The role of the natural history museum in promoting language word learning for young children

DOI:
http://doi.org/10.1002/icd.2400

Abstract

Although strong claims have been made about museums being ideal word learning environments, these are yet to be empirically supported. In the current study 152 four-to-five-year-old children (81-M, 71-F) from minority backgrounds, were taught six vocabulary items either in a museum, in their classroom with museum resources, or in their classroom with classroom resources. At test, children taught in their classroom with museum resources produced significantly more correct responses than children taught in the museum or in their classroom with classroom resources. Children were also significantly better at retaining the target vocabulary items than recalling them. These data demonstrate how context can impact word learning and point to the benefits of a collaborative relationship between schools and museums to support children's language development.

Key words: Word Learning; Context; Vocabulary; Museum

Early in life, children learn words impressively quickly, often from limited exposure (Carey & Bartlett, 1978), despite the complexity of the context in which those words are heard (Quine, 1960). Early word learning theorists have long been devoted to uncovering the mechanisms involved in the process of learning new words, and the factors that give rise to the different rates at which individual children acquire vocabulary. One such factor affecting the rate at which children learn new words is the context in which they learn them (e.g. Fisher et al., 2014; Hoff, 2006; Perry et al., 2010; Vlach & Sandhofer, 2011). Importantly, however, context can be defined in different ways, and each context has different effects on word learning.

First, context can be interpreted in terms of the objects that children are exposed to in their physical environment. For example, in a longitudinal training study, Perry and colleagues demonstrated that training 18-month-old children with variable exemplars of categories of objects supported them in more successfully generalising new words to unfamiliar exemplars, and led to increases in vocabulary development relative to peers who saw the same object repeatedly (Perry et al., 2010). Further research has shown that two-year-old children who were taught novel category names by exposing them to variable exemplars of objects from the same category were able to retain more novel category names than children who were exposed to single exemplars only (Twomey et al., 2014). Thus, exposing children to multiple, variable exemplars rather than only one category member may provide children with the opportunity to compare similar features of each of the exemplars, and therefore facilitate word learning for that category. However, when exemplar variability was too high, that is, exemplars differed on multiple characteristics (shape, size, colour etc), word learning was hindered (Twomey et al., 2014). Twomey and colleagues explained this

finding by suggesting that when exemplar variability is high, more attentional resources are required, leaving fewer for committing the word-object associations to memory.

Relatedly, the presence of multiple competitor objects can negatively affect children's word retention (Horst et al., 2010, 2011; Pereira et al., 2014). Horst and colleagues presented two-and-a-half-year-old children with the target object alongside either two, three or four competitor objects, and asked children to select particular objects each time. Although all children appeared to form initial word-object associations during the referent selection task, only those children who experienced fewer competitor objects showed significant levels of word retention. If children were attending to each of the competitor objects individually in order to rule them out as potential referents, the more competitor objects that are present, the more time children spend attending to the wrong objects, and the less time children spend encoding the novel name-object associations for the new words (Horst et al., 2010). Thus, learning contexts that present too many competitor referents could in fact hinder word learning in young children. Equally, embodiment theories suggest that when children are able to see, touch and act on unfamiliar objects, this provides opportunity for sensory-motor interaction which results in richer knowledge about the objects (Barsalou et al., 2003; Kiefer & Spitzer, 2001; Kiefer & Trumpp, 2012; Lakoff & Johnson, 1999; Martin & Chao, 2001; Pulvermüller, 2005). Several studies show that children use their head, hands and eyes to visually isolate objects of interest, and create one-at-a-time object views, thus limiting other visual distraction (Yu et al., 2009; Smith et al., 2011; Yoshida & Smith, 2008).

An alternative approach to researching learning context is to consider the physical learning environment as a whole. Although young children are often placed in highly decorated, busy and colourful primary school classrooms to learn, too much visual distraction can impair learning (Fisher et al., 2014). Fisher and colleagues argue that children of early primary school age do not have the attentional capacity to remain on task in such

environments: five-year-old children who were taught in highly decorated classrooms spent more time off task, were more distracted, and demonstrated smaller learning gains from pre- to post-test scores in terms of their knowledge of the scientific topics being taught compared to children who were taught in classrooms that were sparsely decorated. However, whilst these again findings provide insight into what may constitute an optimal learning environment for children, Fisher and colleagues did not include a measure for word learning specifically, but rather measured learning more broadly. Thus, the effect of broader environmental context on children's word learning is unknown.

As well as the learning that takes place in classrooms, in recent years, considerable attention has been given to how informal learning spaces promote learning for their visitors (Callanan et al., 2011; Mujtaba et al., 2018; Rogoff et al., 2016). Informal learning spaces such as zoos, aquariums, art galleries and museums, are often characterised by their flexible learning structure, their opportunities for rich interaction, and their diverse learning topics (Callanan et al., 2011). Whilst their structure contrasts substantially with that of the formal school learning environment, informal learning spaces are designed to enhance a visitor's already existing knowledge, and build upon the foundations of the school curriculum (Mujtaba et al., 2018).

Museums, whether it be natural history museums, science museums, children's museums and so on, are perhaps the informal learning spaces that have received the most attention in recent years. With their attractive displays and highly decorated exhibits, they are claimed to be ideal word learning environments for children (Henderson & Atencio, 2007; Kola-Olusanya, 2005; Rodriguez & Tamis-LeMonda, 2011). Kola-Olusanya (2005) claimed that the additional resources that museums provide, such as the opportunity to handle 3D objects, interactive displays presenting multiple category exemplars, and knowledgeable museum staff on hand, have the potential to promote the acquisition of literacy and numeracy

skills. Moreover, the open-ended questions that are often displayed around museum exhibits promote conversation amongst visitors and provide language learning opportunities (Henderson & Atencio, 2007; Rowe et al., 2017).. Museums also often have live exhibits or three-dimensional models which may provide children with a richer mental representation than those they see in textbooks (Cox-Petersen et al., 2003), and it is these models and exhibits that children often recall when remembering their museum experiences, also reporting enjoying being able to see large objects up close and in context (Anderson et al., 2002; Dockett et al., 2011; McRainey & Russick, 2010). Thus, visits to a museum are thought to promote language learning in children (Rodriguez & Tamis-LeMonda, 2011). Museums have long been popular destinations for school trips, and they now frequently provide their resources to be used in the classroom to provide additional learning experiences for children (Henderson & Atencio, 2007).

