

An exploratory analysis of the impact of learners' first language on vocabulary recall using immersive technologies

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Abstract. This exploratory post-hoc analysis examined the impact of learners' first language (L1) on learning vocabulary annotated in immersive 360° pictures. This analysis is a part of a larger, between-subjects study (Papin & Kaplan-Rakowski, 2020) in which learners ($N=63$) of French as a second language (L2) studied vocabulary annotated in (1) Two-Dimensional (2D) pictures viewed on a desktop monitor, (2) 360° pictures viewed on a desktop monitor, and (3) 360° pictures viewed using a Virtual Reality (VR) headset. A multiple regression linear model revealed that native speakers of English benefited significantly more from immersive technologies compared with L1 Chinese speakers. When low-immersion and high-immersion technologies were used, Chinese L1 speakers were significantly disadvantaged by high-immersion VR. This study has implications in the field of L2 vocabulary research and learning materials design.

Keywords: 360° pictures, immersive technologies, virtual reality, low-immersion virtual reality, high-immersion virtual reality, vocabulary learning.

1. Introduction

Teachers have traditionally used 2D pictures as visual aids for vocabulary teaching. Such pictures restrict learners to passively viewing a small fraction of a scene. Technology advances now enable immersion in 360° pictures. The affordances of 360° pictures include omnidirectional viewing and active exploration of the surrounding area, similar to real life. Viewing 360° pictures

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on a desktop monitor can be considered Low-immersion VR (LiVR). These 360° pictures can also be displayed through a headset, yielding High-immersion VR (HiVR). As the terms 'LiVR' and 'HiVR' suggest, the level of immersion is the distinguishing factor between the two types of VR (Kaplan-Rakowski & Gruber, 2019). In this paper, we refer to LiVR and HiVR collectively as immersive technologies.

Similar to 2D pictures, 360° pictures can be annotated with target vocabulary, generating associations between the first language (L1) and the second language (L2). This practice of vocabulary learning through L1-L2 associations is supported by dual-coding theory (Paivio, 1971), the method of loci (Krokos, Plaisant, & Varshney, 2019), and the embodiment theory (Gallagher, 2006).

Despite some contradictory evidence (Kaplan-Rakowski, 2019), immersive technologies can be advantageous for vocabulary recall (Krokos et al., 2019; Lan, Fang, Legault, & Li, 2015). The question of whether all types of learners benefit equally from learning vocabulary in immersive settings has not been answered. Daigle, Mathieu, and Montésinos-Gelet (2008) show that the influence of L1 on L2 French language learning can vary cross-linguistically in more traditional educational settings. We thus explore the question: *does L1 influence the effectiveness of vocabulary learning using immersive technologies?*

2. Method

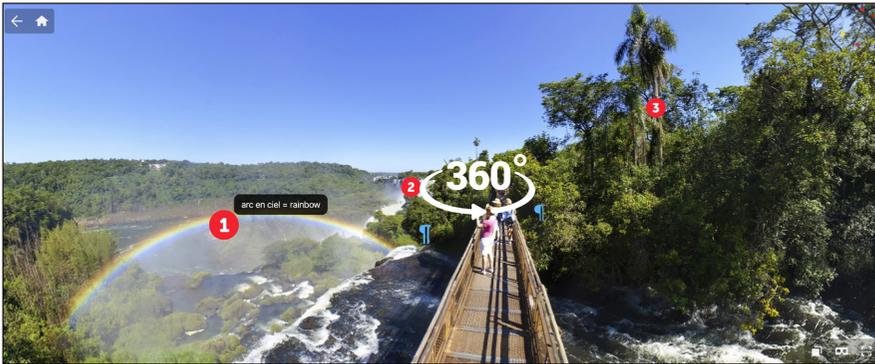
Our sample (mean age=20) consisted of 63 international students learning French as their second language at a large English-speaking Canadian university. We divided the sample into three groups: 27 were native speakers of Chinese (either Mandarin or Cantonese); 24, of English; and 12, of neither Chinese nor English (e.g. Punjabi, Swahili, Turkish, Portuguese). All participants were fluent in English.

