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Bidialectal variety switching: the effects of language use and social contexts

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While previous research shows that bilinguals' ability to mix and switch between two separate languages is influenced by both cross-language similarity and language use contexts, little attention has been paid to bidialectal populations. Given the linguistic and sociolinguistic differences between bilingualism and bidialectalism, it is thus unclear to what extent mechanisms underlying bidialectal variety switching resemble those underlying bilinguals. To investigate the effects of cross-variety phonological distance and variety use contexts on variety switching, we tested two groups of Chinese speakers in a bidialectal auditory word recognition task. Both groups speak a regional dialect (Chengdu Mandarin or Cantonese) as their native language and are also highly proficient in Standard Mandarin. Participants' language background and linguistic experience are collected by a language background questionnaire. Mixing and switching between two varieties are costly for bidialectal speakers in comprehension. Mixing costs can be attributed to variety switches instead of the mere presence of a mixed-variety context. While variety switch and mixing costs are not influenced by cross-variety phonological distance, they are modulated by variety dominance and habitual variety use contexts. This study highlights the similarities between bidialectals and bilinguals in language processing, as well as the significance of recognizing between- and within-group differences in conducting psycholinguistics research with multilingual populations.

KEYWORDS

bidialectalism, variety switching, language switching, language mixing, phonological similarity, language use contexts

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Introduction

Language varies from person to person, but also from community to community. Much of this variation has been historically discarded with the idea that variation represents a deviation from the "standard"[1] language, and that less incorporation of variation better captures cognitive and linguistic processes (Tiv et al., 2021). Studies on multilingual experiences have challenged these views and show that inter- and intra-variation are inherent

1 Throughout the manuscript, we refer to "standard language" (except when it is used with capital letters, e.g., Standard Mandarin) and "native language" in quotation to represent that we as the researchers do not endorse these ideologies, but we are using the terms to refer to the prior research (see Lippi-Green, 2012 for further discussion; see Dewaele et al., 2022 for a recent discussion of the "non-native" vs. "native speaker".).

parts of cognitive and linguistic processes, and that underlying mechanisms must be diverse (Kutlu et al., 2022a), and the experience of bilingualism itself serves as a gradient measure (Sulpizio et al., 2020). However, there is still a gap in literature regarding variability within a language such as bidialectalism (but see Di Dona et al., 2022). Inclusive theories of language processing should include other types of variations observed outside of multilingual context as these cases represent the richness of the contextual differences observed across the globe.

A part of the limitations on understanding variation is driven by the scientific focus on standard languages. Language ideologies and arbitrary geographical boundaries shape the way each community's language is recognized. Named languages are typically tied to a delimited, geographic space that corresponds to a "country" and being a citizen of the country and speaking the corresponding language means being a "native speaker" of the language linked to that space. Sociolinguistically, these concepts have been well-documented in one-nation-one-language ideologies (Milroy, 2001; Irvine et al., 2009; Milani, 2010; Kircher and Kutlu, 2023). However, beyond such ideologies, the naming of a particular linguistic code as a language is arbitrary and the correspondence between nation and language is rarely consistent. This has two important implications. First, there are languages that are mutually intelligible and co-exist in adjacent regions, but with political boundaries separating them. An example of this would be the Scandinavian languages of Swedish, Norwegian, and Danish, spoken in adjacent regions of Northern Europe. These languages are mutually intelligible amongst themselves.[2] Speakers of more than one of these languages are considered bilingual or multilingual because historically recognized political borders delimit where each is spoken and therefore, each code is tied to distinct national identities, and each is recognized as a separate named language. Second, and distinct from the Scandinavian example, there are speakers whose linguistic codes exhibit varying degrees of mutual intelligibility but who live within the same historically and politically delimited "nation". Typically, these linguistic codes are called dialects, and they co-exist with a "standard" dialect that serves as the national language. For example, within the political borders of China, different varieties of Chinese are seen as dialects of the same language, even though they exhibit varying degrees of similarity, reflected by both mutual intelligibilities experimentally tested with native speakers (Tang and van Heuven, 2007, 2009, 2015) and phonological and lexical similarities objectively measured by the Levenshtein distance measure (Tang and van Heuven, 2007, 2015). However, in this case, users of more than one Chinese dialect are not considered bilingual. Thus, arbitrary physical borders can constrain or expand the perception of linguistic diversity and the status of populations as speakers of a language (with political boundaries and identified with a nation) or a dialect (without political boundaries, distinct from the standard).

2 A more detailed exploration of mutual intelligibility across languages lies outside the scope of this paper. According to Gooskens et al. (2018), "mutual intelligibility" can be functionally observed when speakers of different languages can communicate successfully using their own language "without prior instruction" (p. 170).

Individuals who speak more than one dialect are similar to bilinguals as they may represent different sets of linguistic structures (Chevrot and Ghimenton, 2018) and need to switch from one dialect to another when switching from one context to the other, or when speaking to people with different linguistic backgrounds. They are also similar to monolinguals who represent one named underlying system. This raises important theoretical questions regarding how bidialectals deal with switching and mixing across their linguistic systems, and how structural similarity between dialects as well as language ideologies determined by socio-cultural factors play into this. There is now an abundance of sociolinguistic research that suggests that different dialect users have strong preferences for one dialect compared to the other depending on which contexts they are in (Liu, 2018; Didi-Ogren, 2020; Ye, 2023). Extensive experimental research has also shown the use of contextual information in deciding which accent or dialect to choose from or how these are processed (Hanulíková et al., 2012; Hanulíková, 2021; Kutlu et al., 2021, 2022b). Many of these restrictions come from the language ideologies that assign more prestige to one dialect over the others.

It is therefore unknown to what extent bidialectalism resembles bilingualism and influences language behavior. In this study we examine this using a bilingual switching task, which has been studied extensively in the bilingualism literature, as our starting point. This allows us to make comparisons with a large body of research on bilingual switching to examine whether bidialectal individuals show similar effects of language mixing and switching that are observed in bilingual individuals.

Background

Bidialectalism in China

A large number of dialects are spoken in China, and these dialects are characterized by a simple morphological system and highly similar syntax, reducing linguistic variations almost exclusively to lexicon and phonology (Cheng, 1997; Tang and van Heuven, 2009). In the meantime, a "standardized language" variety developed on the basis of Beijing Mandarin, the language variety spoken in the capital of China, has been promoted across the nation (Tang and van Heuven, 2009; Tang, 2017). Subsequently, most Chinese people can speak two Chinese dialects, their regional variety and Standard Mandarin.

The present study targets two Chinese bidialectal populations, namely Chengdu Mandarin-Standard Mandarin bidialectal speakers and Cantonese-Standard Mandarin speakers. Chengdu Mandarin is a Mandarin dialect spoken in Chengdu, a city in Southwestern China, where there are ~20 million residents (China Statistics Press, 2021). Cantonese is spoken in several regions in Southeastern China, including the Guangxi Province, Guangdong Province, Hong Kong, and Macau, with cross-regional linguistic and sociolinguistic variations. To avoid complexity resulting from regional differences, we focus on Cantonese speakers living in Guangzhou, the capital city of Guangdong Province, where there are ~18 million residents (China Statistics Press, 2021).

Regarding linguistic distance, Standard Mandarin is taxonomically (Tang, 2017) and structurally (Cheng, 1997;

Tang and van Heuven, 2015) closer to Chengdu Mandarin than to Cantonese. Of particular interest of the present study, Chengdu Mandarin is phonologically more similar to Standard Mandarin than is Cantonese. While all three varieties are tonal and share the same syllable structure of $(C_1)V(C_2)$ (Chappell and Lan, 2016), Chengdu Mandarin and Standard Mandarin share more phonological characteristics. For example, neither variety allows velar C_1 preceding high front vowels, the realization of C_2 is restricted to [n] and [ŋ], and both varieties have four tonal categories (Cheng, 1991; Duanmu, 2007; Chappell and Lan, 2016). On the other hand, distinct from Mandarin dialects, Cantonese allows velar C_1 preceding high front vowels, has contrastive vowel length, and a large range of consonants are allowed in the C_2 position following short vowels (Bauer and Benedict, 2011). In addition, Cantonese has a larger tonal inventory than Mandarin dialects, where there are six main tones, but nine counting the three checked tones that only appear in closed syllables (Bauer and Benedict, 2011; Chappell and Lan, 2016). Perception studies have reported greater mutual intelligibility between Chengdu Mandarin and Standard Mandarin than between Cantonese and Standard Mandarin (Tang and van Heuven, 2007, 2009, 2015). Nonetheless, in sociolinguistic terms and irrespective of structural similarities or mutual intelligibility, both Chengdu Mandarin and Cantonese are referred to as *dialects* within mainland China, not as languages and therefore speakers of each are not considered bilingual or multilingual.

