Language Control during Bilingual Word Production in Cantonese–English Speaking Autistic and Typically Developing Children

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Abstract

Being bilingual is becoming increasingly common for children worldwide, including those with autism spectrum disorder (ASD). While recent studies have examined the effect of bilingual experience on cognitive and linguistic abilities in autistic children, few have focused on how autistic status influences bilingual language switching and control. For the first time, the present study investigates language control during bilingual word production in autistic and typically developing children with a cued language switching paradigm. Results revealed that autistic children tended to make more cross-language mistakes and had more difficulties when switching between languages, while the overall naming latency and language mixing costs were similar across the two groups. The preliminary findings highlight the potential challenges encountered by autistic children on different levels of language control during bilingual production and also suggest that some aspects of language switching performance are comparable between the groups. Clinical implications are also discussed.

Keywords: Autism spectrum disorder; children; language control; language production; bilingualism

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized mainly by persisting deficits in social and communicative abilities and restrictive and repetitive behaviors (American Psychiatric Association, 2013). As speaking more than one language is becoming a norm rather than an exception for both typically developing and autistic children worldwide, studies in the past decade have started to address language development in bilingual autistic children. Language switching and control are crucial aspects in successful bilingual communication and are affected by the cognitive and linguistic abilities of bilingual individuals. While existing studies conducted on autistic children mainly investigated the role of bilingual experience in overall language development (Hambly & Fombonne, 2012; Zhou et al., 2019) or the specific use of certain linguistic knowledge in a single language (Ge et al., 2024; Meir & Novogrodsky, 2020; Peristeri et al., 2020), less attention has been given to how bilingual autistic children use and switch between the two languages and how their bilingual language use differ from their typically developing peers due to distinct cognitive and linguistic profiles in autistic individuals. The present study therefore aims to examine the pattern of bilingual language control in autistic and typically developing children. The following sections introduce the notion of language control and how its contributing factors motivated the investigation of bilingual autistic children.

Bilingual Language Control

It has been shown that bilingual speakers parallelly activate both languages they know even when only speaking in one of the languages (e.g., Guo & Peng, 2006). As a result, they need to employ a control mechanism to minimize the interference caused by the coactivation of the non-target language. The inhibition control (IC) model (Green, 1998) suggested that bilingual speakers control the use of two languages by exerting inhibition on the non-target language. Later it was proposed that language control can be separated into reactive and proactive types (see Declerck, 2020 for a review): reactive control represents the transient and local-level control exerted on the lexical item of the non-target language after it is parallelly activated, while proactive control indexes a sustained and global-level language control implemented prior to the activation of lexical items in any non-target languages.

One of the frequently used tasks to measure language control is the cued language switching task (e.g., Ma, Li, & Guo, 2016; Meuter & Allport, 1999), in which bilingual participants are asked to name stimuli (often pictures or digits) according to specific cues representing the target language to use. The task usually involves a single language

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phase (stimuli are named in one language only) and a mixed language phase (stimuli are named in different languages) containing switch trials (stimuli are named in a different language than the previous trial) and repeat trials (stimuli are named in the same language as the previous trial). Reactive language control is indexed by the switching cost, which is the difference between switch and repeat trials in the mixed naming phase. Proactive language control is indexed by the mixing cost, which is the difference between single trials and repeat trials in the mixed naming phase. In addition, overall naming latency and cross-language naming intrusion errors are also used by studies with children to index the efficiency of language control (e.g., Gross & Kaushanskaya, 2018).

Factors that Influence Bilingual Language Control

It has been widely acknowledged by major theoretical models that bilingual language control involves the exercise of domain-general executive functions (e.g., Green & Abutalebi, 2013), though there has been mixed evidence about the degree of contribution of the domain-general processes to different components of language control. For example, Linck, Schwieter and Sunderman (2012) found that a smaller Simon task effect (indexing better domain-general inhibitory control) was related to smaller language switching costs, while Calabria et al. (2015) found that older adults were slower in domain-general task switching cost but not in the language switching cost, suggesting the existence of both domain-general and language-specific processes in language control. Moreover, language control is found to correlate with bilingual language experience. Many studies have documented the phenomenon that switching into a dominant language is harder than switching into a less dominant one (e.g., Linck et al., 2012; Meuter & Allport, 1999). This is because the prolonged language control effect is hypothesized to be proportional to language dominance, such that the control exerted on the dominant language is stronger. Therefore, the language control effect is stronger when one is speaking the non-dominant language and trying to inhibit interference from the dominant language, and thus it is also harder for the speaker to switch back to the dominant language. Such an effect of asymmetrical switching cost indicates the dependence of language control strength on relative language dominance. Bonfieni et al. (2019) further revealed the effect of other bilingual language experience indexes on language control, including daily L2 exposure and L2 acquisition age.

