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A longitudinal study of Turkish-Dutch children's language mixing in single-language settings: Language status, language proficiency, cognitive control and developmental language disorder

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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

The aim of this study was to investigate the role of language status, language proficiency, cognitive control and Developmental Language Disorder (DLD) in bilingual Turkish-Dutch children's language mixing in single-language settings. We investigated these factors over time following 31 children (20 with typical development, 11 with DLD), from the age of 5 or 6 years until they were 7 or 8 years old. Children more often mix the majority-societal language (Dutch) into the minority-heritage language (Turkish) than the other way around. Higher proficiency in Dutch, lower proficiency in Turkish, and having DLD are linked to more mixing in the Turkish setting. Effects of cognitive control on children's language mixing are limited. Linguistic factors at a child-external and child-internal level impact on children's mixing in single-language settings, and are more important than domain-general cognitive control. Increasing language proficiency in Turkish could explain why children mix less as they grow older.

1. Introduction

In their daily lives, multilingual children need to adapt their language choice to the context and their interlocutors. To do this successfully, they need awareness of language norms (Lanza, 1992), sufficient language proficiency (Ribot & Hoff, 2014), and cognitive control (Green & Abutalebi, 2013). In addition, language status plays a role, as demonstrated in research showing that balanced bilingual children more often mix the majority-societal language into the minority-heritage language than the other way around (e.g., Montanari et al., 2019; Smolak et al., 2020). The few studies that investigated simultaneous effects of language status, proficiency, and cognitive control on children's mixing in single-language settings are rare and are mostly situated in North America. Hardly anything is known about other sociolinguistic settings or about children with low language ability.

The current study aims to fill these gaps by investigating language mixing by bilingual Turkish-Dutch children in single-language settings, i.e., settings with a monolingual language norm in which the use of one specific language is accepted or expected. Specifically, we compare children's mixing frequency in minority-heritage language (Turkish) and majority-societal language (Dutch) settings. A

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notable strength of the study is the longitudinal design, which allows the investigation of the stability of the patterns over the course of a two-year period from the age of 5–6 years until the age of 7–8 years. Inclusion of a sample of children diagnosed with a Developmental Language Disorder provides an opportunity to explore whether patterns found for children with typical development generalize to this clinical group.

1.1. Language mixing in single-language settings

Language mixing refers to the alternation between different languages during production.[1] To describe such language alternation, researchers have also used the notion code-switching (Smolak et al., 2019). Following others in the field of multilingual child development (Lanza, 1992; Byers-Heinlein, 2013; Montanari et al., 2019), we chose to use the term 'language mixing', acknowledging that the mechanisms that underlie children's mixing of languages are different from those that underlie adult code-switching (see Montanari et al., 2019, for an elaborate motivation). Although children are sensitive to language norms and the language choice of their interlocutors as early as 2 years (Lanza, 1992), they may mix languages while their parent negotiates a monolingual norm (Lanza, 1992; Quick et al., 2018), or may persist to use one language while their interlocutor uses another language (Ribot & Hoff, 2014), resulting in cross-speaker switching. The aim of this study is to determine which factors underlie children's language mixing in single-language settings. In line with Bronfenbrenner's bio-ecological model of child development (Bronfenbrenner & Morris, 2006), we assume that children's language mixing is determined by environmental child-external factors, which can be distal and proximal, as well as personal child-internal characteristics. In the next section, we first turn to the role of language status and societal dominance in language mixing as child-external factors, after which the impact of two child-internal factors will be discussed: language proficiency and cognitive control.

1.1.1. Language status

Three recent longitudinal studies indicate that language status plays an important role in children's use of the non-target language in single-language settings (Montanari et al., 2019; Smolak et al., 2020; Tulloch & Hoff, 2023), following earlier work by Gutiérrez-Clellen et al. (2009). In the United States, where much research is situated, English is spoken by most inhabitants, and has most prestige. Spanish is used by a part of the citizens and mostly confined to informal (home) environments, although in some cities, Spanish is commonly used in the public sphere (Eilers et al., 2006), and there are areas where Spanish use at school is promoted through bilingual Spanish-English education and dual immersion in educational settings (NCELA, 2019; Beaudrie & Marrero-Rivera, 2024). However, especially after becoming acculturated to an English school environment where Spanish is not supported, bilingual Spanish-English children may increasingly feel that it is not appropriate to mix Spanish into English.

Analyzing naturalistic conversations from 26 children in single-language English and Spanish settings, Montanari et al. (2019) found that at the onset of preschool (age 3;6), most children were dominant in Spanish and mixed English into Spanish 11 % of the time and Spanish into English 16 % of the time. At the end of the first year at preschool (age 4;5), the children had developed into more balanced bilinguals, and mixed English into Spanish 14 % of the time and Spanish into English only 3 % of the time. In addition, in the Spanish setting, intrasentential mixing had increased relative to intersentential mixing. Intrasentential mixing refers to switching to another language within a sentence (in contrast to intersentential mixing which refers to switching between sentences), and has been linked to lexical gaps (Paradis & Nicoladis, 2007; Nicoladis & Secco, 2000). These findings are consistent with a deceleration of growth in Spanish, an accelerated growth in English, and may signal an increasing awareness of the status of English. Two other longitudinal studies with 2- and 3-year-old children found similar asymmetrical switching patterns, as well as a decrease of switching from English to Spanish (Smolak et al., 2020; Tulloch & Hoff, 2023), suggesting that effects of language status are already noticeable before preschool.

These conclusions about the role of language status are largely based on Spanish-English bilingualism in the United States, but there are indications that the observed patterns generalize to other sociolinguistic contexts, such as bilingual French-English children in Canada who more frequently switch to English (Paradis & Nicoladis, 2007; Smolak et al., 2020), bilingual Frisian-Dutch children in the Netherlands who more often switch to Dutch (Bosma & Blom, 2019), and children in Switzerland with an Italian or Turkish background who showed a tendency to switch to French or German (Schächinger Ténes et al., 2023).[2]

1.1.2. Language proficiency

Young bilingual children mix more when speaking in their weaker language (Genesee et al., 1995; Lanvers, 2001; Nicoladis & Secco, 2000). Several studies investigating single-language settings confirm that low proficiency in the target language plays a role in children's mixing (e.g., Montanari et al., 2019; Smolak et al., 2020; Tulloch & Hoff, 2023). Tulloch and Hoff (2023) found that both at ages 2;6 and 3;6, children with higher proficiencies in the target language (either Spanish or English) switched less to the other language. Focusing on children in a similar age range, Smolak and colleagues (2020) investigated the combined and unique effects of exposure and proficiency on mixing by bilingual Spanish-English children (San Diego) and French-English children (Montreal). In the Spanish-English group, exposure was more important than proficiency: children used the non-target language more when they had

[1] This definition captures several types of mixing observed in spontaneous interactions in multilingual communities and includes mixing between sentences within and across speakers (i.e., intersentential mixing) and mixing within sentences (i.e., intrasentential mixing), which encompasses insertion, alternation and congruent lexicalization (Muysken, 2000).

