Processing past time reference, but which one? An ERP study on the Mandarin Chinese aspect morphemes *guo₁* and *guo₂* with definite and indefinite time adverbs

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The processing in the brain of the temporal concord of aspect markers in Mandarin has attracted the attention of researchers, but the picture is not complete yet. This study focuses on *GUO*, the phonological realization of the two morphemes *guo₁* and *guo₂*. They occur with time adverbs of different natures: *guo₁* with indefinite time adverbs ('in the past'), *guo₂* with definite time adverbs. The ERP results show that *guo₁* temporally violated elicits a biphasic N400-P600, and *guo₂* a P600, suggesting common cognitive processes ('localization') between the two, and specific cognitive process ('existential') for *guo₁*, in line with their linguistic analyses.

1 Introduction

1.1 The multidimension of the perception of an event in time

The time at which an event occurs can be perceived in different ways by the human cognition (Baggio et al., 2012). For instance, an event can be seen as located in time according to the time of speech ('temporal localization'). Conversely, it can be placed in time by taking another event as its reference, such that the event in question is located in a sequence of two events ('temporal sequencing'). Another facet of the cognitive perception of time concerns the existential status of the event: events placed in the past and in the present are more likely to be taken as *real*, and events in the future as *unreal* (Lyons, 1977). Such cognitive ways to perceive time have correlates in language. 'Tense' in its traditional definition expresses the temporal localization of an event (Comrie, 1985), but it can also be used to refer to events in a sequence (Klein, 1994). Similar claims can be made for 'aspect'. When it comes to the occurrence of an event in time, perfective aspect can exhibit a temporal sequencing meaning. Some aspect markers may also be used to express temporal localization as well (Iljic, 2010).

1.2 Expressing temporal reference in Mandarin with aspect markers and their neuronal processing in temporal concord violation paradigms

Mandarin is considered as a tenseless language, i.e., it does not have morphemes encoding tense distinctions, but several aspect markers can be used to express temporal relations. Among them, the postverbal morphemes *-le* and *-guo* are analyzed as expressing different cognitive facets of time: temporal sequencing for *-le* (Woo, 2018), temporal localization for *-guo* (Iljic, 2010). Interestingly, *-le* and *-guo* are grammatical when occurring with a deictic past time adverb, but not with a deictic future time adverbs. See (1).

(1) Zhangsan zuotian/*mingtian   jiao-le / jiao-guo   yangtai de   hua.
    Zhangsan yesterday/*tomorrow   pour-LE / jiao-GUO   balcony DE   flower
    'Zhangsan (already) poured the flowers on the balcony yesterday/*tomorrow.'

The verb *you* 'to have' has grammaticalized into a verbal auxiliary in some Mandarin-speaking regions, expressing the temporal existence of the event (Collart & Su, 2022). Similar with *-le* and *-guo*, '*you* + VP' exhibits the same temporal concord violation. See (2).

(2) Zhangsan zuotian/*mingtian   you   jiao   yangtai de   hua.
    Zhangsan yesterday/*tomorrow   have pour   balcony DE   flower
    'Zhangsan poured the flowers on the balcony yesterday/*tomorrow.'

The processing in the brain of the temporal concord violations in (1-2) has been explored with the ERP technique in previous experiments. *-Le* elicited a LAN effect, analyzed as reflecting the violation of the temporal sequencing process, *-guo* a P600, reflecting the temporal localization process (Qiu & Zhou, 2012; Collart & Chan, 2021). The temporal concord violation

of '*you* + VP' was reflected by a N400 component on the verb, taken as indicating the violation of the existence of the event in time (Collart, 2018). Overall, it appears that the aspect markers in Mandarin placed in temporal concord configurations can be used to express the different cognitive perceptions of the occurrence of the event in time, and this idea finds supportive evidence from electrophysiological data.

1.3 Distinguishing between *guo₁* and *guo₂*: The present study

However, the picture is not complete. The linguistic literature points out that -*guo* is the phonological realization of two distinct morphemes: guo_1 ('experiential *guo*'), expressing the existence and the localization of the event in time, and guo_2 ('phasal *guo*'), only indicating the localization of the event in time (Iljic, 2010; Collart, 2022). Syntactic tests support this distinction: (a) guo_1 can appear with the negation *mei*, but not guo_2, (b) guo_2 can occur with -*le*, but not guo_1, (c) guo_1 appears after indefinite deictic time adverbs (e.g., *yiqian* 'in the past'), guo_2 after definite deictic time adverbs (e.g., *zuotian* 'yesterday'). Crucially, the temporal concord violation pattern is also found for guo_1 as well (see (3), to compare with (1)).

