Two languages, one mind: the effects of language learning on motion event processing in early Cantonese-English bilinguals

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Abstract

Can learning a second language (L2) redirect what we perceive to be similar events? This study investigated how Cantonese-English bilinguals categorized and processed spontaneous motion when the access to language ranged from maximal to minimal. In Experiment 1, participants verbalized the target events in either Cantonese or English right before making their similarity judgements. Results suggested that bilinguals patterned with English monolinguals in both lexicalization and conceptualization irrespective of the language of operation. In Experiment 2, participants experienced verbal interference while making their decisions. Results showed that bilinguals followed an English-like way in event conceptualization as indicated by their processing efficiency of manner and path. However, no cross-linguistic differences were found in speakers' categorical preferences. The overall findings suggest that subtle typological differences between the L1 and L2 can restructure bilinguals' cognitive behaviour. And the magnitude of such impact is modulated by different degrees of language involvement.

Keywords: cognitive restructuring, spontaneous motion, processing efficiency, language contexts, linguistic relativity

Introduction

Does the language we speak influence the way we think? This age-old question has generated extensive debates among linguists, philosophers, anthropologists, and psycholinguists. The study of how language influences thought, also known as linguistic relativity (Whorf, 1956), has recently received renewed interests as a number of new research paradigms have evolved that allow addressing the connection between language and thought empirically.

Experimental evidence shows that language can exert both temporary and immediate (Athanasopoulos, Bylund, et al., 2015; Montero-Melis, Jaeger, & Bylund, 2016; Papafragou, Hulbert, & Trueswell, 2008), or habitual and durable effects (Lupyan, 2012; Thierry et al., 2009; Winawer et al., 2007) on various cognitive processes, such as perception, recognition, visual discrimination and categorization, in a flexible and context-dependent manner. For example, cross-linguistic differences in colour terms can cause differences in colour categorization, indicating that language effects are profound in the sense of affecting even basic visual perceptions (Lupyan, 2012). However, such linguistic relativity effects are venerable to short-term manipulations, such as linguistic priming (Montero-Melis et al., 2016), the language of operation (Athanasopoulos, Bylund et al., 2015), and verbal interference (Trueswell & Papafragou, 2010).

These mixed findings of how language affects cognition have motivated researchers to explore further when and under what conditions, the language effects are mostly likely to be found (see Bylund & Athanasopoulos, 2014, for a detailed review). Empirical evidence has suggested that the degree to which language affects cognition is modulated by different contextual factors, such as the conceptual domains under investigation, nature of the stimuli, and experimental set-ups that promote or inhibit the access to language (Bylund & Athanasopoulos, 2014; Lupyan, 2012; Montero-Melis & Bylund, 2017; Papafragou & Selimis, 2010; Wolff & Holmes, 2011). Studies show that effects of language on cognition are most likely to appear when participants are encouraged to use language strategically during thinking, or solve a subsequent cognitive task. This process, termed thinking-for-speaking (Slobin, 1996), emphasizes that language affects online thinking when speakers are actively engaged in language-driven activities. There is converging evidence that the effect of thinking-for-speaking is language-specific (Filipović, 2018; Flecken, Carroll, Weimar, & Von Stutterheim, 2015; Gennari, Sloman, Malt, & Fitch, 2002; Papafragou, Hulbert, & Trueswell, 2008), especially when the task does not prevent the use of verbal recourses during task performance (Athanasopoulos, Bylund, et al., 2015; Trueswell & Papafragou, 2010). However, less agreement has been reached on how language affects cognition beyond overt verbalization and when the access to language is interrupted by verbal interference (Athanasopoulos & Bylund, 2013; Flecken, Athanasopoulos, Kuipers, & Thierry, 2015; Ji & Hohenstein, 2018; Papafragou, Massey, & Gleitman, 2002).

Research on the effect of language on thinking starts with monolinguals of typologically different languages, although recent studies have extended the domain of interest to bilinguals and various types of L2 learners (Athanasopoulos, Damjanovic, Burnand, & Bylund, 2015; Bylund & Athanasopoulos, 2015; Cook & Bassetti, 2011). Extending the language-and-thought research to the domain of bilingualism provides researchers with a unique opportunity to explore how different languages reconcile with each other in the learner's mind. Empirical evidence has demonstrated that learning a new language may bring about changes of speakers' entire cognitive outlook, a process called cognitive restructuring (Jarvis & Pavlenko, 2008; Pavlenko, 2011).

