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Brief Report

Variability in toddlers' ability to verbally update their mental representations of absent objects

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ABSTRACT

Early in development children rely on other people's verbal testimony to acquire information about things that are not available to their immediate perception. There is evidence that children as young as 22 months can use language to learn about an object that undergoes a property change (e.g., "Lucy got wet") out of their sight. If the verbal input conveys a change in the location of an absent object (e.g., "The puppy is moved from the bag to the box"), 30-month-olds successfully use this information and find the object in its new location, whereas the majority of 23-month-olds perseverate to the object's initial location. These findings suggest that young children's ability to use verbal testimony to update their mental representations of absent entities shows variability within and across tasks. The goal of the current research was to replicate the pattern of performance observed in previous cross-sectional studies within the same group of children. A total of 59 2-year-olds (M_{age} = 26.9 months, range = 21.4–34.5) were administered two versions of verbal updating tasks: property and location change. As a group, children showed more variable performance when they learned about a change in an object's location (58% success) than when they learned about a change in its property (75% success). Moreover, comparison of individual children's performance across the two tasks revealed that at this age children found the location change harder to update than the property change. We discuss possible explanations for children's differential performance on verbal updating tasks involving property and location change.

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Introduction

Language is a unique human capacity that enables us to acquire knowledge about entities that are distant in space or time such as species that no longer exist (dinosaurs) and microorganisms that are invisible to the naked eye (bacteria). In a dynamically changing world, we rely on linguistic input not only to represent unobservable entities but also to update our existing representations in line with new information (Ganea & Saylor, 2013). This ability to integrate new verbal input into existing mental representations is a major developmental milestone, enabling children to expand their knowledge beyond what is perceptually available (Harris, 2012).

From the early phases of language development, children treat language as a source of information about unseen entities (Galazka, Gredebäck, & Ganea, 2016; Ganea, Fitch, Harris, & Kaldy, 2016; Graham, Kilbreath, & Welder, 2004; Vouloumanos, Onishi, & Pogue, 2012; Xu, Cote, & Baker, 2005). For example, 16-month-olds look surprised when a visual scene does not match the input they hear when the scene is occluded (Ganea et al., 2016). This suggests that children adjust their expectations about the world based on language. Nevertheless, other research on verbal updating indicates that this ability is not only fragile but also highly variable during the second year of life; some contexts seem to impose greater difficulty than others, and some 2-year-olds are better than others within a given context (Ganea & Harris, 2010, 2013).

The existing evidence for children's variable performance is based on cross-sectional studies. To our knowledge, no prior research directly assessed individual children's verbal updating ability across different contexts. Thus, the current research aimed to replicate the previous findings by testing the same individual children in two different verbal updating contexts. Given the importance of data replication and robustness in social science, particularly for developmental psychology (see Duncan, Engel, Claessens, & Dowsett, 2014, for a discussion), the current replication study has the potential to provide corroborating evidence about the variability observed in toddlers' ability to use language as a source of information about absent entities.

Two main types of experimental tasks have been used so far to examine verbal updating in young children. In one type of task, property change (Ganea, Shutts, Spelke, & DeLoache, 2007), 19- and 22-month-olds were told about a new property of a stuffed frog that was not in view at the time of speech ("I spilled water all over Lucy. Lucy is all wet now.") and then were asked to identify Lucy from among three choices (a wet frog, a dry frog, and a wet elephant). The 19-month-olds chose the toy in the form in which they had originally experienced it (i.e., dry frog), failing to update their object representation. The 22-month-olds successfully updated and chose the target toy in the new form (i.e., wet frog).

Surprisingly, at 23 months of age children failed on another type of task when they were told about a change in an object's location, that is, location change (Ganea & Harris, 2010, 2013). In this task, children peeked through a curtain and observed an experimenter hiding the toy in one of four possible locations (e.g., a box). The curtain was then closed, and after a few seconds children were informed about the location change (e.g., "I moved the puppy to the box. The puppy is now in the box."). When asked to find the toy, 23-month-olds were at chance; most of them perseverated to the old location where they initially observed the object being hidden. In contrast, the majority of 30-month-olds successfully searched for the toy in its new location.