The procedure started with a practice activity in which subjects acquainted themselves with the equipment and the format of the experiment to be conducted. A vocabulary pretest confirmed the homogeneity of variances between the groups. Next, the subjects studied 15 advanced French words, none of which was a cognate of English or a Romance language. The words were annotated either in (1) 2D pictures viewed on the desktop monitor, as the control group; (2) 360° pictures viewed in LiVR on a desktop monitor; or (3) 360° pictures viewed in HiVR with a VR headset. The annotated pictures were identical across conditions,

but the interactivity and the immersion level differed. Condition (1) offered no interactivity and little immersion. Condition (2) allowed for interactivity through scrolling and moving within the 360° pictures. Condition (3) embodied the viewers in 360° pictures, providing the highest immersion compared with Conditions (1) and (2). For a more elaborate description of the experiment, see [Papin and Kaplan-Rakowski \(2020\)](#).

The experiment involved the exploration of three annotated 360° pictures. [Figure 1](#) shows a screenshot of a 360° picture, which learners explored by scrolling around. By hovering over the numbered vocabulary items, the names of the items in French and English were revealed. Next, the subjects completed a demographic questionnaire and a survey. The last step of the procedure was a post-test consisting of receptive and productive tasks measuring immediate vocabulary recall. Two independent experts rated all the tests.

Figure 1. An example of a 360° picture annotated with vocabulary



To model the association between L1 and the impact of immersive technologies on learning vocabulary in VR, we estimated the following regression model:

$$(1) \text{Test score}_i = \text{Intercept} + \beta_1 (\text{Chinese}_i * \text{VR}_i) + \beta_2 (\text{English}_i * \text{VR}_i) + \beta_3 (\text{Other}_i * \text{VR}_i) + e_i$$

Chinese_i takes a value of one if a subject reported Chinese as their L1. English_i and Other_i are defined similarly for English and other L1 languages, respectively. VR_i is an indicator variable taking a value of one if subject i was exposed to the VR treatment.

3. Results

Table 1 reports estimates for three specifications of Equation 1 based on the type of immersive technology treatment: either LiVR or HiVR (Model 1), LiVR only (Model 2), and HiVR only (Model 3). The significant positive coefficient for *English*VR* in Model 1 indicates that, relative to the control condition, test scores were about three points higher (that is, about 40% higher) when the subjects reported English as their L1 and were exposed to immersive technology. Model 2 illustrates a similar finding when the immersive technology was restricted to only the LiVR treatment. The combination of English L1 and LiVR was associated with scores 4.64 points higher (approximately 58% better). Model 3 revealed a slightly different effect for HiVR. The significant negative estimate for *Chinese*VR* shows that test scores were lower by 3.89 points (about 40% worse) with the HiVR treatment when Chinese was reported as the L1. In untabulated results, we observed similar patterns for scores on receptive recall tests.

Table 1. Regression results

Variable	Model 1 (LiVR or HiVR)	Model 2 (LiVR)	Model 3 (HiVR)
Intercept	8.13*** (9.08)	8.03*** (14.38)	9.64*** (16.67)
Chinese*VR	-.25 (-0.20)	2.26 (1.58)	-3.89*** (-2.78)
English*VR	3.09** (2.54)	4.64*** (3.60)	0.26 (0.20)
Other*VR	0.04 (0.03)	0.55 (0.38)	-2.04 (-1.19)
R2	0.15	0.20	0.14

Note: Coefficient estimates are reported with t-statistics in parentheses. Significance at the 0.01 level is indicated by *** and at the 0.05 level by **.

4. Discussion and conclusions

Immersive technologies, including LiVR and HiVR, can foster language learning (Gruber & Kaplan-Rakowski, 2020; Kaplan-Rakowski & Wojdyski, 2018; Lan et al., 2015; Papin, 2018; Sadler, 2017). This exploratory analysis showed that native speakers of English benefited significantly more from immersive technologies for vocabulary recall than their Chinese L1 counterparts. This overall trend revealed two distinct components: English L1 speakers did better on LiVR and Chinese L1 speakers were significantly disadvantaged by HiVR.

Our findings are aligned with literature showing that some aspects of the French language are more easily acquired by L1 English speakers than L1 Chinese speakers in a non-immersive learning environment (Daigle et al., 2008). Further, our results could be explained by alphabetic L1 speakers performing better at alphabetic L2 (e.g. English) vocabulary recall than L1 logographic (e.g. Chinese) speakers (Wang, Koda, & Perfetti, 2003).

Based on the results of Papin and Kaplan-Rakowski (2020) and on this post-hoc analysis, future studies should examine the potential of various immersive technologies (augmented, extended, and virtual realities) for L2 vocabulary learning, with a special focus on learners' sociolinguistic background.

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