[2] Schächinger T é nes et al. (2023) found this pattern specifically in the group of balanced bilingual children with above-average proficiency.

limited exposure to the target language, and this was especially the case in the Spanish setting. In the English setting, proficiency was more important than exposure at age 2, but not at age 3. In the French-English sample, proficiency was the key factor, particularly for mixing in the French setting: children with low proficiency in French switched relatively often to English. Investigating slightly older children, Montanari et al. (2019) found that at age 3;6, bilingual Spanish-English children with higher English vocabulary outcomes used less Spanish in the English setting and more English in the Spanish setting than those with lower English vocabulary scores. At age 4;5, mixing was not related to language proficiency.

Language proficiency may have most impact on language mixing in single-language settings if proficiencies in the different languages are unequal. Unequal proficiencies may be typical for, but not restricted to, younger ages. For example, increasing pressure of the majority-societal language may slow down children's development in the minority-heritage language leading to unbalanced bilingualism at later ages. To gain insight into the anticipated patterns of development and the role of language proficiency, it is essential to examine children in their early school years, preferably through a longitudinal research approach.

1.1.3. Language control and cognitive control

Even in single-language settings, all languages of multilingual speakers are active (Kroll et al., 2014), which implies that multilinguals always need to control their languages when speaking. According to the Adaptive Control Model (Green & Abutalebi, 2013) and Control Process Model (Green, 2018), the competitive language control mode in single-language settings requires mostly goal maintenance and interference control to respectively maintain the task of speaking in one language and resolve interference from the other language.

A few studies have examined the relationship between children's language mixing and cognitive control in single-language settings (Bosma & Blom, 2019; Kuzyk et al., 2020), hypothesizing that more mixing implies more use of cognitive control, which, in turn, could result in training and enhanced cognitive control. The outcomes of the studies are open to interpretations in the other direction, i.e., cognitive control predicts children's language mixing frequency; hence, they are relevant for the current study. Kuzyk et al. (2020) studied bilingual French-English children ($n = 29$), who were on average 3 and 5 years old at the respectively the first and second wave of data collection. Data were collected in two single-language (English, French) free-play sessions. At age 5, less intersentential mixing was associated with better inhibition,[3] which is consistent with the idea that children employ inhibition to suppress the non-target language. A study with bilingual Frisian-Dutch children aged 5 and 6 years showed that more intrasentential switching from Dutch to Frisian predicted better inhibition (Bosma & Blom, 2019). The authors argue that language status plays a crucial role in this respect and that switching from Dutch, the majority language, to Frisian, the minority language, involves cognitive control, in contrast to switching from Frisian to Dutch, inducing a training effect.

Methodological differences complicate direct comparisons and interpretations of these contrasting results. To gain insight into relations between control processes and language mixing, further research in single-language settings is needed. To test the predictions of the Adaptive Control Model and Control Process Model, it would be relevant to include cognitive control measures that tap into goal monitoring skills, such as sustained attention, and to examine whether cognitive control predicts language mixing, instead of the other way around.

1.2. Developmental language disorder

In this study, we aimed to investigate children with a wide range of language skills and included children with Developmental Language Disorder (further on called DLD). Children with DLD experience language problems without any associated biomedical condition. They have persisting low language skills and experience functional limitations in everyday communication and broader functioning (Bishop et al., 2017). DLD affects around 5–7 % of the population (Tomblin et al., 1997; Norbury et al., 2016) and is best defined as a complex multifactorial disorder that involves the interaction of multiple genetic and environmental risk factors (Boerma et al., 2023). Because DLD affects children's ability to learn language, it impacts all languages that multilingual children learn (Paradis et al., 2011).

Studies that have investigated mixing by children with (a risk for) DLD report diverging results. Some studies observed similar mixing frequencies and prevalence across DLD and typical development (TD) (Gutiérrez-Clellen et al., 2009; Kapantzoglou et al., 2021). Others found that children with DLD mix more than children with TD (Iluz-Cohen & Walters, 2012), or that effects of DLD on mixing frequency depend on the language of the setting (Greene et al., 2013). Kapantzoglou et al. (2021) studied bilingual Spanish-English 5- to 7-year-old children with DLD ($n = 24$) and TD ($n = 38$) in single-language settings. In line with other research, mixing happened more in the Spanish setting than in the English setting for both groups. In Spanish, lower proficiency was associated with more switches to English in the DLD group only, which supports the suggestion that language proficiency has more impact at lower language levels (Montanari et al., 2019). A recent study by Gross and Castilla-Earls (2023), who studied bilingual Spanish-English 4- to 7-year-old children with DLD ($n = 33$) and TD ($n = 33$) found that children with DLD engaged more in intersentential mixing than their TD peers during a Spanish narrative task.

Children with DLD also tend to have weak interference control (Pauls & Archibald, 2016), and sustained attention (Ebert & Kohnert, 2011), which are, hypothetically, both implied in language control in single-language settings (Green & Abutalebi, 2013).

[3] The relationship was only computed for mixing in the weaker language, because the children mixed too infrequently when speaking in their stronger language. Also, due to floor effects on the inhibition task, no analyses were performed on data collected at the first wave when the children were 3 years old.

Using a computerized scripted confederate dialogue task, Gross & Kaushanskaya, (2020, 2022) addressed the role of cognitive control. They included 62 bilingual Spanish-English children between ages 4 and 6;11, 15 of whom met the criteria for DLD. In the task, the participant took turns identifying pictures described by the confederate and describing pictures to the confederate themselves. The task included two single-language versions in which confederates spoke either Spanish or English, and one dual-language version with turns alternating between monolingual English and Spanish confederates. Cognitive control ability was measured with a dimensional card sorting task that tapped into mental shifting and inhibition. In a first study, Gross and Kaushanskaya (2020) included a continuous global measure of language ability instead of assigning children to DLD and TD groups. Results showed that children used the non-target language more with a confederate who spoke their non-dominant language, children with higher language ability used the non-target language less often (regardless of single- or dual-language setting), and children with lower cognitive control had more difficulties adjusting to the language of the confederate in the dual-language setting. In a second study, children were assigned to TD and DLD groups (Gross & Kaushanskaya, 2022). The DLD group used on average more cross-speaker mixing than the TD group, especially when the interlocutor used Spanish, and independent of language proficiency in both languages. Children with DLD did not fail the cognitive control task at higher rates than their peers with TD. Hence, more cross-speaker mixing in DLD seems unrelated to cognitive control.