This evidence suggests that young 2-year-old children's ability to verbally update their knowledge of an absent object is not uniform across contexts. As a group, 22-month-olds can reliably update their mental representations of an absent object when informed about its new property but not about its new location. The goal of the current research was to replicate this previous pattern of behavior within the same group of individual children. If children's ability to use linguistic input varies as a function of context, we would expect that the same individual children will be more likely to succeed on the property change task but fail on the location task than the other way around. The replication of this response pattern within the same group of children would indicate that the variable updating performance is due to differential demands of the verbal updating contexts rather than the testing of different individual children across different tasks.

In the current study, we tested children across a wider age range than the previous studies that zoomed in on specific time points. Examining performance across a continuous age range rather than a 2-month window, as in prior research, would enable us to check the robustness and generalizability of previous findings throughout the second year of life.

Method

Participants

The sample comprised 59 children aged 21.4 to 34.5 months (M = 26.9 months, SD = 3.58; 33 girls and 26 boys) recruited from a participant pool at a public university in North America. The majority of participants came from White/Caucasian middle-class families and consisted of typically developing children who heard English at least 75% of the time at home. The study involved two sessions scheduled within 2 weeks, with one verbal updating task in each session. Only children who completed both verbal updating tasks were included. An additional 12 children had incomplete data for one of the verbal updating tasks due to uncooperativeness (n = 4), parent canceling the second testing session (n = 4), failing to make a clear response in the property change task (n = 1), or failing the labeling phase of the location change task (n = 3).

Procedure

Each child completed two tasks measuring verbal updating: property change and location change. The order of the updating tasks in a given session was counterbalanced.

Measures

Property change

This task (Ganea et al., 2007) began with a second experimenter (E2) sitting in the corner and pretending to paint on paper using a paintbrush and a transparent bottle of green paint. The main experimenter (E1) presented two identical stuffed ducks and two other stuffed animals (a dog and a monkey) from a box one at a time and engaged the child in play with each for a few seconds. Critically, one of the identical ducks was given a proper name, ‘‘Max.” The other (identical) duck was dubbed ‘‘Max's friend” and placed on a shelf at the back of the room. It remained visible to the child during this phase. E1 ensured that the child was able to identify Max among the other toys (‘‘Can you show me Max?”). If needed, E1 gave feedback and repeated the question. Children needed to correctly identify the target toy on two consecutive trials or on two of three trials. Most children correctly identified the target toy in two trials; only 7 children needed a third trial. Next, E1, the child, and the parent left the room, with the child being told that E2 would stay and continue painting. In their absence, E2 placed a green painted duck (target), a green painted dog (distractor), and a duck without paint (nontarget) in a row on a low table in the center of the room. After 20 s, E2 emerged from the room and delivered the critical verbal input: ‘‘Guess what! I was painting, and I painted Max a different color! Max is all green now, he is all green!” E1 repeated the verbal input and invited the child to enter the room and find the target toy: ‘‘Where is Max? Show me Max!” Because the nontarget and the target were identical stuffed animals except for the fact that one of them had the property change, the distractor was always positioned between the other two toys and functioned as a separator. The position of the other two toys was counterbalanced across participants. Children's first response was recorded as pass/fail. If children did not make a clear response in their first attempt (e.g., pointing to more than one object), E1 repeated the test question. All but 4 children made a clear choice in their first attempt. Among the children who were asked a second time, 1 child did not give a clear answer and, thus, was not included in the analyses.