Despite the learning opportunities that museums provide, the way in which visitors engage with them, and therefore the extent to which they learn from them, very much depends on their prior knowledge, their motivation, expectations and interests (Adams et al., 2003; Black & Hein, 2003; Falk, 2004; Falk & Dierking, 1992; Falk & Storksdieck, 2005; Hein, 2002; Rennie & Johnston, 2004). Specifically, Falk, Moussouri and Coulson (1998) found that adults who had high educational motivations learned significantly more scientific concepts than those visitors with low educational motivations for visiting. Additionally, the increase in the breadth of vocabulary of those visiting the museum for entertainment purposes was found to be significantly greater than those not visiting for entertainment purposes, as was their overall understanding of the scientific topic in question (Falk et al., 1998). Importantly, however. whilst there is considerable support for museums as valuable informal learning spaces, this work relies heavily on anecdotal evidence, particularly when considering

children's learning. Moreover, much of the evidence focusses on the conceptual learning that takes place in museums rather than word learning specifically.

At present, the literature concerning the effects of context on word learning is mixed. On one hand, there is evidence to support the idea that a context offering a wide range of variability promotes word learning, yet on the other hand, a learning context that is too visually busy may in fact hinder learning, and although strong claims have been made about the efficacy of museums as rich language learning environments, there is a lack of supporting empirical evidence. Importantly, irrespective of the extent to which the museum environment supports vocabulary acquisition, there are clear practical demands in taking groups of children to a museum on a regular basis. In the current study, we explored whether four- and five-year-old children learn new words more successfully in a natural history museum environment, in their regular classroom environment using 3D museum resources, or in their regular classroom environment using conventional classroom resources using a between-participants design.

Given there is some evidence that variability supports word learning, the idea that museums promote conversation amongst visitors, and provide an abundance of additional resources to promote language acquisition, we might expect that the children in this study will learn target vocabulary items more successfully in the museum compared to the classroom environment. However, there is also evidence suggesting that overly distracting environments hinder learning in children of this age. It is therefore possible that a novel museum environment, filled with attractive, busy exhibits, with multiple competitor objects and high exemplar variability, might be distracting, and therefore impede children's word learning relative to their regular classroom. On balance, it could be that children learn novel vocabulary items more successfully when learning with novel, 3D resources provided by the museum, but used in their regular classroom setting to minimise distraction. As this present

study is exploratory in nature in terms of finding out what exactly the effects of context on children's word learning are, we make no directional hypotheses.

As of January 2018, 21.2% of primary school pupils in the UK were recorded as using English as an additional language (EAL) (Department for Education, 2018). Data from the National Pupil Database show that EAL pupils do not achieve as highly in reading, writing and maths compared to their monolingual English speaking peers in Key Stage 2, though this attainment increases as the level of English Language proficiency increases (Demie, 2018). Given that early language skills have been found to be a significant predictor of literacy skills at age 11, and vocabulary skills at age five, predict academic outcomes at the end of school (Gross, 2018), it is important to promote these skills in children with EAL so that they have the best possible chance of achieving. Therefore, the present study focusses on a sample of children with EAL to explore whether and how learning context can promote language learning opportunities for this population.

Materials and Methods

Participants

We tested 152 children recruited from an inner-city primary school in England. Prior informed consent for the children to take part was obtained from parents/caregivers by providing them with detailed information sheets about the study and asking them to return a form if they wished to opt their child out of the study. All children originated from an ethnic minority background, spoke either Bengali or Urdu with English as an additional language and had no known history of speech or language problems or developmental delays. The children were between 4;4 and 5;8 years old (M = 60.4 months, *SD* = 4.3 months, 71 girls). The participants were randomly assigned to one of 12 groups: each of the six classes were randomly split into two groups. Three groups were taught in the museum, four groups were

taught in the classroom with museum resources, and five groups were taught in the classroom with classroom resources. Group sizes were between 11 and 14 participants and were balanced as closely as possible for males and females. Of the 152 participants, two were missing data at both the two-day and four-week post-tests and were therefore removed from the study. Of the final sample of 150 participants, 27 had missing data at the two-day post-test due to Covid-19 forcing a class bubble to isolate and 16 had missing data at the four-week post-test due to absence from school. Missing data were accounted for in our analyses.

Stimuli

Vocabulary items

We selected the insect names *beetle*, *mantis*, *hornet*, *katydid*, *centipede* and *mosquito* to serve as the words children would learn in each setting. These items were chosen because they were of two or three syllables in length (three of two syllables and three of three syllables), and they had similar frequency ratings (low frequency) according to both the CHILDES corpus (MacWhinney, 1995) and the Kuperman frequency database (Kuperman, 2012).

Museum materials

Museum teaching took place in a natural history museum which was typical of its kind. Although home to numerous exhibits containing real, three-dimensional articles from historical periods, live animals, life-sized taxidermy, dioramas, and interactive technology, when teaching in the museum, teachers were confined to using the existing displays in the insect exhibit for the purposes of this study (Figure 1). Small, plastic magnifying glasses were used by the children to explore the exhibit and find the target insects within the displays. For each of the target vocabulary items, there were multiple exemplars in various displays. A microscope with a single exemplar of each of the target insects was also available. In addition, teachers used boxed specimens of each of the insects (Figure 1), which

children were able to handle, allowing them to closely inspect the insects. Teachers were told they were free to use the materials however they would like, and in a way that reflected how they would naturally teach in such an environment.

Figure 1

Museum insect exhibit

Note. Beauty and the Beasts exhibition 2019, Full copyright information to be provided after blind review has been completed. Photography by Michael Pollard.

Museum resources in the classroom

The exact same boxed specimens of each of the insects that were used in the museum were provided to use in the classroom. Again, children were able to handle the boxed specimens. The boxes contained real insects that had been preserved for educational purposes (Figure 2).

