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Nouns are not always processed faster than verbs in bilingual speakers: effects of language distance

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Abstract

The purpose of the current report is to study the effects of language distance on noun and verb processing in bilingual speakers. We recruited two groups of bilingual speakers: one group spoke two typologically distant languages (Cantonese and English) and the other group spoke two typologically similar languages (Mandarin and Cantonese). Participants named object and action pictures in their first language. We controlled psycholinguistic properties of words such as frequency, AoA, imageability, name agreement, visual complexity, familiarity, and participants' bilingual language experiences. Our findings revealed a significant role for language distance. We observed a difference between noun and verb processing in the similar language pair (Mandarin–Cantonese) due to interference induced by language similarity. However, in the distant language pair (Cantonese–English), the difference disappeared because of the lack of cross-language interference. Our findings support that current and future models of bilingual language processing should take into account the effects of language distance.

Introduction

Results from studies of timed picture naming across many languages support the hypothesis that objects (i.e., nouns) are processed faster than actions (i.e., verbs). This effect has been widely reproduced across a range of healthy and impaired samples (see Mätzig et al., 2009; Vigliocco et al., 2011). Several explanations have been proposed for this effect, focusing on semantic and morphosyntactic differences between each class of words. Verbs are more complex morphosyntactically, with an argument structure denoting relations between other words in a sentence, unlike nouns. Verbs are usually marked for tense, aspect, person, and number in many of the languages of the world, while nouns are generally marked only for number and gender. Nouns also have lower visual complexity (VC), as well as earlier age of acquisition (AoA) and higher name agreement (NA) in the majority of languages studied, resulting in faster lexical retrieval compared to verbs.

Most studies which support a double dissociation account come from the neuropsychological literature (Cappa & Perani, 2003). Damage to the temporal lobe generally results in an impairment to noun production while frontal lobe lesions are associated with problems in verb production. However, some reports are not consistent with these accounts (De Renzi & di Pellegrino, 1995). Previous neuroimaging studies have identified common regions in the brain for both noun and verb processing. Greater activation for verb processing has been usually attributed to the language-specific morphosyntactic properties of verbs (Momenian et al., 2016). However, studies conducted in samples of bilingual speakers reveal a mixed pattern of results due to the involvement of additional variables such as speakers' language experiences and cross-linguistic features.

The vast majority of timed picture naming studies have been conducted in samples of monolingual speakers of a few Indo-European languages. An underexplored topic is how the experience of bilingualism impacts on performance in these tasks. Substantial variability in the effects of psycholinguistic variables has been reported in the limited studies conducted in bilingual samples (e.g., Momenian et al., 2021; Ramanujan & Weekes, 2020). While language status has traditionally been classified as a categorical variable (Luk & Bialystok, 2013), current evidence supports that such labels are ecologically flawed, ignoring the multidimensionality and inherent heterogeneity of bilingual language experience (Gullifer et al., 2021). Observed variability in previous studies conducted in bilingual samples could be attributed to differences in bilingual language experience, language-specific properties, or other

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individual differences (Momenian et al., 2018; Vigliocco et al., 2011). In two recent studies, Ramanujan and Weekes (2020) and Momenian et al. (2021) showed how the properties of words could interact with the speakers' language experience. Most interesting was the observation in Momenian et al. (2021) that, in bilingual speakers, the effects of NA on naming latency were influenced by the pair of languages spoken. Specifically, variability was higher in bilingual speakers who spoke more similar languages (Mandarin–Cantonese) compared to those speaking less similar (i.e., distant) languages (Cantonese–English), further supporting that bilinguals are not a homogeneous group.

Most prior studies have focused on the effects of the first language (L1) on processing in the second language (L2). More recently, there have been reports of both behavioural and neuroimaging evidence that L1 processing and representation could be modified due to interactions with L2 (Kroll et al., 2014; Malt et al., 2015). There is an abundance of research showing that both languages of a bilingual speaker are active during lexical retrieval (Hoshino & Kroll, 2008; Jared & Kroll, 2001; Wu & Thierry, 2010). There is not, however, consensus on whether this facilitates or interferes with the processing of L1 or L2. Cognate facilitation effects have been reported in samples using both similar language pairs (Costa et al., 2000; Dijkstra et al., 1999; Lallier et al., 2013; van Hell & Dijkstra, 2002) and distant pairs (Chen et al., 2014; Hoshino & Kroll, 2008; Sumiya & Healy, 2004; Zhang et al., 2011). There are also reports of linguistic interference (Misra et al., 2012; van Heuven et al., 2011) as well as null results (Costa et al., 2006).