(3) Zhangsan   yiqian/*yihou   jiao-guo (*-le)   nüwang   de   hua.
     Zhangsan   in.the.past/*in.the.future   jiao-GUO_1 (*-LE)   queen   DE   flower
     'Zhangsan poured the queen's flowers in the past/*in the future.'

The present study proposes to investigate the neuronal processing of the temporal concord violation of guo_1 and to compare with the one of guo_2 in order to determine whether the different linguistic analyses are reflected in their neurophysiological processing. To do so, the processing of sentences as in (1), involving guo_2 (for which the brain process has already been explored) is compared with sentences as in (2), involving guo_1. Different predictions can be made based on their linguistic analyses and previous ERP results: (a) if guo_1 is used to express both temporal existence and temporal localization, then its temporal concord violation is expected to elicit a biphasic N400 + P600 response, while only a P600 is expected for guo_2; (b) if the brain does not distinguish between guo_1 and guo_2 concerning the processing of their temporal concord violation, the same ERP component is expected: A P600 effect.

2   Methodology

2.1 Participants

The participants were 24 native speakers of Mandarin (14F, mean age: 26.2 y.o., range: 20–40 y.o.), right-handed and without brain disorder. They signed a consent form approved by the Center for Research Ethics of National Taiwan Normal University.

2.2 Materials

The material was the same as in Collart & Chan (2021), except for the deictic time adverbs: the definite time adverbs were *zuotian* 'yesterday' and *mingtian* 'tomorrow', the indefinite time adverbs were *guoqu* 'in the past' and *weilai* 'in the future', and not *yiqian*/*yihou* to avoid 'past in the past/future' interpretation. The 272 sentences, dispatched into four lists with a Latin square design (34 per condition + 136 fillers to counterbalance the grammaticality of the sentences) were tested for naturalness in an online pilot study (74 participants who did not take part in the ERP experiment, 7-point Likert scale).

2.3 Procedure and data acquisition

The procedure and data acquisition parameters replicated the ones in Collart & Chan (2021).

2.4 Preprocessing pipeline and statistical analyses

The preprocessing pipeline and statistical plan in Collart & Chan (2021) was adopted, except for the length of the ERP epochs. The epochs were computed starting from the onset of the deictic time adverbs and lasted until the end of the sentence (3200ms long). The ERP data

were analyzed with repeated-measure ANOVAs (DV = voltage, IV = Type (*Definite* vs. *Indefinite*, Grammaticality (*Grammatical* Vs. *Ingrammaticall*), Anteriority (*Frontal* vs. *Central* vs. *Posterior*), Hemisphere (*Left* vs. *Midline* vs. *Right*) at two time windows.