From the beginning of the national movement to promote Standard Mandarin started in 1956, it has become the official language variety used across the country in governmental communication as well as television and radio broadcasts. It is also the required instructional variety for education and in formal institutional settings. Consequently, a prestige status is associated with Standard Mandarin as the language of the formally educated population. It is common for parents to choose not to teach their children the regional dialect in order to avoid regional accent marking on their children's Standard Mandarin production. Nonetheless, the picture can be more complicated than the prestige vs. non-prestige distinction may suggest. The actual usage of Standard Mandarin and local dialects across China is mixed. Regional dialects, associated with in-group identity, commonly enjoy covert prestige among the local residents, and there are people who still choose to use their regional dialect in the workplace, school, or other formal situations. Importantly, Standard Mandarin is not exclusively restricted to formal contexts either. With the large intra-national migration to urban areas, metropoles like Chengdu and Guangzhou have attracted a great number of individuals from other places of China who do not speak the local dialect. When local residents communicate with these newcomers or encounter someone for the first time whose language identity cannot be readily perceived, they would choose to use Standard Mandarin even in informal contexts. Therefore, the usage of a regional dialect and Standard Mandarin can be characterized as dependent upon both the communicative context and the identity of the interlocuters.

Bilingual language switching in comprehension

Various experimental paradigms have been developed to investigate language switching (see Declerck and Philipp, 2015 for a review). In a typical language switching study, trial languages are either blocked or mixed. Consequently, in mixed-language conditions, a language switch occurs when the trial language is different from that of the previous trial, or when there is a switch of languages in the sentence presented in a trial. Bilinguals are considered to produce switch costs if a poorer performance is associated with switch trials in relation to non-switch trials and produce mixing costs if the performance is better in single-language conditions than in mixed-language conditions (see Bobb and Wodniecka, 2013 for a review).

As it has been widely suggested that certain language control mechanisms underly bilingual language processing (Green, 1998; Meuter and Allport, 1999; Abutalebi et al., 2007; Christoffels et al., 2007; Wang et al., 2009; Hilchey and Klein, 2011; Green and Abutalebi, 2013), the presence and magnitudes of switch and mixing costs as a function of language dominance are argued to inform such mechanisms (see Bobb and Wodniecka, 2013 for a review). In the production domain, one important finding is the asymmetry in switch and mixing costs. Bilinguals have been found to produce larger switch costs when switching from the less dominant language (L2) to the more dominant language (L1) (Meuter and Allport, 1999; Costa and Santesteban, 2004; Costa et al., 2006; Verhoef et al., 2009; Wang et al., 2009; Linck et al., 2011; Tarlowski et al., 2013; Peeters et al., 2014; Reynolds et al., 2015; Ma et al., 2016). Similarly, bilinguals also produced greater mixing costs in L1 than in L2 (Christoffels et al., 2007; Ma et al., 2016; Mosca and de Bot, 2017; Peeters and Dijkstra, 2017). One of the explanations for the asymmetry is that L1 exerts greater interference when processing L2, and therefore, more control is placed upon L1 to facilitate L2 production (Green, 1998; Meuter and Allport, 1999; Abutalebi and Green, 2007; Runnqvist et al., 2011). Thus, the asymmetries in switch and mixing costs have served as evidence for two separate language control mechanisms. Specifically, switch cost asymmetry is associated with reactive inhibitory control, implemented when a non-target language disrupts the selection of the target language (Green, 1998; Meuter and Allport, 1999; Costa and Santesteban, 2004; Costa et al., 2006; Christoffels et al., 2007; Wang et al., 2009; Linck et al., 2011; Prior and Gollan, 2011; Macizo et al., 2012; Peeters et al., 2014; Ma et al., 2016; Mosca and de Bot, 2017; Declerck et al., 2019). Mixing cost asymmetry is associated with proactive inhibitory control, implemented as anticipation of the target language selection being disrupted by a non-target language (Christoffels et al., 2007; Wang et al., 2009; Prior and Gollan, 2011; Ma et al., 2016; Mosca and de Bot, 2017; Peeters and Dijkstra, 2017).

This study focuses on receptive language switching, which has been the focus of much less research, and the underlying mechanisms are less well-understood. For example, many studies with comprehension-based tasks observed switch costs only in certain conditions (Jackson et al., 2004; Declerck and Grainger, 2017; Hut et al., 2017; Mosca and de Bot, 2017; Olson, 2017) or no switch costs at all (Struys et al., 2018; Declerck et al., 2019). Studies have also found a language-switch benefit in comprehension if a response switch occurred with the language switch (Thomas and Allport, 2000; von Studnitz and Green, 2002a; Orfanidou and Sumner, 2005). In conditions where switch costs were observed, mixed results regarding switch cost asymmetry were also observed. Larger costs in L1 than in L2 (Jackson et al., 2004; Macizo et al., 2012; Declerck and Grainger, 2017; Hut et al., 2017; Mosca and de Bot, 2017; Olson, 2017), larger costs in L2 than in L1 (Proverbio et al., 2004; Abutalebi et al., 2007; Koeth, 2012; Aparicio et al., 2013; Byers-Heinlein et al., 2017; Struck and Jiang, 2021), and symmetrical switch costs regardless of language dominance (von Studnitz and Green, 1997, 2002a; Thomas and Allport, 2000; Macizo et al., 2012; Hirsch et al., 2015; Ong et al., 2019) have all been reported. Mixing costs have been rarely investigated in receptive language switching research, and the existing findings are equivocal. Specifically, Grainger and Beauvillain (1987) found that mixing costs were only present for switch trials in a lexical decision task. In a semantic categorization task, Koeth (2012) observed no mixing costs for L1 but mixing benefits for L2. Lastly, Declerck et al. (2019) observed mixing costs in a number categorization task with a group of French-Spanish bilinguals but not with French-Spanish bilinguals. Together these results suggest that costs in receptive language switching are more task-dependent, and listeners' strategies for switching between languages in comprehension may be more flexible.

Some scholars have suggested that a more bottom-up and activation-based model, such as those proposed by the Bilingual Interactive Activation [BIA (Dijkstra and van Heuven, 1998) and BIA+ (Dijkstra and Van Heuven, 2002)] models, is involved in receptive language switching, and any observed switch costs result from the organization of a shared bilingual lexicon without the involvement of domain-general inhibitory control mechanisms (e.g., Blanco-Elorrieta and Pylkkanen, 2016; Struck and Jiang, 2021, but also see von Studnitz and Green, 2002a; Hut et al., 2017; Ong et al., 2019). Declerck et al. (2019) further explain the absence of inhibitory control in receptive language switching to the low degree of cross-language interference in comprehension-based tasks. This is because between-language competition is resolved quickly when a language-specific cue (e.g., a language-specific phonetic or orthographic feature) is detected by the subject (Declerck et al., 2019).

One prediction under this account is that increased cross-language similarity should result in larger costs, due to larger degrees of co-activation of interfering items in the non-target language (Dijkstra et al., 2000; de Groot et al., 2002; von Studnitz and Green, 2002b; Cutler et al., 2006; Blumenfeld and Marian, 2007; Marian et al., 2008). When the comprehension task is language-exclusive and the response varies by the language identity of the trial, larger switch costs have been found to be associated with stimuli containing language-unspecific orthographic cues (Thomas and Allport, 2000; Orfanidou and Sumner, 2005) and interlingual cognate homographs (Thomas and Allport, 2000). However, in tasks where the language identity was not explicitly cued, the effects of linguistic similarity are less clear. For example, Dalrymple-Alford (1985) found that the presentation of cognates eliminated switch costs when participants were asked to read mixed-language word lists. However, Bultena et al. (2015) found that switch costs were not modulated by the presence of a cognate in a shadowing task. Moreover, in a grammaticality judgment task, Deibel (2020) found an increasing trend of switch costs as the grammatical distance of a bilingual's language pair increased.

Declerck et al. (2019) found that increased linguistic similarity may also prompt listeners to exercise language control proactively in comprehension. Comparing the performances of French-English and French-Spanish bilinguals between a number-categorization task and semantic-categorization task, the researchers only found mixing costs in the number-categorization task for the French-Spanish bilingual group. The researchers attributed the finding to the linguistically closer relationship between French and Spanish, as well as the large quantity of cognates in the number systems of the two languages, as opposed to the linguistically farther distanced French and English stimuli (also see Grainger and Beauvillain, 1987).

