COPiL CAMBRIDGE OCCASIONAL PAPERS *in* LINGUISTICS
Volume **17**, Article 8: pp. 140–156, 2025 | ISSN: 2050-5949

Exploring the Effects of Second Language Proficiency on Bilinguals' Spatio-Temporal Conceptualisation*

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1 Introduction

Time is an abstract concept which is often projected and understood through the more experiential concept of space (Bender & Beller 2014, Fuhrman & Boroditsky 2010). There are many temporal expressions framed in spatial representations (Casasanto & Boroditsky 2008). For example, English has phrases such as "push back the deadline", "leaving dark times behind", and "walking toward a bright future". However, the spatialisation of time varies across languages and is shaped by multiple factors such as language, culture, and individuals (e.g. Grasso, Ziegler, Mirault, Coull & Montant 2022, Lai & Boroditsky 2013). Variations in space-time metaphors (Boroditsky, Fuhrman & McCormick 2011, Núñez & Sweetser 2006), spatial representation (Matlock, Ramscar & Boroditsky 2005, Núñez, Motz & Teuscher 2006), cultural artifacts such as writing direction (Bergen & Chan Lau 2012, Ouellet, Santiago, Israeli & Gabay 2010), and cultural or individual-level influences (Carstensen 2006, Ji, Guo, Zhang & Messervey 2009) have led to diverse habits among native speakers of various languages in conceptualising time spatially (Cheng & Wu 2024). In short, the tendency to conceptualise time in spatial terms permeates language, action, and cognition (Miles, Tan, Noble, Lumsden & Macrae 2011).

These differences become even more complex in the context of learners who use more than one language (e.g. Fuhrman & Boroditsky 2010). How the first language (L1) and second language (L2) interact, and what factors influence this interaction, has long been a focus of researchers. At present, although numerous studies have explored the topic of temporal representation, their findings often contradict each other regarding the conceptualisation patterns of speakers with different native languages and the influencing factors contributing to these variations (e.g. Lai & Boroditsky 2013, Qian 2016, Yang, Gu, Fang & Sun 2022). Moreover, many studies have ignored aspects of spatial representations of time, leaving key influencing factors undefined (Cheng & Wu 2024). Therefore, further research is needed to explore the mechanisms underlying the spatial-temporal representations of bilingual learners. This study aims to analyse how Mandarin-English (ME) bilingual participants construct temporal concepts using spatial representations and whether the level of proficiency in L2 is associated with participants' cognitive

* I would like to express my sincere gratitude to my supervisor, Henriette Hendriks, for her patient guidance and insightful feedback throughout the development of this paper.

patterns of time across different spatial axes and temporal motions. Therefore, this study proposes the following research questions:

i. How do ME bilinguals conceptualise time through space?

ii. Do individuals with higher proficiency in L2 adopt time conceptualisation patterns more aligned with L2 cognitive patterns, while becoming less influenced by temporal expressions inherent in their native language?

2 Literature Review

2.1 Axes of time

Languages differ in how they represent time through spatial orientation, and numerous studies have explored how speakers of different native languages conceptualise time through spatial orientation (e.g. Xiao, Zhao & Chen 2018, Yang & Sun 2016). While many languages rely on horizontal terms, they may vary in using front-back or back-front mappings to represent the past and future. For instance, English and Spanish map the past to "behind" and the future to "ahead" (Boroditsky 2011, Casasanto & Jasmin 2012). In contrast, Vietnamese and Aymara associate "behind" with the future (Boroditsky 2011, Núñez & Sweetser 2006, Sullivan & Bui 2016). In Mandarin, *qian* (front) and *hou* (back) can refer to both past and future, depending on context (e.g. Sun & Zhang 2021, Wu 2022, Xiao et al. 2018, Xue, Yang & Zhao 2014, Yang, Sinha & Filipovic 2023).

Examples:

(1) a. ***qian*** *tian*
front day

'The day before yesterday'

b. ***qian*** *jing*
front view

'Prospects or future'

c. *wang* ***hou*** *zhuisu* *lishi*
toward back tracing history

'Looking back in history'

d. *ri* ***hou***
day back

'In the days to come'

Some languages and in particular Mandarin also widely use vertical spatial reference (e.g. Boroditsky 2011). For example, with *shang* ("last" as in *shangqi*, "last period") indicating the past and *xia* ("next" as in *xiabeizi*, "next life") indicating the

future (e.g. Fu & Wang 2024). Although English also employs vertical spatial terms to discuss time (e.g. "pass down a tradition"), such usages are neither as prevalent nor as systematic as the use of *shang* and *xia* in Mandarin (Boroditsky 2001, Gu, Zheng & Swerts 2019). Compared to other languages, the highly flexible linguistic pattern in Mandarin results in non-fixed spatial-temporal metaphorical representations among native Chinese speakers. This characteristic has drawn significant research interest in the study of Mandarin speakers.