With respect to different stages in cognitive restructuring, some studies have suggested that L2 learners may continue drawing on their L1-based patterns for thinking and speaking during L2 learning (Filipović, 2018; Flecken et al., 2015). However, other studies report that learners can successfully internalize the L2-based concepts and restructure the already-established patterns towards the target language (Athanasopoulos et al., 2015; Montero-Melis et al., 2016; Wang & Li, 2019). In fact, the degree of cognitive restructuring is modulated by various extra-linguistic factors, such as age of acquisition (Bylund, 2009; Vanek & Selinker, 2017), language proficiency (Park & Ziegler, 2014), task types (implicit or explicit measures), and the involvement of language during task performance (Athanasopoulos et al., 2015; Gennari et al., 2002).

To better understand how language affects thought, motion events serve as a suitable testing ground as world languages exhibit great diversities in how motion is lexically encoded. Talmy (2000) divided world languages into two distinct categories: satellite-framed (S-languages) and verb-framed languages (V-languages), depending on the semantic distribution of path of motion. S-languages, such as German and English, typically encode path in the satellite (particles) whereas manner in the verb root, as shown in example (1):

    1) He walked [Manner] across [Path] the street.
However, in V-languages, such as French and Japanese, path is lexicalized in the main verb, leaving manner not expressed (by default) or via peripheral devices.

    2) Il traverse [Path] la rue.
        'He crossed the street.'

Talmy's typology has been widely applied in analyzing the Indo-European languages, but cannot fit perfectly well for serial-verb languages and other Sino-Tibetan languages, such as Chinese and Thai where path and manner are encoded in compound verb forms. Cantonese, widely spoken in Hong Kong and Guangdong Province in China, is a serial-verb language (Matthews & Yip, 2011). In Cantonese, the serial-verb construction normally takes up two or more semantic components, and each of them can stand alone as an independent element. In the examples below, 翻 (return) and 入 (enter) are path of motion and can be encoded either with the manner verb 跑 (run) in (3), or as independent verbs in (4) and (5). Therefore, Cantonese is regarded as an equipollent-framed language that "both manner and path are expressed by equipollent elements, that is, elements that are equal in formal linguistic terms, and appear to be equal in force or significance" (Slobin, 2004, p. 226).

    3) 個男仔　跑　咗　翻　　入　　辦公室
        A boy　　run ASP return enter office
        'S/he run back into the office.'
    4) 個男仔　翻　　咗　　　辦公室
        A boy　　return ASP　　office
        'A boy returned the office.'
    5) 個男仔　入　　咗　　　辦公室
        A boy　　enter ASP　　　office
        'A boy entered the office.'

Given the cross-linguistic differences, it is important to ask whether different ways of talking about motion affects how motion is presented in cognition. According to the manner salience hypothesis (Slobin, 2004), the cognitive salience of manner is closely related to its codability in lexicalization. This view is well-supported by Cognitive Grammar that speakers may have an easy access to the constructions highlighted by grammar when perceiving and retrieving relevant information from memory (Langacker, 2008). Under this view, English is a high-manner-salience language where manner is encoded with high frequency via prominent verb forms, whereas path is encoded via the satellite. Although Cantonese encodes both manner and path in compound verbs, the availability of path verbs in Cantonese makes manner to be more easily added or dropped in speech. Thus, it is reasonable to hypothesize that given these typological differences, speakers of Cantonese and English may construe the same event in conceptually different ways (Wang & Li, 2019; 2021).

So far, the language-and-thought research mainly focus on late bilinguals or L2 learners with contrastive language pairs (satellite- vs verb-framed), while very little is known about how early bilinguals with partial overlapping linguistic systems lexicalize and conceptualize motion events from a lexical perspective of manner versus path. Second, recent studies show that L2 learners can flexibly switch between different thinking patterns depending on which language they are using (Athanasopoulos et al., 2015; Montero-Melis, Jaeger, & Bylund, 2016). However, the magnitude of L2 influence on cognitive processing remains largely unexplored (Vanek, 2020).