While receptive language switching seems not to rely too much on a domain-general control mechanism, studies focusing on the effects of language use have found that the amount of control recruited during switching tasks is closely linked to how bilinguals use and switch between the two languages in daily communicative practice (see Beatty-Martínez and Titone, 2021 for a review). Although this line of research has primarily focused on production (Prior and Gollan, 2011; Babcock and Vallesi, 2015; Beatty-Martinez et al., 2020), studies in language comprehension with non-switch paradigms have found an association between bilingual language parallel activation and subjects' bilingual experience (Jared and Kroll, 2001; Blumenfeld and Marian, 2007; Canseco-Gonzalez et al., 2010; Bartolotti and Marian, 2012; Sarrett et al., 2021). These results suggest that bilinguals with less experience using two languages in a shared context experience greater cross-language interference in a mixed-language context, thus requiring additional top-down controls. This hypothesis was tested by Beatty-Martínez and Dussias (2017) with a codeswitched sentence comprehension task. The researchers compared the neural activities of two groups of Spanish-English bilinguals with different degrees of codeswitching experience. Their results showed that the codeswitchers demonstrated sensitivity to codeswitched sentences that violated determiner-noun gender congruency, but no sensitivity to language switches. On the other hand, the non-codeswitchers showed sensitivity to language switches regardless of the congruency manipulation. Similarly, in a semantic categorization task, Struys et al. (2018) found that the magnitudes of switch costs in L2 were negatively associated with the participant's recent L2 exposure (also see Gullifer and Titone, 2019), and were also positively correlated with the global reaction times in a non-linguistic Simon task, a measure that is argued to reflect domain-general conflict monitoring skills (Costa et al., 2009; Hilchey and Klein, 2011).

Relatedly, Grosjean (1997, 2000, 2008) has proposed the concept of language mode, which is defined as the place where an individual exists on a communicative continuum from being completely monolingual in one language to another, with gradient degrees of bilingual operations in the middle. Following this proposal, studies have examined the effect of language mode on bilingual language processing, and it is shown that participants' language expectation also affects their control of the non-target language co-activation. For example, while prior exclusive exposure to a certain language can significantly reduce cross-language competition in a subsequent comprehension task in the same language (Elston-Guttler et al., 2005; Canseco-Gonzalez et al., 2010), this effect can be reversed by an explicit cue of language switching between the two monolingual tasks (Mercier et al., 2015). The effect of language expectation on receptive language switching have also been observed. In an auditory comprehension task, Olson (2017) only observed switch costs in conditions where 95% of the trials were in the same language and the costs were larger for L1, parallel to the switch cost asymmetry observed in production studies. In addition, Declerck and Grainger (2017) found that practicing L1, but not L2, prior to a language switching task can induce asymmetrical switching costs in a size-categorization task.

Theoretical models such as the Adaptive Control Hypothesis (ACH, Green, 2011; Green and Abutalebi, 2013) or the Control Process Model (CPM, Green and Wei, 2014; Green, 2018) have been developed to account for the role of language use contexts in determining language control mechanisms. According to these models, bilingual speakers who use their two languages in separate contexts experience greater cognitive costs in mixed-language situations compared to those who use their two languages in overlapping contexts. For bilingual speakers who use languages in a cooperative manner (i.e., dense codeswitching), language switching and mixing is not costly and can even be facilitative. However, while a clear difference between codeswitching and non-codeswitching bilinguals has been found in the literature, much less is known about the exact differences within the bidialectal communities. These communities provide great opportunities, as there exists a large amount of group and individual variability in the compartmentalization of language varieties. However, while recent language switching studies have started to shift attention to bidialectal communities, they were exclusively focusing on production (Kirk et al., 2018, 2021; Vorwerg et al., 2019; Declerck and Kirk, 2021, 2023), whereas no receptive language switching study has been conducted with these populations.

The objective of the current study is to explore how bidialectal speakers switch between language varieties in auditory comprehension. We aimed to address three specific research questions: (1) Is mixing and switching between two varieties costly for bidialectal subjects who do not codeswitch but nevertheless have overlapping dialect usages across communicative contexts? (2) Are the mixing or switch costs modulated by cross-variety phonological distance? (3) Are the mixing or switch costs influenced by how the subject uses the two spoken varieties?

Bidialectal subjects' variety-switching ability in auditory comprehension was tested using an auditory word recognition task with isolated words in a typical language-switching paradigm (Declerck et al., 2019). This task was specifically chosen because the few existing language switching studies using auditory comprehension have almost exclusively studied language switching in a sentential context (i.e., target word recognition in same-language sentences vs. switched-language sentences) (e.g., Byers-Heinlein et al., 2017; Olson, 2017, but also see Hut et al., 2017). As sentential contexts can facilitate auditory word recognition for both monolinguals and bilinguals (see Van Assche et al., 2012 for a review), it is hard to compare language switching performances observed in sentences to the findings in visual comprehension or production, where tasks with isolated words were more frequently used. In addition, cross-variety phonological distance was manipulated by including two groups of bidialectal subjects: a Chengdu Mandarin-Standard Mandarin group and a Cantonese-Standard Mandarin group, with the former group speaking two varieties that are phonologically more similar to each other than the two by the latter group (Cheng, 1997; Tang and van Heuven, 2015). Lastly, the effects of language use background were examined from an individual analysis approach, as we did not have prior evidence suggesting a group-level difference in dialect usage between the two communities.

Current study

Methods

Participants

Participants were recruited via social media. The recruiting criteria were restricted to being (i) native speakers of either Chengdu Mandarin or Cantonese, and also fluent in Standard Mandarin, (ii) born, raised, and currently residing in the cities of Chengdu or Guangzhou to control for influence of migration or language contact on the lexicon, and (iii) between the ages of 20 and 40 with at least a college-level education to control for the influence of age and socioeconomic status on cognitive control and linguistic competence. In total, 73 bidialectal speakers participated in the study. 37 participants were Chengdu Mandarin-Standard Mandarin speakers (Chengdu group) and 37 Cantonese-Standard Mandarin bidialectal speakers (Cantonese group).

To investigate the effect of habitual variety usage on variety-switching abilities, we collected information on participants' language learning history and language use patterns via an adapted version of the Language History Questionnaire (LHQ, Li et al., 2006). As the LHQ was designed for multilinguals, modifications to the questions were made to gather information of dialect use. The modified questionnaire included questions about the general demographic background, the acquisition and proficiency of each variety (and foreign languages if applicable), as well as the use of language varieties in various social contexts. Both groups of participants completed the language background questionnaire in written Chinese.

Because the study was conducted online, we checked participants' responses to the language background questionnaire to evaluate whether they fit the recruiting criteria. Two participants (one from each group) were excluded from the data analysis because they were above the age of 40, and two participants (one from each group) were excluded because their highest education level reported was high school. Seven participants (three in the Chengdu group and four in the Cantonese group) were further excluded from the analysis because of low accuracy in the word recognition task (see the next section, *Accuracy* < 0.60). After removal, 31 participants in the Chengdu group (20 women, 11 men) and 31 participants in the Cantonese group (11 women, 20 men) were included in the analysis.

The demographic information and linguistic background of the 62 participants are reported in Table 1. The average age of participants was 28.84 (SD = 5.25) for the Chengdu group and 28.06 (SD = 4.98) for the Cantonese group. A two-sample student's t-test was conducted and no significant difference in age was found between the two groups [$t_{(60)} = -0.60$, $p = 0.554$, $d = -0.15$]. All participants had at least college-level education. No participants had lived outside of Chengdu or Guangzhou for more than a year. None of the participants reported any speech impairments or hearing disabilities, and all had normal or corrected-to-normal vision.

Most of the participants in both groups identified the regional dialect as their first dialect and Standard Mandarin as their second dialect with few exceptions. Five Cantonese participants and two Chengdu participants identified both the regional dialect and Standard Mandarin as their first dialects, and four Cantonese participants and two Chengdu participants identified Standard Mandarin as their first dialect and the regional dialect as the second dialect. On average, both groups acquired the regional dialects prior to Standard Mandarin. The self-reported proficiency on a five-point Likert scale was at ceiling in both varieties across the two groups. For each variety, two separate Welch's t-tests were conducted to test if the proficiencies of the two groups differed significantly in either listening or speaking. Welch's t-tests were chosen because the equal variances assumption was not achieved (see Table 1) (Welch, 1947; Ruxton, 2006). The tests did not find any between-group differences in speaking or listening. For the Cantonese group, paired t-tests did not find any significant between-variety differences in listening or speaking; for the Chengdu group, paired t-tests found significant between-variety differences in speaking [$t_{(30)} = 2.36$, $p = 0.025$, $d = 0.42$] but not in listening, suggesting Chengdu participants self-rated their Chengdu Mandarin speaking proficiency higher than Standard Mandarin.

For variety usage, participants also reported the respective proportions of using the regional dialect, Standard Mandarin, and other languages or language varieties in the contexts of home, work, and outside (i.e., not home nor work) on a daily basis. For a few participants, the summations of the proportions in certain social contexts were not one, and we rescaled their self-reported proportions so that for each social context, the summation of a participant's proportions of using each variety was one. An aggregated proportion of using each variety was then calculated for each individual participant by averaging the proportions of the given variety across the three social contexts.