Temporal perception is influenced by linguistic expressions and writing direction (Boroditsky 2011, Park, Gagné & Spalding 2024, Tversky, Kugelmass & Winter 1991). While languages commonly express time along the front-back and vertical axes, direct left-right temporal expressions are absent. However, studies reveal that people often represent time on the left-right axis. For instance, Fuhrman & Boroditsky (2010) found that English speakers arranged events left-to-right, while Hebrew speakers, influenced by their writing direction, used right-to-left. Similarly, Fuhrman, McCormick, Chen, Jiang, Shu, Mao & Boroditsky (2011) observed alignment between writing direction and non-verbal left-to-right temporal representations in English and Mandarin speakers. These findings underscore the significance of the horizontal axis in experimental design.

2.2 Motion in time

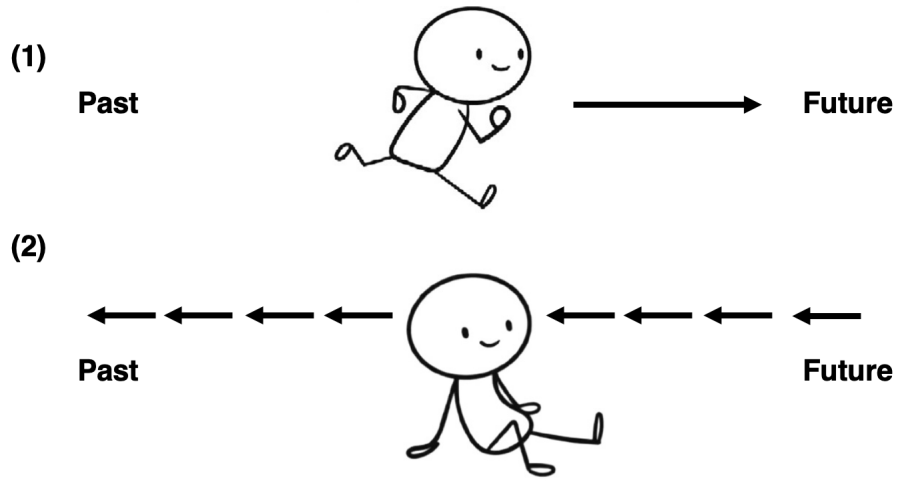

Figure 1 (1) The ego-moving schema. (2) The time-moving schema.

Ego-moving and time-moving are two spatial metaphors for time that describe how people perceive and sequence events (Chen 2014). In the ego-moving metaphor, the individual (ego) moves forward along a stationary timeline toward the future (Figure 1.2). Conversely, the time-moving metaphor views time as a moving object, while the individual remains stationary as events move toward them from the future (Figure 1.2). These metaphors assign "front" and "back" differently on the timeline, leading to variations in how individuals understand time (Lakoff & Johnson 1980).

Questions like the *Meeting Question* (i.e. "A meeting originally scheduled for next Wednesday has been moved forward by two days. What is the new date of the meeting?") and the *Clock Question* (i.e. "If this clock currently shows 1 PM, and you move it forward/afterward by one hour, what time will it show?") have been frequently used to distinguish between ego-moving and time-moving metaphors (Boroditsky & Ramscar 2002, McGlone & Harding 1998). Responses reveal whether participants align with ego-moving or time-moving perspectives, based on their interpretation of "forward" as referring to the past or future. Boroditsky & Ramscar (2002) found that English speakers were equally likely to respond with "Monday" or "Friday". In contrast, Gentner, Imai & Boroditsky (2002) reported that English speakers favored the ego-moving framework for understanding time. Bender, Beller & Bennardo (2010) revealed that over 96% of Mandarin speakers chose "Monday" and were more likely than English speakers to adopt a time-moving perspective for the clock question. These results suggest that the time-moving metaphor is more common among Mandarin speakers than the ego-moving metaphor. Xiao et al. (2018) argued that this preference may arise from the Mandarin term *qian* (forward), where *xiangqian* can be interpreted as "moving forward", reducing the question's ambiguity. These metaphorical differences have sparked scholarly discussions about the variations in how English and Mandarin speakers conceptualise time.

2.3 Research subjects of interest: Mandarin-English bilinguals

The differences across languages raise interesting questions about how bilingual individuals map time and space, and whether L2 can, in turn, shape new ways of conceptualising time. Speakers of different languages may be influenced by more than one linguistic system, suggesting that L2 learners could develop more than one spatial representation of time. For instance, Miles et al. (2011) showed that ME bilinguals exhibit both horizontal time mapping, consistent with English, and vertical temporal representations, aligned with Mandarin. Growing research interest focuses on the cognitive mechanisms of bilinguals, particularly how they spatially conceptualise time, examining whether time conceptualisation is shaped by their linguistic and cultural backgrounds, especially in the context of differences between Chinese and English learners (Miles et al. 2011, Lai & Boroditsky 2013, Park et al. 2024).