One limit of these previous studies stems from the almost exclusive use of nouns as linguistic stimuli, making it impossible to test whether facilitation or interference occurs similarly across grammatical categories. Li et al. (2019b) and Faroqi-Shah et al. (2021) used nouns and verbs with monolingual and bilingual speakers to investigate whether bilingual cost had a similar effect on both classes of stimuli. Bilingual speakers are normally slower than monolingual speakers in lexical retrieval which is referred to as bilingual cost. Both studies reported smaller bilingual costs during the processing of verbs, supporting that differences in lexical retrieval between bilinguals and monolinguals are smaller in verbs compared with nouns. Their explanation was that the cross-language connections between verbs create more facilitation during bilingual verb retrieval. Facilitation was also evidenced in translation speeds for verbs which were faster compared to nouns (Faroqi-Shah et al., 2021). These findings from picture naming and translation experiments in bilingual speakers were consolidated and serve as the foundation of the Bilingual Integrated Grammatical Category (BIGC) Model.

Whether language distance modulates reported cross-linguistic effects in lexical retrieval is an open question. Language distance refers to the relative (dis)similarity in script, lexical, morphosyntactic, semantic, and phonological features between two languages (Ramanujan, 2019). Languages which belong to the same family (e.g., Cantonese and Mandarin) share more similarities compared to languages which come from different families (e.g., Cantonese and English). For example, the frequency of cognate words in similar languages supports that these languages belong to the same family. This research gap has emerged, in part, because the majority of previous studies have been conducted in samples of bilinguals who were proficient in pairs of similar Indo-European languages (Degani et al., 2018). Although it is believed that both languages of a bilingual speaker are active during lexical retrieval regardless of what languages they speak, it is not clear whether language distance modulates the amount of this joint activation (Ramanujan, 2019). Furthermore, it is unknown whether language distance influences lexical retrieval, and whether the effects are the same for different grammatical classes (GC). Present findings on the influence of language distance on cognitive processes are mixed. There is some neuroimaging evidence showing an effect of language distance on the cognitive control system in bilingual speakers (Radman et al., 2021; Ramanujan, 2019). However, a meta-analysis of studies on language impairment in bilinguals with aphasia showed no effect for language distance (Kuzmina et al.,, 2019).

The purpose of the present study was to determine how language distance modulates the robust GC effect. To investigate this, we recruited two groups of bilinguals that spoke language pairs that differed in language distance. This allowed for results to be compared between speakers of two typologically similar languages (Mandarin–Cantonese) and two typologically distant languages (Cantonese–English). We also investigated whether differences in bilingual experience impacted on lexical retrieval in L1 by having participants name pictures in monolingual mode (Grosjean, 2001). Monolingual mode is a condition where bilingual speakers use one of their languages in a sustained manner while inhibiting the other language. There is no code-switching in this mode.

Two contrasting hypotheses are proposed in this study. One hypothesis is based on predictions from the BIGC model (Faroqi-Shah et al., 2021). This model predicts a boost (or lower bilingual cost) in verb retrieval due to stronger cross-language connections in verb meanings between languages. Stronger connections could result in less interference which happens due to the spreading activation of competitors (Faroqi-Shah et al., 2021). If this prediction is correct, we should observe stronger facilitation in verb retrieval in the Mandarin–Cantonese group than the Cantonese–English group because verbs in the former have more in common in terms of script, semantics, and phonology. Stronger facilitation in verb retrieval may influence the previously-reported GC effect, reducing or eliminating differences between noun and verb processing in the Mandarin–Cantonese group.

An alternative hypothesis which informs our stance in this paper is based on previous findings from our own work (Momenian et al., 2021). In an earlier study, bilinguals speaking a pair of similar languages (Mandarin–Cantonese speakers) showed more variability in the effects of psycholinguistic variables and their interaction with GC than distant-pair bilinguals (Cantonese–English speakers) suggesting they were experiencing higher levels of interference. Higher levels of cross-language interference in bilinguals using similar language pairs have previously been described in the context of visual word recognition, forming the foundation of the Bilingual Interactive Activation + (BIA+) model (Dijkstra & Van Heuven, 2002). If predictions generated from this account are correct, we should see greater interference in the similar language pair sample. This would manifest as longer reaction times (RT) in the Mandarin–Cantonese group in comparison with the Cantonese–English group when naming in L1. In terms of the GC effect, we would expect processing differences between nouns and verbs would disappear in the Cantonese–English group due to the lack of interference.