In sum, the results of language mixing studies that include children with DLD are mixed. Methodological decisions could be key in this respect. Some previous research focused on intrasentential mixing only (Gutiérrez-Clellen et al., 2009), but to detect effects of DLD on language mixing, intersentential and cross-speaker mixing seem crucial as well (Gross & Kaushanskaya, 2022; Gross & Castilla-Earls, 2023). Regarding effects of cognitive control, tasks need to be included that tap into abilities deemed relevant for mixing in single-language contexts and where DLD shows weaknesses.

1.3. The present study

Insights on the role of language status, language proficiency and cognitive control on children's mixing in single-language settings stem predominantly from studies on Spanish-English bilingualism in the United States. It is imperative to conduct research in diverse sociolinguistic settings to broaden our understanding of the factors that underlie children's language mixing in single-language settings. For the purpose of this study, we analyzed semi-spontaneous longitudinal speech data collected from bilingual Turkish-Dutch children in single-language Turkish and Dutch settings. In the Netherlands, Dutch is spoken by most inhabitants, and has most prestige. Like Spanish in the United States, Turkish is used by a part of the citizens in the Netherlands and is mostly confined to informal (home) environments. However, while there are areas in the United States where Spanish is promoted in education, this is not the case for Turkish in the Netherlands.[4] The Turkish community in the Netherlands is known for its intense mixing of Turkish and Dutch (Backus & Demirçay, 2021) and strong intergenerational transmission of Turkish (Extra & Yağmur, 2010), although children's proficiency in Turkish seems to be declining (Akoğlu & Yağmur, 2016). In the current study, data from three waves, with one-year intervals, were analyzed. The sample includes 20 children with typical development (TD) and 11 children with DLD who are 5 or 6 years old at the first wave of data collection.

The research questions that guided our study are: To what extent do language status, language proficiency and cognitive control predict mixing frequency in single-language contexts in bilingual Turkish-Dutch school-aged children? Do effects change over time? Do effects differ across children with TD and DLD? We formulated five hypotheses on respectively language status, language proficiency, cognitive control, development, and DLD:

1. Children more often use Dutch words and phrases in the Turkish setting than Turkish words and phrases in the Dutch setting, because in the context of the Netherlands, Dutch is the majority-societal language and Turkish a minority-heritage language.
2. Lower proficiency in Turkish is associated with more mixing in the Turkish setting and with less mixing in the Dutch setting. Lower proficiency in Dutch is associated with more mixing in the Dutch setting and with less mixing in the Turkish setting.
3. Children with better inhibition and sustained attention abilities show lower mixing frequency in single-language settings.
4. Mixing frequency decreases over time because of children's improving language proficiencies and control. However, we also take into account the possibility that mixing frequency in the Turkish setting increases due to larger effects of societal dominance at later ages. In this case, children would use more Dutch in the Turkish setting with increasing age, despite growing Turkish abilities.
5. Children with DLD show more (cross-speaker) language mixing than their peers with TD. We hypothesize that this difference may be related to their weaker language proficiency and lower inhibition and sustained attention abilities. We do not expect differences between TD and DLD for hypotheses 1, 3 and 4. Regarding hypothesis 2, effects of language proficiency could be more prominent in DLD compared to TD.

2. Methods

2.1. Participants

The participants of the current study took part in a longitudinal research project on the linguistic and cognitive development of

[4] Bilingual education in the Netherlands is restricted to English, French and German (in addition to Dutch); the vast majority of dual language programs are English-Dutch (https://www.nuffic.nl/).

bilingual children in the Netherlands (see Boerma, 2017). The final sample included all participating children in this project from Turkish descent who completed all three test waves and were able to speak Turkish ($n = 31$; $n_{TD} = 20$, $n_{DLD} = 11$). The ability to speak Turkish was determined based on children's behavior during the Turkish test session, resulting in the exclusion of two children who hardly spoke Turkish in this session. The children's behavior was consistent with parental report: for both children the parents had indicated that they had a preference for Dutch and low expressive skills in Turkish. Background characteristics of the final sample are displayed in Table 1. The two groups did not differ in chronological age ($t = -0.166$, p = .870, 95 % CI [−6.433, 5.487]) or socio-economic status ($t = -0.361$, $p = .721$, 95 % CI [−1.911, 1.341]) at wave 1 of data collection. The DLD group included relatively many boys ($\chi^2 = 3.028$, $p = 0.082$), which is expected given previously reported prevalence rates (e.g., Tomblin et al., 1997). Children with DLD had on average lower scores on nonverbal intelligence as assessed with the short version of the Wechsler Nonverbal test in Dutch (Wechsler & Naglieri, 2008) at wave 1 of data collection ($t = -3.151$, $p = .0048$, 95 % CI [−21.526, −4.410]).

The TD children were recruited via regular elementary schools. They did not have documented developmental problems. The children with DLD were recruited via Royal Auris Group or Royal Dutch Kentalis, which are organizations that provide care and education services for individuals with communication problems. All children with DLD were diagnosed by a licensed clinician before, and independent of, participation in research. For one child, this diagnosis was determined during the longitudinal research. Their nonverbal intelligence was 70 or above and their hearing was normal. They attended special education schools for their language difficulties. To be eligible for such schools, strict criteria must be met. This means that all children scored low on a standardized language assessment (i.e., either −1.5 *SD* on two out of four subscales of a test battery or −2 *SD* on an overall score of this test battery; for an elaborate overview of the criteria, see Stichting Siméa, 2014). A multilingual anamnesis was part of the diagnostic procedure and, if possible, both Turkish and Dutch language skills were evaluated (see Stichting Siméa, 2016).

At the first wave of data collection, a parental questionnaire (Questionnaire for Parents of Bilingual Children; PaBiQ; Tuller, 2015) was used to gain information on the language environment of the participants. All participants had at least one parent who was a native speaker of Turkish and spoke Turkish with their child on a regular basis. The children were born in the Netherlands and started attending elementary school, with Dutch as the language of instruction, at the age of 4. Although all children were exposed to Dutch to some extent, the amount of Dutch input before the age of 4 and the amount of Dutch input at home at the start of the research varied per child. On average, the TD children heard 38.8 % (range 33.3–50.0 %, $SD = 6.5$) of Dutch before the age of 4 % and 45.1 % (range 29.4–66.7 %, $SD = 9.9$) of Dutch at home at wave 1. This was 33.6 % (range 20.0–50.0 %, $SD = 12.0$) and 33.9 % (range 14.3–47.1 %, $SD = 9.7$), respectively, for the DLD group. The amount of Turkish input is the counterpart of these numbers. This information was missing for two TD children.

2.2. Instruments and procedures

The research was approved by the Standing Ethical Assessment Committee of the Faculty of Social and Behavioral Sciences of Utrecht University (#22–0098). Testing was done individually in a quiet room at school. Children completed tasks tapping into language, memory, and attention (not all relevant for the current study). At each of the three waves, the first one-hour test session was in Turkish. The experimenter, who was a bilingual native speaker of Turkish and Dutch, only spoke Turkish with the child. The second and third one-hour test sessions were in Dutch, with a native speaker of Dutch as experimenter. The Dutch test sessions took place on a different day than the Turkish session.

