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## Holding a real object during encoding helps the learning of foreign vocabulary

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## Abstract

This study aims at assessing and comparing two different methods for learning new vocabulary words in a foreign language. Learning vocabulary with images as non verbal aids was compared to learning vocabulary with real objects. The Rwandan children who participated in this study learnt French as a third language. They took part in training sessions to learn different French words either seeing the corresponding image or holding the corresponding object. The training program was implemented in a Rwandan primary school with children of different ages (from five to 10 years old). The results showed that the words associated to objects that were held by the children during learning were better memorized than the words associated with images. The global memory performance was lower for the youngest children; however, learning with objects proved to be superior over learning with images for all ages. Taken together, the findings underscore that learning vocabulary with real objects is particularly efficient and support the idea that the embodied theory of language is a key element to effectively master a foreign language.

**Key words:** vocabulary, learning, memory, perception, action

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Authors' Contribution: F.B. carried out and coordinated the teaching training. G.K. was responsible for the statistical analysis. All authors participated in manuscript preparation.

# HOLDING A REAL OBJECT DURING ENCODING HELPS THE LEARNING OF FOREIGN VOCABULARY

## **Abstract**

This study aims at assessing and comparing two different methods for learning new vocabulary words in a foreign language. Learning vocabulary with images as non verbal aids was compared to learning vocabulary with real objects. The Rwandan children who participated in this study learnt French as a third language. They took part in training sessions to learn different French words either seeing the corresponding image or holding the corresponding object. The training program was implemented in a Rwandan primary school with children of different ages (from five to 10 years old). The results showed that the words associated to objects that were held by the children during learning were better memorized than the words associated with images. The global memory performance was lower for the youngest children; however, learning with objects proved to be superior over learning with images for all ages. Taken together, the findings underscore that learning vocabulary with real objects is particularly efficient and support the idea that the embodied theory of language is a key element to effectively master a foreign language.

**Key words:** vocabulary, learning, memory, perception, action

26 In most societies learning different languages is a necessity, whether at school, at work  
27 or sometimes even for everyday life activities. Learning a native language differs from  
28 learning a second language in the amount of experiences and the variability of situations in  
29 which the language is learnt and used. In their native language, from the very first months of  
30 life, children make many sensorimotor experiences by interacting intensively with their social  
31 and physical environment, which help them to better learn the language (Khul, 2010;  
32 Tomasello, 2003). Part of language learning consists in memorizing new words in order to  
33 use them in sentences to communicate. Vocabulary is a fundamental component of language  
34 learning that predicts second language competence in general, particularly because it  
35 determines the transmission of meaning (Barcroft, 2004). Foreign vocabulary learning  
36 requires linking an established semantic concept to a new phonological form. Exploring  
37 strategies to provide a rich learning environment as is the case in native language learning  
38 might be a key in foreign vocabulary teaching.

39 Foreign vocabulary can be introduced by various activities, using pictures, drawings or  
40 real world items, by providing definitions of target words, and more indirectly by explaining  
41 the words while telling or reading stories, or discussing topics. The use of pictures to  
42 complement verbal information is prevalent in the class environment for both native language  
43 and foreign language learning, and it supports word learning (Gersten & Baker, 2000; Loftus,  
44 Coyne, McCoach, Zipoli, & Pullen, 2010; Pollard-Durodola *et al.*, 2011; Silverman, 2007).  
45 As young children are able to learn words from pictures and to generalize to real objects, the  
46 use of pictures in word learning seems to be an appropriate instructional strategy (Ganea,  
47 Pickard, & DeLoache, 2008; Preissler & Carey, 2004). The growing body of evidence in  
48 embodied cognition and language (Barsalou, 2008; Kiefer & Trumpp, 2012; Willems &  
49 Hagoort, 2007) suggests that other supports relying on movement and action could also be

50 useful to learn language. As language is grounded, children's sensorimotor interactions with  
51 real life objects should benefit vocabulary learning (Hockema & Smith, 2009).