Given this, the current study addresses this lacuna by examining how Cantonese-English bilinguals gauge and process motion similarity when the degree of language involvement is manipulated during decision-making. This will allow a direct comparison across tasks where the linguistic involvement ranges from minimal to maximal (Vanek, 2020). The aim of this study is to test whether subtle typological differences between the L1 and the L2 can redirect bilinguals' cognitive behaviour, and if yes, under what conditions such effects are the most prominent. Two types of measurements are used: an explicit measurement of event categorization (i.e., decision strategies) and an implicit measurement of processing efficiency (i.e., reaction time). To this end, we have conducted two experiments: Experiment 1 manipulated a Cantonese and an English language context where the L1- or L2-based labels were explicitly elicited right prior to the similarity judgement. If different languages are linked to different thinking patterns, bilinguals' cognitive behaviours tend to vary according to the language of operation. Experiment 2 put all participants under verbal interference throughout the similarity judgement. If the same cross-linguistic patterns persist, we can conclude that the effect of language on cognition is robust and not mediated by the online recruitment of language during task performance.

Experiment 1: similarity judgments in Cantonese and English context

Method

Participants

Altogether 120 university students were recruited for the study. Monolinguals of Cantonese (Mage=22.1, SD=2.1) and English (Mage=23.7, SD=1.9) (N=30 for each) came from local universities of Guangdong Province, China and London, UK. 60 Cantonese-English bilinguals (Mage=21.7, SD=2.7) came from Hong Kong where both Cantonese and English are the official languages. According to the language education policy in Hong Kong, children are encouraged to start English learning early at an average age of three years old (Mage=3.7, SD=1.5). This learning continues throughout their school years and many attend English-medium schools. In line with previous studies (Athanasopoulos, Damjanovic, et al., 2015; Park & Ziegler, 2014), participants self-evaluated their English proficiency based on a seven-point scale where 7 is the maximum rating. As indicated by the score, bilinguals achieved an advanced proficiency in English (M=6.31; SD=0.73).

Materials

Two tasks were used in Experiment 1: the linguistic encoding and non-linguistic similarity judgment task. The linguistic encoding task showed 54 dynamic stimuli of voluntary motion with 36 test items and 18 control items. Each animation was 6 seconds long. Following Hickmann and Hendriks (2010), the test items depicted a boy performing voluntary motion with various types of manner and path, while the control items minimized path but highlighted manner of motion only. The control items were designed to distract participants from using the same lexicalization patterns and to test whether bilinguals have mastered the specific vocabulary to describe different types of manner in the target language. For test items, a diverse range of manners were included, such as manner with (walk, run, jump, crawl, march) and without instruments (cycling, skating, surfing), combined with six different path types falling into two broad categories: trajectory events (up, down, away from, towards), and events with boundary-crossing (into, cross).

The non-linguistic similarity judgement task consisted of 18 sets of stimuli, with12 sets of test triads and 6 filler items. The stimuli used in these two tasks shared the same content. This was to make sure that participants had verbalized all the items in the target language (Cantonese or English) before making their decisions. Each triad contained three events: the target event (e.g., A boy jumps out of a room) and two alternating events with manner and path as the contrast of interest. For manner-match alternate, it shared the same manner with the target event but different path (e.g., A boy jumps into a room). On the contrary, for path-match alternate, it shared the same path with the target but differed in manner (e.g., A boy runs out of a room).

Procedure

In the linguistic encoding, participants were instructed to watch the stimuli first and describe "what happened" in each video right after the viewing. Monolinguals narrated in their respective L1s. Bilinguals were randomly assigned to one of the two conditions: a Cantonese-speaking context and an English-speaking context (N=30 for each) where Cantonese or English was the target language for verbalization.