Welch's t-tests were first conducted to test whether the two groups differed significantly in the proportion of using each variety in each context. The full results are reported in Table 2. No significant differences in using Standard Mandarin or the regional dialects at home were found between the two groups. The differences were significant for the use of the regional dialect in the contexts of work [$t_{(55.72)} = -3.16$, $p = 0.003$, $d = -0.80$] and outside [$t_{(53.76)} = -2.52$, $p = 0.015$, $d = -0.64$], and also for the use of Standard Mandarin in the contexts of work [$t_{(59.64)} = 2.59$, $p = 0.012$, $d = 0.66$] and outside [$t_{(59.65)} = 2.40$, $p = 0.020$, $d = 0.61$], suggesting the Cantonese group used less regional dialect and more Standard Mandarin in these two contexts than the Chengdu group. The difference was also significant for the aggregated proportion of using regional dialect [$t_{(52.87)} = -2.25$, $p = 0.028$, $d = -0.57$] and Standard Mandarin [$t_{(58.44)} = 2.09$, $p = 0.041$, $d = 0.53$] between the two groups, suggesting the Cantonese group used less regional dialect and more Standard Mandarin across in general than the Chengdu group.

Then, paired t-tests were conducted to test whether the difference between using the regional dialect and Standard Mandarin was significant for each group in each context. The full results are reported in Table 3. Significant differences were found in all pairwise contrasts involving other languages or varieties, suggesting both groups primarily used the regional dialect or Standard Mandarin in all contexts. The differences between the regional dialect and Standard Mandarin were also significant for the Cantonese group in the contexts of home [$t_{(30)} = 2.59$, $p = 0.015$, $d = 0.47$] and work [$t_{(30)} = -4.66$, $p < 0.001$, $d = -0.84$], and for the Chengdu group in the contexts of home [$t_{(30)} = 2.91$, $p = 0.007$, $d = 0.52$]. These results suggest that the Cantonese group used Cantonese more frequently at home but less frequently at work than Standard Mandarin, and the Chengdu group used Chengdu Mandarin more frequently than Standard Mandarin at home.

Spoken word recognition task

A spoken word recognition task was used to test the ability of bidialectal speakers to switch between a regional dialect and Standard Mandarin. The task comprised two single-variety blocks, one in the regional dialect and one in Standard Mandarin, as well as three mixed-variety blocks. Each block consisted of 30 study trials. In the single-variety block, all trials were in the same variety. In the mixed-variety blocks, the trials were equally divided between the regional dialect and Standard Mandarin and alternated randomly. Consequently, a variety switch occurred when a trial was in a different variety from the previous trial, and the switches were unpredictable. Each group completed the task in their respective regional dialect and Standard Mandarin. Hence, the Chengdu group carried out the task in Chengdu Mandarin and Standard Mandarin, while the Cantonese group in Cantonese and Standard Mandarin.

In each trial, the visual display consisted of two pictures, one representing the target word and the other representing a distractor that was phonologically and semantically unrelated to the target word (e.g., *bianfu*, "bat" vs. *chouti*, "drawer"). The target and distractor pictures of each trial were juxtaposed on the screen, with their relative positions counterbalanced across the trials. All target and distractor words were inter-dialectal cognates among the three varieties. Due to the promotion of Standard Mandarin across China, almost every Standard Mandarin lexical item can be produced with Chengdu Mandarin and Cantonese pronunciations, and the productions can be understood by the native speakers of the two dialects, but not vice versa. In other words, while there are regional dialect-specific lexical items, Standard Mandarin-specific lexical items are rare and insufficient to make up a stimulus list. Moreover, the dialect-specific and Standard Mandarin-specific lexical items are different between the two bidialectal communities. Therefore, the inter-dialectal cognates were chosen to avoid any unbalanced dialect-specific lexical effects on word recognition and restrict the between-group differences to the phonetic realization

 10.3389/flang.2023.1302027

TABLE 1 The demographic and linguistic background of participants.

	Chengdu group				Cantonese group			
Demographics								
Sample size (*N*)	31				31			
Women (*N*)	20				11			
Men (*N*)	11				20			
Age	28.84 (5.25)				28.06 (4.98)			
First dialect (*N*)								
Regional dialect	27				22			
Standard Mandarin	2				4			
Both	2				5			
Age of onset								
	Through immersion		In class		Through immersion		In class	
Regional dialect	2.17 (3)		4.23 (4.09)		2.23 (2.75)		4.17 (2.94)	
Standard Mandarin	5.63 (4.45)		6.63 (4.05)		5.32 (3.22)		6.13 (2.67)	
Variety proficiency 1 (low proficiency) to 5 (native)								
	Listening		Speaking		Listening		Speaking	
Regional dialect	4.68 (0.48)		4.68 (0.48)		4.65 (0.55)		4.52 (0.57)	
Standard Mandarin	4.58 (0.62)		4.32 (0.94)		4.74 (0.51)		4.61 (0.62)	
Proportion of daily variety use								
	Home	Work	Outside	Aggregated	Home	Work	Outside	Aggregated
Regional dialect	0.61 (0.33)	0.44 (0.28)	0.54 (0.32)	0.53 (0.28)	0.57 (0.31)	0.24 (0.21)	0.36 (0.23)	0.39 (0.19)
Standard Mandarin	0.29 (0.29)	0.46 (0.26)	0.37 (0.27)	0.38 (0.24)	0.31 (0.27)	0.64 (0.29)	0.53 (0.25)	0.50 (0.21)
Others	0.10 (0.14)	0.10 (0.14)	0.09 (0.15)	0.09 (0.14)	0.12 (0.15)	0.11 (0.15)	0.11 (0.14)	0.11 (0.13)

Standard deviations are reported in parentheses.

of the auditory stimuli. Nevertheless, it must be noted that some cognates may not be the most used oral forms in Chengdu Mandarin or Cantonese, thus unavoidably raising the possibility of a processing advantage in Standard Mandarin in the word recognition task.

The lexical items were disyllabic concrete nouns selected from the Chinese Lexical Database (Sun et al., 2018), with phonological frequency balanced within each target-distractor dyad in Standard Mandarin. The auditory stimuli of Chengdu Mandarin and Cantonese were recorded by a female native speaker of the respective varieties. The auditory stimuli of Standard Mandarin were recorded by a female native speaker of Beijing Mandarin who was a certified Standard Mandarin instructor. All three speakers were between the ages of 30–33 at the time of recording. All recordings were carried out in a sound-attenuated room at the Phonetics Lab of the University of Iowa, with a Marantz PMD671 recorder and Shure Beta 58A model microphone using a sampling rate of 44.1 kHz. The recorded stimuli were further normalized for duration ($M = 0.77$ s) and amplitude ($M = 73$ dB) across the three speakers. The display pictures were colored drawings selected from the MultiPic data set (Duñabeitia et al., 2018). Since the data set was not normed for Chinese languages, the selected pictures underwent a norming procedure by 10 native speakers of each tested variety. The norming procedure was similar to that of a picture-naming task. Native speakers received a PowerPoint with each slide containing one picture stimulus and were prompted to orally produce a disyllabic word describing the picture. Pictures that received at least 8 responses consistent with the intended target or distractor word were selected. In total, the experiment included 316 pictures (158 target-distractor dyads) and 158 spoken words, with 16 practice items and 300 experiment items. The full list of lexical items used in the experiment is provided in the Supplementary material.

The 150 target-distractor dyads used as experiment items were counterbalanced across the five blocks. The order of the blocks was semi-counterbalanced, with the three mixed-variety blocks always administered consecutively. Each trial began with the picture display, and the auditory stimulus was presented 500 ms after the onset of the picture display. Participants were instructed to identify the picture corresponding to the auditory stimulus by pressing the arrow keys on the keyboard. After the response, there was a 500 ms response-stimulus interval, during which a cross remained fixed

TABLE 2 Results of the Welch's *t*-tests on group-level differences in the proportion using of each variety in each social context on a daily basis.

Social context	Variety	Cantonese—Chengdu group difference			
		Estimate	*t*	*df*	*p*
Home	Regional dialect	−0.04	−0.45	59.85	0.656
	Standard Mandarin	0.02	0.24	59.61	0.814
	Other	0.02	0.54	59.87	0.590
Work	Regional dialect	−0.20**	−3.16	55.72	0.003
	Standard Mandarin	0.18*	2.59	59.64	0.012
	Others	0.02	0.50	59.98	0.617
Outside	Regional dialect	−0.18*	−2.52	53.76	0.015
	Standard Mandarin	0.16*	2.40	59.65	0.020
	Others	0.02	0.48	59.96	0.630
Aggregated	Regional dialect	−0.14*	−2.25	52.87	0.028
	Standard Mandarin	0.12*	2.09	58.44	0.041
	Others	0.02	0.55	59.75	0.588

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
The statistic estimates were calculated by subtracting the Chengdu group mean from the Cantonese group mean.

TABLE 3 Results of the paired t-tests on pairwise between-variety differences in the proportion of daily usage in each social context.