52         Neuroimaging studies on action-language showed that the comprehension of action  
53 verbs, action sentences and words denoting manipulable objects reliably activated the  
54 cerebral motor system (Aziz-Zadeh, Wilson, Rizzolatti, & Iacoboni, 2006; Chao & Martin,  
55 2000; Hauk, Johnsrude, & Pulvermüller, 2004; Tettamanti *et al.*, 2005). Sensorimotor areas  
56 become an integral part of lexical-semantic representations over time (Pulvermüller, 2005)  
57 and brain areas generally dedicated to action are also involved in the representation and  
58 comprehension of language (Horchak, Giger, Cabral, & Pochwatko, 2013). In behavioral  
59 studies, it has been shown that words or sentences were better memorized if learners  
60 performed the action during encoding and/or retrieval than if they only heard or read the  
61 words (Nooijer, van Gog, Paas, & Zwaan, 2013; Zimmer *et al.*, 2001). The same effect was  
62 also shown when children only pretend to perform an action (Mecklenbräuker, Steffens,  
63 Jelenec, & Goergens, 2011). The impact of gesture on language learning has been shown in  
64 adults and children learning their native language, a foreign language or an artificial  
65 language, either for concrete or abstract words (Kelly, McDevitt, & Esch, 2009; Macedonia  
66 & Knosche, 2011; Macedonia, Muller, & Friederici, 2011). This physical enactment (*i.e.*, the  
67 phenomenon of acting something out) creates a motor trace in the memory representation of  
68 the verbal item, which strengthens a multimodal trace in memory and thus helps to encode  
69 and to retrieve information (Engelkamp & Zimmer, 1985). A challenging explanation of the  
70 superiority of a dual-modality presentation of information was also proposed by cognitive  
71 load theory (Paas & Sweller, 2012), which argues that under certain circumstances,  
72 presenting information in different modalities should decrease the cognitive overload in  
73 working memory.

74           Among the studies on the physical enactment effect, some focused specifically on  
75 children and foreign vocabulary learning. The study by Rowe, Silverman, and Mullan (2013)  
76 investigated the role of non-verbal aids, picture and gesture, in preschoolers' word learning in  
77 a second language. They showed that providing redundant information (visual and motor)  
78 was more helpful for novice learners and for a difficult task. In Tellier's study (2008) five-  
79 year-old French children were trained to learn common words in English either by seeing a  
80 picture or a video illustrating a gesture for each word. The children were able to remember  
81 more items when they imitated the gesture that accompanied the word. In the same way, two  
82 studies (Toumpaniari, Loyens, Mavilidi, & Paas, 2015; Mavilidi, Okely, Chandler, Cliff &  
83 Paas, 2015) revealed that the impact of gesture on vocabulary learning improved when  
84 gesture was performed through gross motor movements. Mavilidi *et al.* (2015) asked  
85 preschool children to learn foreign vocabulary in four conditions: enacting the word in  
86 physical exercises, performing physical exercises regardless of the meaning of the words,  
87 enacting the word by gesturing while remaining seated, and repeating the word without  
88 moving. The results showed that the combination of physical activity and gesture lead to the  
89 best recall rate. Recently, Vlaar, Verhagen, Oudgenoeg-Paz and Leseman (2017) showed that  
90 the enactment effect could also occur in a virtual space. They compared the learning of new  
91 words among kindergarten children when they manipulated the physical object or the virtual  
92 object. No significant difference was found between the two conditions, leading to the  
93 conclusion that the prevailing factor in improving memorization appears to be the action  
94 more than the medium.

95           New vocabulary learning, particularly during the earliest stages of acquisition, depends  
96 on phonological memory (Cheung, 1996; Gathercole & Baddeley, 1989; Gathercole, Willis,  
97 Emslie, & Baddeley, 1992; Masoura & Gathercole, 2005; Service, 1992). As the working  
98 memory span and strategies for memorization increase with age, the learning of new



99 vocabulary might be age-dependent. After the age of seven, the rehearsal mechanism is  
100 progressively more efficient and children are able to access information stored in long-term  
101 memory more rapidly (Gaonac'h & Fradet, 2003; Gathercole & Baddeley, 1993). The studies  
102 that assessed a developmental significance of the enactment effect in memory have yielded  
103 mixed results. Some of these studies showed age-related improvements in action memory  
104 between six and 10 years whereas others found an age invariant enactment effect (Baker-  
105 Ward, Hess, & Flanagan, 1990; Foley & Johnson, 1985; Parker, 1995; Ratner & Hill, 1991).  
106 In Ratner and Hill's (1991) study, acting on an imagined object during encoding facilitated  
107 recall performance for all age groups (six-year-olds, nine-year-olds, and adults) as compared  
108 to verbal learning; however, this facilitation in recall was weaker for the youngest group. In  
109 Ghetti, Lyons, Lazarrin, and Conoldi's (2008) study with seven-year-olds, ten-year-olds, and  
110 adults, no age-related improvements in recognition of actions performed with real objects  
111 were observed, but there was an age-related effect in recognition of imagined actions. The  
112 advantage of performing actions as compared to imagining them was greater for the youngest  
113 group than for the two older groups. Mecklenbräucker *et al.* (2011) showed that the overall  
114 enactment effect in free recall was larger for eight-year-old than for six-year-old children,  
115 whereas the enactment effects in the cued recall and recognition tests were the same size for  
116 both age groups. The age-related increase in the enactment effect seems to depend on the  
117 memory test used.