2.2.1. Outcome measure: language mixing in spontaneous speech

Spontaneous speech in Turkish and Dutch was elicited during a conversation and narrative task at the end of the, respectively, monolingual Turkish and (second) Dutch test session at each wave of data collection. We collapsed data from the conversation and narrative task to increase the number of utterances per child. The conversation was about day-to-day topics, such as birthdays and favorite activities. The goal of the conversation, which lasted approximately 10 min, was to elicit as much spontaneous speech from the child as possible. After the conversation, the Multilingual Assessment Instrument for Narratives (MAIN; Gagarina et al., 2012) was administered. The Dutch version of the MAIN (Blom et al., 2020) was used to elicit Dutch narratives, and a Turkish translation of this task was used to elicit Turkish narratives. For details on the procedure that we used, see Blom and colleagues (2022).

Both the conversation and narrative task were audio-recorded and transcribed using the Codes for the Human Analysis of Transcripts (CHAT; MacWhinney, 2000). All children's switches from the target language (i.e., Turkish in the Turkish session and Dutch in the Dutch session) to the non-target language (i.e., Dutch in the Turkish session and Turkish in the Dutch session) were coded. These switches were classified as (1) cross-speaker intersentential mixing (i.e., an entire utterance of the child in the nontarget language as a

Table 1
Background characteristics of the participants.

			Chronological age in months				
		Gender	**Wave 1**	**Wave 2**	**Wave 3**	**Nonverbal intelligence**	**Socio-economic status**[a]
	N	Girls/Boys	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Median (range)
TD	20	10/10	70.2 (6.9)	82.3 (6.6)	93.9 (6.6)	101.2 (11.1)	4.5 (2 – 9)
DLD	11	2/9	69.7 (7.9)	80.3 (8.3)	92.0 (8.4)	88.2 (10.9)	5.0 (2 – 7)

[a] Socio-economic status was indexed by the average educational level of both parents, measured on a scale from 1 (no education) to 9 (university degree). A value of 5 corresponds to intermediate vocational education. This information was missing for two TD children.

response to an utterance of the experimenter in the target language), (2) other intersentential mixing (i.e., an entire utterance of the child in the nontarget language preceded by an utterance of the child in the target language, within the same conversational turn), and (3) intrasentential mixing (i.e., element(s) in the nontarget language within an utterance of the child in the target language). Instances of intrasentential language mixing were most often insertions of one word in the non-target language, but some switches back and forth within an utterance were also observed. These were counted as one intrasentential switch. Names of persons, cities, countries, tv-series, games, toys, and cartoons (e.g., Lego, Barbie, Pokemon) were not coded as switches because these were the same in both languages. Exact and direct repetitions were counted only once. To prevent overfitting the statistical models and reduce the number of predictors, we did not distinguish between mixing types in the main analysis. We do report different mixing types for descriptive purposes. Explorative analyses focusing on specific mixing types are added to the Supplemental Analyses on the Open Science Framework (OSF), as will be further explained below.

2.2.2. Predictors of language mixing

Language proficiency, cognitive control abilities, wave of testing (1, 2, 3) and group (TD, DLD) were included as predictors of switching to the non-target language in spontaneous speech. Language proficiency in the target and non-target language was indexed by receptive vocabulary (Milton, 2013; Qian & Lin, 2019; but see Calder et al., 2023 for limitations of this measure as a proxy of language proficiency in DLD). For Dutch, the standardized PPVT-III-NL (Schlichting, 2005) was used. For Turkish, a translation of the PPVT-III-NL was used (see, for details: Blom, 2019). The percentage of correct answers was used as the outcome measure.

Children's cognitive control abilities were assessed with an integrated auditory and visual Continuous Performance Task (CPT). The CPT was administered on a laptop screen using E-Prime 2.0 (Schneider et al., 2002). In contrast to all other tasks described above, this task was only administered at wave 1. Children were asked to press the space bar in response to seeing or hearing the number '1' ('one'), which was the target. When seeing or hearing the number '2' ('two'), children had to refrain from pressing the space bar. After a practice phase, the test phase started with 168 trials. Auditory and visual trials were mixed. The number of hits on the space bar in response to the target was included as our measure of sustained attention. Hits with a reaction time below 100 ms were excluded (<1 % of all trails). The number of false alarms (i.e., pressing the space bar in response to the distractor '2' or 'two') was our measure of response inhibition.

2.3. Data-analysis

Raw data and the analysis script and outcomes are available on OSF (https://osf.io/4eg8h/). First, we descriptively present the percentages of mixing in Dutch and Turkish settings (hypothesis 1). This was calculated by dividing the total number of switches to, respectively, Turkish and Dutch (non-target language) by the total number of utterances in the, respectively, Dutch and Turkish (target language) spontaneous speech samples, subsequently multiplying this by 100. We calculated the overall mixing frequency per child for each of the three test waves. The same was done for mixing frequency per subtype, based on our classification described above.

Second, we analyzed the predictors of overall mixing frequency (hypotheses 2 through 5), using a linear mixed effects model with the lme4 package (version 1.1.31, Bates et al., 2015) for R software (R Core Team, 2016).[5] The predictors included in the model were language proficiency in the target and non-target language, cognitive control abilities as indexed by sustained attention and response inhibition, wave (1, 2, 3) and impairment status (TD, DLD). Because the two groups of children differed in terms of their nonverbal intelligence, this variable was included as a covariate in our model. Continuous predictors were scaled and centered. Categorical predictors (wave, impairment status) were coded as orthogonal contrasts. Wave was coded so that we compared wave 1, marked as -0.5, with wave 3, marked with $+0.5$ and wave 2, marked with $+0.67$, with waves 1 and 3, marked with -0.33. The first comparison (i.e., wave 1 vs. wave 3) was our primary measure of time. Impairment status was coded such that the TD group was marked as -0.5 and the DLD group as $+0.5$. The random effect structure included by-subject random intercepts. Prior to presenting our model results, we present descriptive group results on language proficiency in both languages, sustained attention, and response inhibition.

For two TD children and one child with DLD, scores on sets 1 through 5 of the Turkish receptive vocabulary test at wave 1 were missing. As the vocabulary test increases in difficulty across sets, a percentage of correct answers calculated over the children's scores on sets 6 through 8 was considered unrepresentative of their performance. Therefore, we applied multiple imputation to impute the missing values (Van Buuren, 2018). We used the Mice package (Multivariate Imputation via Chained Equations; version 3.16.0, van Van Buuren & Groothuis-Oudshoorn, 2011) with predictive mean matching using the TD sample at wave 1 for the two TD children and the DLD sample at wave 1 for the child with DLD. We compared the histograms of the imputed variables prior and post imputation to ensure the imputation did not affect their distribution. The imputation analysis can be found under the Supplementary Materials on our OSF-page.

