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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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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

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

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

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

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

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

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

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

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

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

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

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

Material

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

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

Insert Tables 1 and 2

Procedure

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

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

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

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

Data Analysis

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

model was selected on the basis of the Akaike Information Criterion (AIC) — the best model being the one with the lowest value for AIC and, integrates only the age of the participants and the learning conditions as fixed effect. To test the significance of fixed effects, we compared models with and without the specific fixed effect, using Log Likelihood Ratio (LLR) tests (Zuur, Hilbe & Leno 2013). Means and odd-ratios (OR) were computed with the 95% confidence interval in brackets. Statistical analysis was performed using the computing environment R (R Development Core Team, 2016). Scripts for all analyses and anonymized data are available at the Open Science Framework. Additional analyses concerning random effects (items and school classes) are also available in the OSF. (https://osf.io/esyac/?view_only=a164b70d5cc24772895c78c6eecdcac2).

RESULTS

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

Insert Figures 2

DISCUSSION

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

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

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

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

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

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

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

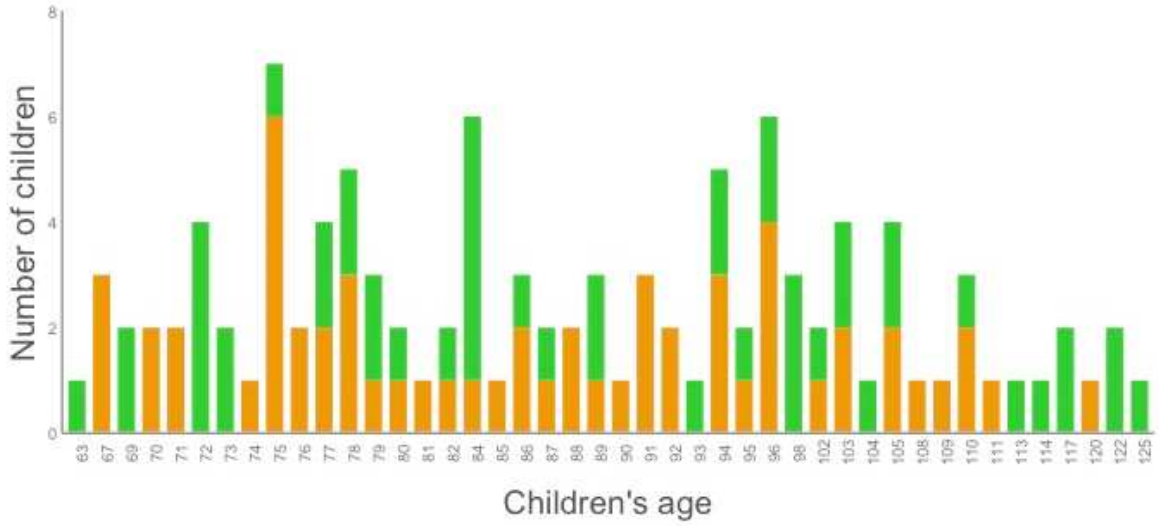


Figure 2. Effects of items and the child's age on memory performance

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.

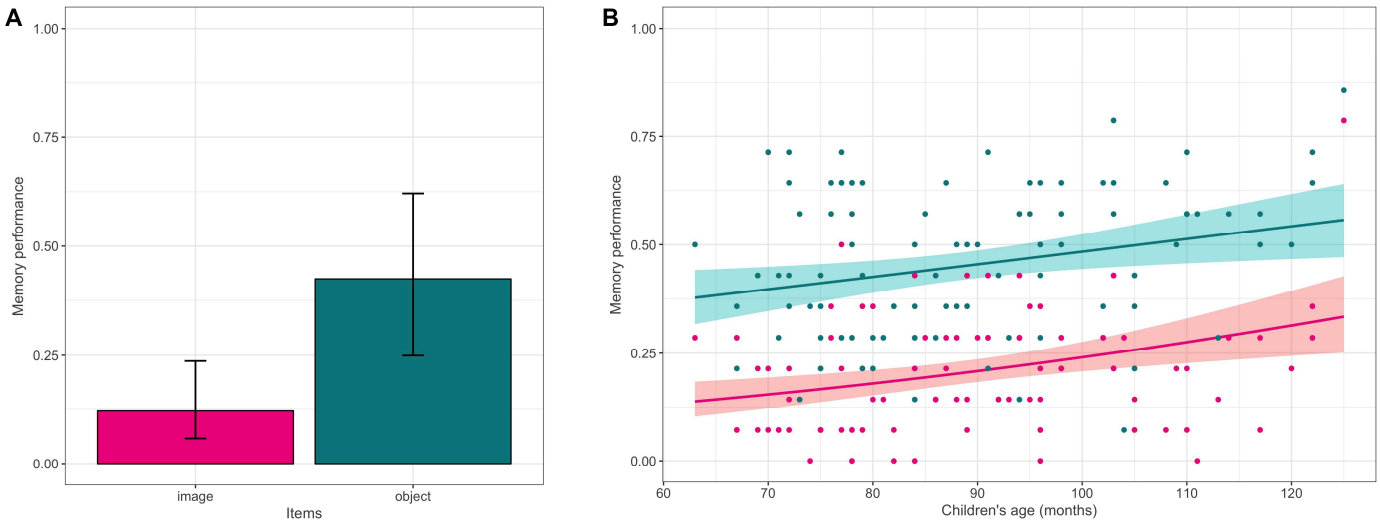


Table 1. Characteristics of the words used in the two learning conditions

Learning condition	Frequency	Syllables	Phonemes	Vowels	Consonants
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

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