118 Most of the studies on vocabulary learning made use of pictures or gestures to support  
119 learning and compared their effectiveness. To the best of our knowledge, however, none  
120 investigated the use of real life objects. Even if 3-D objects and images share a high level of  
121 visual similarity (apart from depth cues), a major distinction between them deals with the  
122 potential to directly act upon them. When seeing an object, individuals extract the visual and  
123 semantic properties of the object as well as the affordances (*i.e.* the motor possibilities an

124 object offers) and their possible translation into action (Gibson, 1977; Ellis & Tucker, 2000;  
125 Jeannerod *et al.*, 1995). The sensitivity to affordance is usually measured by the decrease in  
126 reaction time when the subject executes a motor act that is congruent with the one afforded  
127 by a seen object. Maranesi, Bonini and Fogassi, (2014) reviewed studies on the cortical  
128 processing of objects and outlined that: (i) the processing of real objects does not rely only on  
129 visual brain areas but also on motor areas; (ii) subjects transform the physical properties of  
130 objects into a motor plan to interact with them; (iii) the visual perception of objects  
131 automatically triggers the representation of action if the objects are situated in the  
132 peripersonal space of the subject (the space immediately surrounding his/her body, where  
133 s/he can reach an object by a simple arm movement without moving). As shown by  
134 Costantini *et al.* (2010), with the use of 3-D objects presented in a virtual environment, the  
135 physical distance of the object from the observer predicts the extraction of affordances. The  
136 possibility of genuinely reaching the object is a determining factor in triggering the motor  
137 representation, since if a transparent plastic barrier is placed between the participant and the  
138 object (which decreases the potentiality of reaching the object), the sensitivity to affordance  
139 is reduced. In addition, seeing an object creates affordance not only if it is situated within  
140 reach of the subject but also if it is within the reach of another person (Costantini *et al.*,  
141 2011). This phenomenon can be linked with mirror neurons that are known to discharge both  
142 when an individual performs an action and when s/he observes another individual doing the  
143 same kind of action, and thus play a role in action understanding and imitation (Rizzolatti &  
144 Craighero, 2004). Some studies specifically compared how real objects and pictures are  
145 processed. The main finding was that real objects provoke different behaviors as well as  
146 different neural processing than images even during passive viewing (Snow *et al.*, 2011).  
147 Snow, Skiba, Coleman and Berryhill (2014) showed that the recall and recognition  
148 performance of common household objects in adults was better for real objects than for

149 colored photographs or black and white line drawings. Freud, Macdonald, Chen, Quinlan,  
150 Goodale, and Culham (2018) investigated the neural representations of grasping and reaching  
151 movements directed toward real 3-D objects and images, and showed a distinct representation  
152 of action upon real objects compared to images. These results corroborate behavioural  
153 findings and suggest that the visuo-motor system creates a model of planned actions that  
154 takes into account the constraints and outcomes associated with real objects, which are  
155 different from those associated to images.

156 As shown by various studies, the use of gestures and large body movements depicting  
157 the words might be a useful help to strengthen the memory process. Another way to facilitate  
158 encoding, at least for concrete words, would be to be directly in contact with the real 3D-  
159 object rather than seeing an image or performing a gesture. Our underlying assumption is that  
160 holding the object will automatically mobilize the representation of the action that can be  
161 performed on it, and consequently might be a more powerful way to trigger a motor trace  
162 than just seeing its visual representation. The aim of the study was thus to test the proposal  
163 that holding the real object while saying the corresponding word, without performing any  
164 specific gesture, allows an efficient encoding in memory and facilitates the retrieval of the  
165 name of the object. To test this hypothesis, we compared the effect of two nonverbal aids,  
166 images *versus* real objects, in the learning of French words as a third language. Our study was  
167 conducted in a Rwandan primary school with children of different ages (from five to 10 years  
168 old). We predicted that the learning condition that made use of real objects would be more  
169 efficient for vocabulary learning than the use of images. We also predicted, considering the  
170 development of memory, that the youngest children would obtain lower performances in the  
171 number of words learnt, but we did not expect an age-related effect of the learning conditions  
172 as our learning task requires that children interact with a real object, which is easier and more  
173 suitable for young children than performing an imagined action. Moreover, our retrieval task

174 involved the same identical context as the encoding task, which might help the youngest  
175 children to obtain the same performance as the older ones.