The analysis script on our OSF-page also includes supplementary analyses in which we analyzed the abovementioned predictors of mixing frequency in relation to cross-speaker mixing and intrasentential mixing as the outcome variables, as requested by a reviewer. We will turn to these analyses in the exploratory results section, investigating whether the patterns found are specific to cross-speaker mixing. This is based on previous research which showed that, for example, lower language proficiency, less cognitive control and having DLD have been specifically linked to cross-speaker mixing (Ribot & Hoff, 2014; Quirk, 2021; Gross & Kaushanskaya, 2022).

[5] A sensitivity analysis was performed to ensure the robustness of our linear mixed effects analysis. To this end, we conducted a logistic regression model with the number of utterances with mixing and the number of utterances without mixing as the outcome variable. Since there were no differences in terms of significance of effects, we refer interested readers to the analysis script and outcomes on our OSF-page.

3. Results

3.1. Mixing frequency in single-language settings and effects of language status

Mixing Turkish into Dutch was highly infrequent (Table 2). In total, collapsed across waves and groups, we observed only 8 switches to Turkish in the Dutch conversation and narrative task (out of a total of 9091 utterances, < 0.1 %), which were made by 4 individual children ($n = 2$ children in TD group, $n = 2$ children in DLD group). Mixing of Dutch into Turkish occurred more frequently, in line with hypothesis 1. Although some children did not engage in any mixing of Dutch into Turkish at certain waves of data collection ($n = 7$ in TD group, $n = 2$ in DLD group), these children did engage in mixing at other waves. In other words, collapsed across waves, all participants showed one or more occurrences of mixing Dutch into Turkish, and variability in the frequency of mixing was high (see Table 2 and Table 3). For the next steps in our analyses, we therefore focused on mixing of Dutch into Turkish. For descriptive purposes, we present the percentage of mixing per session per subtype in Table 3, distinguishing between cross-speaker intersentential, other intersentential and intrasentential mixing. Total mixing frequencies remained below 10 % in TD and below 17 % in DLD. The percentages in Table 3 suggest that while the intrasentential mixing percentages were quite similar in the two groups, intersentential mixing was more frequent in the DLD group, in particular cross-speaker mixing.

3.2. Effects of language proficiency and cognitive control on mixing

Table 4 presents the descriptive results on language proficiency in Dutch and Turkish, as well as sustained attention and response inhibition scores. Collapsing the groups of participants, we found a significant, negative effect of Turkish proficiency on mixing Dutch into Turkish (estimate $= -3.442$, $t = -2.224$, $p = .030$) and a significant, positive effect of Dutch proficiency (estimate $= 4.593$, $t = 3.052$, $p = .003$). This is in line with hypothesis 2 and suggests that lower proficiency in Turkish is associated with more use of Dutch in the Turkish setting, while a lower proficiency in Dutch is associated with less use of Dutch in the Turkish setting. Hypothesis 3 is not supported: there were no significant main effects of inhibition (estimate $= 2.542$, $t = 1.607$, $p = .117$) or sustained attention (estimate $= 1.350$, $t = 0.704$, $p = .487$). Regarding changes over time, mixing in the Turkish setting decreased with wave (estimate $= -14.640$, $t = -3.610$, $p < .001$; see also Fig. 1), as predicted (hypothesis 4). No evidence was found for an influence of children's cognitive control on decreasing language mixing (inhibition: estimate $= -3.901$, $t = -1.593$, $p = .117$, sustained attention: estimate $= 2.818$, $t = 0.997$, $p = .323$; but see Section 3.4.). The effect of wave on mixing frequency was found to interact with children's language proficiency in Dutch (hypothesis 4; estimate $= -11.187$, $t = -3.496$, $p < .001$), but not in Turkish (estimate $= -1.629$, $t = -0.609$, $p = .545$). Fig. 2 shows the differential effects of Dutch proficiency on mixing frequency across waves (and groups), suggesting that the positive effect of Dutch proficiency on mixing Dutch into Turkish is stronger in wave 1 than in wave 3. We will get back to this interaction after presenting the results on the effect of group, since this effect appears to be carried by the DLD group.

3.3. Effects of impairment status on mixing frequency

As hypothesized, children with DLD mixed more than their TD peers (hypothesis 5; estimate $= 16.917$, $t = 3.852$, $p < .001$), and this difference between groups decreased with wave (estimate $= -42.496$, $t = 8.110$, $p < .001$). As depicted in Fig. 1, the mixing frequency of children with DLD decreased across waves while the mixing frequency of peers with TD increased slightly. Also in line with hypothesis 5, the abovementioned effect of Dutch vocabulary on children's mixing frequency is larger in the DLD than in the TD group (estimate $= 8.465$, $t = 3.010$, $p = .006$). Moreover, there is a three-way interaction with wave (estimate $= -26.733$, $t = 6.400$, $p < .001$). This effect is shown in Fig. 2: while at wave 1 there is a strong positive association between Dutch vocabulary scores and mixing frequency in the DLD group, the TD group shows a negative association between Dutch vocabulary scores and mixing frequency. At wave 3, there is a positive association between Dutch vocabulary scores and mixing frequency in both groups, albeit less strong than for the DLD group at wave 1. Please note that these effects should be interpreted with caution given the small number of children with DLD in the current sample ($n = 11$).

3.4. Exploratory results

Although we found no effects of cognitive control on use of Dutch in the Turkish session when looking at our primary measure of time (i.e., wave 1 versus wave 3), there were some exploratory findings involving the secondary measure of time (i.e., wave 2 versus

Table 2
Percentage of mixing in the Dutch and Turkish sessions per group per test wave.

		Mixing Turkish into Dutch			**Mixing Dutch into Turkish**		
		Wave 1	**Wave 2**	**Wave 3**	**Wave 1**	**Wave 2**	**Wave 3**
	N	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)
TD	20	0.05 % (0.22)	0.05 % (0.22)	0.10 % (0.45)	7.85 % (8.39)	9.40 % (8.56)	9.30 % (8.89)
DLD	11	0.0 % (0.0)	0.0 % (0.0)	0.18 % (0.40)	16.27 % (17.78)	12.00 % (11.98)	12.55 % (8.65)

Table 3
Percentage of mixing in the Turkish session per subtype.