Figure 2

Boxed Specimens of insects

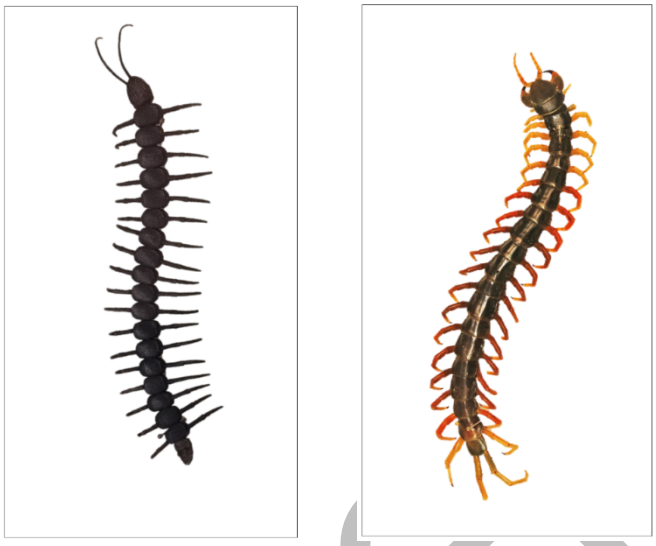
Classroom materials

Prior to the beginning of the study, the class teachers were asked as a group what materials they would normally use in the classroom to teach new vocabulary items. Teachers collectively agreed that they would typically use 2D pictures and non-fiction books. Allowing teachers to jointly decide on what materials would be used ensured that we were able to control the materials used across classrooms, however teachers were free to use them in a way that reflected their individual teaching style, thus keeping the conditions as natural as possible. Two different exemplars of each of the target insects were presented on 12 A4 (can you add the dimensions for US audiences – they don't use A4 in America) coloured, laminated sheets (Figures 3). Additionally, a book titled 'Everything Insects' by Carrie Gleason (produced as part of the 'National Geographic for kids' range) was provided for each

of the teaching sessions (Figure 4). Sticky labels were placed on each of the pages containing the target insects to allow easy access. Each of the pages contained multiple, coloured images of each of the insects alongside some factual information about each one (Figure 4). Again, teachers were told they were able to use the resources however they would like.

Figure 3

A4 Sheet insect exemplars



Note. Laminated A4 sheets depicting different exemplars of the target insects used as part of the classroom resources.

Figure 4

Everything Insects Textbook

Note. Front cover and example page from the textbook used as a teaching resource in the classroom resources condition. From 'Everything Insects' by Carrie Gleason (2015) https://www.dogobooks.com//National Geographic Kids Everything Insects: All the Facts, Photos, and Fun to Make You Buzz Book Review and Ratings by Kids - Carrie Gleason (dogobooks.com)

Test materials

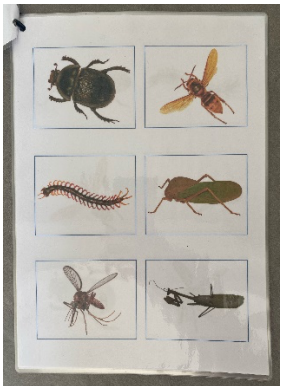
A total of 24 six-page picture booklets were created for testing. Six of the booklets were designed to test retention of the new vocabulary items via a pointing task, using familiar exemplars of the insects (Figure 5); six were designed to test generalisation using unfamiliar exemplars (Figure 6); six were designed to test recall via a naming task using familiar exemplars (Figure 7); and finally, six were designed to test generalisation of recall using unfamiliar exemplars (Figure 8).

The pages in the booklets designed to test retention contained six boxes (8.5 cm x 7.0 cm), each containing one coloured image depicting one of the new vocabulary items. Boxes were evenly spaced and in an identical location on each page in each booklet. Six versions of each booklet were created by Latin-square counterbalancing the location of each of the

insects inside the boxes, the location of the target vocabulary item for each page, and the page order for each booklet. The pages in the booklets designed to test recall contained one box (18.5 cm x 18.0 cm) containing one coloured image depicting one of the new vocabulary items. Positioning of the box was identical on each of the pages. Six versions of each booklet were created by counterbalancing the page order for each booklet. Children's responses were recorded manually by the experimenter and were later transferred to an electronic spreadsheet.

Figure 5

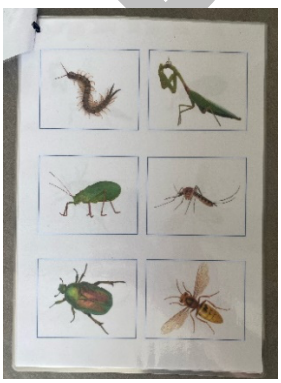
Retention familiar test booklet



Note. Page from booklet designed to test retention using familiar exemplars.

Figure 6

Retention generalisation test booklet



Note. Page from booklet designed to test retention using unfamiliar exemplars.

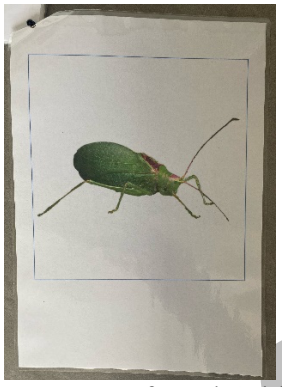
Figure 7

Recall familiar test booklet

Note. Page from booklet designed to test recall using familiar exemplars.

Figure 8

Recall generalisation test booklet



Note. Page from booklet designed to test recall using unfamiliar exemplars.

Procedure

The present study used a between-participants design such that children only experienced one experimental condition. Children were taught the six novel vocabulary items either in their regular classroom setting with typical classroom resources, in their regular classroom setting with resources from the museum, or in the insect exhibit at the museum (see below for details). Prior to each teaching session, each class teacher was asked if the children were familiar with any of the vocabulary items, and they confirmed that the children taking part had no prior knowledge of any of these labels or the objects themselves

in both English and their other language. Each of the teaching sessions lasted approximately 20 minutes and was taught by the children's regular class teacher.