## 176 METHOD

### 177 Participants

178 One hundred and eight Rwandan children participated in the study (50 boys, 58 girls),  
179 with a mean age of 88.8 months ( $SD = 14.6$ , range 63 to 125). The children belonged to three  
180 school classes. Information about participants (age, gender) is shown in Figure 1.

181 -----

182 Insert Figure 1

183 -----

184

185 The children's native language was Kinyarwanda. However, even if it is the language  
186 shared by all the inhabitants, it is not the language for teaching. In 1996, Rwanda adopted a  
187 bilingual teaching system, where French and English were used alternatively. Since 2008,  
188 instruction has been in English since fourth grade in all schools. However, some schools,  
189 such as the school where we did the intervention, choose to teach English since kindergarten  
190 or the beginning of primary school. The children who participated in our study belonged to  
191 three classes in the first, second and third years of primary school. The time spent in school  
192 varied according to the children since even if school is compulsory in Rwanda, a certain  
193 number of children attend seldom or not at all. Thus, there could be age-gaps of five years  
194 between some children in the same class. The research took place in a specific context where  
195 teachers had just been asked to start teaching French from the beginning of primary school as  
196 a third language. They had no experience and no equipment to teach French. They tried to

197 collect images to support vocabulary learning or to draw, whereas multiple real objects were  
198 available around them. The purpose of the study was particularly relevant in this context.

199 In our children population, all spoke Kinyarwanda as their first language, all of them  
200 learnt English which was the language used for teaching all academic subjects. None of them  
201 knew French or had been taught it before the research training program. The study was  
202 performed in accordance with the Declaration of Helsinki; it was conducted with the  
203 understanding and written consent of each participant's parents, and was approved by the  
204 teachers and the parents' committee.

205

## 206 **Material**

207 Twenty-eight words were selected and divided into two lists. One list was learnt with  
208 real 3D-objects, and the other with images. The words were concrete nouns from everyday  
209 life that corresponded to objects that can be manipulated. These words were selected in order  
210 to have a high level of body-object interaction, which corresponds to the ease with which a  
211 human body can physically interact with the word's referent (Siakaluk, Pexman, Aguilera,  
212 Owen, & Sears, 2008). The words were chosen so as to be easily understandable and  
213 recognizable for Rwandan children and to correspond to objects they encounter in daily life.  
214 Before performing our learning program and in order to validate the list of words, two control  
215 tests were carried out. Firstly, as phonological factors and lexical frequency influence  
216 accuracy in the production of non-native sequences (Davidson, 2006), we presented the two  
217 lists of words to four Kinyarwanda native adult speakers, in order to select the most  
218 appropriate words to teach. We made sure that the words were easily and accurately  
219 pronounced. The words that were too similar to words used in their native language were  
220 removed; some words used in kinyarwanda have been taken from French (e.g. "ballon"/ ball,  
221 "ananas"/ pineapple, "carotte"/carrot). The two sets of words were matched on the following

222 criteria: frequency in children's books in French (Lété, Sprenger-Charolles & Colé, 2004),  
223 number of phonemes, number of syllables, number of vowels, number of consonants, and  
224 type of consonants (location in the mouth for enunciation: lips, teeth, palate). In our second  
225 control test, we asked 10 children (not included in the current study) to help in selecting the  
226 nonverbal aids. Only objects and images that were easily recognized and named in their  
227 native language were retained. The characteristics of the words are reported in Tables 1 and  
228 2. Independent sample t-tests showed no significant difference between the two lists of words  
229 on these criteria (all  $P > .25$ ).

230

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231

Insert Tables 1 and 2

232

-----

### 233 **Procedure**

234 This quasi-experimental study was implemented by a researcher during school teaching  
235 sessions. A within-participant design, where each child participated in both conditions (with  
236 images and with objects), was used. As we worked with the existing class groups of the  
237 school (with all children in one classroom and at the same time), it would have been  
238 impossible to compose our own groups and to pair subjects between the groups on the basis  
239 of a pre-test, or to assign children randomly to the learning conditions. It was also impossible  
240 to counterbalance the lists of words between the learning conditions. For all children, the  
241 same words were learnt in the objects learning condition and in the pictures learning  
242 condition.