Regarding temporal axes, the two-dimensional picture arrangement method is a commonly used research approach (e.g. Boroditsky 2001, Miles et al. 2011, Weist, Atanassova, Wysocka & Pawlak 1999) to examine contextual backgrounds along different axes. For instance, Miles et al. (2011) found that ME bilinguals use horizontal and vertical axes for temporal sequences in a 2D picture arrangement experiment, preferring left-to-right or top-to-bottom arrangements. Similarly, Boroditsky (2001) observed that Mandarin speakers were more sensitive to the vertical axis, showing faster responses to vertical arrangements, whereas English speakers responded faster to horizontal arrangements. Regarding motion in time, Lai & Boroditsky (2013) found that ME bilinguals blend influences from their native and second languages when processing temporal metaphors. For example, in the "Wednesday" meeting

question, the responses of ME bilinguals differed from those of English monolinguals but aligned with the results of Mandarin monolinguals in Mandarin-based tests. This suggests that bilinguals may incorporate cognitive structures more commonly found in their native language into their understanding of *Clock Question*, Lai & Boroditsky (2013) showed that most English monolinguals adopted the ego-moving perspective (100%), followed by ME bilinguals (41%) and Mandarin monolinguals (12.5%).

Boroditsky (2001) argued that linguistic habits shape how individuals conceptualise abstract concepts like time. In Boroditsky's (2001) Experiment 3, English speakers learned to use vertical spatial terms for time, mimicking Mandarin usage. These speakers subsequently adopted a vertical time conceptualisation similar to Mandarin speakers, supporting the Linguistic Relativity Hypothesis, which suggests that language influences thought and perception (Hunt & Agnoli 1991). However, replication attempts by Chen (2007) and January & Kako (2007) failed to validate these findings, questioning the robustness of Boroditsky's (2001) claim that learning a new language reshapes cognitive frameworks. Athanasopoulos, Bylund, Montero-Melis, Damjanovic, Schartner, Kibbe & Thierry (2015), however, showed that language can dynamically influence cognitive processes like categorisation among German-English bilinguals, with bilinguals adopting cognitive patterns aligned with the language used during testing. This indicates that while learning a new language may not fully reshape time conceptualisation, language still influences the cognitive representation of abstract concepts.

2.4 Influencing factors to be confirmed

Subsequent research explores why bilinguals are not equally influenced by their first and second languages during experimental tasks, focusing on factors like age of L2 acquisition (e.g. Malyshevskaya, Fischer, Shtyrov & Myachykov 2024), L1 proficiency (e.g. Lai & Boroditsky 2013), and L2 proficiency (e.g. Hulstijn 2011, Johnson & Rosano 1993, Serafini & Sanz 2016). Studies examining L2 proficiency as an independent variable have yielded mixed results, including positive effects (e.g. Ahlberg, Bischoff, Kaup, Bryant & Strozyk 2018, Cheng & Wu 2024, Qian 2016) and null effects (e.g. Kogan, García-Marco, Birba, Cortés, Melloni, Ibáñez & García 2020, Monaco, Jost, Lancheros, Harquel, Schmidlin & Annoni 2021, Yang et al. 2022). For instance, Yang et al. (2022) found that higher English proficiency did not alter the temporal spatialisation patterns of ME bilinguals, while Cheng & Wu (2024) noted differences in spatio-temporal representations linked to proficiency but suggested age of acquisition or other factors might also contribute.

Overall, while previous research has explored monolinguals' patterns of time conceptualisation, studies on how bilinguals use space to conceptualise time remain limited, particularly regarding the interaction between horizontal and vertical axes and their spatio-temporal conceptualisation preferences. Additionally, the impact of L2 proficiency has yielded inconsistent findings. This study aims to address these gaps by evaluating English proficiency through factors such as language level, age

of acquisition, duration of use, and prominence, providing a more comprehensive perspective.

3 Methodology

3.1 Participants

In this study, 30 ME bilingual students (13 males, 17 females; average age 22.57, range 20–25) participated. All were native Mandarin speakers with English as their L2. Participants completed a language background questionnaire, reporting their language exposure and actual English proficiency on a 1–5 scale.

3.2 Design and procedure

This experiment examines how varying English proficiency levels influence time cognition. The experimental design includes three parts: Study 1 investigates cognitive differences related to the axes of time, Study 2 explores temporal motion conceptualisation, and a language history questionnaire follows the experiments. Combining the two experiments to address Research Question 1 aims to gain a more holistic understanding of how bilinguals adapt to their L2 in terms of both the static and dynamic aspects of spatio-temporal conceptualisation. The total duration is 8–10 minutes. A balanced design will control for task order effects, and all questions will be presented in English to maintain a monolingual mode.

3.2.1 Experiment 1: Axes of time

Figure 2 Physical 3D cubes, arranged in three directions representing the process of an apple being eaten.

Experiment 1 uses three identical three-dimensional cubes (Figure 2) to investigate participants' spatial conceptualisation of time. Each cube represents a temporal stage — past, present, or future — and participants arrange them in one of six possible orientations: left-to-right, right-to-left, front-to-back, back-to-front, up-to-down, or down-to-up. Each cube face displays identical images corresponding to one of three themes: (a) Mandarin time expressions implying an "up-down axis" metaphor (e.g. morning, noon, afternoon; last week, this week, next week); (b) Mandarin time expressions implying a "front-back axis" metaphor (e.g. the day before yesterday,

today, the day after tomorrow; two years ago, this year, two years from now); and (c) a broader concept of time (e.g. life stages such as youth, middle age, and old age; an apple at different stages). This three-dimensional design overcomes the limitations of traditional two-dimensional sorting methods (e.g. Miles et al. 2011, Weist et al. 1999, Yang & Sun 2016), which compress spatial dimensions and obscure distinctions between axes. By transforming two-dimensional images into three-dimensional cubes, this innovative design enables participants to express temporal mappings more directly.

