Do age of acquisition and orthographic transparency have the same effects in different modalities?

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Abstract

This paper is intended to study the effects of age of acquisition (AoA) and orthographic transparency on word retrieval in Persian, which is an understudied language. A naming task (both pictures and words) and a recall task (both pictures and words) were used to explore how lexical retrieval and verbal memory are affected by AoA and transparency. Seventy two native speakers of Persian were recruited to participate in two experiments. The results showed that early acquired words are processed faster than late acquired words only when pictures were used as stimuli. Transparency of the words was not an influential factor. However, in the recall experiment a three-way interaction was observed: early acquired pictures and words were processed faster than late acquired stimuli except the words in the transparent condition. The findings speak to the fact that language-specific properties of languages are very important.

1 Introduction

The majority of research on word retrieval and recall are done only on few languages of the word such as English (Cycowicz et al.,1997; Snodgrass & Vanderwart,1980), Dutch (Shao & Stiegert, 2016), French (Alario & Ferrand,1999; Bonin et al.,2003), Spanish (Cuetos et al.,1999; Manoiloff et al.,2010) and Italian (Dell'Acqua et al., 2000; Navarrete et al., 2019). There are only few reports available in other languages of the world such as Persian.

Age of acquisition (AoA) is known to have a strong effect on word retrieval. Words which are learned earlier are usually processed faster than late acquired words (Alario et al.,2004). This finding has been replicated across several languages in

Fixed effects	Estimate	Std. Error	t value
(Intercept)	915.32	31.44	29.11
Condition	265.35	-37.34	-7.10
AoA	169.14	17.16	9.86
Condition*AoA	-147.16	15.59	-9.44

Random effects	Variance	Standard Deviation
Items	2833	53.22
Subjects	10540	102.66
Residual	31399	177.20

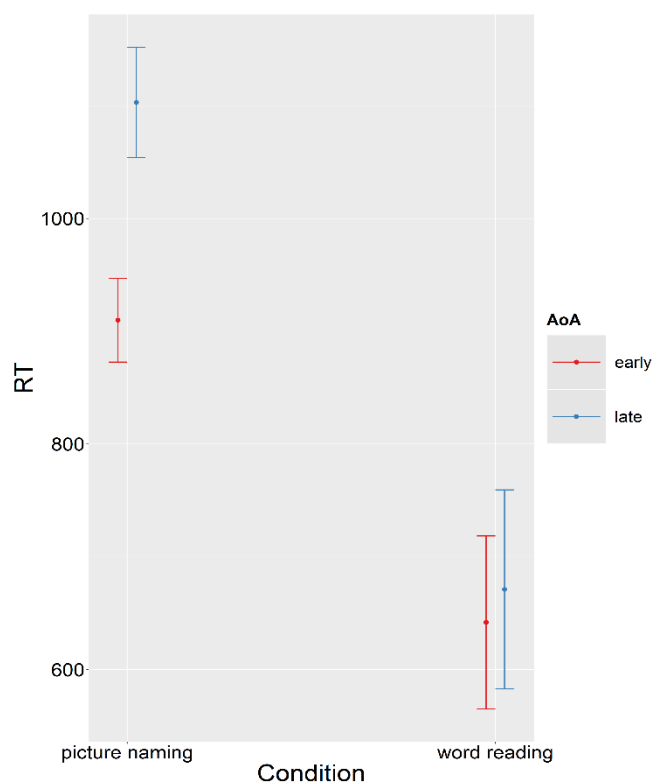Table 1: Summary of significant effects in the reaction time experiment

Figure 1: Interaction between Condition and AoA

picture naming. However, when it comes to word recall, the findings are mixed. For example, Cortese et al. (2010, 2015) showed that later acquired stimuli were recalled better than early acquired ones. Raman et al., (2018) found no effects of AoA.

Where AoA effect interacts with orthographic transparency is another question. Orthographic transparency refers to the level of consistency in grapheme to morpheme correspondence. For instance, the word car is orthographically transparent, while the word night is not. Arbitrary Mapping Hypothesis (AMH) (Ellis & Lambon Ralph, 2000) posits that AoA effect is only observable in words where print to sound correspondence is inconsistent (opaque). They believe that AoA effects is diminished in the transparent orthographies. Findings from highly transparent orthographies in other languages such as Turkish failed to replicate the predictions of AMH (Raman, 2006).

The aim of this paper is to see if previous findings could be replicated in Persian which is an understudied language. Persian orthography is both opaque and transparent thus allowing researchers to test AoA effects within one single language. This report is intended to see if AoA interacts with transparency similarly across both naming and recall tasks.