Testing sessions. Post-testing took place at two different time points. Two days after children had taken part in a taught session, they were tested for retention and recall (test type) of the six new vocabulary items using two pointing tasks and two naming tasks, each containing six trials (corresponding to the four types of test booklet outlined above). Each child was taken individually to a quiet area of their school by the researcher and was first presented with a booklet to test recall of the vocabulary items using familiar exemplars. The researcher asked the child 'What is this?' on each page of the booklet. This was then repeated using a booklet to test recall with unfamiliar exemplars. Next, each child was presented with a booklet that tested retention of the vocabulary items using familiar exemplars. The researcher asked the child to point to a target insect on each page by asking 'Where is the X? Can you point to the X?'. Following this, each child was presented with a booklet that tested generalisation of the new vocabulary items using unfamiliar exemplars. Again, the researcher asked the child to point to a particular target insect. Throughout the entire testing procedure, the researcher did not provide children with any feedback for their responses, but instead replied with neutral responses such as 'thank you' or 'okay'. Children's responses were recorded online. For the pointing tasks, a correct response was recorded if children pointed to the correct target insect for each trial. Pointing to any insect other than the target one for each trial was recorded as an incorrect response. For the naming tasks, a correct response was recorded if the children produced the correct, full name of the target insect for each trial. Producing the name of any insect other than the target insect, or only partially stating the name of the target insect (i.e. *Katy* instead of *Katydid*) was recorded as incorrect. All tests were completed in one session and each session lasted approximately ten minutes. Children were tested again four weeks after the initial teaching session, using an

identical procedure. The order of the testing sessions had to remain the same for each child as both recall and retention were being tested; specifically, if some children were presented with the retention test first, in which the researcher names the insects, this could give them an advantage on the recall tests as they will have previously been reminded of the names of the insects. We therefore did not counterbalance testing sessions.

Museum sessions. Groups attended the museum one at a time with their regular class teacher, two supporting adults, and the researcher (first author) who is a female native speaker of British English. On arrival at the museum, the researcher took each group to the insect exhibit, which was closed to public visitors for the duration of the teaching sessions. While the children were getting acquainted with their surroundings under the supervision of a supporting adult, the researcher explained to the class teacher where each of the target insects could be found in the exhibit, and which of the target insects were in each of the handling boxes. The researcher then instructed the teacher to spend approximately 20 minutes in the exhibit teaching their group of children the six new vocabulary items using the resources available. All teachers chose to enter the exhibit and ask their group of children to sit in a circle on the floor in the centre of the exhibit. Teachers introduced each of the boxed specimens one by one and, after asking the children if they knew what the insect inside was (all children in all groups did not know, or guessed incorrectly), they labelled each of the insects inside in turn. They asked children to pass the box around the circle and examine the insect inside. Teachers asked the children questions as they passed the box around such as *'what can you see?' 'How many legs does it have?' 'What colour is the x?'* whilst asking the children to frequently repeat the name of the insect being passed around. Once all six insects had been passed around the circle, all teachers asked their groups to verbally repeat the names of the insects they had just seen, before handing them a magnifying glass each and asking them to go and find each of the insects in the exhibit, and to shout the name of the insect

when they had found it. Teachers then proceeded to follow children around the exhibit, asking children questions about the target insects they had found in the exhibit at random as they passed them.

Classroom sessions. Groups were taught the six new vocabulary items in their classroom setting by their regular class teacher using typical classroom resources. Prior to the start of each teaching session, the researcher provided the teaching resources to each teacher, explained which images depicted which of the target vocabulary items, and where each of the target vocabulary items could be found in the book. The researcher then instructed each teacher to spend approximately 20 minutes teaching the six new vocabulary items to their group of children. As with the other two conditions, teachers chose to teach with the resources in very similar ways. They each asked their groups of children to sit in a circle on the classroom floor. First, they spent a short amount of time holding up both of the laminated pictures of each insect, again asking the children if they knew what the insect was (as above, all children in all groups did not know, or guessed incorrectly). The teachers then repeated the insect's name two or three times before asking the children what they could see, how many legs it had, and so on. They then the book, showing the children each of the insects on their relevant pages, and reading aloud the associated information. Children were given the opportunity to ask questions.

Museum resources sessions. Groups were taken one at a time to a small, quiet library area of their classroom by their regular class teacher to be taught the six vocabulary items using the museum resources. Prior to the start of each teaching session, the researcher provided the teaching resources to each teacher and explained which insects were in each box. The researcher then instructed each teacher to spend approximately 20 minutes teaching the six new vocabulary items to their group of children. Similar to in the museum, all teachers chose to sit their groups of children in a circle on the floor of the classroom. They chose to

teach the names of the insects in exactly the same way as they did in the museum, by passing the boxes around one by one, asking the children questions and labelling the insects and asking children to label the insects multiple times. As the teachers could not send the children off around the exhibit to look for the target insects, they made the discussion of the boxed specimens last longer to fill out the twenty-minute session.

Note that due to restrictions imposed due to Covid-19, the original design was amended. Please see Appendix 1 for details. This meant that in total, the current study had five classroom resource sessions, three sessions taught in the museum, and four sessions taught using museum resources in the classroom setting. Prior to Covid-19, all teaching sessions took place over three consecutive days. Three teachers taught a total of two sessions each: one in the classroom with classroom resources and one in the classroom with museum resources, or one in the classroom with classroom resources and one in the museum. One teacher taught four sessions in total as she had one class pre-Covid-19 and then a different class post-Covid-19: one session in the museum, two sessions in the classroom with museum resources, and one session in the classroom with classroom resources. Two teachers taught one session each due to sharing a class: one taught in the museum and one taught in the classroom with classroom resources. Two museum sessions and one classroom session were taught on day one, one classroom and one museum session were taught on day two, and one classroom session was taught on day three. The order in which teachers taught the classroom or museum session was counterbalanced. Post Covid-19 restrictions, sessions took place over two consecutive days. Teachers taught one classroom resources session and one museum resources session, and the order in which they did so was counterbalanced, with the exception of one teacher who taught two museum resources sessions. Two museum resources sessions and one classroom session were taught on day one, and two museum resources sessions and one classroom session were taught on day two.

Analyses

All analyses were carried out in R (R Development Core Team, 2018) using the lme4 package (Bates, Maechler, Bolker, & Walker, 2015) to fit generalised linear mixed effect (glmer) models for analysis of accuracy (a binary outcome variable with the levels 'correct' and 'incorrect.'). We used the R package lmerTest (Kuznetsova, Brockhoff, & Bojesen Christensen, 2016) to calculate *p*-values for the models. Fixed and random effects were added incrementally to a minimal model, and we tested if the inclusion of an additional term was justified using the likelihood ratio test for model comparisons (Pinheiro & Bates, 2000). Non-significant effects were subsequently removed from the model. The binary factor 'Context' was coded using treatment contrast (the default coding in R), with a reference level 'Classroom'.