3.2.2 Experiment 2: Motion in time

In Experiment 2, participants will answer two classic questions — the *Meeting Question* and the *Clock Question* — to explore their cognitive pattern for time. These questions help identify whether participants conceptualise time from an ego-referential perspective (ego-RP) or a time-referential perspective (time-RP). Both questions, widely used in prior research, aim to assess whether individuals perceive time as moving around them or themselves as moving through time (e.g. Boroditsky 2000, Boroditsky & Ramscar 2002, McGlone & Harding 1998, Huang & Hsieh 2007). For the *Meeting Question* ("A meeting originally scheduled for next Wednesday has been moved forward by two days. What is the new date of the meeting?"), responses reveal time perception: an ego-moving perspective shifts the meeting to Friday, while a time-moving perspective shifts it to Monday. For the *Clock Question* ("If this clock shows 1 PM and you move it forward by one-hour, what time will it show?"), answers of 2 PM (ego-moving) or 12 PM (time-moving) further clarify participants' time conceptualisation.

3.2.3 Questionnaire

The questionnaire investigates the influence of L2 proficiency on bilinguals' temporal cognition. Details of the questionnaire are provided in the appendix. It includes two sections: the first gathers demographic and background information (e.g., gender, age, native language, and L2 details), while the second assesses English proficiency across four dimensions informed by prior studies. These dimensions are recent English test scores (e.g. Lai & Boroditsky 2013), age of English acquisition (e.g. Malyshevskaya et al. 2024), daily usage duration, and frequency of use in various contexts, such as home, school, public spaces, and online (e.g. Huang & Hsieh 2007). A 5-point scale is used for all questions in the second section. Higher scores correspond to higher English proficiency, determined by factors like test performance (e.g. IELTS scores of 4–4.5 receive 1 point, 8–8.5 receive 5 points), longer usage duration, and greater frequency and salience of English use. Overall proficiency is calculated as the average score across the four dimensions.

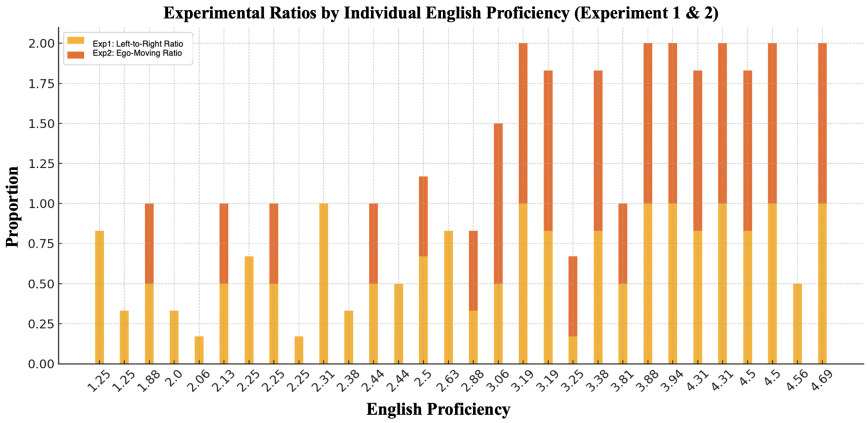

Figure 3 Overall participant performance across two experiments.

4 Results: Exploratory Findings

4.1 English proficiency

This study assessed participants' English proficiency across four dimensions: English performance, duration of English learning, duration of English usage, and the prominence of English use (mean across contexts). Significant variation was observed across these dimensions. The overall mean proficiency score was 2.98 (*SD* = 1.01), reflecting participants' general English proficiency. The mean scores for each dimension were as follows: English test performance (3.10, *SD* = 1.40), age of English acquisition (3.30, *SD* = 1.21), daily duration of English usage (3.03, SD = 1.59), and salience of English usage (2.49, *SD* = 1.02). Salience of English usage was calculated as a composite measure across four contexts. English usage at home was the lowest (mean = 1.33, *SD* = 0.71), while usage at school or work was the highest (mean = 3.20, *SD* = 1.42). Usage in public spaces (mean = 2.57, *SD* = 1.63) and online (mean = 2.87, *SD* = 1.28) fell in between. Substantial variation in proficiency levels was evident, ranging from the highest proficiency participant (e.g. P17, mean = 4.69) to the lowest (e.g. P6, mean = 1.25).

