, the magnitude of the effect of DLD on verbal working memory decreased substantially due to the inclusion of the covariate, and differences between children with TD and DLD failed to reach significance at wave 2 when verbal short-term memory was controlled for. This may indicate that children with DLD are less able to retain the task instructions which, in turn, weakens their performance. Nevertheless, verbal working memory differences at wave 1 and 3 did not disappear, nor did the negative effect of DLD on inhibition. Our results thus suggest that EF deficits of children with DLD may be partly explained by limitations in verbal-short-term memory, but are not entirely secondary to these limitations.

Bilingualism did not influence children's EF performance when children's vocabulary and morphology skills in Dutch were not controlled for. The absence of an effect of bilingualism on EF corresponds to previous studies (Duñabeitia et al., 2014; Laloi et al., 2017; Sandgren & Holmström, 2015), but also stands in contrast with other work that did show a bilingual EF advantage, despite weaker language abilities of the bilinguals in the majority language (Engel de Abreu et al., 2012, 2014; Morales et al., 2013). The bilinguals in the present study scored lower on Dutch vocabulary and morphology than the monolinguals (see, Table 2), reflecting that they have had less exposure in Dutch. Our study was limited by the fact that we were not able to assess language ability in both languages of the bilingual children, which is more representative of a bilingual child's knowledge and experience. However, as the EF tasks were administered in Dutch and as language proficiency has been shown to affect EF performance (Blom et al., 2014; Okanda et al., 2010), we further explored the effects of bilingualism on EF and controlled for children's language knowledge in Dutch. We conducted these analyses in the TD and DLD groups separately, because children with DLD were found to have weaker skills in both language and EF domains.

When controlling for Dutch language knowledge, results showed that the bilingual children with DLD scored better on verbal working memory in comparison with the monolingual children with DLD, and, in addition, also outperformed their monolingual peers on visuospatial working memory at wave 1. However, working memory advantages were not found in the group of TD children. Instead, the bilingual TD children outperformed their monolingual TD peers on selective attention. Furthermore, a marginally significant positive effect of bilingualism on inhibition at wave 1 was found in the TD group. When language knowledge in Dutch was entered as a covariate, the bilingual TD children thus excelled on tasks that involved a high degree of conflicting information (comparable to, for example, Engel de Abreu et al. (2012) and Poarch and van Hell (2012)).

These results thus show similarities and differences between the effect of bilingualism on EF in the TD and DLD groups. In both groups, a bilingual advantage on EF was only found when controlling for language knowledge. This finding emphasizes the importance of language ability as a factor moderating EF performance, which has been demonstrated in several other studies (e.g., Blom et al., 2017; Carlson & Meltzoff, 2008). Moreover, in both groups, bilingual EF benefits were most prominent at wave 1, when children were youngest. This contrasts with a previous study which showed that bilingual advantages emerged over the course of time as a function of growing bilingual proficiency (Blom et al., 2014). The differences between the present study and the work by Blom et al. (2014) may be related to characteristics of the bilingual sample. The bilinguals in the study of Blom et al. (2014) were Turkish-Dutch children, whereas the sample in the current study also included many children from Moroccan descent. Previous research with Turkish-Dutch and Moroccan-Dutch populations showed that the Turkish group maintains the minority language to a stronger degree than the Moroccan group (Scheele, Leseman, & Mayo, 2010). It is therefore likely that the bilingual children in the current study were, on average, more Dutch-dominant than the children in the study of Blom et al. (2014), and they may have become even more Dutch-dominant over time due to the increase of exposure to Dutch at school. Increasing dominance in Dutch may imply a diminished need to continuously manage two languages, explaining why positive effects of bilingualism were less prominent at an older age than at a younger age. Future longitudinal work is needed to support these speculations.

Besides the similarities in developmental trends, effects of bilingualism in the TD and DLD groups differed with respect to which EF domains were affected. Although we do not have a conclusive explanation for this difference, an interesting pattern emerged which may suggest an interaction of working memory and language. A bilingual advantage on verbal and visuospatial working memory was only found in the DLD group, and morphology was found to be a significant covariate. As the covariates morphology and vocabulary did not reach significance in the analyses showing a positive effect of bilingualism on selective attention and inhibition in the TD group, this pattern may point to a specific association between working memory and language skills. As the morphology task is an expressive language task, in contrast to our vocabulary measure, these results may furthermore suggest that verbal mediation plays a role (see, Weiland, Barata, & Yoshikawa, 2014), and that verbal mediation is thus more important for performance on working memory tasks than for selective attention/inhibition. Further research on the relation between language and different EF domains is needed to fully understand these findings, but the differences between the TD and DLD group add to the many mixed findings in the literature and indicate that it is far from clear which conditions moderate the effects of bilingualism on EF.

5. Clinical implications

Due to the increasing number of bilingual children on clinical caseloads, it is necessary to better understand the strengths and weaknesses of bilingual children with DLD. There is a growing body of work on the language abilities of these children, but knowledge on their cognitive development is still limited. The current study showed that both monolingual and bilingual children with DLD, in comparison with TD peers, have persistent EF deficits in working memory and inhibition. As EF is crucial for many aspects in life (Diamond, 2013), therapy aiming to strengthen EF in children with DLD is recommended. In addition, it is sometimes suggested that EF can contribute to a reliable diagnosis of DLD in bilingual children, because, in contrast to language measures, performance on EF tasks may be sensitive to DLD and relatively insensitive to bilingualism (e.g., Engel de Abreu et al., 2014; Laloi et al., 2017). Although the current study did not examine the diagnostic accuracy of the EF measures, we join Laloi et al. (2017) in the view that the presence of group differences cannot be equated with clinical validity. The magnitude of the effects of DLD on EF was relatively small in the present study, with the exception of verbal working memory at wave 1, and variation in performance was large. Caution with respect to the use of EF tasks as clinical tools is thus warranted until such tasks have been proven diagnostically adequate. Finally, next to weaknesses, the present study also revealed that working memory may be a relative strength of bilingual children with DLD in comparison with their monolingual peers with DLD. Future research needs to investigate if these strengths can be deployed to support language learning.

CRediT authorship contribution statement

Tessel Boerma: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Writing - review & editing. **Elma Blom:** Conceptualization, Methodology, Writing - review & editing, Supervision, Funding acquisition.

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