Is there an L2-related working memory advantage? Unravelling the effects of culture and task complexity

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The issues

- **Does L2 experience confer an advantage in executive functions (EF)** (Valian 2015)**, and in particular in working memory (WM)?**
- No consistent correlation between bilingualism and EF in young adults (Kousaie et al 2014), in contrast with younger or older groups (Bialystok et al 2014):
  → **Could this be in part due to insufficiently demanding tasks?**
- Chinese participants outperform peers from other cultures on WM tasks (Demetriou et al 2015), but this advantage might be limited to tasks that are numerically based rather than visual (Hedden et al 2002) or of low complexity (Ellefson et al 2017)
  → **How can the effect of second language experience be disentangled from the effect of culture?**

Research questions

1. Does the impact of culture and second language experience on WM performance vary depending on task demands?
2. Is it possible to disentangle the effect of second language experience from that of culture? Does this vary across WM tasks?

Previous Study (Xu, 2018)

PARTICIPANTS (all in UK)

- L1 English group: 29 L2 learners of Chinese (15 female, mean age = 22)
- L1 Chinese group: 25 L2 learners of English (18 female, mean age = 25)

PROCEDURE

Digit Span tests (procedure from Turner and Ridsdale, 2004): Forward and Backward.

RESULT Significant advantage of the L1 Chinese group (t = 10.23, p < .0001)

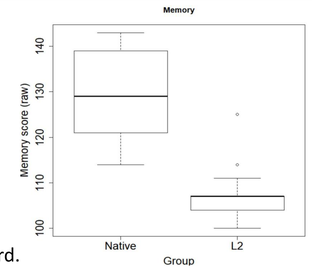

Fig.1: Memory score in the Digit Span test, by Group (Native = English native speakers; L2 = English L2 speakers), showing mean and inter-quartile range.

This study

PARTICIPANTS

- L1 English group: 29 English learners of Chinese (19 female, mean age = 25; 8 without Time Abroad)
- L1 Chinese group: 59 Chinese learners of English (38 female, mean age = 26; 31 without Time Abroad)

- **L2 proficiency** assessed with LexTale (Abroad group), University Assessment (Home group) for English (http://www.lextale.com/) or Easy.Mandarin for Mandarin Chinese (https://www.easymandarin.cn/test-your-chinese-level/)
- **L2 experience** estimated based on a questionnaire. Time Abroad: 4 levels (none / less than 6 mo. / 6 mo. – 2 y. / more)

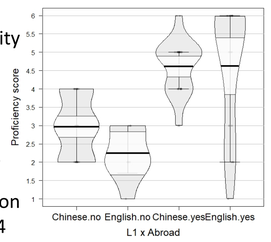

Fig.2: Proficiency score by L1 & time abroad, showing mean and .95 confidence interval

Procedure

WM battery (Berry, Waterman, Baddeley, Hitch & Allen, 2018) manipulating Executive Control **complexity** (low/high) and presentation **modality** (verbal/visuo-spatial):

-	Forward Digit span (FDT):	low, verbal
-	Backward Digit span (BDT):	high, verbal
-	Corsi Block Tapping (CBT):	low, visuo-spatial
-	Odd-one-Out (OoOT):	high, visuo-spatial

- **Response:** non-verbal (mouse click)
- **Sequence length:** 4 trials at 3 sequence lengths → more sensitive measure (proportion correct per trial)

- **Stimulus:** (randomly generated across participants)
  - **FDT / BDT:** auditory presentation
  - **CBT:** 9 boxes, lit-up in pre-fixed sequence
  - **OoOT:** 3 shapes (incl. 2 identical), each in a different box → identify the odd-one-out and recall its position.

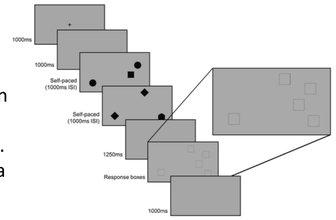

Fig.3: Procedure illustrated for the Odd-one-Out task (self-paced stimulus slides; 1250 ms ISI)

Raw results

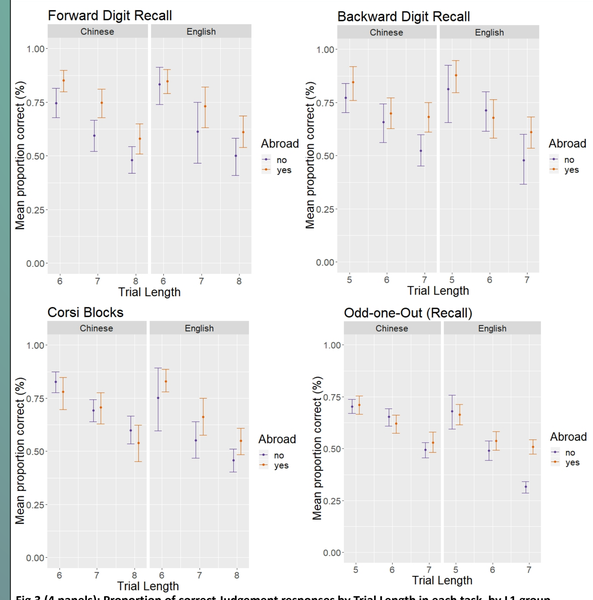

Fig.3 (4 panels): Proportion of correct Judgement responses by Trial Length in each task, by L1 group and Stay Abroad, showing mean and .95 confidence interval