243 **Learning sessions.** The words from the two lists were taught during four thematic  
244 sessions (to correspond to school practices and make sense for the children) on the following  
245 themes: school objects, clothes, food, and house objects. The learning program was

246 implemented within the existing class organization of the school, i.e. one group of 43, one  
247 group of 41 and one group of 24 children. Children of different ages were present in the three  
248 groups. The learning program lasted for a period of two months. At the beginning of the  
249 training program, a Rwandan teacher explained the instruction to the children in their native  
250 language. He told them that they would have to learn French words that corresponded to the  
251 image or the object that the experimenter showed them, and that at the end of the program,  
252 they would be evaluated on the memorization of these French words. One learning session  
253 (lasting around 40 minutes) was performed each week with the three school groups. The  
254 series of four themes was repeated twice, and for each theme the two sessions were separated  
255 by an interval of one month. Thus, the whole set of words was presented twice. The  
256 procedure was exactly the same for each of the three groups. During each session, around  
257 half of the words were presented with images (black and white line drawings of the objects)  
258 and half of the words were presented with the real objects. The words were presented in a  
259 randomized order. The researcher said the word first and asked the group to repeat once.  
260 Then each child repeated the word once, either when seeing the image or when holding the  
261 object. The children were not asked to perform a specific action on the object, only to hold it  
262 in their hand while saying the French word and then to give it to the next child, and so on. In  
263 the image learning condition, the researcher showed the image in front of each child who had  
264 to say the word. The researcher made sure that each child repeated each word once, in each  
265 learning condition. Note that the two learning conditions (with images and with objects) were  
266 new for the children. They did not receive specific English vocabulary learning sessions and  
267 learning of new words occurred during general teaching lessons in social studies or  
268 mathematics for example. They did not have cards with drawings and they did not use real  
269 objects either. Usually, their teachers taught them new vocabulary words in an informal way  
270 during discussion and occasionally for a few words by drawing on the black board.

271           **Testing session.** The children were assessed individually one month after the last  
272 session. During this month, children were on holiday and received no supplementary  
273 language instruction. To avoid a context effect in memory, the same items were used in the  
274 learning sessions and in the testing session. For the words in the image learning condition, the  
275 experimenter showed a black and white drawing and the child had to find the word that  
276 corresponded. For the words in the objects learning condition, the experimenter showed the  
277 object and the child had to find the corresponding word. The words were presented in a  
278 random order. The assessment session lasted between 15 to 20 minutes per child.

279

### 280           **Data Analysis**

281 The child's response for each word was scored 0 for incorrect recall (no recall or  
282 phonological errors) and 1 for correct recall. Data were analyzed using a multiple mixed  
283 logistic regression, predicting the probability of words correctly recalled. Explanatory  
284 variables for the model included the age of the participants, the learning conditions (two  
285 modalities: real object *vs* image), the gender of the participants and the two-way interaction  
286 between the age of the participants and the learning conditions. All predictors were  
287 considered fixed-effects variables. Due to our experimental design which included both  
288 within-subjects and within-items (word) data, we included the identity of the participant and  
289 that of the word as random effects. We also entered the school classes as a random effect.  
290 This model was used to take into account the sources of variability related to participants, to  
291 school class and to items (some words might be more distinctive or memorable, for instance).  
292 Random slopes were firstly specified maximally in our model, and the model was  
293 progressively simplified until convergence was reached. To simplified the model until  
294 convergence was reached, the random effect associated with the smallest variance was  
295 dropped and this was done progressively (Barr, Levy, Scheepers & Tily, 2013). The best



296 model was selected on the basis of the Akaike Information Criterion (AIC) — the best model  
297 being the one with the lowest value for AIC and, integrates only the age of the participants  
298 and the learning conditions as fixed effect. To test the significance of fixed effects, we  
299 compared models with and without the specific fixed effect, using Log Likelihood Ratio  
300 (LLR) tests (Zuur, Hilbe & Leno 2013). Means and odd-ratios (OR) were computed with the  
301 95% confidence interval in brackets. Statistical analysis was performed using the computing  
302 environment R (R Development Core Team, 2016). Scripts for all analyses and anonymized  
303 data are available at the Open Science Framework. Additional analyses concerning random  
304 effects (items and school classes) are also available in the OSF.  
305 ([https://osf.io/esyac/?view\\_only=a164b70d5cc24772895c78c6eecdac2](https://osf.io/esyac/?view_only=a164b70d5cc24772895c78c6eecdac2)).