Following other well-established studies (e.g., Filipović, 2018; Gennari et al., 2002; Montero-Melis et al. 2016; Papafragou & Selimis, 2010; Vanek, 2020), participants were instructed to move on to a similarity judgement task immediately after their linguistic descriptions. This was to maximally boost the involvement of language in their decision-making process. In the similarity judgement, participants were informed that the stimuli were presented in a synchronized order where the target event played first at the bottom of the screen. Then the target disappeared right after its completion, followed by two alternating events playing side by side at the top of the screen. A half-second black screen was placed between the target and its two alternates within each triad and a one-second black screen was placed between triads. The presentation order of each triad was counterbalanced across participants. The location of manner- and path-match variant on the screen (right-or left-side) was counterbalanced in a fixed order. Participants needed to decide which variant is more similar to the target by pressing A and L respectively on the keyboard. Participants were asked to make their decisions as quickly as possible as their reaction time would be automatically recorded.

Data analysis

The linguistic data was transcribed by L1 Cantonese and English speakers. Only test items were included for the analysis. The linguistic data was segmented into clauses and coded in terms of 1) the frequency of manner and path encoding, and 2) the semantic distribution of manner and path within each utterance. Participants' categorical preference in similarity judgements was coded as a binary dependent variable, where '0' and '1' represented a manner-and path-match preference, respectively. Participants' reaction time in their decision-making was calculated from the onset of the alternate videos till the point when participants made their decisions. Theoretically, the longest RT to each triad is 6 seconds (the same length of the video clip). Outliers of extremely long and short values were trimmed with plus and minus two standard deviations (SD) from the mean. After the trimming, 70 outliers out of 1,440 items (4.9%) were replaced by two SDs from the mean in Experiment 1, and 56 outliers out of 1,440 items (3.9%) were replaced in Experiment 2.

Results and discussion

A total of 4,320 linguistic descriptions were included in the analysis. To assess whether the likelihood of manner or path encoding differed significantly as a function of participant groups, we built two separate logistic mixed effect models by the package *lme4* (Bates et al., 2014) in the R environment (R development team, 2020). Within each model, the respective

binary dependent variable was the presence (code=1) or absence (code=0) of manner and path. Each model included participant group (four levels) as a dummy coded fixed effect, and the random effects were random intercepts for subject and item. To assess the validity of the models, likelihood ratio tests were performed using the *anova* ( ) function to compare models with fixed effects to models with random effects only (null model).

For path encoding, results showed that the inclusion of participant group did not significantly improve the model fit compared to the null model (χ^2(3) =2.69, p=0.441), suggesting that language group was not a main effect. In fact, participants of each group reached a ceiling level in path encoding (Cantonese: M = 95.65%, SD =4.71%; bilinguals in a Cantonese context: M = 95.00%, SD = 5.85%; bilinguals in an English context: M = 95.89%, SD = 5.18%; English: M = 94.88%, SD = 5.67%), indicating that path is the most central element in motion. In contrast, for manner encoding, the likelihood ratio test showed that including language group as the fixed effect significantly improved the model fit, confirming that language group was a significant predictor (χ^2(3) =102.8, p<.001). Results showed that bilinguals in a Cantonese context (M=96.01; SD=4.98) encoded manner more frequently than Cantonese monolinguals (M=77.59; SD=8.93) (β_0 =3.39, SE = 0.40, Wald z=8.48, p < .001), yet patterned with bilinguals in an English context (M=97.13; SD=3.38) (β_0 =-0. 39, SE = 0.42, Wald z=-0.94, p=0.387) and English monolinguals (M=98.05; SD=3.43) (β_0 = -0.99, SE = 0.45, Wald z=-2.20, p=0.08). The results showed that bilinguals underwent a cognitive shift towards English-based patterns in lexicalization irrespective of the language in use, as shown in Figure 1.
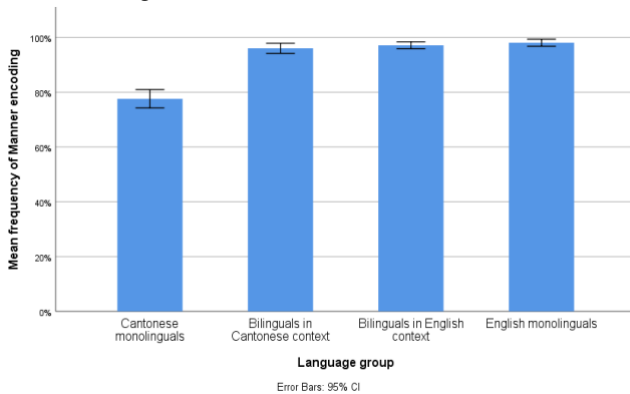