		Cross-speaker intersentential			**Other intersentential**			**Intrasentential**		
		Wave 1	**Wave 2**	**Wave 3**	**Wave 1**	**Wave 2**	**Wave 3**	**Wave 1**	**Wave 2**	**Wave 3**
	N	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)
TD	20	1.73 % (2.93)	4.01 % (4.70)	4.64 % (6.18)	0.12 % (0.41)	0.31 % (0.50)	0.34 % (0.71)	6.01 % (7.05)	5.10 % (5.78)	4.36 % (3.86)
DLD	11	10.67 % (12.95)	8.62 % (11.40)	7.12 % (4.58)	0.47 % (1.22)	0.31 % (0.75)	0.22 % (0.52)	5.15 % (9.81)	3.05 % (3.69)	5.26 % (6.32)

Table 4
Receptive vocabulary skills and performance on the Continuous Performance Task (CPT).

		Receptive vocabulary in Dutch			Receptive vocabulary in Turkish			Continuous Performance Task[a]	
		Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3	Sustained attention	Response inhibition
	N	Mean % (*SD*)	Mean % (*SD*)	Mean % (*SD*)	Mean % (*SD*)	Mean % (*SD*)	Mean % (*SD*)	Mean hits (*SD*)	Mean false alarms (*SD*)
TD	20	74.89 (11.34)	84.95 (10.34)	92.85 (10.59)	57.50 (7.51)	63.50 (8.15)	69.10 (8.20)	61.05 (14.05)	13.35 (10.92)
DLD	11	55.09 * (13.31)	71.55 * (15.22)	80.91 * (14.38)	51.27† (10.36)	55.09 * (10.59)	55.27 * (19.69)	50.18 * (8.01)	25.36† (20.55)

[a] Sustained attention was measured as the number of hits on the space bar in response to the target (out of 168 trials). Response inhibition was measured as the number of false alarms (i.e., a higher score represents lower performance). Significant differences between the TD and DLD group are indicated with an asterisk (i.e., $p < .05$), while trends are indicated with † (i.e., $p < .1$).

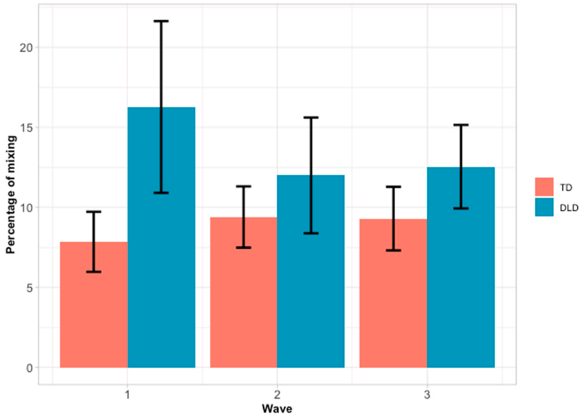

Fig. 1. Percentage of mixing presented per group across wave of data collection.

waves 1 and 3). There was a significant interaction between children's sustained attention scores and mixing frequencies at wave 2 versus waves 1 and 3 (estimate = 8.103, $t = 3.137$, $p = .003$), suggesting that the positive main effect of attention on mixing, albeit small, is more present in wave 2 as opposed to waves 1 and 3. Further, there was a three-way interaction involving impairment status (estimate = 16.040, $t = 3.105$, $p = .003$). Fig. 3 shows that the (small) positive effect of attention on mixing is carried by the DLD group, especially at wave 2. For the TD group, on the other hand, we see the opposite effect: a (small) negative association between attention and mixing frequency, which is in line with hypothesis 3. For children with DLD, the association between attention and mixing frequency was positive at earlier waves of data collection, but negative at wave 3 of data collection. Again, these complex relationships should be interpreted with caution given the low number of children with DLD.

In addition to inspecting some secondary effects of time, we explored whether the patterns reported above for overall mixing frequency are, in fact, specific to cross-speaker mixing. The association between Turkish and Dutch proficiency and mixing frequency (hypothesis 2) is supported in the analysis of cross-speaker mixing but not intrasentential mixing. As in our main analyses, we find no support for hypothesis 3 regarding effects of inhibition or sustained attention on cross-speaker or intrasentential mixing. Both cross-speaker mixing and intrasentential mixing decreased with wave, as does mixing overall (hypothesis 4). Moreover, the interaction between Dutch proficiency and wave found for mixing overall emerged for cross-speaker mixing, but not intrasentential mixing. As for effects of DLD status (hypothesis 5), results reveal that children with DLD show more cross-speaker mixing than their peers with TD while the effect of DLD status for intrasentential mixing borders on significance ($p = .053$); both differences tend to decrease with wave comparable to the analysis of overall mixing. Finally, in line with analyses of overall mixing frequency, the effect of Dutch vocabulary on children's mixing frequency is larger in the DLD than in the TD group, both for cross-speaker and intrasentential mixing. Details on these supplementary analyses are presented on our OSF-page.

4. Discussion

The aim of this study was to investigate the role of language status, language proficiency, and cognitive control in bilingual Turkish-Dutch children's language mixing in single-language settings. We investigated these factors over time following children with a wide range of language abilities from the age of 5 or 6 years until they were 7 or 8 years old. Low mixing frequencies confirm that the children separate Dutch and Turkish and adjust their language to the setting and interlocutor, regardless of age and language ability. Comparing the two settings, we observed hardly any mixing in the Dutch setting, while there was mixing in the Turkish setting (i.e.,

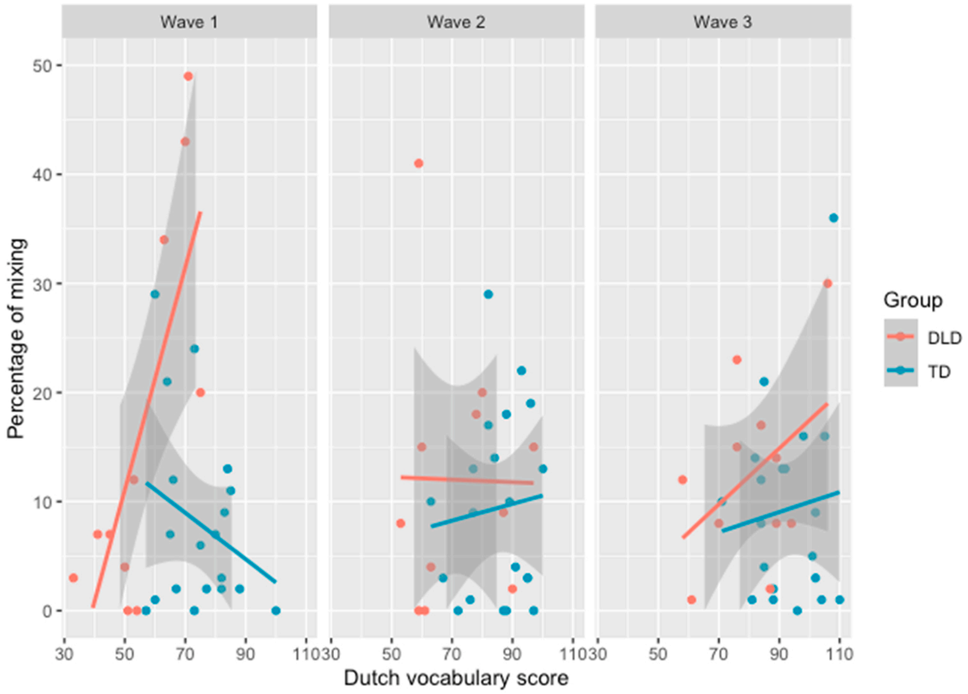

Fig. 2. Relationships between Dutch proficiency on the x-axis and the frequency of mixing on the y-axis, presented per wave of data collection and per group.