3 ERP Results

The temporal concord violation involving definite adverbs only elicited a P600 (see Fig. 1), but a biphasic N400-P600 was found for the indefinite adverbs (see Fig. 2).
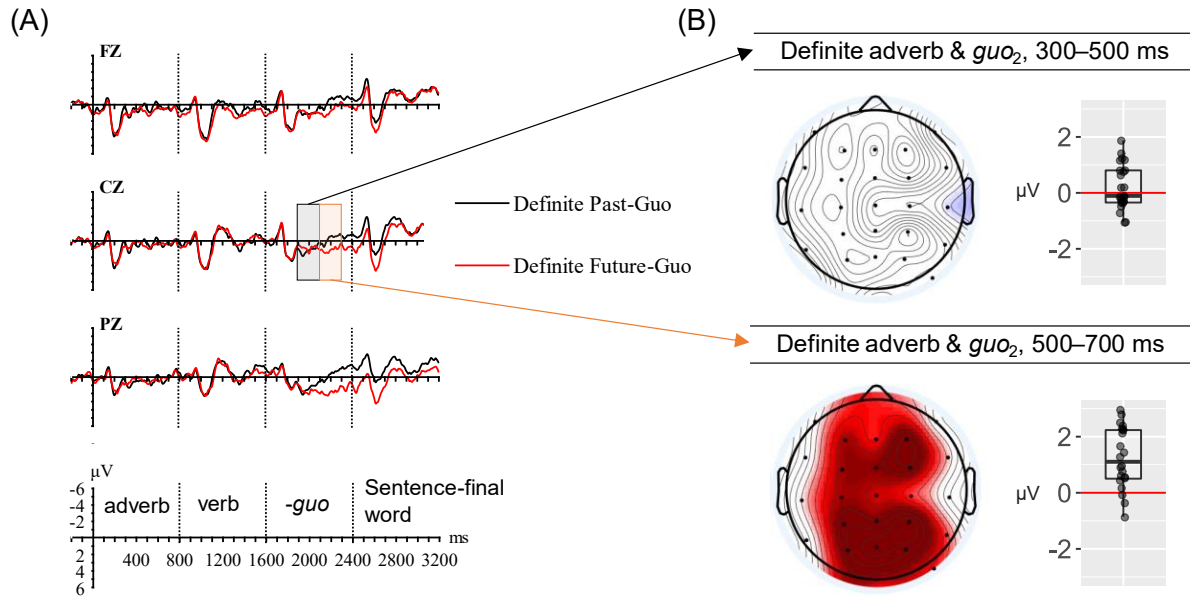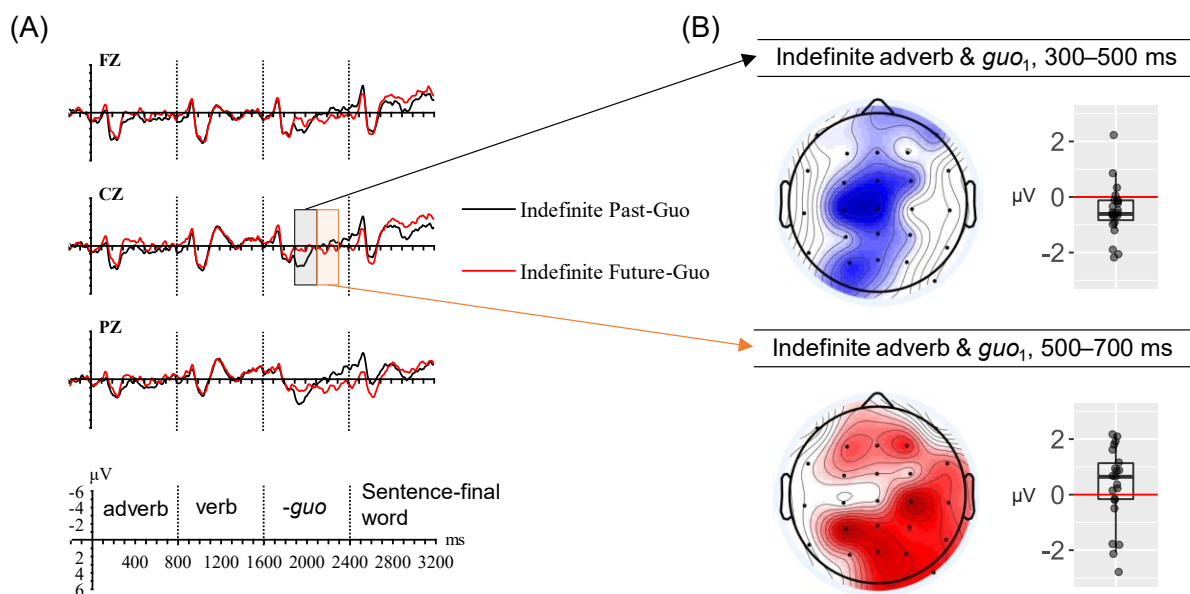

Fig. 1. *Panel A*: ERP waves of the definite temporal concord conditions (black = grammatical, red = ungrammatical, negative voltage plotted upward). ***Panel B***: topographic maps and boxplots of the difference wave at guo_2 (ungrammatical *minus* grammatical; mean amplitude from -1.5 µv (blue) to +1.5 µv (red)) at the 300–500 and 500–700 ms time windows

Figure 2. *Panel A*: ERP waves of the indefinite temporal concord conditions (black = grammatical, red = ungrammatical, negative voltage plotted upward). ***Panel B***: topographic maps and boxplots of the difference wave at guo_1 (ungrammatical *minus* grammatical; mean amplitude from -1.5 µv (blue) to +1.5 µv (red)) at the 300–500 and 500–700 ms time windows

These observations were statistically verified: only the Type x Grammaticality interaction was significant at the 300–500ms time window ($F(1,23) = 9.62$, $p < .01$); only the main effect of Grammaticality was significant at the 500–700ms time window ($F(1,23) = 13.89$, $p < .01$).