4.2 Axes of time

Participants appeared to show a general preference for the left-right axis when arranging cubes for temporal sequences, with left-to-right being the most common orientation (mean = 0.64, SD = 0.28). Participants with higher English proficiency (e.g. P11, P17, P27) tended to favor this pattern, while right-to-left arrangements were rare and observed only in a few cases (e.g. P10, P12). The front-back axis was chosen less frequently, and only a few participants demonstrated preferences for front-to-back or back-to-front arrangements. Similarly, the up-down axis was rarely used (e.g. P1, P22). Pearson correlation analysis revealed a significant positive correlation between English proficiency and the left-to-right bias (r = 0.514, p = 0.0037). This result suggests that participants with higher English proficiency tend to

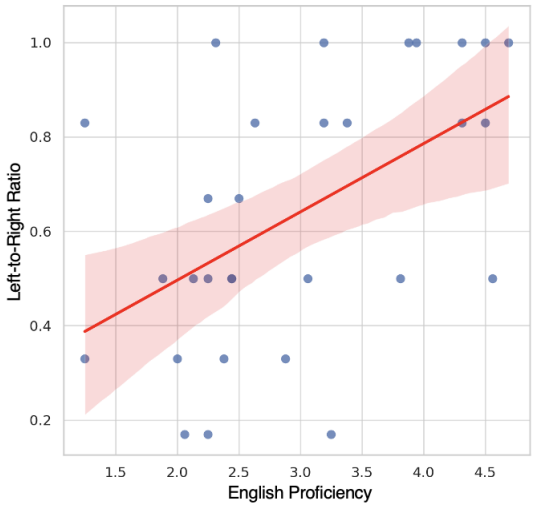

Figure 4 Left-to-right ratio distributions in Experiment 1.

show a stronger preference for the left-to-right thinking pattern (see Figure 4). The image materials include visual cues directly related to different axes of expression, such as images representing morning, noon, and afternoon, as well as images simply corresponding to past, present, and future. However, when exposed to different stimuli, both the front-back axis and the up-down axis were used by the bilingual experiment participants. This suggests that in this process, they are thinking about the timeline that can be extracted from the different pictures on the cubes. Notably, participants with English proficiency scores above 3 predominantly used left-to-right and ego-moving patterns, while those with scores below 2 exhibited greater reliance on vertical (up-down) and sagittal (front-back) axes (see Figure 3). These timelines persisted even for expressions that did not explicitly reference a specific axis, indicating that such axial concepts already existed in their minds.

4.3 Motion in time

In the meeting task, 16 participants chose Monday, and 14 chose Friday; in the clock task, 14 selected 12 PM, and 16 chose 2 PM. Overall, the probability of choosing the time-moving or ego-moving perspective was 1:1. English proficiency influenced the choice of temporal motion patterns. Participants with higher proficiency (e.g. P3, 11, and 20) favored the ego-moving perspective (average proportion: 0.50, SD = 0.44), reflecting English timeline patterns. In contrast, lower-proficiency participants (e.g. P6 and 19) preferred the time-moving perspective. Some participants (e.g. P8, and 23) alternated between perspectives, indicating an interaction of temporal cognitive patterns. Similarly, a significant positive correlation was found between English proficiency and the ego-moving bias (r = 0.691, $p < 0.001$). This indicates that participants with higher English proficiency are more inclined to adopt an ego-moving temporal perspective (see Figure 5). Overall, these findings suggest that

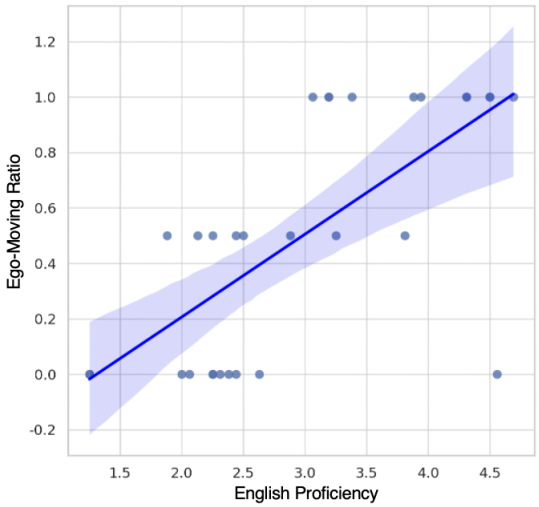

Figure 5 Ego-moving ratio distributions in Experiment 2.

English proficiency plays a significant role in shaping cognitive patterns related to L2 spatial and temporal frameworks.

5 Discussion

This study examines how ME bilingual participants use spatial constructs to conceptualise time and explores the influence of L2 proficiency on temporal cognitive patterns. The findings suggest that participants with higher English proficiency exhibit cognitive patterns more consistent with English temporal conceptualisation, while relying less on Chinese native temporal concepts. The discussion is divided into three parts: axes of time, motion in time, and the influence of English proficiency. Unlike previous findings in studies of bilingual temporal cognition (e.g. Boroditsky 2001, Xiao et al. 2018), results indicate that bilinguals exhibit flexibility in their use of spatial-temporal constructs, which may come from the interaction between two cognitive systems of timeline.