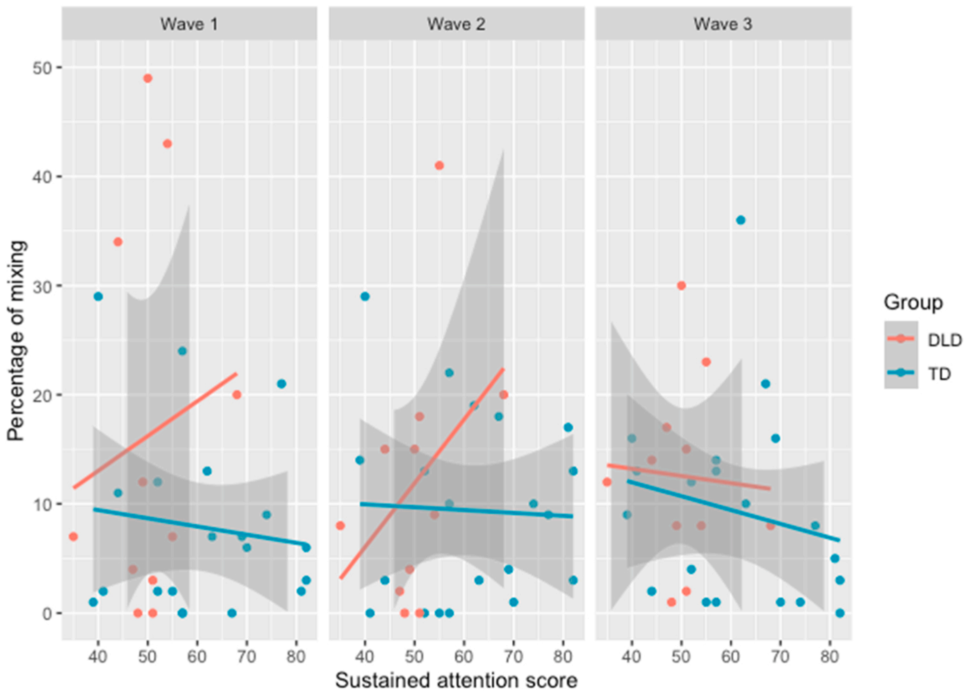

Fig. 3. Relationships between sustained attention on the x-axis and the frequency of mixing on the y-axis, presented per wave of data collection and per group.

maximum 10 % in TD and 17 % in DLD). This pattern replicates findings on bilingual Spanish-English children in the United States (Gutiérrez-Clellen et al., 2009; Montanari et al., 2019; Smolak et al., 2020; Tulloch & Hoff, 2023), and demonstrates that children more easily mix the majority-societal language into the minority-heritage language than vice versa. The children in our study are slightly older and have spent more time in school than those in most previous, similar studies. A longer socialization within the majority society may explain why mixing of the minority-heritage language into the majority-societal language was more infrequent in our study than in the other studies. For example, Montanari et al. (2019) found that at age 3;6 (onset of preschool), the children mixed Spanish into English 16 % of the time, while at age 4;5 (end of first preschool year), this percentage dropped to 3 %. The absence of mixing Turkish into Dutch at the age of 5–6 years (wave 1) fits this trend.

Overall, children with lower Turkish proficiency and children with higher Dutch proficiency used more Dutch in the Turkish setting than those with higher Turkish and lower Dutch proficiency. The findings are in line with previous research showing that both proficiency in the target language (Montanari et al., 2019; Smolak et al., 2020; Tulloch & Hoff, 2023) and proficiency in non-target language (Montanari et al., 2019; Schächinger Tenés et al., 2023) are associated with children's mixing frequency, and constitute separate effects. Also in line with previous research (Montanari et al., 2019) is our finding that the positive effect of (Dutch) language proficiency on children's mixing declines with age. Early in life, development in the minority-heritage language can be strong for many children with migrant backgrounds, in particular if they spend most time at home, resulting in borrowing from the minority-heritage language to fill gaps when speaking in the majority-societal language. In this state of unbalanced bilingualism, language proficiency is an important determining factor in children's mixing. As a result of socialization processes and assimilative forces, the children's minority-heritage language development will slow down in contrast to development in the majority-societal language (Toppelberg & Collins, 2010). Once children reach a state of balanced bilingualism, language proficiency may become a less important factor in children's language mixing, (Montanari et al., 2019), but it is expected to become more important again when the majority-societal language starts to dominate and children borrow from this language to fill gaps in the minority-heritage language. This would explain why in our study proficiency in Dutch and Turkish emerged as significant predictors regardless of wave of data collection.

Previous research on relationships between children's cognitive control and mixing frequency report different results, both in the presence and direction of significant relationships (Bosma & Blom, 2019; Gross & Kaushanskaya, 2022; Kuzyk et al., 2020). We found no significant main effects of cognitive control on children's switching frequency, either as measured through inhibition or sustained attention. A closer look at the exploratory significant three-way interaction between sustained attention, impairment status and wave (wave 2 versus waves 1 and 3) suggests that there is overall a small negative relation between sustained attention and mixing frequency in the TD group indicating that children with better sustained attention tend to mix somewhat less in singe-language settings. This relationship is in line with the Adaptive Control Hypothesis (Green & Abutalebi, 2013), according to which single-language settings require maintaining the goal of using one language and avoiding mixing, which, in turn, draws on sustained attention. However, these overall limited effects suggest that cognitive control is less involved than assumed. The single-language settings in our study may require a lower level of bilingual activation than, for example, dual-language settings in which both languages are highly activated as in homes where each caregiver speaks a different language with the child (Verhagen et al., 2017). Consequently, less cognitive control is needed to suppress the non-target language. Also, if children mixed, this was voluntary and may represent more how they mix in their daily lives which is not necessarily effortful (Backus & Demirçay, 2021; Blanco-Elorrieta & Pylkkänen, 2018).

