Long-term retention of vocabulary in two phonetically similar foreign languages is aided when learning occurs in highly distinctive virtual reality environments

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Background

Resolving interference is a constant demand for the human mind. We often must cope with learning multiple sets of information that are similar and easily confusable. For instance, when traveling to a place where multiple languages are spoken, one might wish to learn vocabulary items in each language without losing track of which translation goes with which language.

Due to the context-dependent nature of memory[1], we posit that learning each set of memoranda in a distinctive environment, as is afforded by immersive virtual environments (VEs), could reduce interference.[2,3]

However, this strategy has a caveat: context-dependent forgetting.[4] Context-dependent forgetting is the retrieval impairment that occurs when encoding and retrieval environments differ greatly, as VEs and the real world do. This could be a key weakness of VEs as a pedagogical tool—the lack of *transfer*.

Extrapolating past research, the current study aims to use mental reinstatement—a mnemonic technique to recall the learning context during retrieval[5,6]—to overcome context-dependent forgetting, and thereby enabling the use of distinctive VEs as contextual support in resolving interference between confusable memoranda sets.

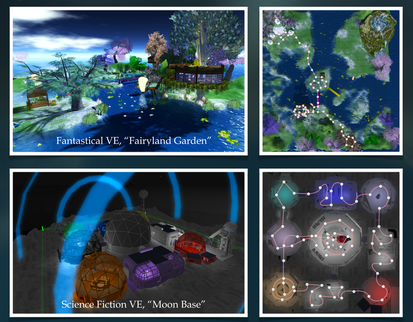
Methods

Participants. 48 healthy undergraduate university students (17 F, age *M*=20.18, *SD*=1.72 years) participated in this study. Amongst these, 7 new datasets have not yet been scored, 1 was missing immersion data, 2 had outlying performance during T1 and T2, and were excluded from analyses.

Design. A 2 x 2 x 2 x 2 mixed design, with one between-subject factor (*context group*; Single- vs. Dual Context) and three within-subject factors: number of foreign *translations* learned for a given English word (1- *vs*. 2-Translations), congruence of mental *reinstatement* context (congruent *vs*. incongruent), and *immersion* (low- *vs*. high- immersion). Two dependent variables were analyzed: transfer (ability to retrieve information learned within VE when tested outside VE), and 1-week forgetting.

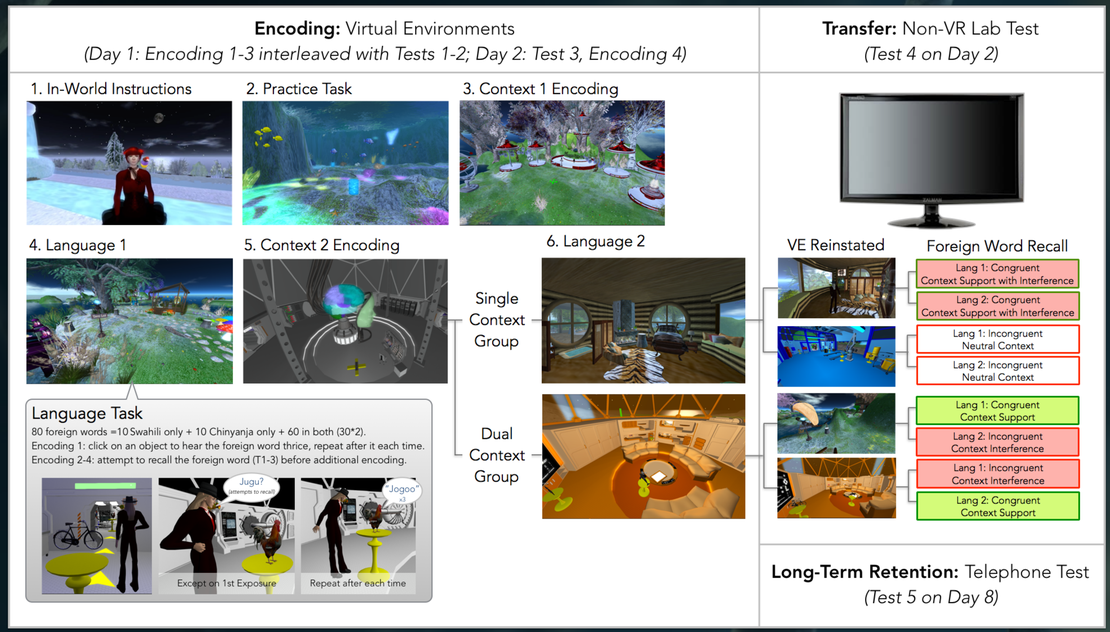
Material. Two learning paths through two custom-built VEs (Figure 1), powered by OpenSimulator. For procedure and other material, see Figure 2.

