Not necessarily first language "attrition": On-line reflexive processing among Mandarin-English late bilingual speakers

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During a conversation, tracking and retrieving the reference of pronouns is crucial to fully comprehending the speaker's intention. Pronoun resolution involves linguistic information, real-word knowledge, and general cognitive functions [1], and this task appears even more demanding for bilingual speakers whose two languages differ in terms of pronominal syntax. Unlike English reflexives, which are always bound within the local domain [2], the Mandarin reflexive *'ziji' (self)* allows both local binding (LOC) and long-distance binding (LD) [3]. When '*ziji'* has multiple potential antecedents in the sentence, the ambiguity is resolved either through discourse information, or semantic meaning of the verb [4], leaving reflexive-antecedent binding at the syntax-discourse or the syntax-semantics interface [5]. Research has shown that *interface structures* are vulnerable to cross-linguistic influence, and bilingual speakers in a L2 dominant environment diverge from monolingual speakers in their interpretation of pronominal subjects [6]. This L2-induced change in the L1 is called L1 attrition.

In the current study, we investigated whether Mandarin-English late bilingual speakers show attrition effects during on-line reflexive processing, and how is this process affected by language, experience and cognitive load. 79 participants, 39 recruited from China (the control group), 40 from the U.K. (the bilingual group), participated in the study. Note that participants in the control group only received English education in classroom-settings; they were not functional bilingual speakers. 25 participants from the bilingual group (retest) were also retested 6 months later, to investigate whether their on-line performance is sensitive to length of residence (LoR) in the L2 English environment (Table 1). We used a word-by-word speeded comprehension task with two-alternative forced-choice (2AFC). Using a 2*2 (interface * binding distance) design, we constructed 144 stimuli with the structure of "context sentence + target sentence (P-NP1 + VP1 + P-NP2 + VP2 + *ziji*)" (Table 2). During the experiment, sentences were presented word-by-word in a rapid serial visual presentation (RSVP) mode at the center of the screen (Figure 1). The presentation rate was 240*cpm* (characters per minute), which encouraged participants to parse the sentence as fast as they could without compromising the comprehension [7]. After reading the sentence, participants were asked to answer whether *'ziji'* referred to the matrix or the local subject by button press within 3000*ms*. Their responses and reaction times to comprehension questions were recorded. In addition to the linguistic task, we conducted a battery of cognitive tasks to measure working memory capacities (complex span tasks) [8] and cognitive control abilities such as attention maintenance, response inhibition and mental shifting (elevator counting tasks from *Test of Everyday Attention*) [9].

We evaluated the effect of **group** (reference level: control group) and **interface** (reference level: syntax-semantics interface) on comprehension **accuracy** with logistic mixed effects models (*GLMM*, maximum *RE* structure) [10]. Results showed that pronoun processing at the syntax-semantics interface was more accurate than that at the syntax-discourse interface (β = −0.71, z = −4.45***). *Post hoc* group comparisons with Tukey adjustment showed that short-term bilinguals were more accurate in the retest than they were 6 months earlier (β = 0.23, z = 3.31**) (Figure 2). In addition, we found a positive correlation between the *Elevator Counting task with interference*, designed to measure response inhibition, and comprehension accuracy: participants with better inhibition control were more accurate when processing reflexives on-line (β = 0.25, z = 5.76***). We also found a positive correlation between the *Symmetry span task*, which was designed to measure spatial working memory, and comprehension accuracy: participants with better spatial working memory were also more accurate in the comprehension task (β = 0.06, z = 2.98**).

We also evaluated the effect of **group** and **distance** (reference level: LOC) on **reaction time** with linear mixed effects models (*LMM*; maximum *RE* structure) [10]. Results showed that participants took longer time to process long-distance binding than they did for local binding (β = 99.56, t = 3.22**), replicating the "locality effect" found in previous studies [11]. In addition, participants in the control group were slower than those in the bilingual group (β = -140.38, t = 2.16*); *post hoc* group comparisons with Tukey adjustment revealed that the bilingual group were faster in the retest than they were 6 months ago (β = -64.35, z = -5.56***) (Figure 3). Results from the *Elevator counting tasks with reversal* and the *Symmetry span task* negatively correlated with reaction time (β = -35.72, t = -5.06***; β = -11.27, t = -3.35***), indicating that participants with better mental shifting abilities and larger spatial working memory establish reflexive-antecedent binding more efficiently.

In contrast to other work showing a bilingual *disadvantage* in linguistic tasks [12], we showed that during on-line reflexive processing, where one must inhibit irrelevant reflexive-antecedent mappings, retrieve and integrate changing context information to the representation, bilingual speakers have higher accuracy and shorter reaction time than their non-bilingual peers. Significant correlations between cognitive tasks and the

linguistic task suggest that general cognitive functions, such as working memory and attention control, play a significant role during on-line processing, especially when the comprehension demands are high.