306

307

## RESULTS

308 We found direct effects of the age of the participants and the learning conditions (Figure 2),  
309 while the effect of participant gender was not statistically significant ( $\text{Chi}^2=0.04$ ,  $\text{df}= 1$ ,  
310  $P=0.83$ ). Consistent with the development of memory, older children performed better than  
311 younger children ( $\text{Chi}^2=14.07$ ,  $\text{df}= 1$ ,  $P<0.001$ ). As age increased by one month, the  
312 probability of words correctly recalled increased by 1.02 [1.01-1.03]. The words that were  
313 learnt with real objects (0.45 [0.23-0.69]) were recalled 6 times more often ( $\text{OR}=6.72$  [1.59-  
314 28.33];  $\text{Chi}^2=5.33$ ,  $\text{df}= 1$ ,  $P=0.021$ ; Figure 2.A) than the words that were learnt with images  
315 (0.11 [0.05-0.24]). Our results did not detect an interaction between age and learning  
316 conditions ( $\text{Chi}^2=1.02$ ,  $\text{df}= 1$ ,  $P=0.31$ ; Figure 2.B).

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Insert Figures 2

319

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320

321

## DISCUSSION

322

323 This study has a strong educational interest, specifically in the African context, because  
324 of the difficulty finding images to use as nonverbal teaching aids. Traditionally teachers use  
325 only verbal information; occasionally, they draw a visual representation of some words on the  
326 black board and spend a lot of time doing so, whereas many objects are directly available in  
327 the environment and can be used to support vocabulary learning. The aim of this study was  
328 thus to develop and to test an efficient way to learn new vocabulary words in a foreign  
329 language using real objects.

330 Findings showed that the use of real objects was efficient for learning, and revealed that  
331 the words associated to objects that were held by the children were better memorized than the  
332 words associated with images. This learning condition was particularly profitable, as shown  
333 by the huge difference between our two conditions: the words that were learnt with real  
334 objects were memorized six times more often than the words that were learnt with images.  
335 These results are particularly interesting for practitioners looking for ways to teach foreign  
336 vocabulary. For researchers who try to understand the cognitive mechanism that underlines  
337 learning, it raises some fundamental questions: What happened when children held the  
338 object? What are the cognitive processes responsible for the benefit in vocabulary learning?  
339 A number of findings from the literature in the field are consistent with our results and lead  
340 us to propose some hypotheses. We assume that when children held the real object, they  
341 automatically activated the motor act they could produce on it, and that this strong motor  
342 trace was used in turn to retrieve the verbal information stored in memory. As we worked  
343 with concrete words that represent objects that humans can interact with, whatever the  
344 learning condition, these words were considered to have a sensorimotor representation in the

345 brain because an action can be performed on the object they represent. However, even if  
346 either seeing the image or seeing the object activates motor areas in the brain (Chao &  
347 Martin, 2000), the perception of images and objects does not rely on the same neural  
348 processes and entails different behaviors. Our hypothesis finds some grounding in the results  
349 of recent studies that showed: (i) that the perception of 3D objects and images relies on  
350 distinct neural representations (Freud *et al.*, 2018); (ii) an advantage of the memorization of  
351 objects compared to images (Snow, *et al.* 2014); (iii) a higher sensitivity to affordance when  
352 the object is situated in peripersonal space or close to another person the observer can see  
353 (Maranesi, *et al.*, 2014). In accordance with our proposal, we can note that some children  
354 wanted to perform the action when they held the object and the researcher had to stop them.  
355 Just seeing the images never led to such action behaviors. Another aspect that needs to be  
356 taken into account is that, as the learning sessions were performed in a whole class situation,  
357 the children saw each other holding the object. The observation of other children holding the  
358 object might have increased the probability of triggering a motor representation (Costantini *et*  
359 *al.*, 2010; 2011). Thus the learning condition with objects was highly favorable for  
360 affordances. To deepen our understanding of the learning mechanisms, future studies should  
361 consider comparing making the gesture with no object, making the gesture with the real  
362 object and just holding the object. It would also be interesting to compare the difference  
363 between just seeing a real object and seeing an image. Would it make a difference in the  
364 encoding and retrieval of verbal information if the children do not touch the object? The  
365 answer probably depends on the distance between the subject and the object, which  
366 modulates the sensitivity to affordance (Costantini, *et al.* 2011).