Figure 1: Mean frequency of manner encoding as a function of language groups

To further investigate whether participants made their similarity judgements based on the criteria, the proportion of manner-match preferences was compared across language groups (Cantonese: M=46.67%, SD=30.76%; Bilinguals in a Cantonese context: M=62.78%, SD=19.78%; Bilinguals in an English context: M=70.56%, SD=25.40%; English: M=68.89%, SD=19.44%), as shown in Figure 2. A logistic mixed effects model was built with participants' categorical preference (0 or 1) as the binary dependent variable. The

fixed effect (dummy coded) was language group. The random effects were random intercepts for subject and item. The likelihood ratio test confirmed that including language group as a fixed effect significantly improved the model fit compared with the null model (χ^2(3) =16.689, p<.001), indicating that group was a main predictor. Results showed that bilinguals in a Cantonese context chose manner more frequently than Cantonese monolinguals (β_0 =0.87, SE = 0.34, Wald z=2.58, p=0.009), yet patterned with bilinguals in an English context (β_0=-0.43, SE= 0.34, Wald z=-1.27, p=0.611) and English monolinguals (β_0=-0.31, SE =0.34, Wald z=-0.92, p=0.717), indicating a cognitive shift towards English-based patterns in event perception regardless of the language in use.
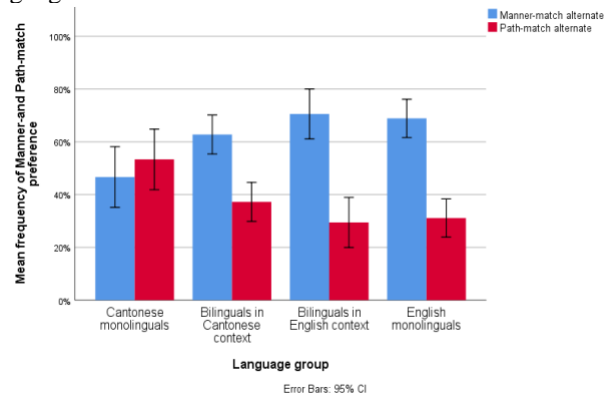

Figure 2: Mean frequency of Manner-and Path-match preference as a function of language groups

In addition to the categorical choices, participants' mean RT to manner-or path-match variant was measured for the processing efficiency in their decision-making (Table 1).

Table 1: Mean RT to manner-and path-math alternate as a function of language groups

Group	Mean RT to Manner	Mean RT to Path
Cantonese	2210 (694)	2232 (752)
Bilinguals in Cantonese	2098 (677)	2383 (841)
Bilinguals in English	2004 (689)	2334 (723)
English	2163 (671)	2482 (919)

A mixed effect model was built with log-transformed RT as the dependent variable. The fixed effects (dummy coded) were participant groups (four levels), preference types (two levels: manner- or path-match) and their interaction. For random effects, we had crossed random intercepts for subject and item. This model was determined by likelihood ratio tests and the current model with the maximal structure had the lowest AIC value. Collinearity was not an issue for this model as the VIF for each predictor was below 1.02. Results suggested that both preference type and its interaction with group were statistically significant, as shown in Table 2.

Table 2: Fixed effects of the RT as a function of language groups and preference types

Fixed effects	Estimate	SE	t value	Pr(>t)
Intercept	7.71	0.04	183.0	<.001***
Preference type	-0.12	0.03	-3.51	<.001***
Language group				
Bilinguals in English	-0.03	0.06	-0.44	0.663
Cantonese	-0.07	0.05	-1.12	0.009**
English	0.02	0.06	0.25	0.804
Preference* Language group				
Manner*Bilinguals English	-0.01	-0.04	-0.38	0.700
Manner* Cantonese	0.12	0.05	2.43	0.045*
Manner* English	0.02	0.05	0.48	0.271

Note: The baseline for comparison is Path preference for types and bilinguals in a Cantonese context for language groups.