Social context	Variety contrast	Between-variety difference ($df = 30$)					
		Chengdu group			Cantonese group		
		Estimate	*t*	*P*	Estimate	*t*	*p*
Home	Dialect—Mandarin	0.31**	2.91	0.007	0.26*	2.59	0.015
	Dialect—Others	0.51***	6.88	<0.001	0.46***	6.20	<0.001
	Mandarin—Others	0.20**	3.52	0.001	0.19***	3.66	<0.001
Work	Dialect—Mandarin	−0.02	−0.23	0.820	−0.40***	−4.66	<0.001
	Dialect—Others	0.35***	5.34	<0.001	0.13**	3.14	0.004
	Mandarin—Others	0.37***	6.40	<0.001	0.53***	7.34	<0.001
Outside	Dialect—Mandarin	0.17	1.66	0.107	−1.67	−2.01	0.053
	Dialect—Others	0.45***	5.99	<0.001	0.26***	5.07	<0.001
	Mandarin—Others	0.28***	5.21	<0.001	0.42***	6.83	<0.001
Aggregated	Dialect—Mandarin	0.16	1.70	0.010	−0.10	−1.52	0.140
	Dialect—Others	0.44***	6.52	<0.001	0.28***	6.09	<0.001
	Mandarin – Others	0.28***	5.61	<0.001	0.38***	7.41	<0.001

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
The statistic estimates were calculated by subtracting the group mean proportion of using the second variety in a given variety contrast from that of the first variety.

at the center of the screen for 300 ms. At the beginning of each single-variety block, there were two practice trials. For the mixed-variety blocks, there were four practice trials. The procedure for the practice trials was identical to that of the study trials, except that feedback regarding correctness was provided in each practice trial.

Procedure

The study was conducted online via Gorilla (Anwyl-Irvine et al., 2020) and received the institutional review board's approval. After giving consent, participants answered a few screening questions (i.e., yes/no questions on whether the participant fit the recruiting criteria listed in the Participants section). Based on their responses, participants were either excluded from the study or directed to the version of the spoken word recognition task corresponding to their regional dialect. The instructions for the word recognition task were provided in written Chinese at the beginning of each block. Following the word recognition task, participants carried out a non-linguistic task as part of a larger project and subsequently completed the language background questionnaire. Participants received monetary compensation upon the successful completion of the study.

Results

Data cleaning

All data were cleaned and analyzed with R version 4.2.3 (R Core Team, 2023). The average accuracy of the word recognition task in the regional dialect trials was 0.98 ($SD = 0.03$) for the Cantonese group and 0.99 ($SD = 0.01$) for the Chengdu group, and the average accuracy in the Standard Mandarin trials was 0.98 ($SD = 0.02$) for the Cantonese group and 0.997 ($SD = 0.01$) for the Chengdu group. Trials with incorrect responses were removed from the analysis. We further excluded trials with reaction times outside of 2.5 standard deviations from the grand mean of the task as well as from the mean for each participant in each block type (single-variety, mixed-variety), each trial language (regional dialect, Standard Mandarin), and each trial type (switch, non-switch), resulting in 4.89% of the data in the Cantonese group and 4.00% of the data in the Chengdu group being removed from the analysis.

TABLE 4 Full reports of the fixed effects in the LMR model for the two groups' baseline performances in the two single-variety blocks.

	Standardized log RT		
	Estimate (se)	t	p
(Intercept)	−0.00 (0.08)	−0.03	0.975
LANGUAGE [regional dialect]	0.21* (0.08)	2.60	0.011
GROUP [Cantonese]	−0.24 (0.16)	−1.56	0.119
LANGUAGE : GROUP	0.24 (0.15)	1.58	0.114
Observations	3,523		
Log Likelihood	−4,165.639		
AIC	8,349.278		
BIC	8,404.782		

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.
Model structure: logRT_ct~language*group + (1+language|participant)+(1|audio_word).

Spoken word recognition task

Separate linear mixed-effects regression models (LMM) were fit to the data with the R package lmerTest (Kuznetsova et al., 2017) to analyze (i) the baseline performances in each variety, (ii) the variety-mixing costs, and (iii) the variety-switch costs of the two groups in the spoken word recognition task. The dependent variable in all models was the reaction time, measured as the time difference between the onset of the spoken word stimulus and the time when a key response was recorded. The reaction time was log-transformed and standardized for the analysis (standardized log RT). All independent variables involved in the models were categorical variables with two-level contrast. All independent variables were deviation-coded, with the values of the two levels coded as −0.5 and 0.5 respectively, so the contrast was between a given level in the variable to the overall mean of the variable. For each model, random effects were initially conditioned on participant and lexical item, including random intercepts and random slopes for all terms in the fixed effects of the model. The method of stepwise backward selection was used to remove overfitting random effects until the model converged.

The LMM for the baseline performances was fit to the data of the two single-variety blocks. The independent variables were LANGUAGE (Standard Mandarin vs. regional dialect), GROUP (Cantonese vs. Chengdu), and their interaction. The results of the fixed effects are provided in Table 4. The model found a significant main effect of LANGUAGE ($\beta = 0.21$, $t = 2.60$, $p = 0.011$), suggesting both groups were faster in the single-Standard Mandarin block ($M = -0.11$, $SE = 0.02$) than in the single-regional dialect block ($M = 0.08$, $SE = 0.02$).

Two separate LMMs were fit for the variety-mixing costs (Mixed-model A and Mixed-model B). Both compared the two groups' standardized log RT between single-variety and mixed-variety blocks. The independent variables in both models were BLOCK TYPE (single-variety vs. mixed-variety), LANGUAGE (Standard Mandarin vs. regional dialect), GROUP (Cantonese vs. Chengdu), and their interactions (pairwise and three-way). The two models differed on whether the switch trials in the mixed-variety blocks were included (Mixed-model A) or excluded (Mixed-model B). We chose to include two methods for the analysis because both have been used in bilingual studies for language-mixing effects (e.g., Grainger and Beauvillain, 1987; Declerck et al., 2019). As an exploratory study, we did not have a theoretically driven preference for one specific method over another and also would like to present the full results. The results of both models are provided in Table 5.

Mixed-model A, which included all trials, revealed a main effect of LANGUAGE ($\beta = 0.19$, $t = 3.36$, $p = 0.001$) and a three-way interaction between BLOCK TYPE, LANGUAGE, and GROUP ($\beta = -0.23$, $t = -3.17$, $p = 0.002$). The main effect of LANGUAGE suggests that participants were on average faster in Standard Mandarin trials ($M = -0.08$, $SE = 0.01$) than in regional dialect trials ($M = 0.08$, $SE = 0.02$) across blocks. The three-way interaction suggests that the effects of BLOCK TYPE were different between groups and trial languages. Follow-up models found main effects of BLOCK TYPE in Standard Mandarin trials for the Cantonese group ($\beta = 0.09$, $t = 2.62$, $p = 0.009$) and in regional dialect trials for the Chengdu group ($\beta = 0.13$, $t = 3.22$, $p = 0.002$). The results suggest that for the Cantonese group, participants were slower in mixed-variety blocks ($M = -0.18$, $SE = 0.03$) than in single-variety blocks ($M = -0.31$, $SE = 0.04$) for Standard Mandarin trials; for the Chengdu group, participants were slower in mixed-variety blocks ($M = 0.21$, $SE = 0.03$) than in single-variety blocks ($M = 0.15$, $SE = 0.03$) for Chengdu Mandarin trials, as shown in Figure 1A. The full reports of the fixed effects of the follow-up models are provided in Table 6.

Mixed-model B, which excluded the switch trial, found a main effect of LANGUAGE ($\beta = 0.18$, $t = 2.98$, $p = 0.003$), and a three-way interaction between BLOCK TYPE, LANGUAGE, and GROUP ($\beta = -0.19$, $t = -2.25$, $p = 0.025$). The main effect of LANGUAGE suggests that both groups were faster in Standard Mandarin ($M = -0.10$, $SE = 0.02$) than in regional dialects ($M = 0.06$, $SE = 0.02$) across block types in non-switch trials. The three-way interaction suggests that the magnitudes of the BLOCK TYPE effects were

TABLE 5 Full reports of the fixed effects in the LMR models for variety-mixing costs.