367 Findings showed an effect of age on memory: the global memory performance was  
368 lower for the youngest children – however the superiority of learning with objects over  
369 learning with images was obtained for all ages. The development of phonological memory

370 and the development of the use of conscious memory strategies might explain why the mean  
371 number of words correctly recalled was lower for the youngest children. Previous studies  
372 have shown that an interaction between age and physical enactment depends on the task. A  
373 difference between younger and older children was only found when children had to imagine  
374 the action instead of performing it (Ratner & Hill, 1991; Ghetti *et al.*, 2008), and when a free  
375 recall task was used (Mecklenbräuker *et al.*, 2011). In our study, the concordance between the  
376 encoding task and the recall task might explain why we did not find an age-related effect of  
377 the learning conditions. Our matching task required fewer memory strategies than another  
378 task that entailed finding the words and using them in different contexts, for example.  
379 Another explanation of the absence of interaction between age and learning condition might  
380 be the specific context of this study where different age levels are found in the same class.  
381 The two factors of number of years of schooling and age are therefore partially confused. As  
382 the development of memory depends on the amount of experience of interaction with the  
383 environment, we can assume that it depends on age as well as on time spent at school.

384 This study compared, in a quasi-experimental design implemented in an ecological  
385 setting, the use of real objects and of images, and showed a large advantage of the former  
386 condition in learning foreign vocabulary. However, at least two limitations that could reduce  
387 the generalization of these effects need to be highlighted and discussed. First, this study was  
388 conducted in a specific context, both linguistically and culturally. It concerns the learning of a  
389 third language (French), different from the first and school languages (Kinyarwanda and  
390 English respectively). Moreover it has been shown that African children develop their motor  
391 skills earlier than European and American children (Geber, 1973; Vaivre-Douret, 1994).  
392 African children are more encouraged to explore their environment by touch, and to  
393 physically act on it. This might explain the strong difference obtained between learning with  
394 images and learning with objects. The difference between the two conditions might be lower

395 in other cultures. Second, we only assessed the ability to match a foreign word with the object  
396 it represents. It is noteworthy that our recall test was performed one month after the last  
397 training session – one month of holidays –, which means that we obtained interesting long-  
398 term memory effects. However, learning vocabulary means being able to match the words  
399 with their corresponding meaning and using them in sentences and communication situations.  
400 The children were able to find the corresponding word in an identical context as we used the  
401 same items in the encoding and the recall phases. Thus we do not know if the children would  
402 have been able to use the word with other representations of the objects (different drawings  
403 or photographs of the same items), or if they would have been able to mobilize the new  
404 vocabulary words in a communication situation and to include the words in sentences. It  
405 would be interesting to use several assessment methods, for example, translation tasks,  
406 comprehension tasks in addition to recall tasks (Vlarr, *et al.* 2017).

407 In conclusion, this study has strong practical applications, and the outcomes should be  
408 used to make school practices in foreign language teaching advance. In a world where  
409 multimedia and pictures are omnipresent, we sometimes forget to use simple things from  
410 everyday life for teaching. In countries where multimedia is less available, in particular,  
411 teachers can feel helpless if they think that it is the best way to develop children's knowledge.  
412 Instead of using pictures as is traditionally the case, it might be more efficient to bring real  
413 objects into the class environment and to ask children to manipulate them or to perform the  
414 action that can be associated to the objects while repeating their name. When interacting with  
415 the objects, children mobilize the motor representation in the brain, which helps them to  
416 better memorize the associated word. Although the mechanisms underlying this learning  
417 remain to be fully elucidated, we believe that these findings shed new light on the relevance  
418 of holding a real object in the learning of foreign vocabulary.