The significant interaction suggested that participants of each group exhibited different patterns in their processing efficiency to manner- or path-match variant. To further address this within-group difference, three separate mixed effect models were built with log-transformed RT as the dependent variable and preference type as the fixed effect. The results showed that Cantonese monolinguals reacted equally quickly when making manner- or path-match decisions (β_0 = 0.03, SE = 0.04, t =0.9, p=0.369). However, bilinguals patterned with English monolinguals (β_0 = -0.09, SE = 0.04, t =-2.61, p =.009) in making manner-match decisions significantly faster than path-match decisions, regardless of the language context (Cantonese context: β_0= -0.10, SE = 0.03, t =-3.15, p =.001; English context: β_0= -0.14, SE=0.04, t =-3.66, p < .001), indicating a cognitive shift towards English-based patterns in event processing regardless of the language in use.

Experiment 2: similarity judgments under verbal interference

Method

Participants
Participants were recruited from the same student population in Experiment 1 and divided into three groups: monolinguals for Cantonese and English (N=30 each) and Cantonese-English bilinguals (N=60). To avoid a potential task effect, the order of these two experiments was counterbalanced across participants and there was a one-week gap in between.

Materials and procedure
Experiment 2 shared the same materials and procedure with Experiment 1, except for the dual task methodology. Following Athanasopoulos and Bylund (2013) and Trueswell and Papafragou (2010), participants of each group were asked to repeat out loud a string of two-digit random numbers in their L1 while performing a non-linguistic categorization task. This number-shadowing was to prevent the participants from subconscious verbalization or verbal rehearsal during their cognitive processing (Baddeley, 2003).

Results and discussion

Following the analysis conducted in Experiment 1, we built a logistic mixed effect model with participants' categorical preference as a binary dependent variable and participant group as the fixed effect. Involving participant group as a fixed effect didn't significantly optimize the model (χ^2(2) =4.34, p=0.11), indicating that participants of each group exhibited a similar pattern in categorization (Manner-match preference: Cantonese: M=44.44%, SD=20.91%; Bilinguals: M=47.92%,SD=34.26%; English: M=34.44%, SD=30.92%). However, the RT to manner- and path-match variant exhibited language-specific patterns, as shown in Table 3.

Table 3: Mean RT to manner-and path-math alternate as a function of language groups

Group	Mean RT to Manner	Mean RT to Path
Cantonese	2293 (760)	2374 (908)
English	2024 (682)	2428 (835)
Bilinguals	2348 (556)	2542 (821)

A mixed effect model was built with log-transformed RT as the dependent variable. The fixed effects (dummy coded) were participant groups (three levels), preference types (two levels: manner- or path-match) and their interaction. Results showed that both preference type and its interaction with group were statistically significant, as shown in Table 4.

Table 4: Fixed effects of the RT as a function of language groups and preference types

Fixed effects	Estimate	SE	t value	Pr(>t)
Intercept	7.79	0.02	316.14	<.001***
Preference type	-0.07	0.03	-2.63	.008**
Language group				
Cantonese	-0.10	0.03	-3.57	<.001***
English	-0.05	0.03	-1.93	0.053
Preference* Language group				
Manner* Cantonese	0.08	0.04	1.93	0.050*
Manner* English	-0.10	0.04	-2.25	0.024*

Note: The baseline for comparison is Path preference for preference types and bilinguals for language groups.

To further address the within-group difference, three separate mixed effect models were built with log-transformed RT as the dependent variable and preference type as the fixed effect. Results confirmed that Cantonese monolinguals reacted equally quickly in making manner and path decisions, while bilinguals (β_0= -0.11, SE = 0.03, t =-4.49, p <.001) patterned with English monolinguals in making manner decisions significantly quicker than path decisions (β_0 = -0.14, SE = 0.03, t =-3.55, p <.001), indicating a cognitive shift towards English-based patterns in event processing even when the access to language was blocked in the decision-making process.