Methods

Participants

We recruited 84 participants. These participants were either Cantonese–English or Mandarin–Cantonese speakers. Participants completed an online version of the Language History Questionnaire (LHQ-3; Li et al., 2019a). Based on reported language history and usage data, the LHQ-3 computes aggregate scores for proficiency, dominance, and immersion for each language a person uses. We defined L1 as the first acquired and most commonly spoken language on a daily basis based on answers reported on the questionnaire. Participants were initially screened for language experience including the order of acquisition of each language in their spoken pair. Data from 15 participants were removed because their pattern of acquisition or language pair did not match those needed for the present study. For example, some participants reported being Cantonese–Mandarin or Mandarin–English bilingual speakers. After initial screening, we analyzed the data for 37 Mandarin–Cantonese (28 females, M_{age}: 22.52, SD: 2.76, range: 12, $M_{education}$:19.68, SD: 2.72, range: 12) and 32 Cantonese–English speakers (17 females, M_{age}: 22.34, SD: 2.34, range:14, $M_{education}$:19.34, SD: 2.34, range: 14). The participants were recruited mainly from higher education institutions. Full participant language experience details are reported in Table 1. Some Mandarin–Cantonese speakers reported experience with English as their third language, while Cantonese–English participants reported some experience with Mandarin as their third language. Among those who reported to know a third language, average scores for L3 proficiency, L3 dominance, and L3 immersion were 0.57, 0.34, and 0.60, respectively. All participants were right-handed and reported no history of neurological or cognitive disorders. Vouchers were provided in exchange for participation in the study. Ethical approval was obtained from the Human Research Ethics Committee at the University of Hong Kong. Informed consent was obtained from all participants prior to the collection of any data.

Materials

Object and action picture stimuli were taken from Druks and Masterson's Object and Action Naming Battery (OANB; (Druks & Masterson, 2000). This battery was previously normed in monolingual and bilingual speakers in both Cantonese and Mandarin (Momenian et al., 2021). The total number of items used in each group differed initially, with 144 objects and 86 actions used in the Cantonese–English group, and 145 objects and 84 actions in the Mandarin–Cantonese group. However, we removed images which did not exist in the other group, resulting in 141 objects and 77 actions in each group. Psycholinguistic properties for each item including frequency, VC, NA, imageability, familiarity, and AoA were available from our previous work (Momenian et al., 2021). Nine nouns and 0 verbs were cognates between Cantonese and English, and 90 nouns and 25 verbs were cognates between Mandarin and Cantonese. We did an ANOVA to look at the interaction between GC and cognate status in Mandarin–Cantonese bilingual speakers. Specifically, we checked whether cognate words were processed faster than non-cognate words. Results showed no interaction, plus no effect for the cognate status. Therefore, we did not include cognate status in the main analysis.

We determined cross-language connections based on two measures: NA data and a translation task. Pictures with lower NA have less robust picture-name connections and more competitors in the mental lexicon (Britt et al., 2016; Fang et al., 2016). Based on our prior study with the same set of pictures (Momenian et al., 2021), NA for nouns was 92% and 93.5% among Mandarin–Cantonese and Cantonese–English bilinguals, respectively. NA for verbs was 87.1% and 93.8% among Mandarin–Cantonese and Cantonese–English bilinguals, respectively. The results of independent samples t-test showed a significant difference only in verbs in NA. This means that verbs in Mandarin and Cantonese have more competitors (more overlap with other words) than verbs in Cantonese and English.

We also designed a translation task asking a separate group of participants (Cantonese–English and Mandarin–Cantonese bilinguals) to either translate words from Cantonese into English or from Mandarin into Cantonese. The results were consistent with what we observed in the NA analysis. The number of alternate words in the verb condition in the Mandarin–Cantonese group was higher than the Cantonese–English group. This means that there is more overlap between Mandarin and Cantonese verbs than Cantonese and English verbs.