Location change

This task (Ganea & Harris, 2013) began with a hide-and-seek game. E1 hid a stuffed animal (e.g., lion) in one of four hiding locations (i.e., box, bag, drawer, or pillow) positioned in each corner of a square room, and the child was asked to help E2 find it. The majority of children were able to find the object in their first search. Only 8 children needed a second search to find the object. The order in which hiding locations were used was randomized across participants. After the child successfully retrieved the toy from each location, E1 ensured that the child comprehended the label for each hiding location (e.g., "Where is the drawer?"). Three children failed to answer correctly for at least one hiding location and were not included in the analyses. Next, E2 brought a new stuffed animal (i.e., alligator) to hide. E1, the child, and the parent moved behind a curtain through which the child was invited to peek while E2 hid the toy (see Fig. 1 for the experimental room layout). E1 ensured that children paid attention when E2 was hiding the toy. Next, after E1, the child, and the parent left the room, E2 moved the toy to a different location. After 20 s, E2 came out and delivered the critical verbal input: "Guess what! I moved the alligator! I moved the alligator to the bag. Now the alligator is in the bag." E1 repeated the verbal input and invited the child to enter the room and find the toy: "Let's go find the alligator." Children's first search was scored as pass/fail. The location in which E2 initially hid the toy was randomized across participants. To ensure that the revision of the location entailed distinct areas of the room, the toy was always moved diagonally.

Results

Preliminary analyses

Independent samples *t* tests confirmed that children's mean age was not significantly different across genders (*ps* > .14) and test order groups (*ps* > .40). In addition, separate chi-square tests showed that children's success on the verbal updating tasks did not differ as a function of gender or test order (all *ps* > .26). Lastly, a chi-square analysis showed that children's performance did not differ depending on whether the object was moved from front to back or from back to front, $\chi^2(1, N = 59) = 1.270$, $p = .26$.

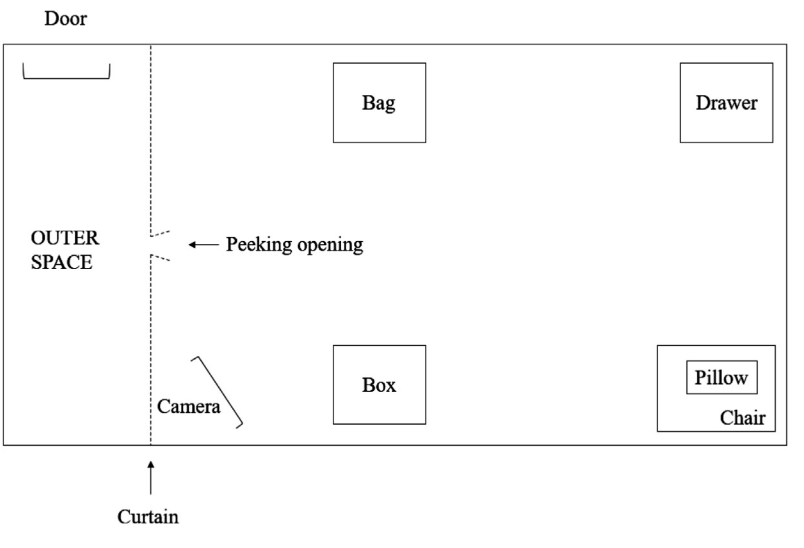

Fig. 1. Experimental room layout for the location change task.

Performance on verbal updating tasks

On the property change task, the majority of children (75%, 44 of 59) selected the target object, that is, the duck with green paint. Among the children who failed, only 2 chose the distractor (the other animal painted green) and the rest (n = 13) chose the outdated version of the target object (the duck with no green paint). Although children were presented with three stuffed animals from which to choose, which theoretically sets the chance level to 0.33, we followed the standard approach for single-shot designs and grouped children's responses into two categories: (a) choosing the target toy and (b) choosing a nontarget of any sort. Therefore, we tested children's correct responses across a more stringent criterion by using 0.50 as the chance level (see also Ganea et al., 2007). A binomial test revealed that children's performance was above chance level ($p < .001$).

