Why do young children fail in the scale-model task?

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Abstract

Symbol use is considered to be one of the few capacities that are unique to humans. The most influential series of studies on the development of symbolic competence, spearheaded by Judy DeLoache and colleagues, adopted the scale-model task. These studies showed that it is not until three years of age that children display an understanding of symbols, while younger children fail to establish stand-for relations between symbols and their referents. Here we propose that young children's failure in the scale-model task does not reflect a limitation in symbolic competence, but a limitation in mapping depicted discourse episodes onto actual situations. By distinguishing between (reality-directed) representations and (discourse-directed) depictions, we argue that the scale-model task conflates symbolic understanding with an additional operation: linking internally represented episodes to real-world situations.

Keywords: symbol processing; depictions; cognitive development; scale model task

Introduction

Interpreting arrangements of objects as representing something beyond the objects themselves is a hallmark of symbolic competence and has been a focus in the study of the development of human cognition. In a series of influential studies, Judy DeLoache and colleagues investigated whether young children understand the symbolic nature of scale models and other visual representations (for reviews, see DeLoache, 2004; Uttal & Yuan, 2014). Scale models in her tasks were miniature versions of real rooms, in which the toy furnishings were arranged analogously to the items in the corresponding room. The children's task was to find an object in the real room (e.g., a toy dog hidden under a pillow) on the basis of the location of the miniature replica of the target object in the model (e.g., a miniature toy dog hidden under a miniature pillow in the model). While 3-year-olds generally succeeded in this task, younger children often failed. To account for these results, DeLoache argued that young children struggle in such tasks because they do not yet understand the dual nature of symbols: that they are objects in their own right and at the same time they represent something else.

However, this explanation is at odds with toddlers' symbolic competence in another domain: pretence. In play contexts, 2-year-olds, or even younger children, can understand, for example, that a puppet dog stands for 'a dog', or that a banana stands for 'a telephone' when an adult holds it to her ear like a handset and talks into it (Leslie, 1987; Harris et al., 1993; Lillard et al., 2011; Revencu, 2026). If 2-year-olds can set up a stand-for relation between a phone and a banana, what prevents them from interpreting such a relation between an object and its miniature replica? After all, the object in the hand of the adult plays the dual roles of being a banana and standing for a phone at the same time. This discrepancy between the two sets of results is either due to the fact that different symbolic capacities are required in the scale-model task and in pretense, or to the fact that some additional ability, which goes beyond symbolic competence, is needed for solving the scale-model task but is not yet in place before 3 years of age.

We propose here an account that is compatible with this latter explanation and suggests that children's symbolic competence is underestimated by the standard scale-model task. We hypothesize that object symbols are not directly linked to real-world referents (e.g., a pillow in the model is not directly linked to a specific pillow in the room) but are interpreted to stand for discourse referents in communicative contexts (the pillow in the model is interpreted as standing for a pillow, not a specific one). If this is the case, an additional cognitive operation is needed to link discourse referents to real objects in the world, and consequently to transfer the information from the episode depicted by the model to the real-world situation corresponding to it. In other words, this account assumes a two-step process behind the understanding of scale models: first mapping symbols to discourse referents and then mapping discourse referents to real-world objects. According to this account, it is not the lack of symbolic competence that prevents young children from succeeding in the scale-model task.

The scale-model task: Evidence

The classic demonstration of young children's difficulty with symbols comes from DeLoache's scale-model task (DeLoache, 1987, 1989). In this paradigm, children observe a miniature toy being hidden in a scale model of a room and are then asked to retrieve a larger toy hidden in the corresponding location in the real room. Across studies, 2.5-year-olds consistently failed to use the model to guide their search, whereas 3-year-olds succeeded. Importantly, this failure could not be attributed to limitations in spatial knowledge (as demonstrated in the credible shrinking room experiment, DeLoache et al., 1997) or inhibitory control (Sharon & DeLoache, 2003), difficulties matching the objects in the model to the objects in the room (even 2.5-year-olds could see the correspondence, Troseth et al., 2007),

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memory failure (children of all ages remembered where the objects were hidden in the model, even after they failed to place them in the room), or motor ability (children were able to explore the room and interact with the hiding places). Children were also asked to perform a placement or imitation task, in which they themselves put a toy in the location corresponding to the one shown in the scale model. This manipulation did not improve 2.5-year-olds' performance.