In typically developing children, it has been found that both cognitive and linguistic factors contribute to bilingual language control (Gross & Kaushanskaya, 2020; Gross & Kaushanskaya, 2018; Kubota, Chevalier, & Sorace, 2020; Timmermeister et al., 2020). For instance, Kubota et al. (2020) found that in Japanese-English bilingual children, English exposure and executive control development predicted differences in mixed repetition trials in L2 English. Gross and Kaushanskaya (2020) found that in Spanish-English bilingual children, lower language abilities were related to more language selection errors, while lower task control abilities were correlated with a larger difference in language selection errors in the mixed language context than in the single language context. In autistic individuals, deficits in executive functions have been extensively documented across developmental stages (Demetriou et al., 2018) and are found to relate to other symptoms in ASD, such as restricted and repetitive behaviors (Iversen & Lewis, 2021) and degraded theory of mind abilities (Jones et al., 2018). Furthermore, successful bilingual language communication requires picking the appropriate language according to context and interlocutors and switching between languages when necessary. This process requires extensive use of social cognition and theory of mind abilities alongside executive functioning, which all are impaired among autistic children.

Putting together, the extensive social, communicative and cognitive impairments documented in autistic children provide the motivation for investigating bilingual language switching and control in this group (De Bruin & Hayiou-Thomas, 2022). Regarding the role of bilingualism and bilingual language use in autism, most existing studies have focused on the effect of bilingual experience on linguistic abilities (e.g., Ge et al., 2024) and cognitive abilities (e.g., Montgomery et al., 2022) in autistic children. However, there have not been systematic experimental studies on *bilingual language switching* and *language control* in this group, although preliminary anecdotal evidence from parents and practitioners suggests that some autistic children appeared to use a language that is not supposed to be used given the context and the listeners, such as using a school-only language at home while parents cannot speak that language (Prévost & Tuller, 2022).

The current study

To the best of our knowledge, there have not been experimental studies examining the use and switching of two languages in bilingual autistic children. The present study aims to examine the language switching and control patterns of bilingual autistic children and compare the patterns with their bilingual typically developing peers. The research questions are as follows:

RQ1: Do bilingual autistic children differ from their typically developing peers in overall naming efficiency (manifested by overall naming accuracy and overall naming latency) during bilingual language production?

RQ2. Do bilingual autistic children differ from their typically developing peers in language switching cost and mixing cost during bilingual language production?

Methods

Participants. Sixteen autistic and sixteen TD children aged between 5;08 and 9;08 participated in the study[1]. All children

[1] This is a study that is still on-going. We plan to recruit around 30 children for each group based on a preliminary power analysis and past studies on language control in different groups of children (e.g., Gross & Kaushanskaya, 2022).

were born and raised in Hong Kong and attend local primary schools. They acquired Cantonese as the first and dominant language and learned English as a second language before or from age 3 when entering kindergartens, as English was officially incorporated into the kindergarten curriculum of Hong Kong (The Curriculum Development Council, 2006). For autistic children, they have received the official diagnosis of autism spectrum disorder from qualified clinical service providers in Hong Kong. TD children have no history of diagnosis of neurodevelopmental disorders.

The nonverbal IQs of children were assessed with the Primary Test of Nonverbal Intelligence (PTONI; Ehrler & McGhee, 2008), and the maternal education level was used as the index of children's social economic status (SES). The receptive vocabulary level of Cantonese was assessed by the Cantonese Receptive Vocabulary Test (CRVT; Cheung, Lee, & Lee, 1997). The two groups of children were matched in chronological age (M_{ASD} = 96.38 months, SD_{ASD} = 13.59; M_{TD} = 93.38 months, SD_{TD} = 14.63; p = .55) and Cantonese receptive vocabulary (M_{ASD} = 61.44, SD_{ASD} = 3.12; M_{TD} = 62.75, SD_{TD} = 1.95; p = .17). The TD children had higher nonverbal intelligence (M_{ASD} = 77.75, SD_{ASD} = 21.93; M_{TD} = 114.88, SD_{TD} = 19.02; p <.001) and maternal education level (M_{ASD} = 1.75, SD_{ASD} = 1.00; M_{TD} = 2.81, SD_{TD} = 1.33; p = .02) compared to the autistic children, and therefore these two factors were included as covariates to control for their influences in the data analysis.