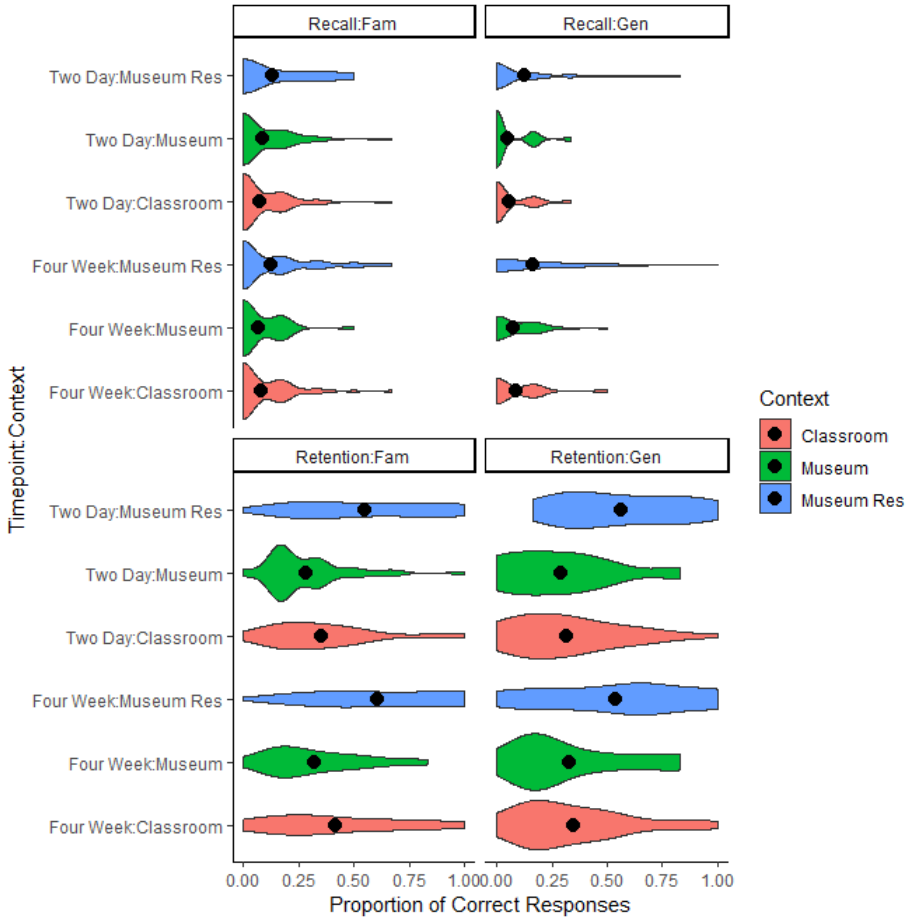
Results

First, we were interested in whether the context in which children were taught the novel vocabulary items affected the number of correct responses at test. We first counted the number of correct responses provided by children in all contexts, tests and timepoints, and then submitted this measure to a generalised linear mixed effects model with fixed effects of context (museum, classroom with classroom resources, classroom with museum resources), test type (retention, recall) and timepoint (two-day, four-week), and random intercepts for participant, participant age and item. Proportion of children's correct responses are plotted against context, test-type and timepoint as depicted in Figure 9. When children were taught in the museum resources sessions, the number of correct responses at test increased compared to when children were taught in the classroom sessions, and when children were taught in the museum sessions (main effect of context: $\beta = .82$, $SE = 0.23$, $z = 3.54$, $p < .001$). As well as context, there was a significant effect of timepoint; that is, when the testing sessions took place. Specifically, the number of correct responses was significantly lower at

the two-day than the four-week post-test (main effect of timepoint: $\beta = -.21$, $SE = 0.08$, $z = -2.75$, $p = .006$), meaning children produced more correct responses over time. Finally, test type had a significant effect on the number of correct responses that children produced: children produced more correct responses on retention tests (pointing) than recall tests (naming) (main effect of test type: $\beta = 2.48$, $SE = 0.09$, $z = 28.76$, $p < .001$).

Figure 9

Proportion of correct responses by context, test-type and timepoint



Note. Bold point represents the mean for each condition.

Whether or not the exemplars at test were familiar or unfamiliar had no significant effect on the number of correct responses children produced at test and a chi-squared

comparison showed that a model with the addition of the familiarity variable (familiar, novel) did not statistically differ from a model that only contained fixed effects of context, timepoint and test type ($\chi^2(1)=2.64$, $p = .10$). Thus, the addition of 'familiarity as a fixed effect was not justified, and this variable was removed from the final model. Similarly, chi-squared comparisons including the timepoint-by-test type interaction term ($\chi^2(1) = 0.004$, $p = .95$) and context-by-timepoint interaction term ($\chi^2(2) = 0.41$, $p = .81$) did not statistically differ from the model that included only the three fixed effects of context, test-type and timepoint. Therefore, the addition of these interaction terms was also not justified, and they were consequently removed from the final model. Thus, the final model was: model <- glmer(correct ~ Context+Timepoint+Test + (1|Participant) + (1|Age.Months) + (1|Word), family=binomial, data=Data)

Finally, taking part in the study prior to the Covid-19 pandemic or post Covid-19 had no significant effect on the number of correct responses produced by children at test. A chi-squared comparison showed that the addition of the 'Covid' variable (pre-Covid, post-Covid), did not improve model fit, and was therefore removed from the final model ($\chi^2(1) = 0.03$, $p = .86$). This variable was included in the analysis to check for the possibility that prolonged periods of time away from school might have impacted children's ability to learn new words in either a positive or negative direction. The data supporting the findings reported in this paper are openly available from the Open Science Framework repository at: https://osf.io/5yw62/?view_only=5e3e4e261ebe4deabe09032e85997c6

Finaly, two-tailed, one-sample t-tests confirmed that for all contexts, timepoints and test-types, children learned the target vocabulary items at levels significantly greater than chance (0.167; see Table 1).