Limited effects could also have to do with specific measures of cognitive control. We measured response inhibition, which refers to the ability to suppress or countermand a dominant or prepotent response. Response inhibition is theoretically less relevant for mixing than interference inhibition, which is the ability to resist interference and ignore distraction (Green & Abutalebi, 2013). Both response and interference inhibition fall under the umbrella of inhibitory control and have been found to load onto a common factor representing inhibition ability in adults (Friedman & Miyake, 2004) and two-year old children (Gandolfi et al., 2014), but for three- to four-year old children, a two-factor model is a better fit (Gandolfi et al., 2014). A measure of interference inhibition may potentially increase the likelihood of finding relations with mixing frequency in single-language settings. Such a measure should remain subject to scrutiny, because of well-known issues with task impurity, reliability, and validity of executive function measures for children (Souissi et al., 2022). For example, using a child-friendly Flanker task to measure interference inhibition, we noticed in previous research that a quarter of the children responded faster to the incongruent trails than to the congruent trials. The resulting, unexpected, negative flanker effects suggest that for part of the children a Flanker task taps into contrast enhancement rather than interference inhibition (Blom et al., 2017; Rouder & King, 2003). This complicates the interpretation of the Flanker task results and led to our decision to use the response inhibition measure from the CPT in the current study.

The longitudinal design of the study enabled us to observe that mixing frequency in the Turkish setting decreases. Descriptive receptive vocabulary data (Table 4) suggest that Turkish development shows limited growth, which confirms challenges with developing Turkish as a minority-heritage language (Akoğlu & Yağmur, 2016). Despite these challenges, we found in a previous study with a subsample of the children who participated in the current study that Turkish sentence complexity increased somewhat and that grammatical errors in Turkish decreased across the three waves of data collection (Blom et al., 2022). This indicates that Turkish skills continue to develop and may explain that the children mixed less Dutch into their Turkish as they grow older. In addition, better sustained attention could contribute to the decline in mixing frequency, as sustained attention grows considerably between ages five and eight years (Betts et al., 2006).

Our final set of main results concern the children with DLD. In the Turkish-language setting, children with DLD mixed more often than their peers with TD. Other studies also found a higher mixing frequency in DLD compared to TD (Gross & Castilla-Earls, 2023; Gross & Kaushanskaya, 2022; Iluz-Cohen & Walters, 2012; but see: Gutiérrez-Clellen et al., 2009; Kapantzoglou et al., 2021). A closer look at the data reveals that the children with DLD tend to respond in Dutch while their interlocutor speaks Turkish (cross-speaker intersentential mixing; Table 3), which replicates Gross and Kaushanskaya's (2022) findings on Spanish-English bilinguals with DLD. A combination of the challenging conditions for learning Turkish and DLD affecting mainly expressive language skills (Conti-Ramsden & Botting, 2006) may explain why children with DLD resort to Dutch so often. However, even though we found that the children with DLD mixed more often than their peers with TD, we want to highlight that in the DLD sample mixing Turkish into Dutch hardly ever happened and that mixing Dutch into Turkish was also limited. Thus, the overall picture that emerges is that children with DLD separate their languages. Consequently, mixing languages should not be seen as a sign of DLD nor treated as a clinical marker (Miccio et al., 2009). Results furthermore showed that Dutch proficiency had a stronger impact on mixing in DLD compared to TD, especially at wave 1 of data collection, supporting that language proficiency influences children's mixing behavior more at low levels of language ability (Kapantzoglou et al., 2021). Finally, over time, the distinction in language mixing frequency between children with DLD and children with TD diminished. This change is primarily due to a decrease in language mixing frequency among those with DLD. Additionally, as children with DLD age, effects of sustained attention on mixing frequency seem to become more similar to those of TD children. These findings are consistent with an overall delayed developmental profile of children with DLD.

Finally, as part of the exploratory analyses, we looked more closely into the patterns of subtypes of mixing, specifically intersentential cross-speaker mixing versus intrasentential mixing. The results of the main analysis in which the different types of mixing were collapsed showed more resemblances with the results of the analysis on cross-speaker mixing than with the results of the analysis that focused on intrasentential mixing. A comparison of the results suggests that language proficiency as well as DLD status are more strongly linked to cross-speaker mixing than to intrasentential mixing, which would support findings in other research (Ribot & Hoff, 2014; Quirk, 2021; Gross & Kaushanskaya, 2022).

4.1. Limitations and future research

Because of the low sample size, we are hesitant to interpret a few complex interactions, in particular the negative relation between proficiency in Dutch and mixing frequency in TD at wave 1 and a relatively strong positive relation between sustained attention and mixing frequency in DLD at wave 2. In addition, the results of the exploratory analyses need to be treated with caution because of limited power and the overall higher frequency of cross-speaker mixing compared to intrasentential mixing. Future longitudinal research with larger samples is thus important. Another limitation of our study concerns the use of receptive vocabulary as a proxy for language proficiency. Recent research indicates that children with DLD tend to perform within the average range on receptive vocabulary, suggesting that this measure may overestimate the language proficiency of children with DLD (Calder et al., 2023). In addition, it is well conceivable that language mixing behavior would be more closely related to expressive vocabulary than to receptive vocabulary. Furthermore, in our study, data collection took place in schools. Schools are not neutral places in terms of language norms and practices, which may have amplified effects of language status. In addition, it is possible that certain topics such as favorite activities or food elicited language mixing and that mixing frequencies were impacted by the elicitation method (Gutiérrez-Clellen et al., 2009). It is relevant to know whether children's mixing behavior, as well as linguistic and cognitive mechanisms involved in their mixing, is impacted by data collection place, tasks employed and topics discussed, and if mixing frequencies in our study relate to children's mixing behaviors at home. The Turkish community in the Netherlands is known for its intense mixing, but mixing is not the norm in the wider Dutch society. Future research on children's mixing in single-language settings could focus on contexts where mixing is the societal norm and on minority-heritage language learners growing up in communities with less intense mixing. Such research would provide further insight into the relevance of norms and daily language practices for children's ability to focus on a single language.

5. Conclusion

The results on bilingual Turkish-Dutch children in the Netherlands confirm a priori hypothesized effects of language status, language proficiency, age, and language ability on children's language mixing. It can be concluded that in single-language settings, children who are heritage language learners more often mix the majority-societal language into the minority-heritage language than the other way around. Higher proficiency in the majority-societal language, lower proficiency in the minority-heritage language as well as general language ability impact on mixing in the minority-heritage language setting. Increasing language proficiency in the minority-heritage language could explain why children mix less as they grow older. Overarchingly, our findings suggest that linguistic factors at a child-external macro level and a child-internal individual level affect children's mixing in single-language settings, and are more important than children's domain-general cognitive control.

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Declaration of Interest

None.

CRediT authorship contribution statement

Elma Blom: Writing – review & editing, Writing – original draft, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization. **Gülşah Yazıcı:** Writing – review & editing, Data curation. **Tessel Boerma:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation. **Merel van Witteloostuijn:** Writing – review & editing, Writing –

original draft, Formal analysis, Data curation.

Data Availability

Raw data and the analysis script are available on the Open Science Framework (https://osf.io/4eg8h/).

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