	Standardized log RT					
	Mixed-model A			Mixed-model B		
	Estimate (se)	*t*	*p*	Estimate (se)	*t*	*p*
(Intercept)	0.01 (0.07)	0.14	0.886	−0.01 (0.07)	−0.11	0.917
BLOCK TYPE [mix-variety]	0.04 (0.04)	1.13	0.257	0.00 (0.04)	0.06	0.954
LANGUAGE [regional dialect]	0.19*** (0.06)	3.36	0.001	0.18** (0.06)	2.98	0.003
GROUP [Cantonese]	−0.26 (0.16)	−1.70	0.090	−0.24 (0.15)	−1.63	0.104
BLOCK TYPE : LANGUAGE	−0.03 (0.04)	−0.83	0.407	−0.04 (0.05)	−0.84	0.403
BLOCK TYPE : GROUP	−0.02 (0.07)	−0.21	0.832	−0.00 (0.07)	−0.05	0.964
LANGUAGE : GROUP	0.14 (0.10)	1.38	0.168	0.15 (0.11)	1.36	0.176
BLOCK TYPE : LANGUAGE : GROUP	−0.23** (0.07)	−3.17	0.002	−0.19* (0.09)	−2.25	0.025
Observations	8,856			6,170		
Log likelihood	−10,327.380			−7,339.444		
AIC	20,686.760			14,710.890		
BIC	20,800.180			14,818.530		

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Mixed-model A compared all trials in the mixed-variety blocks to the single-variety blocks. Mixed-model B compared the non-switch trials in the mixed-variety blocks to the single-variety blocks. Both models had the same structure: logRT_ct∼block_type*language*group+(1+block_type+language| participant)+(1|audio_word).

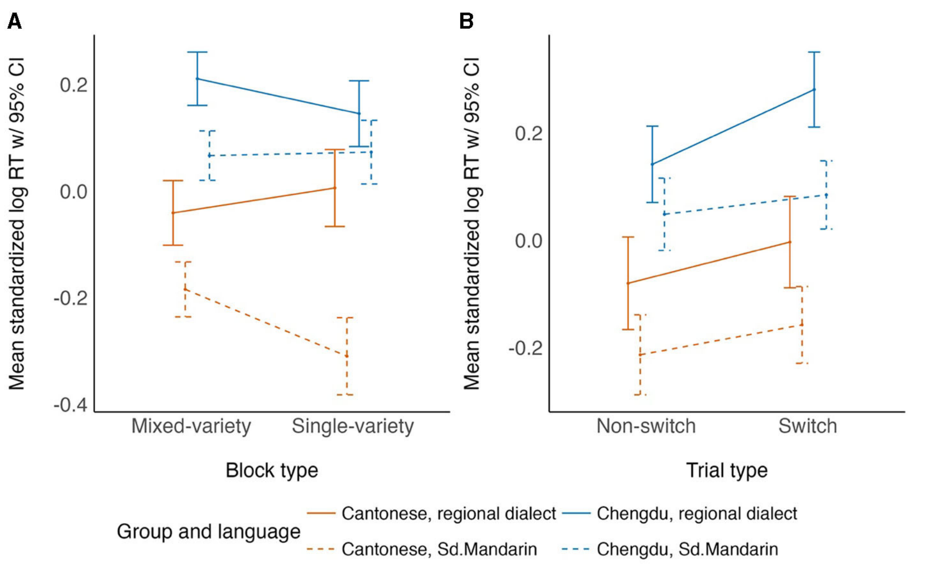

FIGURE 1
Mean standardized log RT of each group. **(A)** The average standardized log RT of each group in mixed-variety blocks and single-variety blocks, split by trial language. The mixed-single variety effect was found in Standard Mandarin trials for the Cantonese group and in regional dialect trials for the Chengdu group. **(B)** The average standardized log RT of each group in non-switch and switch trials in the mixed-variety blocks, split by trial language. Both groups were slower in switch trials than in non-switch trials, and the RT increase magnitudes were comparable between two varieties.

different in each variety between the two groups. However, follow-up models did not find any significant effects for BLOCK TYPE in either variety for each group. The full reports of the fixed effects of the follow-up models are provided in Supplementary Table S1.

The LMM for the variety-switch costs was fit to the data of the mixed-variety blocks. The independent variables were TRIAL TYPE (switch trials vs. non-switch trials), LANGUAGE (Standard Mandarin vs. regional dialect), GROUP (Cantonese vs. Chengdu), and their interactions (pairwise and three-way). The results of the fixed effects are provided in Table 7. The model found main effects for TRIAL TYPE ($\beta = -0.07$, $t = -3.20$, $p = 0.002$) and LANGUAGE ($\beta = 0.17$, $t = 2.99$, $p = 0.003$). The TRIAL TYPE effect suggests that both groups were slower in switch trials ($M = 0.05$, $SE = 0.02$) than in non-switch trials ($M = -0.02$, $SE = 0.02$) in the mixed-variety blocks, as shown in Figure 1B. The LANGUAGE effect suggests that both groups were slower in the regional dialect (M

TABLE 6 Full reports of the fixed effects in the follow-up LMR models for the three-way interaction between block type, language, and group found in the Mix-model A for variety-mixing costs.

	Log RT (standardized)			
	Cantonese regional dialect	Cantonese Sd. Mandarin	Chengdu regional dialect	Chengdu Sd. Mandarin
(Intercept)	0.02 (0.14)	−0.24* (0.12)	0.19* (0.09)	0.07 (0.09)
	$t = 0.11$	$t = -1.99$	$t = 2.18$	$t = 0.85$
	$p = 0.913$	$p = 0.047$	$p = 0.030$	$p = 0.395$
BLOCK TYPE [mix-variety]	−0.03 (0.04)	0.09** (0.04)	0.13** (0.04)	0.0 (0.03)
	$t = -0.69$	$t = 2.62$	$t = 3.22$	$t = 0.11$
	$p = 0.492$	$p = 0.009$	$p = 0.002$	$p = 0.913$
Observations	2,183	2,209	2,221	2,243
Log likelihood	−2,687.894	−2,568.495	−2,649.864	−2,547.888
AIC	5,385.787	5,146.989	5,309.727	5,105.776
BIC	5,414.229	5,175.491	5,338.256	5,134.353

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
The models shared the same structure: logRT_ct~block_type+(1|participant)+(1|audio_word).

= 0.09, SE = 0.02) than Standard Mandarin (M = −0.06, SE = 0.02) in the mixed-variety blocks. Critically, the model did not find any interactions among TRIAL TYPE, LANGUAGE, and GROUP, suggesting the magnitudes of switch costs when switching into either language variety were comparable between the two groups.

Influences of variety usage on language processing

To explore the effects of variety usage on variety switch and mixing costs, we fit linear regression models (LM) to predict individual differences in the cost magnitude by individuals' proportion of using each variety. The dependent variables were (i) the participant's standardized log RT differences between switch and non-switch trials (switch costs), (ii) the participant's standardized log RT differences between single-variety and mixed-variety blocks (mixing costs in Mixed-model A), and (iii) the participant's standardized log RT differences between single-variety blocks and the non-switch trials in the mixed-variety blocks (mixing costs in Mixed-model B).

First, to test the explanatory power of variety usage on switch costs, two separate LMs were fit to predict switch costs by the aggregated proportion of using each variety (LM1: AGGREGATED-MANDARIN; LM2: AGGREGATED-DIALECT), LANGUAGE, and their interactions. The models found a marginal interaction between the AGGREGATED-DIALECT and LANGUAGE (β = 0.36, t = 1.95, p = 0.054), suggesting the effects of AGGREGATED-DIALECT on switch costs were different between switching into the regional dialect and Standard Mandarin. Follow-up models found an effect of AGGREGATED-DIALECT on the switch cost for Standard Mandarin (β = 0.32, t = −2.52, p = 0.015), suggesting the more often participants use the regional dialect on a daily basis, the less costly it was for them to switch into Standard Mandarin, as shown in Figure 2.

TABLE 7 Full reports of the fixed effects in the LMR model for the variety-switch costs in the mixed-variety blocks.

	Standardized log RT		
	Estimate (se)	t	p
(Intercept)	0.03 (0.07)	0.37	0.712
TRIAL TYPE [non-switch]	−0.07** (0.02)	−3.20	0.002
LANGUAGE [regional dialect]	0.17** (0.06)	2.99	0.003
GROUP [Cantonese]	−0.25 (0.14)	−1.75	0.080
TRIAL TYPE : LANGUAGE	−0.03 (0.04)	−0.75	0.456
TRIAL TYPE : GROUP	0.05 (0.04)	1.17	0.244
LANGUAGE : GROUP	0.04 (0.10)	0.47	0.643
TRIAL TYPE : LANGUAGE : GROUP	0.10 (0.08)	1.24	0.217
Observations	5,333		
Log likelihood	−6,247.236		
AIC	12,526.470		
BIC	12,631.780		

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
Model structure: logRT_ct~trial_type*language*group+(1+trial_type+language|participant)+(1|audio_word).

The full reports of the follow-up models are presented in Table 8.