5.1 Axes of time

The study found that Mandarin and English participants tended to conceptualise time more frequently along the left-right axis, consistent with previous research (e.g. Fuhrman & Boroditsky 2010, Fuhrman et al. 2011) indicating that people often use the left-right axis for temporal representation, even without explicit linguistic associations. However, participants in the study engaged with all six possible arrangements (left-to-right, right-to-left, front-to-back, back-to-front, top-to-bottom, bottom-to-top), suggesting that temporal conceptualisation is not limited to a single representation. This diversity contrasts with earlier studies (e.g. Boroditsky 2001, Xue et al. 2014), which primarily reported left-to-right or top-to-bottom preferences. The difference may arise from the innovative use of 3D blocks in this study, intro-

ducing an additional dimension beyond traditional 2D image arrangements on a flat plane. Further research with larger samples is needed to determine if this diversity reflects a broader trend among ME bilinguals.

5.2 Motion in time

The results of this study reveal that bilingual learners exhibit a 50% probability of using the ego-moving perspective. This finding is similar to the results for bilinguals reported by Lai & Boroditsky (2013), where 41% ME bilinguals chose the ego-moving perspective. Notably, ME bilinguals displayed a slight alignment with native English speakers. Future research with larger sample sizes is needed for more precise data. Unlike Lai & Boroditsky's (2013) suggestion that ME bilinguals incorporate native-language cognitive structures into their L2 metaphorical understanding, this study attributes differences from Mandarin monolinguals to L2 influence on bilinguals. The findings of this study add an ME bilingual perspective to the discussion. It can be argued that the cognitive paradigm of ME bilinguals in addressing this issue more closely aligns with the data for English monolinguals.

5.3 Effects of English proficiency

Mandarin speakers conceptualise time using both horizontal and vertical axes, while English speakers rely solely on the horizontal axis (Fuhrman et al. 2011). This study hypothesises that individuals with higher proficiency in English as a second language are more likely to conceptualise time exclusively along the horizontal axis, as the vertical axis is eliminated by the influence of L2. In short, as English proficiency improves, participants are expected to develop a time conceptualisation pattern more aligned with that of English. The research findings partially support this hypothesis. Based on the findings of the two separate experiments mentioned above, this study reveals that English proficiency influences how ME bilinguals construct temporal concepts. Unlike prior research that often relied on self-reported proficiency (e.g. Boroditsky 2001), this study measured proficiency across four dimensions for a more accurate assessment. Building on Cheng & Wu (2024), it validates the effects of various aspects of L2 proficiency on spatial-temporal representation. The results showed a positive correlation between English proficiency and the use of the left-to-right time axis, which contradicts the view of Yang et al. (2022), who emphasized individual differences in axis selection. Additionally, English proficiency significantly affects preferences for temporal motion patterns: participants with higher proficiency favor the ego-moving perspective typical of English speakers over the time-moving perspective common among Mandarin speakers. This challenges claims that L2 proficiency does not influence time conceptualisation (e.g. Kogan et al. 2020, Monaco et al. 2021). Moreover, unlike previous experiments that failed to replicate Boroditsky (2001) (e.g. Chen 2007, January & Kako 2007), this study provides a potential research approach for further exploring Linguistic Relativity (Whorfian) Hypothesis.

6 Conclusion

In summary, this study explored how ME bilingual participants conceptualise time using spatial constructs and examined the relationship between L2 proficiency and spatial-temporal conceptualisation patterns. Findings indicate that bilinguals exhibit complex spatiotemporal conceptualisation, blending preferences from both their native and second languages. Higher L2 proficiency aligns time perception more closely with the second language while reducing reliance on native-language temporal expressions. These findings contribute to a broader understanding of the dynamic interplay between language and cognition in bilinguals and highlight the potential influence of L2 proficiency.

References

Ahlberg, D. K., H. Bischoff, B. Kaup, D. Bryant & J. V. Strozyk. 2018. Grounded cognition: Comparing language × space interactions in first language and second language. *Applied Psycholinguistics* 39(2). 437–459.

Athanasopoulos, P., E. Bylund, G. Montero-Melis, L. Damjanovic, A. Schartner, A. Kibbe & G. Thierry. 2015. Two languages, two minds: Flexible cognitive processing driven by language of operation. *Psychological Science* 26(4). 518–526.

Bender, A. & S. Beller. 2014. Mapping spatial frames of reference onto time: A review of theoretical accounts and empirical findings. *Cognition* 132(3). 342–382.

Bender, A., S. Beller & G. Bennardo. 2010. Temporal frames of reference: Conceptual analysis and empirical evidence from German, English, Mandarin Chinese and Tongan. *Journal of Cognition and Culture* 10(3-4). 283–307.

Bergen, B. K. & T. T. Chan Lau. 2012. Writing direction affects how people map space onto time. *Frontiers in Psychology* 3. 109.

Boroditsky, L. 2000. Metaphoric structuring: Understanding time through spatial metaphors. *Cognition* 75(1). 1–28.

Boroditsky, L. 2001. Does language shape thought? mandarin and English speakers' conceptions of time. *Cognitive Psychology* 43(1). 1–22.

Boroditsky, L. 2011. How languages construct time. In *Space, Time and Number in the Brain*, 333–341. Academic Press.

Boroditsky, L., O. Fuhrman & K. McCormick. 2011. Do English and Mandarin speakers think about time differently? *Cognition* 118(1). 123–129.

Boroditsky, L. & M. Ramscar. 2002. The roles of body and mind in abstract thought. *Psychological Science* 13(2). 185–189.