Table 1

T-tests by context, timepoint and test-type for retention trials

Context	Time Point	Familiarisation	*M*	*t*	*df*	*p*
Museum	Two-Day	Familiar	.28	3.45	34	.002
Museum	Two-Day	Generalisation	.29	3.01	34	.005
Museum	Four-Week	Familiar	.32	3.82	29	<.001
Museum	Four-Week	Generalisation	.29	3.01	34	.005
Museum Resources	Two-Day	Familiar	.55	7.84	39	<.001
Museum Resources	Two-Day	Generalisation	.56	9.23	39	<.001
Museum Resources	Four-Week	Familiar	.61	10.41	49	<.001
Museum Resources	Four-Week	Generalisation	.56	9.23	39	<.001
Classroom	Two-Day	Familiar	.35	5.26	49	<.001
Classroom	Two-Day	Generalisation	.32	4.24	49	<.001
Classroom	Four-Week	Familiar	.42	6.28	56	<.001
Classroom	Four-Week	Generalisation	.32	4.24	49	<.001

Discussion

The current study explored whether the context in which children were taught new words would affect how successfully they were able to retain and recall them. Four- and five-year-old children were taught six novel vocabulary items either at the museum, in their classroom with museum resources, or in their classroom using regular classroom resources. The current findings make an important contribution to our understanding of the role of learning context in supporting children's word learning. Specifically, children who were taught in their classroom using museum resources produced significantly more correct responses at test compared to children who were taught in the museum or in their classroom with regular classroom resources. Children also produced significantly more correct

responses over time. There was no significant difference between the number of correct responses produced at test by children who were taught in the museum compared to children who were taught in the classroom with regular classroom resources. Below, we explore the possible reasons for why the combination of museum objects and classroom learning seemed to be most beneficial.

Learning in the classroom with museum resources versus classroom resources

Children who were taught in the classroom using regular classroom resources were presented with images of single exemplars of the target insects and with a non-fiction book with images and some written information about the target insects. From observing these teaching sessions, the first author noted that although teachers briefly referred to the singular images, they spent generally spent a larger proportion of the time discussing the non-fiction book. When considering the book itself, it could be that the presence of competitor objects such as images of unrelated items together with text was distracting. Therefore, children may have spent more time attending to other items on the pages and spent less time encoding the word-object associations for the target insects. Moreover, having target items embedded into pages of a book that were neither presented centrally, nor necessarily larger than competitor objects on the page meant that the target items were not necessarily the dominant items in the visual field. In particular, embodiment theories suggest that when children are able to touch and act on unfamiliar objects, this sensory-motor interaction results in richer knowledge about the objects (Barsalou et al., 2003; Kiefer & Spitzer, 2001; Kiefer & Trumpp, 2012; Lakoff & Johnson, 1999; Martin & Chao, 2001; Pulvermüller, 2005). Moreover, children use their head, hands and eyes to visually isolate objects of interest, and create one-at-a-time object views, thus limiting other visual distraction (Yu et al., 2009; Smith et al., 2011; Yoshida & Smith, 2008). Thus, when taught in the classroom with museum resources, the target items, being held in the children's hands, would have appeared much larger and more

dominant in the visual field than any other potentially competing items, therefore, facilitating learning relative to the classroom resources.

Learning in the classroom with museum resources versus learning in the museum

The finding that children learned more when taught in-class with museum resources relative to learning in the museum contrasts with literature that argues museums are an optimal environment for learning. It is possible that children learned words more successfully when taught with museum resources in the classroom because although they were presented with identical interesting and novel resources in both contexts, the museum may have been too visually distracting, making it more difficult for children to learn the target vocabulary items (Fisher et al., 2014; McMillan & Saffran, 2016). Instead, children taught in their classrooms were likely habituated to any distractions and therefore spent more time on task, thus learning the words more successfully. Importantly, the current findings extend to the critical domain of language Fisher and colleagues' findings that distracting learning environments hindered learning.

Further, in addition to the target items, the exhibits in the museum also contained both multiple exemplars of each of the target items and also various other insects. Similar to the classroom resources (book), the museum may equally have provided too many competitor objects and therefore interfered with learning. Specifically, children may have spent considerable time attending to these non-target items, and consequently spent less time encoding the word-object associations for the target items. Indeed, evidence from lab-based studies suggests that increasing the number of competitor objects present during word learning can hinder children's retention of those words (Horst et al., 2010). In contrast, when children were taught in the classroom with museum resources, they were presented with multiple exemplars (two to three) of the target insects, but no other competitor objects were

simultaneously presented in the visual field. Children may therefore have been able to capitalise on this simplified classroom learning environment, as reflected by higher recall and retention rates than after learning in the museum.

Linguistic input across different contextual settings

Of course, it is possible that the linguistic input provided by teachers differed between contexts and between the teachers themselves. There is evidence to suggest that a high-quality linguistic input is positively associated with children's vocabulary size, narrative comprehension and production, and use of auxiliary verbs (Blake et al., 2006; Reese et al., 2010; Rowe et al., 2017; Salo et al., 2016). Existing research also demonstrates that context can affect the quality of linguistic input, though context in these instances often refers to the task itself, rather than environmental context as in the present study. Specifically, higher quality input has been found in more structured contexts with a focal task, compared to more naturalistic settings and free play (Tamis-LeMonda et al., 2017; Tamis-LeMonda et al., 2019). Thus, if teachers produced higher quality linguistic inputs in some contexts compared to others, this, alongside the aforementioned contextual affects, may have affected the number of correct responses children produced at test. Importantly, this possibility points to fruitful avenues for future research.

Recall versus retention and familiarity versus generalisation

Children were also significantly better at retaining than recalling the new vocabulary items, but there was no significant effect of the familiarity of exemplars at test. Specifically, there was no difference between the number of correct responses children produced when they were tested using familiar exemplars, or exemplars they had never seen before. This is somewhat interesting as there is a general assumption in the existing literature that retention and generalisation are two separate mechanisms and should be measured and discussed as

such (e.g. Axelsson et al., 2016; Behrend et al., 2001; Hartley et al., 2020; Perry et al., 2010; Vlach et al., 2008; Vlach & Sandhofer, 2012; Waxman & Booth, 2000). For example, Perry and colleagues report that children in all conditions successfully retained words when tested using familiar exemplars, but only children who were taught in multiple exemplar contexts demonstrated successful generalisation (Perry et al., 2010). Here, we find no evidence for a difference in retention and generalisation. Although this null result should be interpreted with caution, we speculate that this finding may be age-related: children in the current study were five years old, while children in previous work have typically been two to three years of age. Thus, the additional linguistic experience of the current children may result in stronger generalisation ability. However, the effect of age on generalisation should be investigated in dedicated future studies.