To further explore the effects of variety usage in each social context on switch costs, two separate LMs were fit to predict switch costs by the proportions of using each

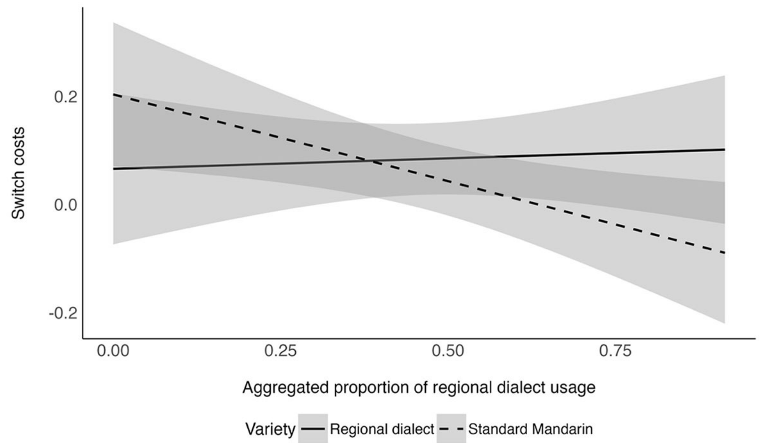

FIGURE 2
The interaction effect of aggregated-dialect and language on switch costs. The relationship between switch costs and the proportion of using regional dialect aggregated across social contexts, split by trial language variety. The aggregated proportion of regional dialect was negatively associated with switch costs when switching into Standard Mandarin.

TABLE 8 Full reports of the LMs for the interaction between aggregated-dialect and language found in the models on the effects of aggregated variety usage on switch costs.

	Switch costs					
	Switch into the regional dialect			Switch into Standard Mandarin		
	Estimate (se)	*t*	*p*	Estimate (se)	*t*	*p*
(Intercept)	0.07 (0.07)	0.94	0.350	0.20** (0.07)	3.05	0.004
AGGREGATED-DIALECT	0.04 (0.13)	0.29	0.772	−0.32* (0.13)	−2.52	0.015
Observations	62			62		
R^2	0.001			0.096		
Adjusted R^2	−0.015			0.081		
Residual std. error ($df = 60$)	0.260			0.248		
F-statistic ($df = 1; 60$)	0.085 ($p = 0.772$)			6.358** ($p = 0.015$)		

*$p < 0.05$; **$p < 0.01$; ***$p <0 .001$.
Model structure: switch_cost~dialect_prop.

variety in the three contexts (LM1: HOME-DIALECT, WORK-DIALECT, OUTSIDE-DIALECT; LM2: HOME-MANDARIN, WORK-MANDARIN, OUTSIDE-MANDARIN). None of the models revealed any significant effects.

Models with the same sets of independent variables were fit to the data to predict the two types of mixing costs. For each mixing cost, we first fit two LMs to predict mixing costs by the aggregated proportion of each variety (LM1: AGGREGATED-MANDARIN; LM2: AGGREGATED-DIALECT), LANGUAGE, and their interactions. We then fit two LMs to predict mixing costs by the proportion of each variety usage in the three contexts (LM1: HOME-DIALECT, WORK-DIALECT, OUTSIDE-DIALECT; LM2: HOME-MANDARIN, WORK-MANDARIN, OUTSIDE-MANDARIN) and their respective interactions with trial language. None of the models found any significant effects. The full reports of the models reported in this section are provided in Supplementary Tables S2–S5.

Discussion

The present study investigated bidialectal speakers' ability to switch between two language varieties in auditory comprehension, and how this ability was affected by linguistic and sociolinguistic factors. Specifically, the study aimed to assess (i) whether mixing and switching between two closely related language varieties was costly for bidialectal subjects, and (ii) if so, whether the costs were modulated by cross-variety phonological distance or (iii) habitual language usage such as language dominance and habitual variety use. To answer these questions, we conducted a spoken word recognition experiment in both single-variety and mixed-variety conditions with two groups of bidialectal speakers who varied in the phonological distance between the two varieties they spoke.

First, bidialectal speakers produced variety switch and mixing costs in auditory comprehension, as the reaction times were longer in switch trials than non-switch trials as well as longer in mixed-variety blocks than single-variety blocks. However, the observed mixing costs can be attributed to the increase in response latencies in switch trials. Second, we cannot conclude that switch or mixing costs were modulated by cross-variety phonological distance, as no between-group difference was found in switch or mixing cost magnitude. Third, variety switch and mixing costs were influenced by language dominance. At the group level, a mixing cost asymmetry was found across the two groups, as the Cantonese group produced greater mixing costs in Standard Mandarin, whereas the Chengdu group produced greater mixing costs in the regional dialect. At the individual level, switch costs were correlated with language dominance, as participants produced smaller switch costs when switching into Standard Mandarin if they used regional dialects more frequently on a daily basis. These results are discussed in detail with reference to previous bilingual studies in the remainder of this section.

The effects of variety usage

Variety switch costs

Regarding variety switch costs, we found symmetrical switch costs in bidialectal auditory comprehension. More precisely, participants of both groups responded to non-switch trials faster than switch trials in the mixed-variety blocks, and the reaction time discrepancies between switch and non-switch trials were comparable when switching into the regional dialect and Standard Mandarin. These results are in line with previous findings of symmetrical switch costs in balanced or highly proficient bilinguals (Costa and Santesteban, 2004; Costa et al., 2006; Schwieter and Sunderman, 2008) and consistent with findings from Costa et al. (2006), showing that proficiency, rather than the age of onset, was a stronger predictor of switch cost (a)symmetry. In the current study, neither group differed in the aggregated proportion of variety usage across social contexts, nor in self-reported listening proficiency between the regional dialect and Standard Mandarin. Therefore, it is reasonable to conclude that the participants were equally dominant across their two varieties. Although the Chengdu group had higher self-reported speaking proficiencies in Chengdu Mandarin than in Standard Mandarin, considering the task was comprehension-based, it is therefore not surprising that symmetrical switch costs were observed.

Nevertheless, we still observed a language dominance effect on switch costs at the individual level. More precisely, the aggregated proportion of regional dialect usage was found to be negatively associated with switch costs into Standard Mandarin. This suggests that for participants who used more regional dialects on a daily basis, they produced smaller switch costs when switching into Standard Mandarin. In other words, the more dominant participants were in one variety, their switch costs were smaller when switching into the other, less-used variety, in line with the patterns of switch cost asymmetry reported in previous studies (Jackson et al., 2004; Macizo et al., 2012; Declerck and Grainger, 2017; Hut et al., 2017; Mosca and de Bot, 2017; Olson, 2017).

Variety mixing costs

Regarding variety mixing costs, we found asymmetrical mixing costs, but the pattern was rather complex. First, BLOCK TYPE interacted with GROUP and LANGUAGE on reaction times in both Mixed-models A and B (including and excluding switch trials, respectively) but follow-up models only found the main effect of BLOCK TYPE when switch trials were included. Therefore, the observed mixing costs should be attributed to longer reaction times in the switch trials instead of the mere presence of a mixed-variety context.

Second, the mixing cost asymmetry observed in the two groups were rather non-intuitive. As discussed in the previous section, since the two groups did not differ in the overall dominance between the two varieties, we would expect symmetrical mixing costs for both groups. However, reaction times in the mixed-variety blocks were longer than those in the single-variety blocks in Standard Mandarin for the Cantonese group, but for the Chengdu group, the regional dialect blocks showed longer reaction times, suggesting that variety-mixing was more costly in Standard Mandarin for the Cantonese group but in Chengdu Mandarin for the Chengdu group. The variety-use data helped clarify these results, since the Cantonese group had a lower aggregated proportion of using the regional dialect and a higher aggregated proportion of using Standard Mandarin than the Chengdu group, suggesting that on a daily basis, the Cantonese group used more Standard Mandarin and less regional dialect than the Chengdu group across social contexts. This group-level difference was greater in the social contexts of work and outside, as both groups reported using their respective regional dialects more often than Standard Mandarin at home. Our tests regarding between-variety differences within each group also revealed that the Cantonese group used more Standard Mandarin than the regional dialect at work, and this difference was marginally significant in the context of outside. On the other hand, the Chengdu group reported comparable proportions of the two varieties in the contexts of work and outside. Therefore, it is reasonable to conjecture that the Cantonese group was relatively more dominant in Standard Mandarin, whereas the Chengdu group was more dominant in the regional dialect, and this divergence was more salient in the contexts outside of home. We further postulate that the different directions of mixing cost asymmetry observed between the two groups can be explained by this divergence in variety usage, as each group produced greater mixing costs in the respective language varieties that they used more frequently.

Our results regarding variety mixing costs are partly in line with those in Grainger and Beauvillain (1987), who also observed mixing costs only when switch trials were included in the analysis. However, Grainger and Beauvillain (1987) did not find an effect of language on mixing costs (also see Declerck et al., 2019). We have two possible explanations for the discrepancies between the results, both of which relate to the interpretation of mixing cost asymmetry as a marker for proactive inhibitory control. First, additional inhibitory control might be recruited by our participants due to the greater overlap between their language varieties (two Chinese dialects), compared to English and French, which were tested by Grainger and Beauvillain (1987). This is because cross-linguistic similarity increases cross-language interference, resulting in greater language control demand (Dijkstra et al., 2000; de Groot et al., 2002; von Studnitz and Green, 2002b; Cutler et al., 2006; Blumenfeld and Marian, 2007; Marian et al., 2008; Declerck et al., 2019). However, this explanation does not account for the lack of a group-level difference in mixing cost magnitude in the current study. The two language varieties spoken by the Chengdu group were linguistically more similar to each other than those spoken by the Cantonese. Hence, if additional inhibitory control was recruited due to cross-language interference, we would expect to find greater mixing costs in the Chengdu group than the Cantonese group, which was not supported by the data. We return to this in detail in the following sub-section.