If predictions of ARH are correct, it is hypothesized that in both modalities (words vs. picture) of naming and recall tasks AoA should only show an effect in the opaque condition. In the transparent condition, AoA effect should disappear based on ARH predictions.

2 Methods

2. 1 Participants
Number of participants in this study included 72 native speakers of Farsi. Thirty six people participated in the naming experiment (mean age: 23.27, gender: 22 male) and 36 in the recall experiment (mean age: 21.56, gender: 17 male). They were all undergraduate university students. The participants had normal or corrected to normal visual acuity, and reported no history of neurological or psychiatric disorders. They received course credit and gave informed consent before their participation.

2. 2 Materials

Sixty words and their pictures were selected from Farsi Snodgrass and Vanderwart naming battery (Bakhtiar, Nilipour, & Weekes, 2013). These words and pictures were divided, on the basis of a 3.8 cut-off point, into two categories: early acquired and late acquired words. Each category of words was then divided into 15 opaque and 15 transparent ones. The stimuli included both tools and animals. Orthographic transparency was defined based on how well the letters in a word were matched with the sounds in the same words. For instance, the word 'car' in English is transparent, but 'psychology' is not as transparent because not all the letters have a phonological representation in the production stage of the word.

2.3 Procedure

Recall experiment: in this experiment the participants were required to recall the words and pictures that were just presented to them. Half of the participants recalled the words and the other half recalled the pictures. It should be noted that a distractor task was performed by the participants for about two minutes after the presentation of the words or pictures was finished in order to create a delay in the recall process. After this, the participants were required to write down as many names as possible they could remember. There was no time limit on finishing the task.

Reaction time experiment: This experiment follows the same procedure adopted in the recall one. Using DMDX software, half of the participants named the pictures. In the same session, the other half of the participants read words for the same pictures. Ten words or pictures were used as practice items so that the participants would get familiar with the type of the task. Each word was shown to the participants for 1500ms and each picture was presented for 2000ms. If participants could not answer in the time provided, the software moved on to the next item automatically. Participants were instructed not to cough or make any unnecessary noises during this task particularly at the beginning of each picture. Any response which did not match with the correct most

dominant name of the picture was considered incorrect.

3   Results

Linear Mixed Effect (LME) Modeling is gaining popularity in psycholinguistic research. LME modeling offers several advantages over the classic statistical analyses. LME modeling takes into account item and subject random effects which leads to higher generalizability of findings to the larger population and stimuli (Baayen, Davidson, & Bates, 2008). In this study, lme4 package (https://cran.r-project.org/web/packages/lme4/) was used in R software (R Development Core Team, 2012) in order to analyze the data in both experiments.

3. 1 Reaction time experiment

Our dependent variable was transformed reaction time (RT) using common log trans-formation. The model tested included all fixed variables such as AoA (early vs. late), transparency (transparent vs. opaque), and condition (picture vs. print) and their interactions along with the random effects for subjects and items. Random intercepts were not included because the variables had less than 5 levels which could result in singularity. To test the collinearity among the variables, a variance inflation factor (VIF) was used. Variables with a VIF above 5 should be removed from the analysis based on the recommendation by Craney and Surles (2002). In order to find which variables and interaction had significant effects, conditional F-tests were adopted because doing Lilehood Ratio Tests (LRT) on the fixed effects is anti-conservative and could result in misleading findings (Pinheiro & Bates,2000). Kenward-Roger approximations were used to calculate denominator degrees of freedom which have shown more acceptable type 1 error rates in com-parison with LRT and Wald tests (Kuznetsova, Brockhoff, &Christensen,2017).

The results of the analysis for this section are presented in Table 1. Since the interaction between Condition and AoA is significant, it doesn't make sense to look into main effects. See Figure 1 for the interaction patterns.

3. 2 Recall experiment

Since the response variable in this experiment was a binomial variable, a generalized linear mixed effect model (GLMER) was used. First, a full model was created including AoA, transparency, and condition as main effects, AoA*transparency*condition as the interaction effect, and random effects of subjects and items. Conditional F-tests were used to find the significant effects just like the reaction time experiment.

The results of the analysis for the recall experiment are presented in Table 2. For the interactions, see Figure 2.

4 Discussion and Conclusion

Regardless of the interaction patterns, the significant effect of AoA in this report is in line with many previous picture naming studies in other languages (Alario et al., 2004) and Persian (Nilipour, Bakhtiar, Momenian, & Weekes, 2017). Words and pictures which were learned earlier were processed faster and recalled more accurately than the late acquired stimuli regardless of the modality. However, the existence of interactions in both the reaction time and recall analyses reveals that AoA effect is more complicated than a simple main effect.