Limitations

Whilst our findings challenge the claims made about museums being ideal word-learning environments for children (Henderson & Atencio, 2007; Kola-Olusanya *, 2005; Rodriguez & Tamis-LeMonda, 2011), it should be noted that children only spent a short 20 minute period at the museum during this study. It could be that there was not sufficient time for children to gain from the benefits that museums have to offer such as knowledgeable staff, interacting with displays, and considering the answers to some of the open-ended questions that were displayed around the exhibits. Future research could explore the possible impact on children's vocabulary development of less regular, but longer visits to the museum, complemented by shorter, more regular sessions with museum resources in classroom.

Conclusions

Overall, our findings make an important contribution: children can benefit from museum resources without having to go and visit the museum itself. The current study therefore points to a more collaborative relationship between schools and museums. If museums frequently loan resources to schools, this eliminates the practical demands of taking children to museums on a regular basis, and also enables opportunities to improve vocabulary development above and beyond those that normal classroom resources can provide.

References

Adams, M., Falk, J. H., & Dierking, L. D. (2003). Things change. In M. Xanthoudaki, L. Tickle, & V. Sekules (Eds.), *Researching Visual Arts Education in Museums and Galleries* (Vol. 2, pp. 15–32). Springer Netherlands. https://doi.org/10.1007/978-94-010-0043-7_2

Anderson, D., Piscitelli, B., Weier, K., Everett, M., & Tayler, C. (2002). Children's museum experiences: Identifying powerful mediators of learning. *Curator: The Museum Journal*, *45*(3), 213–231. https://doi.org/10.1111/j.2151-6952.2002.tb00057.x

Axelsson, E. L., Williams, S. E., & Horst, J. S. (2016). The effect of sleep on children's word retention and generalization. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01192

Barsalou, L. W., Kyle Simmons, W., Barbey, A. K., & Wilson, C. D. (2003). Grounding conceptual knowledge in modality-specific systems. *Trends in Cognitive Sciences*, *7*(2), 84–91. https://doi.org/10.1016/S1364-6613(02)00029-3

Behrend, D. A., Scofield, J., & Kleinknecht, E. E. (2001). Beyond fast mapping: Young children's extensions of novel words and novel facts. *Developmental Psychology*, *37*(5), 698–705. https://doi.org/10.1037/0012-1649.37.5.698

Black, M., & Hein, G. E. (2003). You're Taking Us Where? In M. Xanthoudaki, L. Tickle, & V. Sekules (Eds.), *Researching Visual Arts Education in Museums and Galleries* (Vol. 2, pp. 117–133). Springer Netherlands. https://doi.org/10.1007/978-94-010-0043-7_9

Blake, J., Macdonald, S., Bayrami, L., Agosta, V., & Milian, A. (2006). Book reading styles in dual-parent and single-mother families. *British Journal of Educational Psychology*, *76*(3), 501–515. https://doi.org/10.1348/000709905X49719

Callanan, M., Cervantes, C., & Loomis, M. (2011). Informal learning: Informal learning. *Wiley Interdisciplinary Reviews: Cognitive Science*, *2*(6), 646–655. https://doi.org/10.1002/wcs.143

Chen Yu, Smith, L. B., Hongwei Shen, Pereira, A. F., & Smith, T. (2009). Active information selection: Visual attention through the hands. *IEEE Transactions on Autonomous Mental Development*, *1*(2), 141–151. https://doi.org/10.1109/TAMD.2009.2031513

Cox-Petersen, A. M., Marsh, D. D., Kisiel, J., & Melber, L. M. (2003). Investigation of guided school tours, student learning, and science reform recommendations at a museum of natural history. *Journal of Research in Science Teaching*, *40*(2), 200–218. https://doi.org/10.1002/tea.10072

Demie, F. (2018). English as an additional language and attainment in primary schools in England. *Journal of Multilingual and Multicultural Development*, *39*(3), 210–223. https://doi.org/10.1080/01434632.2017.1348508

Dockett, S., Main, S., & Kelly, L. (2011). Consulting young children: Experiences from a museum. *Visitor Studies*, *14*(1), 13–33. https://doi.org/10.1080/10645578.2011.557626

Falk, J. (2004). The director's cut: Toward an improved understanding of learning from museums. *Science Education*, *88*(S1), S83–S96. https://doi.org/10.1002/sce.20014

Falk, J. H., Moussouri, T., & Coulson, D. (1998). The effect of visitors' agendas on museum learning. *Curator: The Museum Journal*, *41*(2), 107–120. https://doi.org/10.1111/j.2151-6952.1998.tb00822.x

Falk, J., & Storksdieck, M. (2005). Using the contextual model of learning to understand visitor learning from a science center exhibition. *Science Education*, *89*(5), 744–778. https://doi.org/10.1002/sce.20078

Fisher, A. V., Godwin, K. E., & Seltman, H. (2014). Visual environment, attention allocation, and learning in young children: When too much of a good thing may be bad. *Psychological Science*, *25*(7), 1362–1370. https://doi.org/10.1177/0956797614533801

Hartley, C., Bird, L.-A., & Monaghan, P. (2020). Comparing cross-situational word learning, retention, and generalisation in children with autism and typical development. *Cognition*, *200*, 104265. https://doi.org/10.1016/j.cognition.2020.104265

Hein, G. E. (2002). *Learning in the Museum* (0 ed.). Routledge. https://doi.org/10.4324/9780203028322

Henderson, T. Z., & Atencio, D. J. (2007). Integration of play, learning, and experience: What museums afford young visitors. *Early Childhood Education Journal*, *35*(3), 245–251. https://doi.org/10.1007/s10643-007-0208-1

Hoff, E. (2006). How social contexts support and shape language development. *Developmental Review*, *26*(1), 55–88. https://doi.org/10.1016/j.dr.2005.11.002

Horst, J. S., Parsons, K. L., & Bryan, N. M. (2011). Get the story straight: Contextual repetition promotes word learning from storybooks. *Frontiers in Psychology*, *2*. https://doi.org/10.3389/fpsyg.2011.00017