Analysis

Outcome variable: mean proportion correct per trial at each length
Mixed-effect modelling (lme4 version 1.1.21, R version 3.0.6)

- Bottom-up approach. Predictors retained only if improving the model fit.
- Random effect: Participant (random slopes did not improve the model fit in any of the analyses, or led to non-convergence)
- Fixed effects **tested for**: L1 (proxy for Culture), Time Abroad and Proficiency (proxy for L2 experience), Sex

	Chinese	English
Less than 4 months	32	13
4 to 12 months	6	3
1 to 2 years	2	9
More than 2 years	19	4

Table 1: Amount of time in the L2 country (number of participants at each level)

Time Abroad strongly correlated with Proficiency (r = .63, p < .0001)

Forward Digit Recall

- Significant effect of Trial Length (no significant interactions)
- Proficiency OR Time Abroad significant as main effects
  → disadvantage for the Chinese group at lower proficiency
- Trend for interaction between L1 and Proficiency (but not between L1 and Time Abroad)

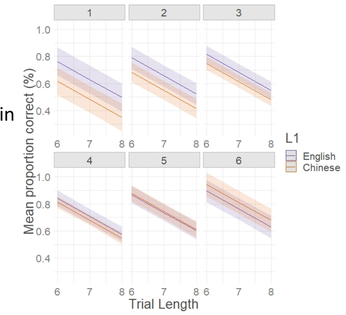

Fig.4: Modelled FDR scores by Trial Length, L1 and Proficiency (6 levels)

→ at high proficiency, the Chinese group might out-perform the English group?

Backward Digit Recall

- Significant effect of Trial Length
- Trend for interaction between Length & L1 (Likelihood ratio test: p = .07)
- Trend for effect of Time Abroad or Proficiency (Likelihood ratio test: p = .07)
  → disadvantage for the Chinese group at lower proficiency

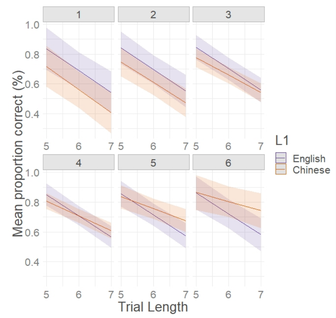

Fig.5: Modelled BDR scores by Trial Length, L1 and Proficiency (6 levels)

→ at high proficiency, Chinese group might out-perform English group in longer digit sequences?

Corsi-block Tapping

- Significant effect of Trial Length (no significant interactions)
- Sex approaches significance (numerical advantage for Males)
- No significant effect of
  - Proficiency (Likelihood ratio test: p = 0.12)
  - Time Abroad (Likelihood ratio test: p = 0.93)
  - L1 (Likelihood ratio test: p = 0.27)

Odd-one-Out

JUDGEMENT RESPONSE:

- Modest but significant effect of Trial Length
- Incorrect judgements excluded from the Recall analysis.

RECALL RESPONSE:

- Significant effect of Trial Length, in 3-way interaction with
  - L1
  - Time Abroad (but not Proficiency)

→ at longer trial length and no Abroad experience: advantage for the Chinese group

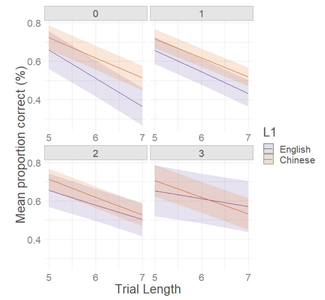

Fig.6: Modelled OOO scores by Trial Length, L1 and Time Abroad (4 levels)

Conclusions

1. **Modest impact** of L2 experience and Culture on WM (consistent with previous research on young adults):
   - Trend towards advantage for the Chinese group in the digit tasks (when Proficiency is taken into account)
   - Time Abroad predicts performance in OOO
   - Trend towards effect of Proficiency or Time Abroad in BDR
2. Effect of **modality**? YES
   - Consistent with Xu (2018): Chinese advantage in numerical tasks (at high proficiency and high difficulty)
3. Effect of task **complexity**? YES
   - Interaction of predictors with Trial Length only in the more complex tasks
4. Can **Culture** be disentangled from **L2 proficiency**?
   - Not reliably in the digit tasks
   - Possibly in the Odd-one-Out (visual, high-complexity)
5. Clearer results might be obtained at higher levels of task demand (longer trial sequences).

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