Materials and Procedures. A cued language switching task built with E-prime (Psychology Software Tools, Inc., 2016) was used to assess the performance of language control in autistic and typically developing children. Cued language switching task is a classical paradigm for assessing language control during bilingual language production, and numbers and pictures are commonly chosen as stimuli to be named (e.g., Ma et al., 2016; Gross & Kaushanskaya, 2018). In the present study, the ten single Arabic numbers (0,1,2,3,4,5,6,7,8,9) were chosen as naming stimuli. Single digits are frequently used by other studies using cued language switching tasks to study language control during bilingual production (e.g., Ma et al., 2016; Meuter & Allport, 1999) and are shown to have reliable language switching costs (Contreras-Saavedra, Koch, Schuch, & Philipp, 2021; although see Liu & Chaouch-Orozco, 2023 for a recent finding on qualitative differences between digit and picture naming). Considering that L1-Cantonese children in Hong Kong have been reported to have relative limited and varied *expressive* vocabulary size at a lower primary school age (Chow et al., 2023), naming pictures in L2 might posit challenges for them to complete the task, while single digits have the advantage of high naming agreement and most children are able to name them without difficulty.

There were three phases of naming in the cued language switching task: blocked naming in Cantonese, blocked naming in English, and mixed naming in both Cantonese and English. The two single naming blocks each consisted of twenty trials of the respective language and the mixed naming phase consisted of forty trials with twenty trials to be named in each language. The single naming blocks were always completed before the mixed naming phase to avoid cross-language interference and their order was counterbalanced across subjects. The mixed naming phase contained either repeat trials (i.e., first trial of each block or current trials that should be named using the same language as the previous trial) or switch trials (i.e., current trials that should be named using a different language than the previous trial) and were separated into two blocks, each containing ten repeat trials and ten switch trials (half of the switch trials were switching from Cantonese into English and the other half were from English into Cantonese). Within each block, each digit appeared twice in a pseudorandom order, and the same digit was not presented consecutively.

Each trial started with a centered fixation cross for 500 ms, followed by the simultaneous appearance of the naming cue and the digit to be named. The digit was presented at the center of the screen, and the naming cue was situated right above the digit. Both the digit and the cue remained on the screen for 3000 ms followed by a 500 ms interval before the onset of the next trial.

A Hong Kong regional flag and a UK flag served as the Cantonese and English naming cues respectively. Compared to using abstract cues like colored shapes, using flags to indicate the target naming language was easier to understand and required less memorization, and flags were also used as naming cues by other studies investigating language control in children (e.g., Kubota et al., 2020). For each block in the single naming phase, children were notified of the language to use and were asked to name the digit in Cantonese or English as soon as possible after the digit and cue appeared. For the mixed naming phase, they were instructed to name the digit in the cued language according to the cue as soon as possible after the digit and the cue appeared. There were three practice trials before each single naming phase and five practice blocks before the mixed naming phase.

Data processing. For each trial, accuracy and reaction time (i.e., naming latency) data were obtained. The accuracy of digit naming was checked manually. Errors were categorized into one of three categories: cross-language errors (correct or incorrect digit named in the language that did not match the cue), other errors (e.g., incorrect digit named in the cued language, no response recorded within 3000 ms post the cue/stimulus onset, or interruption by other sounds). Naming latency for correct trials was manually checked using the Checkvocal program (Protopapas, 2007). Prior to data analysis, naming latency data trimmed by removing outlier trials that exceeded three standard deviations from the mean naming latency of each child, resulting in the removal of 1.12% of the total correctly named trials, and log-transformation was also applied.

Analyses. The data analyses contain four parts: overall naming accuracy, overall naming speed, switching cost, and mixing cost. All analyses were conducted using the *lme4* package (Baayen, Davidson, & Bates, 2008) in R (R Core Team, 2023). All binary predictors were deviation coded with (-0.5, 0.5). Details of modelling of each part are included in the results section.