Carstensen, L. L. 2006. The influence of a sense of time on human development. *Science* 312(5782). 1913–1915.

Casasanto, D. & L. Boroditsky. 2008. Time in the mind: Using space to think about time. *Cognition* 106(2). 579–593.

Casasanto, D. & K. Jasmin. 2012. The hands of time: Temporal gestures in English speakers. *Cognitive Linguistics* 23(4). 643–674.

Chen, C. 2014. A contrastive study of time as space metaphor in English and Chinese. *Theory and Practice in Language Studies* 4(1). 129.

Chen, J. Y. 2007. Do Chinese and English speakers think about time differently? Failure of replicating Boroditsky (2001). *Cognition* 104(2). 427–436.

Cheng, S. & Z. Wu. 2024. Spatialization of time in bilinguals: what do we make of the effect of the testing language? *Frontiers in Psychology* 15. 1355065.

Fu, Y. & C. Wang. 2024. A study on the expression of time in Chinese: Focusing on time words of the type "noun+ shang/xia". *Journal of Research in Social Science and Humanities* 3(12). 23–33.

Fuhrman, O. & L. Boroditsky. 2010. Cross-cultural differences in mental representations of time: Evidence from an implicit nonlinguistic task. *Cognitive Science* 34(8). 1430–1451.

Fuhrman, O., K. McCormick, E. Chen, H. Jiang, D. Shu, S. Mao & L. Boroditsky. 2011. How linguistic and cultural forces shape conceptions of time: English and

Mandarin time in 3D. *Cognitive Science* 35(7). 1305–1328.
Gentner, D., M. Imai & L. Boroditsky. 2002. As time goes by: Evidence for two systems in processing space → time metaphors. *Language and Cognitive Processes* 17(5). 537–565.
Grasso, C. L., J. C. Ziegler, J. Mirault, J. T. Coull & M. Montant. 2022. As time goes by: Space-time compatibility effects in word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 48(2). 304.
Gu, Y., Y. Zheng & M. Swerts. 2019. Which is in front of Chinese people, past or future? the effect of language and culture on temporal gestures and spatial conceptions of time. *Cognitive Science* 43(12). e12804.
Huang, H. M. M. & S. C. Y. Hsieh. 2007. Time-moving metaphors and ego-moving metaphors: Which is better comprehended by Taiwanese? In *Proceedings of the 21st Pacific Asia Conference on Language, Information and Computation*, 173–181.
Hulstijn, J. H. 2011. Language proficiency in native and nonnative speakers: An agenda for research and suggestions for second-language assessment. *Language Assessment Quarterly* 8(3). 229–249.
Hunt, E. & F. Agnoli. 1991. The Whorfian hypothesis: A cognitive psychology perspective. *Psychological Review* 98(3). 377.
January, D. & E. Kako. 2007. Re-evaluating evidence for linguistic relativity: Reply to boroditsky (2001). *Cognition* 104(2). 417–426.
Ji, L. J., T. Guo, Z. Zhang & D. Messervey. 2009. Looking into the past: cultural differences in perception and representation of past information. *Journal of Personality and Social Psychology* 96(4). 761.
Johnson, J. & T. Rosano. 1993. Relation of cognitive style to metaphor interpretation and second language proficiency. *Applied Psycholinguistics* 14(2). 159–175.
Kogan, B., E. García-Marco, A. Birba, C. Cortés, M. Melloni, A. Ibáñez & A. M. García. 2020. How words ripple through bilingual hands: Motor-language coupling during L1 and L2 writing. *Neuropsychologia* 146. 107563.
Lai, V. T. & L. Boroditsky. 2013. The immediate and chronic influence of spatio-temporal metaphors on the mental representations of time in English, Mandarin, and Mandarin-English speakers. *Frontiers in Psychology* 4. 142.
Lakoff, G. & M. Johnson. 1980. *Metaphors we live by.* University of Chicago Press.
Malyshevskaya, A., M. H. Fischer, Y. Shtyrov & A. Myachykov. 2024. Horizontal mapping of time-related words in first and second language. *Scientific Reports* 14(1). 9675.
Matlock, T., M. Ramscar & L. Boroditsky. 2005. On the experiential link between spatial and temporal language. *Cognitive Science* 29(4). 655–664.
McGlone, M. S. & J. L. Harding. 1998. Back (or forward?) to the future: The role of perspective in temporal language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 24(5). 1211.
Miles, L. K., L. Tan, G. D. Noble, J. Lumsden & C. N. Macrae. 2011. Can a mind have two time lines? Exploring space–time mapping in Mandarin and English speakers. *Psychonomic Bulletin Review* 18. 598–604.
Monaco, E., L. B. Jost, M. Lancheros, S. Harquel, E. Schmidlin & J. M. Annoni. 2021. First and second language at hand: A chronometric transcranial-magnetic

stimulation study on semantic and motor resonance. *Journal of Cognitive Neuroscience* 33(8). 1563–1580.

Núñez, R. E., B. A. Motz & U. Teuscher. 2006. Time after time: The psychological reality of the ego-and time-reference-point distinction in metaphorical construals of time. *Metaphor and Symbol* 21(3). 133–146.