Procedure

Timed picture naming data were collected in sound-proof rooms using a microphone. Two blocks of stimuli (objects and actions) were designed using DMDX (Forster & Forster, 2003). Items were randomized within each block and block order was counterbalanced across participants. Before each session, the input threshold level for recording was adjusted to match the natural speaking volume of each participant. Participants were familiarized with the experiment format through practice trials which they were allowed to complete as many times as needed before testing commenced. During the testing phase, participants were instructed to name pictures as quickly and accurately as possible in their L1. They were instructed not to cough, breathe loudly, move their heads, or produce starters or fillers (e.g., 'um') before or during each response. All instructions were given in the participant's L1. Trials began with the presentation of a fixation point in the centre of the screen for 500 ms. Immediately after, a single picture stimulus was presented in the centre of the screen and remained until either a response was detected, or 2000 ms had elapsed. An error was recorded by DMDX if the participant was unable to produce a response within 2000 ms. Participants' errors including production of wrong names, nontarget sounds, hesitations, and voice-key failures were all recorded for off-line analysis.

Table 1 Participants' language history (See LHQ manual for interpretation of these scores)

Group	L1 Proficiency	L2 Proficiency	L1 Dominance	L2 Dominance	L2 to L1 Dominance Ratio	L1 Immersion	L2 Immersion	MLD
Cantonese-English	0.80	0.70	0.58	0.45	0.80	0.89	.80	1.43
Mandarin-Cantonese	0.91	0.78	0.57	.46	0.84	0.93	.71	1.49

MLD: The Multilingual Language Diversity score

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Data analysis plan

Sample size and number of trials were determined based on previous recommendations to ensure sufficient statistical power (Brysbaert & Stevens, 2018). Generalized Linear Mixed Effects Modeling (GLMEM) was used to analyze the data (see Baayen et al., 2008; Lo & Andrews, 2015). GLMEM allows researchers to perform analyses using link functions instead of transforming RT data (Lo & Andrews, 2015). Gamma and Inverse Gaussian distributions have previously been shown to fit RT data well. Before modeling, collinearity among the variables was assessed using variance inflation factor (VIF). We removed any variables which had a VIF above 5 (Craney & Surles, 2002). All continuous predictors were standardized by first centering and then dividing by their standard deviations. We began fitting using a maximal model which was informed by our design (Barr et al.,, 2013; Bates et al., 2015). Missing and incorrect responses accounted for 14.62% of the total data and were not included in our analyses. We fit several models such as raw RT (DV = RT), log transformed RT, inverse RT (DV = − 1000/RT), Gamma and Inverse Gaussian distributions with identity link function, and Gamma and Inverse Gaussian distributions with inverse link function. The most appropriate distribution for our data was determined using diagnostic plots and fit indices such as AIC.

The fixed variables in our analysis included objective VC, imageability, rated AoA, log frequency, NA, number of characters, rated familiarity, their interactions with language (Mandarin vs. Cantonese) and GC, plus aggregate scores for proficiency, immersion, and dominance for both languages of the participants. We did not include measures of the third language because not all participants reported experience with a third language. For the random-effects structure of the model, random intercepts of items and subjects together with by-subject random slopes for GC, VC, AoA, log frequency, NA, and familiarity and by-item random slopes for language were added to the model.

To identify the most appropriate random effects structure, we followed the practice suggested by Bates et al., (Bates et al., 2015). We used Singular Value Decomposition (SVD) using principal component analysis (PCA) accompanied by Likelihood Ratio Tests (LRT). PCA reveals which of the random effects are not contributing substantially to the model and helps simplify the model structure. To avoid convergence problems, random effects correlation parameters were not included in the maximal model (Bates et al., 2015). However, once the most appropriate random effects structure was determined, correlation parameters were added to the model and compared with the model without correlation parameters using LRT. To find which of the variables in our model were significant predictors of RT, we used conditional F-tests because doing LRT on the fixed effects is not usually recommended (Halekoh & Højsgaard, 2014; Luke, 2017; Pinheiro & Bates, 2000). We used Kenward-Roger approximations to calculate denominator degrees of freedom which have shown more acceptable Type 1 error rates in comparison with LRT and Wald tests (Kuznetsova et al., 2017).