Results

Overall naming accuracy. For the analysis of overall accuracy, only cross-language errors were considered, as this kind of error indexed difficulties in language selection (Gross & Kaushanskaya, 2018). Therefore, other kinds of error trials and no-response trials were excluded. The remaining trials from all phases were coded for accuracy (0 or 1) and naming context type (single trials or mixed trials). Figure 1 shows the overall naming accuracy of each context type of the two subject groups. The generalized mixed effects model fitted for overall accuracy included fixed effects of context (single/mixed), group (ASD/TD), language (Cantonese/English) and their interactions, fixed effects of IQ and SES as covariates, and random by-subject and by-trial intercepts. Results revealed a main effect of context (β = 2.29, *SE* = 0.46, *z* = 4.99, $p < .001$) and a marginally significant main effect of group (β = 0.91, *SE* = 0.54, *z* = 1.69, *p* = .091) after controlling for nonverbal IQ and SES, suggesting that both groups of children made more errors in the mixed naming phase than the single naming phase, and autistic children had a numerical trend to make more errors than their TD peers across all trials.

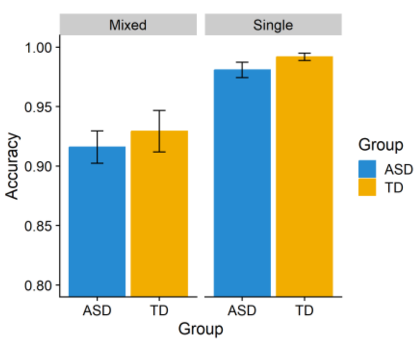

Figure 1: Overall accuracy of digit naming.

Overall naming speed. For the analysis of overall naming speed, correct trials from all phases were coded for naming context type (single or mixed). Figure 2 shows the overall naming latency of each context type of the two subject groups. The linear mixed model included fixed effects of context (single/mixed), group (ASD/TD), language (Cantonese/English) and their interactions, fixed effects of IQ and SES as covariates, and random by-subject and by-trial intercepts. Results showed that there was a main effect of context (β = −0.41, *SE* = 0.02, *t* = −19.36, $p < .001$) and a main effect of language (β = 0.04, *SE* = 0.02, *t* = 2.25, *p* = .026), indicating that children named digits more slowly in the mixed naming phase compared to the single naming phase, and English trials were named more slowly than Cantonese trials. In addition, there was a two-way interaction between context and language (β = 0.08, *SE* = 0.03, *t* = 2.36, *p* = .02). Post-hoc comparisons with Bonferroni correction further showed that English trials were named more slowly than Cantonese only in the single naming phase (β = 0.08, *SE* = 0.01, *t* = 5.37, $p < .001$), but not in the mixed naming phase (β = −0.002, *SE* = 0.03, *t* = −0.07, $p > .99$).

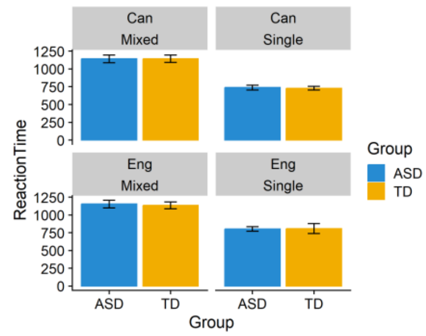

Figure 2: Overall naming speed. “Can” and “Eng” represent Cantonese and English trials respectively.

Switching cost. For the switching cost, only correct trials from the mixed naming phase were included and coded for trial type (repeat trials or switch trials). Figure 3 exhibits the naming accuracy of the two types of trials in the mixed naming phase of the two subject groups. The linear mixed model included fixed effects of trial type (repeat/switch), group (ASD/TD), language (Cantonese/English), and their interactions, fixed effects of IQ and SES as covariates, and random by-subject and by-trial intercepts. Results revealed that there was a main effect of trial type (β = 0.08, *SE* = 0.03, *t* = 2.58, *p* = .01), suggesting that switching trials were named more slowly than repeat trials in the mixed naming phase. While the model did not show interaction effects, considering that our study is still ongoing and the current sample size might limit the statistical power, we did an exploratory analysis and separated the dataset by subject group and fitted two models for each subject group. Each model contained fixed effects of condition, language, condition*language interaction, and the same covariates and random effects as the original model. The *p*-values for each model were corrected with the Bonferroni method. Results revealed that there was a main effect of condition in the autistic group (β = 0.11, *SE* = 0.03, *t* = 3.25, *p* = .005), but not in the typically developing group (β = 0.06, *SE* = 0.04, *t* = 1.66, *p* = .21), suggesting that the switching cost (i.e., the naming speed difference between repeat and switching trials in the mixed naming phase) is more prominent in the autistic group than in the typically developing group.