General discussion
The current study examines how Cantonese-English bilinguals gauge and process motion similarity when the degree of language involvement varies from minimal to maximal during cognitive processing. Results from

Experiment 1 showed that bilinguals differed from Cantonese yet patterned with English monolinguals in both the linguistic encoding and cognitive processing irrespective of the language of operation, indicating that bilinguals underwent a cognitive shift towards English-based patterns. For the linguistic encoding, the Cantonese and English data matched with the typological patterns described in the introduction. That is, speakers of English (M=98.05; SD=3.43) encoded manner more frequently than Cantonese (M=77.59; SD=8.93). Consequently, in the similarity judgement, English speakers (M=70.56%, SD=25.40%) preferred manner-match alternates more than their Cantonese counterparts (M=46.67%, SD=30.76%). The current findings align with the manner salience hypothesis that manner saliency in cognition is closely correlated with its codabiltiy in lexicalization (Slobin, 2004). In the current case, manner in English is compulsory in most cases (Talmy, 2000), while Cantonese uses both manner-path compounds and path verbs frequently in speech. The frequent omission of manner in Cantonese may reduce its cognitive salience in mental representations. As a result, Cantonese speakers may not attach an equal amount of attention to manner in the similarity judgements compared with English.

For bilingual speakers, as Cantonese allows the use of both manner-path compounds and path verbs, while English only allows the former, it would be more efficient for bilinguals to converge to a single lexicalization pattern compatible for both languages. In the current study, the bilinguals were recruited from Hong Kong where both Cantonese and English are official languages. Speakers normally pick up their L2 at a very early age and use both languages interchangeably at school and in daily interactions. As a consequence, the active use of Cantonese and English may facilitate a convergence of L1 and L2 categories to a unitary one (e.g., L2-based), which is not easily affected by short-term manipulations (Wang & Li, 2019).

The RT measurements further showed differences across monolinguals and bilinguals in terms of the processing efficiency. Cantonese monolinguals had similar RTs for both manner-and path-match variants, while bilinguals patterned with English in making quicker manner decisions than path decisions regardless of the language context. The cross-linguistic difference in RTs can be linked to the semantic distribution of manner and path in each language. English encodes manner in the main verb whereas path in the satellite (i.e., manner prominence), while Cantonese encodes both manner and path in verb compounds. As previously mentioned, as bilingual speakers underwent a convergence towards the L2-based patterns, they exhibited an English-like way in making manner decisions more efficiently (Ji & Hohenstein, 2018).

To further explore whether the magnitude of L2 influence on cognitive restructuring is modulated by the degree of language involvement, a number-shadowing method was used in Experiment 2 to block participants' access to language during cognitive processing. In the similarity judgement, no significant difference was found in the frequency of manner- or path-match selection across the monolingual and bilingual group. One possible explanation is that the inter-typological distinctions between Cantonese and English are cline rather than categorical, such that the cross-linguistic differences in the linguistic encoding may not be strong or clear-cut enough for absolute distinctions in categorization (Ji & Hohenstein, 2018). However, this interpretation seems to contract with the language-specific patterns observed in Experiment 1. Given this, another possible explanation comes from the 'thinking-with-language' account that cross-linguistic differences in conceptual representations might be mediated by the access to language. As a result, "it can be eliminated by having people engage in a verbal interference task" (Wolff & Holmes, 2011, p. 256).

On the other hand, unlike the categorical decisions, the implicit measurement of RTs in Experiment 2 exhibited similar language-specific patterns as observed in Experiment 1. That is, speakers of Cantonese spent approximately the same amount of time in making manner and path judgements, while English and bilinguals responded much quicker when making manner decisions. The discrepancy between categorical decisions and processing efficiency can be attributed to the nature and the robustness of the measurement (explicit vs. implicit).

The findings of RTs can be further interpreted by the cognitive grammar (Langacker, 2008), which postulates that speaker's attention is easily drawn to constructions that are highlighted by grammar. Thus, as manner is prominently marked in English via verb forms, speakers may have directed their attention to manner first due to its great salience. Although participants eventually opted for a path-match variant, their reaction time to manner was much quicker. However, as both manner and path in Cantonese are expressed via verb compounds with equal level of salience, it is plausible to assume manner and path were retrieved "in a parallel fashion" with equal amount of attention being paid to both elements simultaneously (Wang & Li, 2021).

In sum, the current study reports a linguistic relativity effect on motion event processing with highly proficient bilinguals in both speech production and event perception. The findings suggest that that learning a new language means acquiring a new way of thinking, and the magnitude of L2 learning on cognitive restructuring is modulated by different degrees of language involvement. The findings underlie the mechanism of how language facilitates cognitive processing and shed light on the complexity and diversity of how language affects thought in the bilingual mind.

Acknowledgment

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