Figure 1. Custom VEs and Learning Paths



Fairyland Garden mostly consists of outdoor, expansive spaces, while Moon Base is entirely enclosed and avatars were blocked from venturing outdoors for their own safety as spacesuits were not provided.

Figure 2: Experimental Task

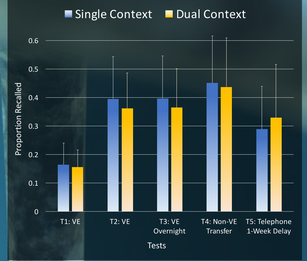


Results

Overall Performance

While there was a trend of multivariate *context group* effect (*p*=.052), the two groups showed comparable overall recall.

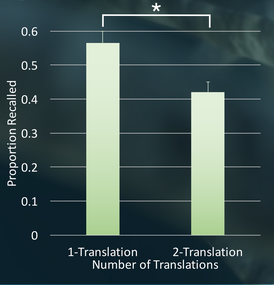
Figure 3. Overall Performance.



Transfer (T4) Performance

There was a significant main effect of *translation* in the transfer test (*p*<.001).

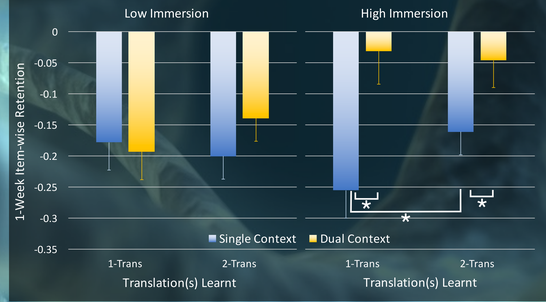
Figure 4. T4 Translation effect.



1-Week Item-wise Retention

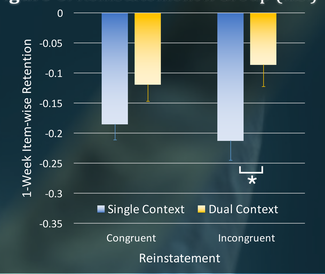
There was a 3-way *Context Group* x *Translation* x *Immersion* interaction (*p*=.03).

Figure 5. 3-way interaction on 1-Week Retention.



While the *Reinstatement* x *Group* interaction was n.s., in the incongruent reinstatement condition, the contrast between the groups was significant (*p*=.02).

Figure 6. Reinstatement x Group (n.s.)



Discussion

- For participants who experienced high VR immersion, those who learned two languages in two distinctive VEs (dual context) had 11.5-22.3% more 1-week retention as compared to those who learned both languages in the same VE (single context).
- Despite showing poorer long-term retention, the single context group performed surprisingly well, and they retained the high interference items better than the low interference ones. This could be due to "desirable difficulties," such that the necessity of learning two languages within the same VE forced them to resolve interference during encoding (e.g., by forming integrated triplet representations).

Taken together, our results showed that context effects emerged over a long retention period, but this effect is contingent on immersion—i.e. VE contextual support only worked for participants to whom the virtual encoding contexts (and avatars) felt real.

Preliminary fMRI Results

A separate group of dual-context participants performed T4 while during fMRI scans. Preliminary multivoxel pattern analyses (MVPA) were conducted.

Figure 7. *fMRI version of T4*

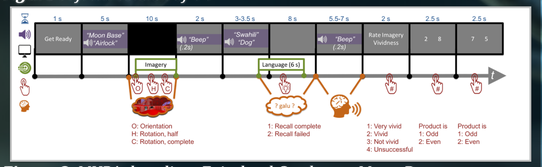


Figure 8. *MVPA decoding: Fairyland Garden vs. Moon Base*

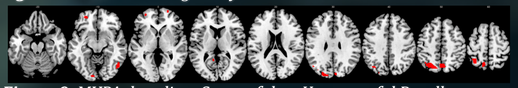
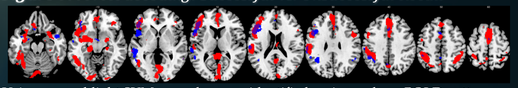


Figure 9. *MVPA decoding: Successful vs. Unsuccessful Recall*



Using a searchlight SVM procedure, we identified regions whose BOLD patterns could decode which world the participants were imagining during mental reinstatement (Fig 8). We also identified regions whose patterns predicted the success of verbal recall seconds before participants spoke their response (Fig 9, red), and a partially overlapping set of regions that could predict recall success 1-week later (Fig 9; blue).

References

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Acknowledgements

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