The second explanation for the discrepancy is that additional inhibitory control might result from the potential difference in language use context between the participant groups. Although we do not have access to the language background data of Grainger and Beauvillain (1987), support for this claim may be found in the nuanced differences between the two bidialectal groups in our study. With a closer examination of our mixing cost analysis without the switch trials (Mixed-model B), we found that for the Cantonese group, the average standardized log RT was larger in non-switch trials of the mixed-variety blocks (Cantonese: $M = 0.01$, $SD = 1.09$; Standard Mandarin: $M = -0.31$, $SD = 1.09$) than in single-variety blocks (Cantonese: $M = -0.08$, $SD = 1.12$; Standard Mandarin: $M = -0.21$, $SD = 0.97$), whereas for the Chengdu group, the difference was negligible. Although none of the follow-up models excluding switch trials in the mixed-variety blocks found a significant effect for BLOCK TYPE, an interaction was indeed observed among BLOCK TYPE, LANGUAGE, and GROUP in the overall model. This suggests that the variety mixing costs were larger for the Cantonese group than for the Chengdu group when only non-switch trials in the mixed-variety blocks were compared to the single-variety blocks. Moreover, language background analysis found that the between-variety difference in usage proportion was significant in two social contexts (home and work) and marginally significant in one (outside) for the Cantonese group but was significant in only one context (home) for the Chengdu group. This suggests that the Cantonese group may have a more compartmentalized usage of the two varieties than the Chengdu group, resulting in less chance of mixing and switching between language varieties within a context. As predicted by the ACH (Green, 2011; Green and Abutalebi, 2013) and CPM (Green and Wei, 2014; Green, 2018), bilingual speakers who rarely mix languages will experience greater cognitive demands in a mixed-language context. Hence, the potentially larger mixing costs observed in the Cantonese group may be due to their lack of mixing varieties in daily communicative practices compared to the Chengdu group.

The effects of phonological similarity

With respect to our second research question, we did not find effects of cross-variety phonological similarity on switch or mixing costs in bidialectal auditory comprehension, as the two groups did not differ in the magnitudes of variety mixing or switch costs. Research on the role of linguistic similarity in receptive language mixing and switching has not reached a consensus, especially for tasks that do not explicitly promote between-language competition (e.g., Dalrymple-Alford, 1985; Bultena et al., 2015; Deibel, 2020). The task in the current study also did not promote between-language conflict. Specifically, when the participant heard the cognate stimulus in a trial, the corresponding lexical items of both varieties were activated, which in turn would have activated a single semantic representation. Therefore, as the participant was not asked to identify which language variety that the auditory stimulus was in, they may not need to inhibit the activation of the lexical item in the non-target variety (Macizo et al., 2012). Subsequently, the higher degree of co-activation of the non-target variety resulting from a closer phonological distance in the Chengdu group will not lead to greater switch or mixing costs.

It should be noted that we did consistently observe a group difference in processing speed on the task, as the Cantonese group had marginally faster reaction times than the Chengdu group (Figure 1). It is possible that the processing advantage was caused by less cross-variety inference for the Cantonese group than for the Chengdu group. However, if this were the case, we would expect to find interaction effects of group and trial type or block type, as the advantage of less cross-variety inference should also be evident in variety mixing and switch costs. Another explanation for this processing advantage aligns with the so-called bilingual advantage in cognitive control, which suggests that bilinguals have better domain-general executive controls than monolinguals because of the long-term practice of language control to inhibit the activation of the irrelevant language and resolve cross-linguistic competition (for example, see Bialystok et al., 2008). In addition, it has been reported that this bilingual cognitive advantage is modulated by linguistic distance, as bilinguals whose languages are linguistically more dissimilar exhibit greater advantage in non-linguistic executive control tasks (Perovic et al., 2022; Lu et al., 2023). Therefore, it is possible that the processing advantage of the Cantonese group found in the current study is due to better cognitive control abilities, which is caused by the long-term practice of controlling two typologically dissimilar linguistic systems than those of the Chengdu group. However, the dissociation between these two explanations is beyond the scope of the current study. In addition, the GROUP effect on the overall processing speed was only marginal in all models. Hence, we do not want to over-interpret this result.

Limitations

As mentioned in the Methods section, one critical limitation of the present study is the selection of inter-dialectal cognates as auditory stimuli. Some of the cognates are not the most common oral forms in Chengdu Mandarin or Cantonese, which may lead to a processing advantage for Standard Mandarin. We indeed observed an overall shorter reaction time in Standard Mandarin trials compared to the regional dialect trials in both groups. On the other hand, in bilingual studies, reversed processing advantage in L2 over L1 is not novel (e.g., Costa and Santesteban, 2004; Costa et al., 2006; Christoffels et al., 2007; Schwieter and Sunderman, 2008; Verhoef et al., 2009; Tarlowski et al., 2013; Mosca and de Bot, 2017). This paradoxical observation has been interpreted as bilingual speakers utilize certain mechanisms to help the process of the weaker language in a bilingual context (Meuter, 2005; Christoffels et al., 2007). Because of the possible Standard Mandarin advantage caused by the stimuli, future research is needed to test whether the reversed L1-L2 processing advantage can be replicated with bidialectal speakers.

Second, while we did not observe a modulating effect of group on switch or mixing costs, we still cannot conclude that phonological distance does not have an impact on the cognition in mixed-variety contexts. One major reason for this uncertainty comes from the potential confounding effect of variety usage. As mentioned earlier, the selection of the two groups and the design of the experiment were based on the presumption that both groups were bidialectal populations. However, the analysis of the language background survey revealed that the Cantonese group had more distinguished usage of different language varieties between social contexts, which may put them toward the diglossic end on the diglossia-bidialectalism continuum (Alrwaita et al., 2022). Unlike bidialectal communities where the use of two language varieties is mixed across contexts, diglossic communities strictly distinguish the use of two varieties between formal and informal contexts (Rowe and Grohmann, 2013; Ferguson, 2015; Alrwaita et al., 2022). According to ACH (Green, 2011; Green and Abutalebi, 2013), speakers in diglossic situations would experience the greatest cognitive demands in mixed-variety tasks because they have fewer chances of mixing or switching between varieties in daily language practice. If this is the case, the Cantonese group's processing advantage in variety mixing or switching expected from the farther phonological distance compared to the Chengdu group may be canceled out by their processing disadvantage due to the more compartmentalized usage of language varieties. However, our current research design does not allow us to disentangle these two confounding effects, and thus further study is needed.

Lastly, as the auditory stimuli for different varieties were recorded by different speakers, it was possible that after some trials, participants might be able to associate the voice of a speaker to a variety and use this information to access the language identity of the auditory stimuli in early timeframe, thus introducing a potentially confounding variable to this study. However, we do not believe this affected the validity of the results. If participants did use the information of a speaker's voice in addition to the stimuli's phonetic features to access the language identity of the stimuli, it in theory should be easier for them to switch between varieties, hence resulting in decreased or eliminated switch costs. However, we still found significant switch costs in both groups and in both varieties. Therefore, if there was not this confounding variable, the most probable difference would be an even larger switch cost across the two groups. We also do not think this limitation is avoidable. Ideally, to eliminate the effects of speakers, the items should be produced by a speaker who is completely balanced among the three varieties, which is almost impossible in practice. The alternative option is to have two bidialectal speakers, one recording the Chengdu Mandarin-Standard Mandarin stimuli, and one recording the Cantonese-Standard Mandarin stimuli. However, this will introduce another confounding variable to the group-level comparison, as participants of the two groups would listen to different Standard Mandarin tokens.

Conclusions

The current study examined bidialectal subjects' ability to mix and switch between two language varieties. The results show that, similar to bilinguals, it was also cognitively costly for bidialectal speakers to mix and switch between two closely related varieties, and the magnitudes of mixing and switch costs were influenced by both group-level and individual variances in the habitual usage of language varieties.

Data availability statement

The original contributions presented in the study are publicly available. This data can be found here: https://osf.io/dr63b/.

Ethics statement

The studies involving humans were approved by Institutional Review Board at the University of Iowa. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

WZ: Conceptualization, Writing—original draft, Writing—review & editing, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Visualization. CS: Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Writing—original draft, Writing—review & editing. JB: Funding and Writing—review & editing. EK: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Resources, Software, Supervision, Writing—original draft, Writing—review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/flang.2023.1302027/full#supplementary-material

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