Table 1 Participants' profiles; mean (standard deviation)

	Control group	Short-term group	Short-term group (Retest)	Comparison
Age (yrs)	25.92 (1.82)	23.43 (1.75)	24.03 (1.55)	*NS*
LoR (mths)	*NA*	6 (1)	12.04 (0.9)	$p < .001^{***}$
L2 Education	1 (0)	0.98 (0.08)	0.98 (0.08)	*NS*
Highest Degree	0.5 (0)	0.74 (0.08)	0.74 (0.08)	*NS*

Table 2 Stimuli structure and examples; words underlined appeared on the same frame in the speeded presentation

Interface	Binding	Number	Sample Sentence
Syntax-discourse	LOC	$N = 40$	*Zhangsan$_i$ kandao Lisi$_j$ zhanzai louding, Zhangsan$_i$ rang Lisi$_j$ buyao shanghai ziji$_j$.* *Zhangsan$_i$ saw Lisi$_j$ stand-on rooftop, Zhangsan$_i$ asked Lisi$_j$ not hurt self$_j$.* 'Zhangsan saw Lisi standing on the rooftop, Zhangsan asked Lisi not to hurt himself.'
	LD	$N = 40$	*Lisi$_j$ nadao weixie Zhangsan$_i$, Zhangsan$_i$ rang Lisi$_j$ buyao shanghai ziji$_i$.* *Lisi$_j$ use-knife threaten Zhangsan$_i$, Zhangsan$_i$ asked Lisi$_j$ not hurt self$_i$.* 'Lisi threaten Zhangsan with a knife, Zhangsan asked Lisi not to hurt him.'
Syntax-semantics	LOC	$N = 32$	*Zhangsan$_i$ faxian Lisi$_j$ zai toudongxi, Zhangsan$_i$ rang Lisi$_j$ tanbai ziji$_j$.* *Zhangsan$_i$ caught Lisi$_j$* PROG *stealing, Zhangsan$_i$ asked Lisi$_j$ confess self$_j$.* 'Zhangsan caught Lisi stealing, Zhangsan asked Lisi to confess himself.'
	LD	$N = 32$	*Zhangsan$_i$ meiyou shoudao Lisi$_j$* DE *huixin, Zhangsan$_i$ rang Lisi$_j$ huida ziji$_i$.* *Zhangsan$_i$ not-yet received Lisi$_j$* POSS *reply, Zhangsan$_i$ asked Lisi$_j$ answer self$_i$.* 'Zhangsan haven't received Lisi's reply, Zhangsan asked Lisi to answer him.'

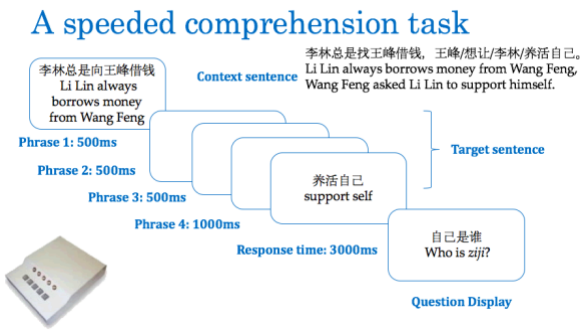

Figure 1

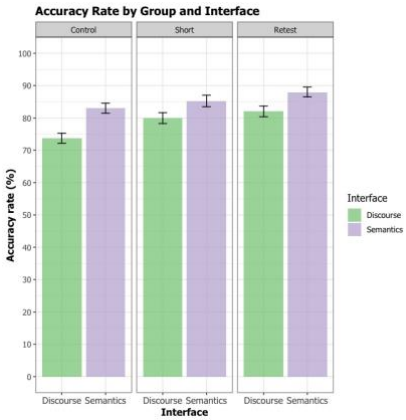

Figure 2

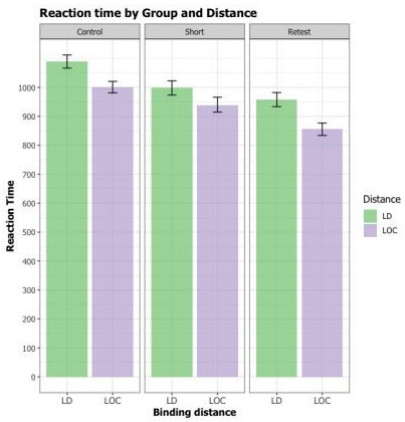

Figure 3

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