The results of the reaction time experiment are not consistent with previous studies. First, there was no interaction between AoA and transparency predicted by AMH (Morrison & Ellis, 2000). Second, AoA had a significant effect only in the picture naming modality, while the effect disappeared in the word reading modality. It is believed that AoA is a fundamental property of lexical retrieval and is independent of the modality. In other words, no matter whether the stimuli are presented as print or picture, the effect should be there. This is a counterintuitive finding which needs further investigation in the future studies.

The results from the recall experiment are partially consistent with AHM. Although, transparency and AoA did not have any interaction in the picture recall, the interaction observed in the word recall is consistent with AHM predictions. Based on AHM predictions, the AoA effect disappeared in the transparent

Fixed effects	Estimate	Std. Error	z value
(Intercept)	-1.11	0.10	-10.2
AoA	-0.62	0.17	-3.66
Condition*AoA *Transparency	1.02	0.40	2.49

Random effects	Variance	Standard Deviation
Items	0.27	0.52
Subjects	0.15	0.39

Table 2: Summary of significant effects in the recall experiment

condition. What is still counterintuitive is that why this effect is only observed in word recall and not in picture recall. If AoA effect is independent of modality, a similar effect should have been witnessed in both modalities.

our findings should be interpreted with caution. However, the counterintuitive findings could pave the way for future studies in other languages. We need more studies with null or counterintuitive effects indeed.

The data and codes for this manuscript are available at the following DOI 10.17605/OSF.IO/RTPH6.

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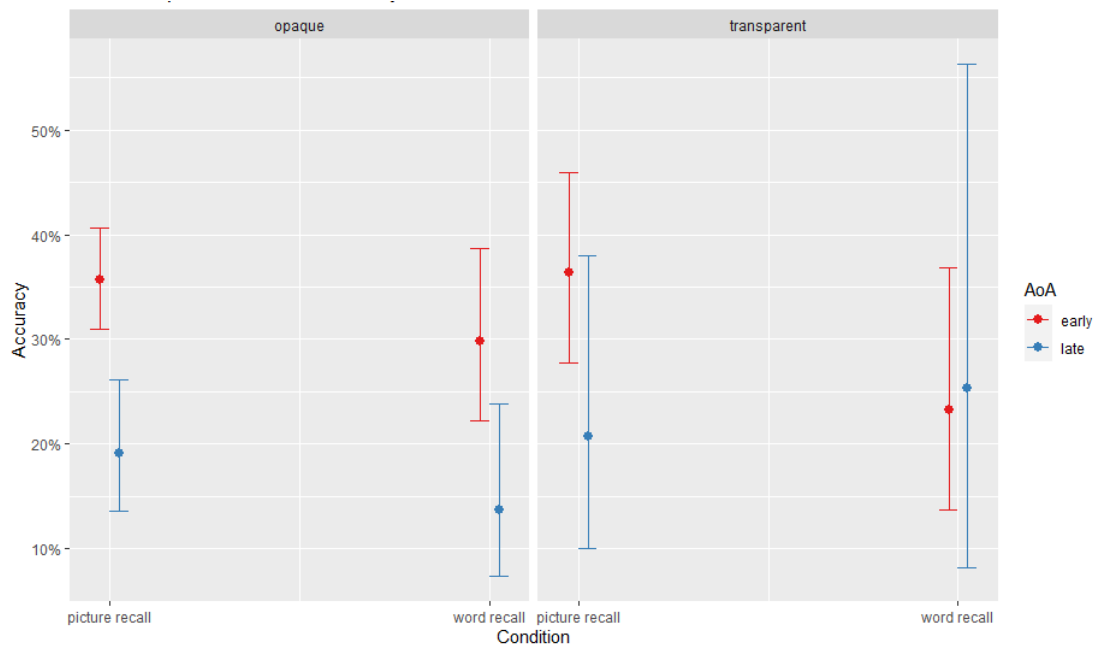
Figure 2: The interactions in the recall experiment

We did not control for other variables such as imageability, visual complexity, familiarity, and frequency. It's possible that the effects observed in this study could be attributed to lack of control over these variables. The number of items was not too many limiting the power of the study and hence generalizability of the findings. Moreover, the participants in the reaction time and recall experiments were different which could be another limitation due to lack of control over inter-individual variability. For these reasons, we believe

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Response to reviewers' comments:

I included figures in the manuscript which clearly show the RTs and accuracy for each condition.

I updated the analysis pipeline adding a few points which were missing in the previous manuscript.

The codes and data have been made available online at the following DOI 10.17605/OSF.IO/RTPH6.

I added extensive information to the introduction and discussion making the paper fitter for CogAlex objectives and audience.