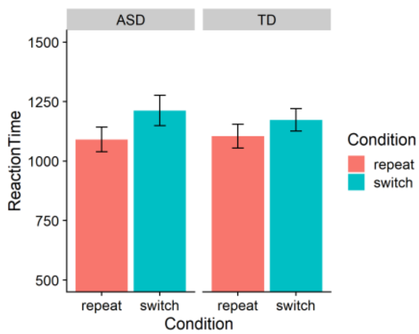

Figure 3: Naming latency during mixed naming phase (repeat and switch trials).

Mixing cost. For the mixing cost, only correct trials from the single naming phase and repeat trials from the mixed naming phase were included and coded for trial type (single trials or repeat trials). The linear mixed model included fixed effects of trial type (single/repeat), group (ASD/TD), language (Cantonese/English) and their interactions, fixed effects of IQ and SES as covariates, and random by-subject and by-trial intercepts. Results revealed that there was a main effect of trial type ($\beta = -0.37$, $SE = 0.03$, $t = -14.68$, $p < .001$) and a marginally significant main effect of language ($\beta = 0.04$, $SE = 0.02$, $t = 1.82$, $p = .073$). No interaction effects were obtained. Further exploratory analysis suggested that there were main effects of condition in both the autistic group ($\beta = -0.36$, $SE = 0.03$, $t = -13.15$, $p < .001$) and the typically developing group ($\beta = -0.38$, $SE = 0.03$, $t = -14.16$, $p < .001$). These results suggested that while both groups of children were slower when naming repeat trials in the mixed naming phase compared to naming trials in the single language phase, the mixing cost (i.e., the naming speed difference between repeat trials in the mixed naming phase and trials in the single naming phase) was similar for autistic and typically developing children.

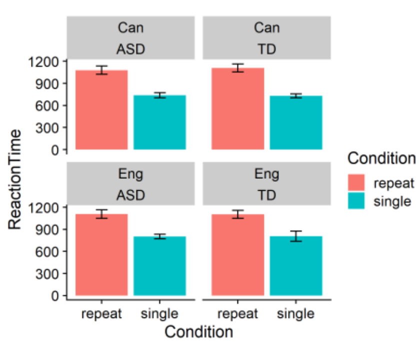

Figure 4: Naming latency during repeat trials of mixed naming phase and single trials (repeat and single trials).

Discussion

Switching between two languages constitutes an important part of real-life bilingual language use, yet most studies have addressed bilingual language control in adults, with bilingual children remaining understudied, especially those with neurodevelopment conditions and varied cognitive and linguistic abilities. The present study provides preliminary findings regarding the similarities and differences of language control ability during bilingual word production in autistic and typically developing children. Regarding the overall accuracy and naming latency (RQ1), we found that autistic children showed a numerical trend to make more cross-language intrusion errors than their TD peers, while two groups of children both named digits more slowly in the mixed language context compared to the single language contexts, with single Cantonese trials named faster than single English trials. Concerning the switching and mixing costs (RQ2), autistic children had larger switching costs than TD children, but mixing costs revealed no group difference.