On the location change task, 34 of 59 children (58%) searched correctly, that is, in the new location where they were told the object had been moved. Consistent with previous research, most of the children who failed the task perseverated to the location where they last saw the object being hidden (n = 23) and only 2 children searched randomly. By implication, children discarded the two other hiding locations as potential choices and made a choice between the outdated and new locations. Thus, similar to the rationale used in the property change task, we grouped children's responses into two categories (pass/fail), which set our chance level to 0.50. A binomial test showed that children's performance was not significantly different from chance (p = .298).

We also examined whether children's performance in the verbal updating correlated with age. To accommodate the nominal nature of our dependent variable, we used Spearman's correlation. There was a significant correlation between age and both verbal updating tasks, r_s = .297, p = .02 (location change task) and r_s = .289, p = .03 (property change task), suggesting that overall older children performed better on verbal updating tasks compared with younger children.

Comparison of performance across verbal updating tasks

Next, we explored individual children's performance across the two tasks. Of 59 children, 37 (63%) showed consistent performance, with 28 passing both tasks and 9 failing both tasks (see Table 1). The remaining 22 children (37%) showed variable performance across tasks. Among children with variable performance, the majority (73%, 16 of 22) updated in the property change task but failed to do so in the location change task, whereas only a small percentage of children (27%, 6 of 22) had the opposite pattern of performance (i.e., failing to update in the property change task but updating in the location change task). An exact McNemar's test on the paired proportions revealed that children's discordant performance across the two types of tasks approached significance (p = .052). In other words, the probability of passing the property change task but failing the location change task was higher than the probability of failing the property change task but passing the location change task.

Together, these findings provide corroborating evidence for the variability in performance among 2-year-old children on verbal updating tasks. As a group, 75% of the children passed the property change task, whereas only 58% of them passed the location change task. Furthermore, individual children who passed the property change task found the location change task to be more difficult, suggesting that the ability to update a location change is more challenging than the ability to update a property change and is still developing during the third year of life.

Finally, given the age-related increase in the verbal updating performance as shown by the significant correlation above, we compared the ages of children who showed variable performance across

Table 1
Numbers of children who successfully updated across the two verbal updating tasks.

		Property change task	
		Updated	Failed to update
Location change task	Updated	28	6
	Failed to update	16	9

the two tasks. An independent samples *t* test showed that children who passed both tasks (M_{age} = 28. 5 months, *SD* = 3.6) were significantly older than children who passed the property change task but failed the location change task (M_{age} = 25.9 months, *SD* = 2.9), $t(42) = 2.470$, $p < .05$.

Discussion

Language-based representations enable children to acquire knowledge about entities that are distant in space and time and to revise this knowledge in light of new evidence. Based on previous research, we know that children's ability to use language to revise their mental representations of absent objects is still developing around 2 years of age and is prone to error depending on the type of verbal updating task.

The current research replicated prior findings. As a group, children showed nonuniform performance across the two tasks. At 27 months of age on average, the majority of children (75%) passed the property change task, whereas only about 58% of children passed the location change task. These success rates were comparable to those in prior research, with 22-month-olds' success rate in the property change task varying between 76% and 80% (Galazka & Ganea, 2014; Ganea et al., 2007) and with 23- and 30-month-olds' success rate in the location change task varying between 38% and 53% and between 77% and 85%, respectively (Ganea & Harris, 2010, 2013).

Furthermore, the nonuniformity in performance was also evident when individual children's success across the two types of verbal updating tasks was compared. We found that 37% of the children in the current sample showed inconsistent performance across the two tasks; that is, they succeeded in one type of task and failed in the other. Among these inconsistent children, the majority of them passed the property change task but failed the location change task, whereas only 27% of these children showed the reverse pattern, that is, failing the property task but passing the location task. Therefore, overall, children found the location change task to be more difficult than the property change task. This finding is particularly important in that the variability in performance across different verbal updating contexts observed in separate studies was replicated in the same study using a repeated-measures design. Furthermore, the current study showed that the variability in verbal updating performance decreased with age; as children got older, they were better able to update their mental representations regardless of the task.