4 Discussion

The ERP results indicate distinct and also overlapping processing patterns for guo_1 and guo_2. Guo_1 elicited a N400 effect followed by a P600. The N400 can be seen as indicating the difficulty to integrate an event which is asserted as existing (meaning of guo_1) in a non-existing context (meaning of future time adverb). The P600 reflects the difficulty to locate an event perceived as be past (meaning of guo_1) in a future time context. Conversely, only a P600 was found for guo_2, which can be analyzed the same way as for the P600 elicited by guo_1. These results, coherent with the linguistic analyses of guo_1 and guo_2, are modelized in Fig. 3.
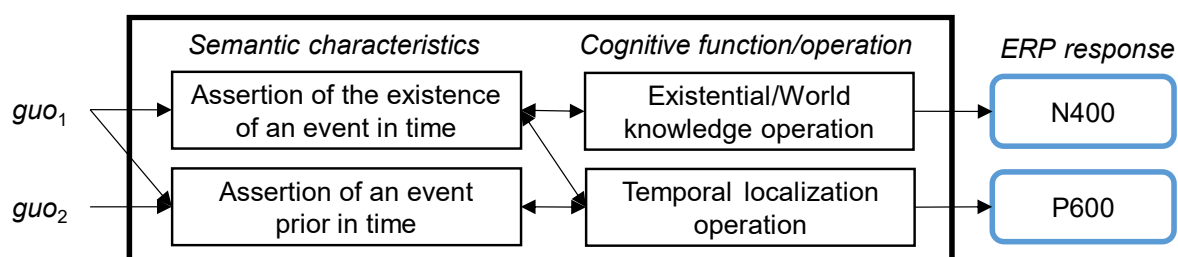

Fig. 3. Linking the linguistic and cognitive analyses of guo_1 and guo_2 with their ERP responses

Finally, these results may even suggest a cognitive continuum between the meaning of the aspect markers in Mandarin and their ERP signatures: '*you* + VP' (N400, existential) – guo_1 (N400+P600, existential+localization) – guo_2 (P600, localization) – *-le* (LAN, sequencing).

5 Conclusion

This study bridges linguistic analyses of the aspect markers guo_1 and guo_2 in Mandarin with their ERP responses as well as a tentative model with other markers. More insight could be given by comparing with the processing of tense markers in Indo-European languages.

Selected references

Baggio, G., van Lambalgen, M., & Hagoort P. (2012). Language, linguistics and cognition. In R. Kempson, T. Fernando, & N. Asher (Eds.). *Handbook of the philosophy of science* (pp. 325–355). Amsterdam: North Holland.

Collart, A. (2018). Same interpretation, different process? The case of verbal *-le* and *You*+VP in Taiwan Mandarin. Paper presented at the joint ICPEAL 17-CLDC 9 conference, National Taiwan University, Taipei.

Collart, A. (2022). *Bridging time in language and in the brain: Insights from Mandarin Chinese*. Doctoral dissertation, National Taiwan Normal University, Taipei, Taiwan. Retrieved from https://hdl.handle.net/11296/w7mrm5.

Collart, A., & Chan, S.-H. (2021). Processing past time reference in a tenseless language: an ERP study on the Mandarin aspectual morphemes -le and -guo. *Journal of Neurolinguistics*, *59*, 100998.

Collart, A., and Su, H.-K. (2022). Encoding the existence of an event with 'you (to have) + VP' in Taiwan Mandarin: A corpus-based investigation. *Concentric: Studies in Linguistics*. Issue TBA.

Comrie, B. (1985). *Tense*. Cambridge, New York: Cambridge University Press.

Iljic, R. (2010). Holisticity, discontinuity, class in Chinese aspect. *Language Research*, *46*(2), 147–198.

Klein, W. (1994). *Time in language*. London: Routledge.

Qiu, Y., & Zhou, X. (2012). Processing temporal agreement in a tenseless language: An ERP study of Mandarin Chinese. *Brain Research*, *1446*, 91–108.

Woo, I.-H. (2018). On perfective -le in Mandarin Chinese: theoretical and pedagogical issues. *Acta Linguistica Asiatica*, *8*(2), 139–158.