Results

The results of the VIF analysis showed that education and L2 dominance had high collinearity with other variables. After we removed these two variables, VIF was under 5 for all variables. Among all the distributions tested against our data, the inverse Gaussian distribution with identity link function had the best fit indicated by the lowest AIC. The removal of by-subject random effects such as word frequency $x^2(1) = 43.12$, $p < 0.001$, VC $x^2(1) = 19.96$, $p < 0.001$, familiarity $x^2(1) = 36.20$, $p < 0.001$, NA $x^2(1) = 59.42$, $p < 0.001$, AoA $x^2(1) = 15.01$, $p < 0.001$, imageability $x^2(1) = 80.51$, $p < 0.001$, and GC $x^2(3) = 135.26$, $p < 0.001$ had significant effects on the model fit. The exclusion of the by-item random effect of language pair significantly influenced the model $x^2(2) = 155.91$, $p < 0.001$. Adding the random effects correlation parameters to the model did not significantly influence the model $x^2(26) = 24.20$, $p = 0.56$, so they were not included.

The results of the significant fixed effects are presented in Table 2 with language and GC deviation coded. To investigate the main effects of GC and language pair, these categorical variables were dummy coded. The effect of GC was marginally significant ($t = 1.79$, $p = 0.07$) with objects being named faster than actions. The effect of language pair was significant ($t = 5.85$, $p < 0.001$) with naming in Mandarin by Mandarin–Cantonese speakers occurring more slowly than in Cantonese by Cantonese–English speakers. Given that there was a significant interaction between language pair and GC (see Figure 1), the main effects of language pair and GC should not be interpreted in isolation (see Figure 2 for extra interactions in the model).

Discussion

This study investigated the interaction between language distance and GC in bilingual speakers. We recruited two groups of bilingual speakers: one using typologically similar languages (Mandarin–Cantonese) and the other using typologically dissimilar languages (Cantonese–English). Our results revealed that language distance modulates the GC effect previously reported in linguistically diverse samples of monolingual speakers. We showed an effect of interference due to language similarity with higher levels of interference identified in speakers of typologically similar languages.

Our findings are more in line with the prediction that speakers of typologically similar languages could experience higher levels interference compared to those speaking typologically dissimilar languages (Chen et al., 2020; de Bot, 2004; Dijkstra & Van Heuven, 2002). In a study on Cantonese–English (typologically distant) and Mandarin–Cantonese (typologically similar) bilingual speakers, participants using similar languages showed more variability in the effects of psycholinguistic variables and their interaction with GC (Momenian et al., 2021). In the present study, this variability turned into interference. We observed higher naming latency (higher interference) in the similar pair.

We can rule out language specific properties as possible explanations for these observed effects. Both Mandarin and Cantonese belong to the same language family. They are very similar in terms of syntax, morphology, script, and semantics and the acquisition of both nouns and verbs follow the same developmental pattern in both languages (Cheung, 2005); Tardif et al.,, 1999, 2009). Unlike with English where verbs tend to be more morphologically complex than nouns, Chinese (both Mandarin and Cantonese) verbs are usually morphologically shallow. Moreover, we have controlled the effects of psycholinguistic variables that have been shown to account for the differences between nouns and verbs in previous studies. Therefore, we submit that semantic and morphological differences between languages cannot explain the present findings.

One explanation for the observation that nouns were processed faster than verbs in the Mandarin–Cantonese group could be that

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Table 2: A Summary of the best model

Fixed effects	*t* value	*Std. Error*	*p value*	*95% CI*
Intercept	147.01	8.12	0.001	1178.35, 1210.20
Imageability	−2.57	7.63	0.05	−36.61, -5.68
NA	−5.18	5.36	0.001	−38.34, −17.30
AoA	2.72	8.45	0.01	5.50, 39.63
Language	6.20	16.99	0.001	71.15, 138.76
GC: Language	−2.72	20.62	0.01	−99.01, −17.89
GC: AoA	2.15	16.46	0.05	3.17, 67.69
GC: Language: AoA	2.71	23.86	0.01	18.02, 112.57
Random effects	Variance		*SD*	
Item (Intercept)	3949.44		62.83	
Language	3135.52		55.93	
Subject (Intercept)	1845.11		42.95	
GC-Action	1388.12		37.05	
GC-Object	656.82		25.96	
NA	373.46		19.16	
AoA	299.07		17.27	
VC	188.35		13.54	
Familiarity	202.68		14.27	
Frequency	186.73		13.39	
Imageability	564.23		23.93	
Residual	0.00004		0.007	

CI: Confidence Interval calculated using the Wald method.