The group difference in switching cost suggests that autistic children were less capable of applying transient and reactive language control to resolve the interference brought by the language schema activated in the previous naming trial. Given that studies have suggested relative intact reactive cognitive control in autistic individuals (Schmitt et al., 2018), our preliminary evidence suggests that mechanisms of language control and domain-general cognitive control may not entirely overlap with each other. In other words, autistic children may encounter specific difficulties when dealing with local-level and transient demands to control for their two languages, even if they may not have challenges with reactive cognitive control. As previous studies suggest, language control ability in children is related to both linguistic and cognitive abilities (Gross & Kaushanskaya, 2018, 2020; Kubota et al., 2020; although see also García González et al., 2024), thus this group difference in language switching cost may be attributed to autistic children's weaker executive functioning or lower language abilities, or a combination of these factors. Therefore, predictors of individual differences in bilingual experience, language proficiency and cognitive abilities should be added to the analysis to decide where the group difference in switching cost come from, and if there are distinct patterns of contributions from these two aspects of abilities in autistic and typically developing children. Regarding cross-language intrusion errors, they typically imply failure in selecting the appropriate language schema according to explicit contextual cues (Gross & Kaushanskaya, 2018) and are typically regarded as happening prior to the selection of specific lexical items, some studies consider it as an index of proactive control. As the present study found only a numerical tendency of difference of the cross-language errors between autistic children and their typically developing peers, there have not been clear evidence to suggest that autistic children have potential difficulties in exerting global-level and prospective language control on the non-target language schema.

On the other hand, it was found that autistic and typically developing children had comparable performance in several other aspects of language control. For example, mixing cost, which is more typically used to index proactive language control, was found to be similar between autistic and TD children. Mixing cost equals the difference of naming speed between two kinds of "non-switch" trials (repeat trials in the mixed naming phase vs. single trials) and reflects the efforts of multi-language task maintenance between two kinds of language contexts (Ma et al., 2016). It is thus possible that autistic children are relatively comparable with their TD peers when globally monitoring the two language schemas according to the contextual cues signaling the use of a different language. In addition, both groups showed comparable performance of overall naming latency. They also both showed a reversed language dominance when comparing the overall naming speed in single versus mixed context, potentially indicating again the ability to exert sustained and proactive language control (i.e., Cantonese trials were named faster than English trials in the respective single blocks, but this difference disappeared in the mixed naming phase; although see Gade et al., 2021 for a systematic review that challenges the theoretical implications of this effect). These evidence reflects that at least some aspects of language control are similar between autistic children and their TD peers. Future studies should continue to explore the mechanism behind the different components of language control performance and examine factors that differentially contribute to the aspects that are comparable or different between autistic and TD children, such as bilingual experience and domain-general executive control.

Additionally, the present study provides clinical implications for language development in bilingual autistic children from a previously understudied linguistic context. While ASD is not a pure language disorder by definition, different levels of linguistic knowledge and use are commonly affected in autistic individuals (e.g., semantics, Floyd, Jeppsen, & Goldberg, 2021; pragmatics, Lam & Yeung, 2012; prosody, Peppé et al., 2007; syntax, Zhou et al., 2015). Given the difficulty in overall language abilities faced by many autistic children, caregivers may choose not to focus on enhancing their children's L2 ability, especially if they think it will hinder their children's overall language performance (Yu, 2013). However, existing studies have suggested that learning more than one language is not harmful to language development in autistic children (e.g., Ge et al., 2024; Hambly & Fombonne, 2012) and may even be beneficial for their overall language ability under certain contexts or learning modes that suit their needs (e.g., non-interactive input, Hindi & Meir, 2025) as well as cognitive abilities (e.g., Montgomery et al., 2022). Our study focused on children from Hong Kong who were unbalanced L1 Cantonese-L2 English bilinguals dominating in their L1. In Hong Kong, English is not the societal dominant language but English proficiency has been found to have a significant relationship with social-economic outcome variables (Terasawa, 2024). Our results suggested that these autistic children were able to switch between and control the use of both languages that they know, despite some potential challenges that they might face. Given the importance of being bilingual, especially for maintaining the proficiency and use of non-dominant language in order to achieve better academic and social outcomes, the results from the present study highlight the need to consider how to provide support for the continued usage of the societal non-dominant L2 for bilingual autistic children in the face of the challenges they may encounter during language use under a bilingual context.

Conclusion

Understanding language control patterns and its contributing factors is crucial for effectively supporting the use of both languages in bilingual children, especially those with neurodevelopment conditions and special education needs in the domain of language. This study serves as a first step towards understanding language control patterns in bilingual autistic children and potential differences with typically developing peers. Preliminary results suggest differences in language switching costs and similar performance regarding overall naming accuracy, naming latency and mixing costs. Future studies should go beyond the group level difference and examine the contribution of individual variabilities in different cognitive, linguistic and social abilities to bilingual language control performance in autistic children on both word level and more naturalistic settings (such as integrating real interlocutors into the design) to fully reflect their unique patterns and potential needs of support during bilingual communication.

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