Horst, J. S., Scott, E. J., & Pollard, J. A. (2010). The role of competition in word learning via referent selection: Competition in word learning. *Developmental Science*, *13*(5), 706–713. https://doi.org/10.1111/j.1467-7687.2009.00926.x

Kiefer, M., & Spitzer, M. (2001). The limits of a distributed account of conceptual knowledge. *Trends in Cognitive Sciences*, *5*(11), 469–471. https://doi.org/10.1016/S1364-6613(00)01798-8

Kiefer, M., & Trumpp, N. M. (2012). Embodiment theory and education: The foundations of cognition in perception and action. *Trends in Neuroscience and Education*, *1*(1), 15–20. https://doi.org/10.1016/j.tine.2012.07.002

Kola-Olusanya *, A. (2005). Free-choice environmental education: Understanding where children learn outside of school. *Environmental Education Research*, *11*(3), 297–307. https://doi.org/10.1080/13504620500081152

Lakoff, G., & Johnson, M. L. (1999). *Philosophy in the flesh: The embodied mind and its challenge to western thought*. Basic books.

Martin, A., & Chao, L. L. (2001). Semantic memory and the brain: Structure and processes. *Current Opinion in Neurobiology*, *11*(2), 194–201. https://doi.org/10.1016/S0959-4388(00)00196-3

McMillan, B. T. M., & Saffran, J. R. (2016). Learning in complex environments: The effects of background speech on early word learning. *Child Development*, *87*(6), 1841–1855. https://doi.org/10.1111/cdev.12559

Mujtaba, T., Lawrence, M., Oliver, M., & Reiss, M. J. (2018). Learning and engagement through natural history museums. *Studies in Science Education*, *54*(1), 41–67. https://doi.org/10.1080/03057267.2018.1442820

Pereira, A. F., Smith, L. B., & Yu, C. (2014). A bottom-up view of toddler word learning. *Psychonomic Bulletin & Review*, *21*(1), 178–185. https://doi.org/10.3758/s13423-013-0466-4

Perry, L. K., Samuelson, L. K., Malloy, L. M., & Schiffer, R. N. (2010). Learn locally, think globally: Exemplar variability supports higher-order generalization and word learning. *Psychological Science*, *21*(12), 1894–1902. https://doi.org/10.1177/0956797610389189

Pulvermüller, F. (2005). Brain mechanisms linking language and action. *Nature Reviews Neuroscience*, *6*(7), 576–582. https://doi.org/10.1038/nrn1706

Reese, E., Leyva, D., Sparks, A., & Grolnick, W. (2010). Maternal elaborative reminiscing increases low-income children's narrative skills relative to dialogic reading. *Early*

Education & Development, *21*(3), 318–342. https://doi.org/10.1080/10409289.2010.481552

Rennie, L. J., & Johnston, D. J. (2004). The nature of learning and its implications for research on learning from museums. *Science Education*, *88*(S1), S4–S16. https://doi.org/10.1002/sce.20017

Rodriguez, E. T., & Tamis-LeMonda, C. S. (2011). Trajectories of the home learning environment across the first 5 years: Associations with children's vocabulary and literacy skills at prekindergarten: Trajectories of the home learning environment. *Child Development*, *82*(4), 1058–1075. https://doi.org/10.1111/j.1467-8624.2011.01614.x

Rogoff, B., Callanan, M., Gutiérrez, K. D., & Erickson, F. (2016). The organization of informal learning. *Review of Research in Education*, *40*(1), 356–401. https://doi.org/10.3102/0091732X16680994

Rowe, M. L., Leech, K. A., & Cabrera, N. (2017). Going beyond input quantity: *Wh* - questions matter for toddlers' language and cognitive development. *Cognitive Science*, *41*, 162–179. https://doi.org/10.1111/cogs.12349

Salo, V. C., Rowe, M. L., Leech, K. A., & Cabrera, N. J. (2016). Low-income fathers' speech to toddlers during book reading versus toy play. *Journal of Child Language*, *43*(6), 1385–1399. https://doi.org/10.1017/S0305000915000550

Smith, L. B., Yu, C., & Pereira, A. F. (2011). Not your mother's view: The dynamics of toddler visual experience: Dynamics of toddler visual experience. *Developmental Science*, *14*(1), 9–17. https://doi.org/10.1111/j.1467-7687.2009.00947.x

Tamis-LeMonda, C. S., Custode, S., Kuchirko, Y., Escobar, K., & Lo, T. (2019). Routine language: Speech directed to infants during home activities. *Child Development*, *90*(6), 2135–2152. https://doi.org/10.1111/cdev.13089

Tamis-LeMonda, C. S., Kuchirko, Y., Luo, R., Escobar, K., & Bornstein, M. H. (2017). Power in methods: Language to infants in structured and naturalistic contexts. *Developmental Science*, *20*(6), e12456. https://doi.org/10.1111/desc.12456

Twomey, K. E., Ranson, S. L., & Horst, J. S. (2014). That's more like it: Multiple exemplars facilitate word learning. *Infant and Child Development*, *23*(2), 105–122. https://doi.org/10.1002/icd.1824

Vlach, H. A., & Sandhofer, C. M. (2011). Developmental differences in children's context-dependent word learning. *Journal of Experimental Child Psychology*, *108*(2), 394–401. https://doi.org/10.1016/j.jecp.2010.09.011

Vlach, H. A., & Sandhofer, C. M. (2012). Fast mapping across time: Memory processes support children's retention of learned words. *Frontiers in Psychology*, *3*. https://doi.org/10.3389/fpsyg.2012.00046

Vlach, H. A., Sandhofer, C. M., & Kornell, N. (2008). The spacing effect in children's memory and category induction. *Cognition*, *109*(1), 163–167. https://doi.org/10.1016/j.cognition.2008.07.013

Waxman, S. R., & Booth, A. E. (2000). Principles that are invoked in the acquisition of words, but not facts. *Cognition*, *77*(2), B33–B43. https://doi.org/10.1016/S0010-0277(00)00103-7

Yoshida, H., & Smith, L. B. (2008). What's in view for toddlers? Using a head camera to study visual experience. *Infancy*, *13*(3), 229–248. https://doi.org/10.1080/15250000802004437