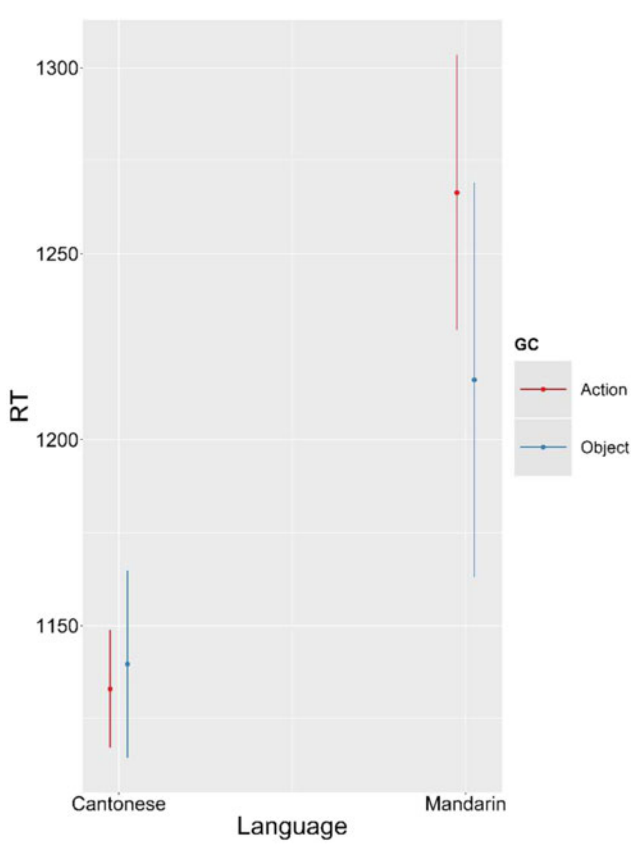

Figure 1: Interaction between language and GC

there were more cognate nouns than cognate verbs. Based on prior research mostly on alphabetic languages, cognate words are processed faster than non-cognate words. This effect is also independent of modality (Hoshino & Kroll, 2008). We did a separate analysis to see if cognate status of the words made a difference and if it interacted with GC. The results showed that cognate words were not processed faster than non-cognate words, and this was consistent across both noun and verb classes. We, therefore, contend that the GC effect in the Mandarin–Cantonese group cannot be attributed to cognate effect.

We observed higher naming latency in the language pair which had the most cognate words among the two groups. Based on previous findings from alphabetic languages, we should have observed the opposite effect. However, our findings are consistent with another picture naming study on Cantonese–Mandarin bilingual speakers (Yan, 2014). In this study, semi-cognate words were named faster than cognate words. Cognate words were words which were both phonologically and orthographically similar, while semi-cognate words were only orthographically similar and lacked the phonological component. The explanation for this finding is that tones for both languages (Cantonese and Mandarin) interfere at the sub-lexical stage of lexical retrieval creating more cognitive demand. This is absent in the typologically dissimilar pair (Cantonese–English) where there is no competition between the phonological representation of the words.

Our findings are consistent with views that claim GC cannot be the only organizing principle for representing words in the mental lexicon (Vigliocco et al., 2011). Based on these accounts, semantic, pragmatic, and distributional cues in the input could