Núñez, R. E. & E. Sweetser. 2006. With the future behind them: Convergent evidence from Aymara language and gesture in the crosslinguistic comparison of spatial construals of time. *Cognitive Science* 30(3). 401–450.

Ouellet, M., J. Santiago, Z. Israeli & S. Gabay. 2010. Is the future the right time? *Experimental Psychology* .

Park, J., C. L. Gagné & T. L. Spalding. 2024. Writing direction and language activation affect how Arabic-English bilingual speakers map time onto space. *Frontiers in Psychology* 14. 1356039.

Qian, W. 2016. Embodied cognition processing and representation of power words by second language learners with different proficiency levels. *Chinese Journal of Applied Linguistics* 39(4). 484–494.

Serafini, E. J. & C. Sanz. 2016. Evidence for the decreasing impact of cognitive ability on second language development as proficiency increases. *Studies in Second Language Acquisition* 38(4). 607–646.

Sullivan, K. & L. T. Bui. 2016. With the future coming up behind them: Evidence that time approaches from behind in Vietnamese. *Cognitive Linguistics* 27(2). 205–233.

Sun, J. & Q. Zhang. 2021. How do Mandarin speakers conceptualize time? Beyond the horizontal and vertical dimensions. *Cognitive Processing* 22(2). 171–181.

Tversky, B., S. Kugelmass & A. Winter. 1991. Cross-cultural and developmental trends in graphic productions. *Cognitive Psychology* 23(4). 515–557.

Weist, R. M., M. Atanassova, H. Wysocka & A. Pawlak. 1999. Spatial and temporal systems in child language and thought: A cross-linguistic study. *First Language* 19(57). 267–308.

Wu, S. 2022. A corpus-based study of the time orientation of *qian* "front" and *hou* "back" in chinese. *Corpus Linguistics and Linguistic Theory* 18(3). 447–475.

Xiao, C., M. Zhao & L. Chen. 2018. Both earlier times and the future are "front": The distinction between time- and ego-reference-points in Mandarin speakers' temporal representation. *Cognitive Science* 42(3). 1026–1040.

Xue, J., J. Yang & Q. Zhao. 2014. Chinese–English bilinguals processing temporal–spatial metaphor. *Cognitive Processing* 15. 269–281.

Yang, W., Y. Gu, Y. Fang & Y. Sun. 2022. Mental representations of time in English monolinguals, Mandarin monolinguals, and Mandarin–English bilinguals. *Frontiers in Psychology* 13. 791197.

Yang, W. & Y. Sun. 2016. A monolingual mind can have two time lines: Exploring space-time mappings in Mandarin monolinguals. *Psychonomic Bulletin & Review* 23. 857–864.

Yang, Y., C. Sinha & L. Filipovic. 2023. Sequential time construal is primary in temporal uses of Mandarin Chinese *qian* 'front' and *hou* 'back'. *Language Sciences* 95. 101511.

Appendix

Part 1: Questionnaire.

i. Please fill in your participant ID: [Open-ended question] _____

ii. Age: [Open-ended question] _____

iii. Gender: [Single-choice question]
   - Male
   - Female

iv. Is Mandarin your native language? [Single choice question]
   - Yes
   - No

v. Besides your native language, which other languages do you speak? [Multiple-choice question]
   - English
   - Others (please specify): _____

vi. Have you ever lived or studied in an English-speaking country? [Single-choice question]
   - Yes (If yes, please specify the duration: _____ years _____ months)
   - No

vii. Have you received education or training entirely in English? [Single-choice question]
   - Yes
   - No

Part 2: English Proficiency as a Second Language

English Learning and Usage

i. What was your most recent English language test (e.g. IELTS, TOEFL, or others) score? Please specify the test name and score: [Open-ended question]
   _____

ii. How long have you been learning English in years? [Open-ended question]
   _____

iii. What is the average amount of time you spend using English daily? [Single-choice question]
   - 1 hour or less

- 2 hours
- 3 hours
- 5 hours
- 8 hours or more

Salience of English

i. How frequently do you use English to communicate with family members at home? [Single-choice question]
   - Almost never (less than once per week)
   - Rarely (1–2 times per week)
   - Occasionally (3–4 times per week)
   - Often (5–6 times per week)
   - Very frequently (daily)

ii. How frequently do you use English at school? [Single-choice question]
   - Almost never (less than once per week)
   - Rarely (1–2 times per week)
   - Occasionally (3–4 times per week)
   - Often (5–6 times per week)
   - Very frequently (daily)

iii. How frequently do you use English in public places? [Single-choice question]
   - Almost never (less than once per week)
   - Rarely (1–2 times per week)
   - Occasionally (3–4 times per week)
   - Often (5–6 times per week)
   - Very frequently (daily)

iv. How frequently do you interact with others online (e.g., email, phone, chat apps, social platforms) in English in your daily life? [Single-choice question]
   - Almost never (less than once per week)
   - Rarely (1–2 times per week)
   - Occasionally (3–4 times per week)
   - Often (5–6 times per week)
   - Very frequently (daily)

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