These findings raise an important question for future research: What accounts for children's discrepant performance across the two verbal updating tasks? One possibility is that the two tasks might have differential working memory demands. Working memory is the cognitive capacity that enables the maintenance and manipulation of information while resisting interference from irrelevant or conflicting information (Engle, 2002). Therefore, the greater the interference from the outdated information, as in the location change, the harder the updating task becomes. We argue that although in both tasks children need to inhibit a response based on outdated information, the level of conflict between the old and new information involved in the updating process is greater in the location change task than in the property change task. In the property change task, because the object's state is not highlighted during initial encoding and an object could in principle have two properties at the same time, the new information about a change in the object's state does not impose an overt conflict in children's representation of the object. In contrast, in the location change task, a specific location is initially encoded in children's representation of the object and, given that an object cannot be in two locations at the same time, there is an overt conflict between the old and new information. Support for this explanation comes from evidence that 23-month-olds' performance is comparable to that of 30-month-olds in the location change task when the conflict is minimized by not having a specific initial location for the target toy (Ganea & Harris, 2010, Study 2). Further studies could focus on whether equating the level of conflict at the informational level across the two tasks affects children's performance.

Another possibility is that the two updating tasks differ in terms of information load. The location change task requires children to represent and actively keep track of more pieces of information (i.e., the object and the hiding location) compared with the property change task (i.e., the object itself). As a result, the number of object files children are required to process and revise is different; children need to activate one mental file (i.e., the file for the object) in the property change task and two mental files (i.e., the file for the object as well as the file for the location) in the location change task (Murez & Recanati, 2016). Thus, children may have difficulty in updating an object's representation when the update requires management of multiple mental files. This may be because of difficulty in updating multiple mental files related to an object, but it also may be because of greater working memory demands. Furthermore, recent research on working memory differentiates between different aspects of working memory (Ecker, Lewandowsky, Oberauer, & Chee, 2010). It is argued that maintenance function (i.e., working memory capacity), which helps selected representations to be held active, is distinct from updating function (i.e., working memory updating), which takes a role in the modification of these selected representations and resistance to the interference from outdated information. Therefore, it is possible that the two verbal updating tasks tap maintenance and updating functions to different degrees. Further research into working memory processes involved in children's storage and updating of information about different object properties (e.g., color, shape, size, location) will be essential for understanding children's ability to revise knowledge about absent things and events.

It is also important to note is that the updating tasks used in this research place differential demands on children's language ability, which may contribute to their variable performance across the two tasks. The verbal input in the location task ("I moved the alligator to the bag. Now the alligator is in the bag") requires children to represent a change to a spatial relation based on containment (e.g., the preposition/particle *in*), whereas in the property task ("I painted Max a different color! Max is all green now, he is all green") children are required to represent a change to a perceptual attribute (e.g., color adjective). Cross-linguistic research points to different developmental trajectories for the acquisition of different word classes, closed-class words (e.g., prepositions) versus adjectives (i.e., qualities/attributes) (Bornstein et al., 2004; Choi, McDonough, Bowerman, & Mandler, 1999). The later acquisition of spatiotemporal terms may place more cognitive demands on children's ability to represent a change in an absent object's location compared to a change in its property.

To conclude, the current findings provide corroborating evidence for the nonuniformity in children's ability to update object representations based on language. The replication of variable performance within the same individual children across tasks points to the influence of differential cognitive demands required by different types of representational updating. Future research examining the cognitive processes and possible factors that contribute to children's performance on tasks that require knowledge revision on the basis of language will shed light on a fundamental aspect of human cognition and learning.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2020.104843 or on the Open Science Framework.

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