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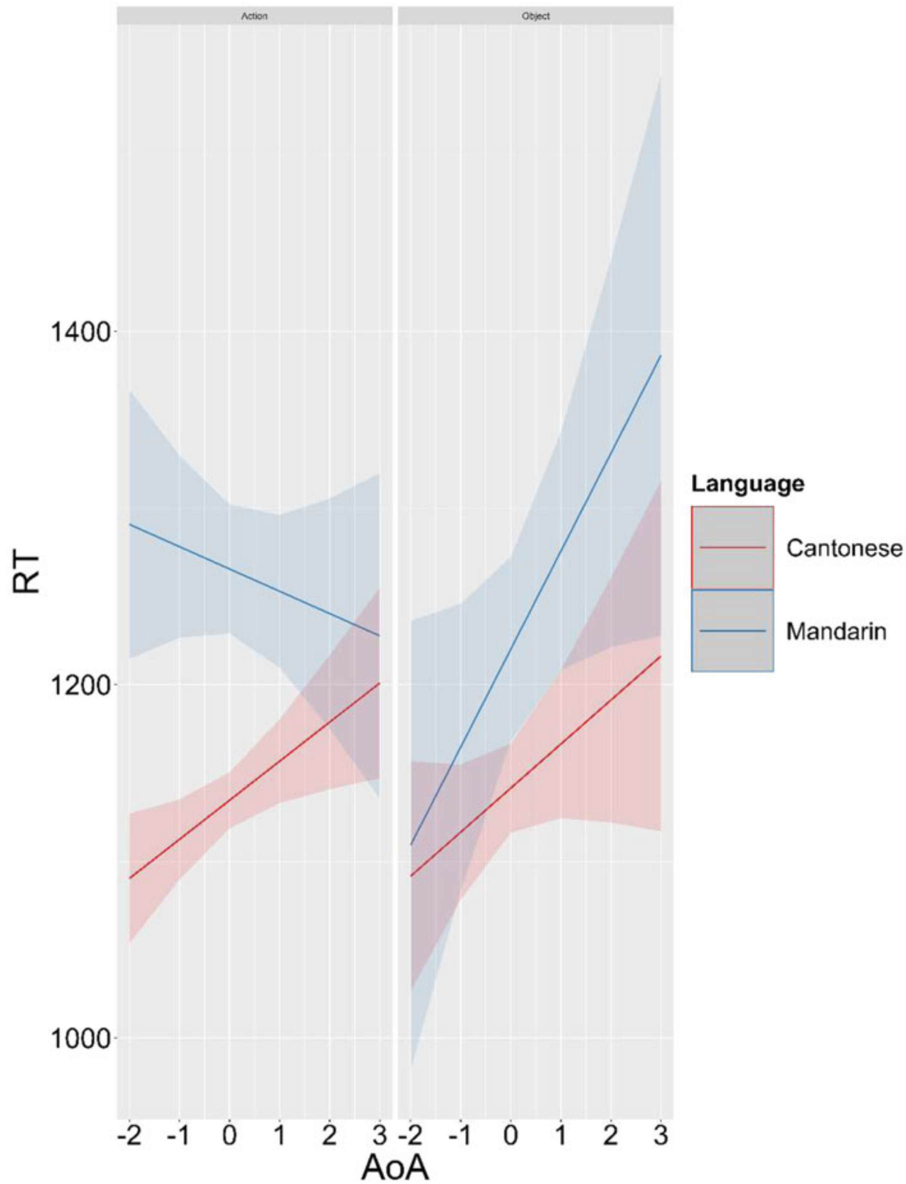

Figure 2: Language, GC and AoA interaction

be the reason behind GC effects across language. We used a picture naming task, so the pragmatic and distributional cues were not present. However, we controlled semantic variables which are supposed to be influential. We think that current and future models of bilingual language processing should consider typological properties of languages in addition to these aforementioned variables.

Bilingual speakers, including those living in similar environments, exhibit a high degree of heterogeneity in their language history and experiences. Not every speaker has the same degree of exposure to each of the languages they use. These meaningful differences in language experience are often ignored through the classification of language status as a categorical variable (Luk & Bialystok, 2013), or not even assessed at all (de Bruin, 2019; Surrain & Luk, 2017). Consequently, many previous studies prevent strong conclusions from being drawn about the influence of bilingualism on cognitive function (Dash et al., 2022). In direct response to these previous methodological issues, we assessed and controlled for differences in language proficiency, immersion, and dominance for each language used. For this reason, observed findings are unlikely to be attributed to differences in speakers' bilingual experience beyond the combination of languages used.

We think language distance plays a key role in the interpretation of our findings. Interest in the underexplored influence of language distance on cognition has recently increased (Antoniou, 2019; Carthery-Goulart et al., 2023). In bilingual speakers using similar language pairs, the semantic and phonological similarities of languages may generate considerable spreading activation across the languages resulting in more competition among the words in the bilingual mental lexicon. This is in line with the cross-linguistic interference hypothesis (Green, 1998). This competition is higher in verb retrieval in the similar language pairs because there is more overlap in verb meanings. The spreading activation and overlap was higher only in verbs in the Mandarin–Cantonese group based on name agreement and translations task results.