419

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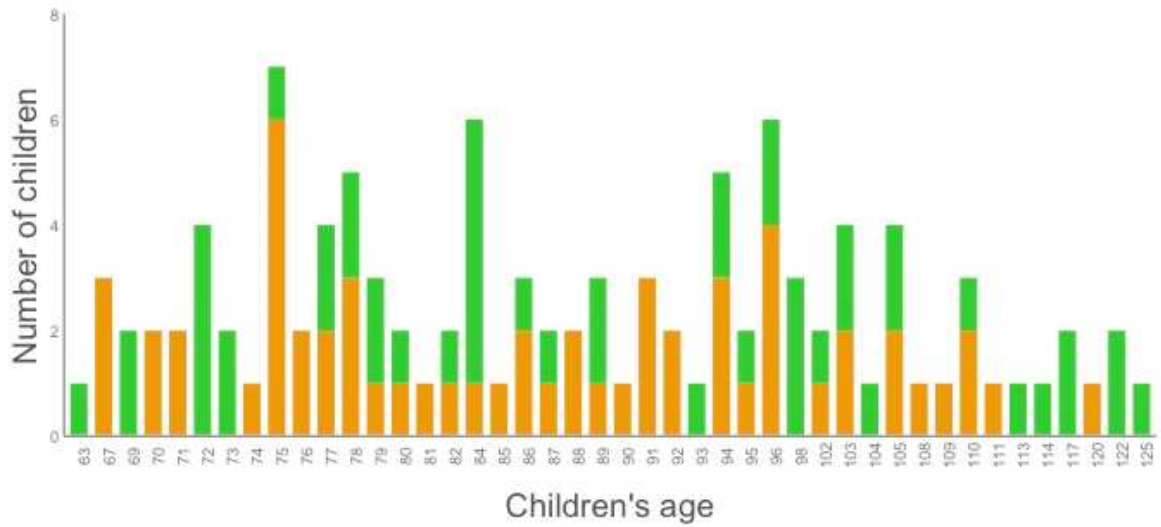
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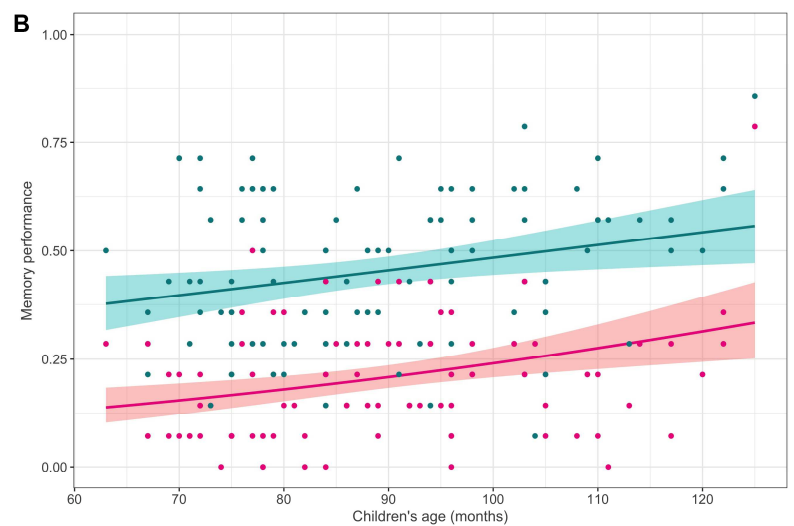
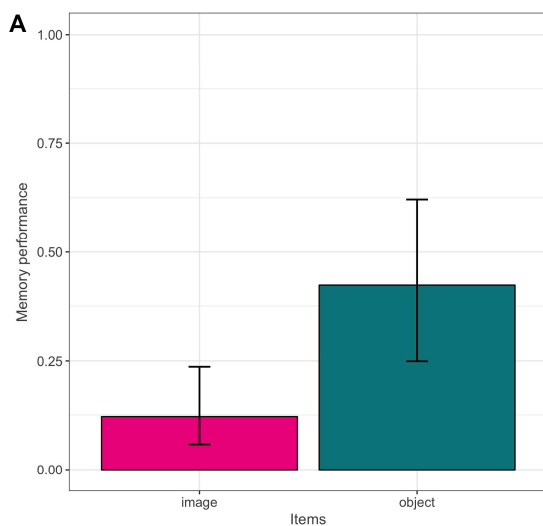
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**Figure 1.** Age distribution of children by sex (girls in orange, boys in green)



**Figure 2.** Effects of items and the child's age on memory performance

**A-** Effect of items on the memory performance: image items (pink bar) were recalled weaker than object items (turquoise bar). Mean and error bars represent 95% confidence intervals. **B-** Children's age induced a significant increase in the memory performance but there was no age-related effect of the learning conditions. Dashed lines (and confidence intervals regions) are the curves predicted by logistic regression: in turquoise for object items and in pink for image items.



**Table 1.** Characteristics of the words used in the two learning conditions

<b>Learning condition</b>	<b>Frequency</b>	<b>Syllables</b>	<b>Phonemes</b>	<b>Vowels</b>	<b>Consonants</b>
Objects	136.95	2.35	4.42	1.78	2.71
Images	146.92	2.14	3.87	1.57	2.28

**Table 2.** Type of consonants in the two lists of words used in each learning condition

<b>Learning condition</b>	<b>Number of consonants</b>	<b>Place of enunciation</b>		
		<b>lips</b>	<b>teeth</b>	<b>palate</b>
Objects	38	8	21	9
Images	32	7	18	7