Our findings are partially in line with the BIGC Model. This model claims a lower bilingual cost for verbs in comparison with nouns. Results observed in the Cantonese–English group are consistent with this model in that the boost in verb retrieval

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diminished the processing difference between noun and verb retrieval. The lower degree of overlap among verb meanings (see Li et al., 2004; Prior et al., 2007) in Cantonese and English creates less interference when other psycholinguistic variables are controlled. No matter how similar or distant the languages are, the meanings of nouns are usually shared among languages. An apple, for example, has the same semantic features in Mandarin, Cantonese, and English. But when it comes to verb meanings, there are differences. For instance, In English we play violin, flute, and piano, but in Chinese (Mandarin and Cantonese) we literally pull violin, blow flute, and pluck piano with our fingers.

On the other hand, the findings from the Mandarin–Cantonese group are not in alignment with the BIGC Model. According to the BIGC model, we should have witnessed a boost in verb retrieval since Mandarin and Cantonese share a lot in their verb meanings. However, we observed higher naming latency for verb retrieval in comparison with noun retrieval. This finding aligns with predictions from the BIA+ (Dijkstra & Van Heuven, 2002) demonstrating how cross-language connections in phonological and semantic features in Mandarin and Cantonese led to more interference in the lexical access process even in the native language. This is also in line with previous fMRI studies where language distance modulated the cognitive control system in bilingual speakers (Ramanujan, 2019).

We think the language history of bilingual speakers is crucial in interpreting the results. Our participants were slightly more proficient and dominant in their L1, but in general they had equal immersion in both languages. The language history of the participants shows that they were balanced bilingual speakers. Models such as the Revised Hierarchical Model posit that once bilingual speakers become more proficient in their L2, they become less sensitive to the meanings of words in the first language (Kroll et al., 2010). Our data show that highly proficient bilingual speakers are still sensitive to the semantic features in the first language no matter whether the languages are typologically similar or not. We observed that L1 naming was influenced by cross-language connections from L2. It was language similarity which determined whether we observed interference or facilitation.

It is possible that AoA is contributing to the finding observed in the similar language pair group. Unlike the distant language pairs, verbs which are learned later are processed faster than earlier acquired verbs. This finding is consistent with other reports in Mandarin speakers (Li et al., 2017; Lou et al., 2019). The question is why AoA has opposite effects in Mandarin and Cantonese verb retrieval. There is the possibility that the developmental pattern for learning verbs differs between Mandarin and Cantonese speaking children. This explanation should be considered speculative due to our absence of data.

Our findings show that cross-language similarity creates interference instead of facilitation. This is in line with models of bilingual language processing where cross-language spreading activation and competition is common (Abutalebi & Green, 2008; Green, 1998). Our data show for the first time that when languages are similar (Mandarin–Cantonese), interference is the mechanism involved in bilingual lexical retrieval. However, in the absence of language similarity such as in Cantonese–English speakers where there is not much connection between words, interference is not strong. We think models of bilingual language processing including the BIGC model should consider cross-linguistic findings, particularly language similarity.

Background characteristics of our sample should be considered when interpreting the findings of the present study. First, participants differed not only in their language pair but in their L1 (i.e., Cantonese or Mandarin). These differences were primarily a result of the linguistic environment in which the study was conducted (Hong Kong). Future studies could be conducted on groups with the same L1, but different L2s to shed more light on how this could change the results. Additionally, some participants had experience with a third language. However, we made sure the two languages we studied in a pair were the most dominant ones which our participants had the most exposure to. Additional research is needed using samples speaking different language pairs, particularly languages which will allow researchers to test effects of language similarity at different levels such as script, phonology, and semantics.

We made the decision to study Mandarin–Cantonese and Cantonese–English bilingual speakers because Mandarin and Cantonese are similar at many levels such as syntax, morphology, semantics, script, and phonology. For this reason, differences observed between noun and verb naming in each of these languages are likely not the result of language properties. Moreover, in the analysis we controlled for effects of psycholinguistic variables such as AoA, frequency, imageability, NA, familiarity, number of characters, and VC. In addition to language-specific and psycholinguistic properties, we took into account participants' language experience such as the level of proficiency, immersion, and dominance in both L1 and L2. By including these psycholinguistic and language history variables in our analyses, we think any observed differences between bilingual samples in this study can likely be attributed to differences in language distance.

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Data Availability Statement. Both the RT data and R codes used to analyze the data are available online at the following link (https://osf.io/r7knb/). None of the experiments was preregistered.

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