DeLoache (1987) also compared children's use of scale models to their use of photographs depicting pieces of furniture in the room to indicate where a toy was hidden. Unlike in the scale-model task, 2.5-year-olds successfully used this information to locate the toy in the room. Using photographs or line drawings (instead of scale models) depicting the whole room also helped 2.5-year-old children to find the target object in the room (DeLoache, 1991; Dow & Pick, 1992; DeLoache & Burns, 1994; Suddendorf, 2003). In fact, when the task was not retrieving but placing the objects to the indicated location, even 2-year-olds succeeded (DeLoache & Burns, 1994). DeLoache proposed that photographs induced better performance because they reduce the demands of dual representation (representing a symbol both as an object and as standing for something else), as they are less compelling as objects in their own right. It is important to note here that, unlike in the original scale model task, the experimenters in these studies pointed to the location or the picture of the hiding furniture item to indicate where the target object is to be found or placed. Thus, these versions of the task (unlike in the scale-model studies), applied no symbols for the target object. Rather, the verbal expression of the experimenter stated the location of the target object ("This is where Snoopy is hiding in his room") together with the pointing gesture accompanying the demonstrative pronoun. In this case, the photographs or drawings of objects may have functioned to substitute words (e.g., "sofa") rather than acted as symbols.

However, while pointing improved 2.5-year-olds' success in the task with photographs or line drawings, it did not improve 2.5-year-olds' performance when it was done on a scale model (DeLoache, 1991; but see Kuhlmeier, 2005). Hiding toys or cut-out photographs of toys behind individual photographs of the hiding places led to the same poor performance as the hiding condition with the model. In sum, if either the scale model or the symbol of the target objects were real 3D entities, young children struggled in the search task, unless the model was hidden behind a transparent window (DeLoache, 2000). This pattern of findings is compatible with DeLoache's account (DeLoache, 2000), according to which young children's difficulty with the task is due to the demands of dual representations. Another supporting argument for this account is the fact that even 3-year-olds find the search task difficult if they previously have played with the model, apparently because they are already familiar with the objects 'as objects' and not 'as symbols' (DeLoache, 2000).

Further studies show that removing the "scale" from the scale-model task may improve children's performance. DeLoache, Kolstad, and Anderson (1991) found that when the target room was made similar in scale to the model, 2.5-year-olds performed nearly as well as 3-year-olds. However, increased similarity does not always help. DeLoache and Sharon (2005) demonstrated that when models and rooms were made perceptually identical, children's performance declined relative to standard conditions. Excessive similarity appeared to obscure the symbolic relation, leading children either to treat the task as a memory problem or to become confused about which space was relevant (see also Jowkar-Baniani & Schmuckler, 2013). It was also shown that size similarity between the model and the room had an effect on performance, but size similarity between the hidden referent toy and its symbol did not (O'Sullivan et al., 2001).

In an effort to demonstrate that failures in the scale-model task reflect difficulty with interpreting symbolic relations, DeLoache and colleagues developed elegant control manipulations. For example, in the "credible shrinking room" paradigm (DeLoache et al., 1997), children were led to believe that a shrinking machine had transformed the real room into the model. Under this non-symbolic interpretation of the relation between model and reality, 2.5-year-olds performed dramatically better than in the standard task. This demonstrates that it is not the match between different-size arrangements that prevents 2.5-year-olds from succeeding in the standard scale-model task. This is also shown by a study in which children of this age spontaneously used highly abstract, geometric maps to locate objects in three-dimensional space (Winkler-Rhoades et al., 2013). Notably, this task differed from the standard scale-model tasks in many respects. Not only was the location information provided by pointing on a 2D map, and it was a placement task, rather than a search task, but also the relation between the map and the room was introduced by providing generic information: the dolls were said to have a "favorite place to sit in the room," which the experimenter indicated by pointing to the corresponding location on the map.

Young children's failure to interpret symbolic artifacts is not restricted to the scale-model task. Tomasello et al. (1999) tested whether, in a "give-me" game, children could select the target object indicated by iconic gestures or objects. Children below 2 years succeeded in this task with gestures representing the conventional use of the target object, but they failed when the sign was an object differing only in color from the target. Similarly, children below 3 years generally fail to conceive of their own body as the potential referent of a doll (DeLoache & Marzolf, 1995). They have an easier time matching a 2D representation to a doll (i.e., another symbol) than to their own body (Herold & Akhtar, 2014).

An important counterpoint to children's difficulties with symbols comes from the literature on early pretense. By the second year of life, children readily engage in pretend scenarios that require them to treat objects, actions, and properties as standing for something other than what they are in reality. Harris and Kavanaugh (1993) and Kavanaugh and Harris (1994) showed that toddlers can flexibly assign pretend identities to objects and track these assignments over

time, even when perceptual evidence conflicts with the pretend state of affairs. For example, after a block is introduced as a carrot or a banana, children feed it selectively according to the pretend preferences of animals and no longer use it once it has been "consumed" (i.e., "fed" to an animal). In another paradigm, when an experimenter pretends that a gorilla spills red paint on a horse, children later indicate that the horse "looks red" by choosing a picture of a red horse, despite the unchanged appearance of the physical toy. Here, children went for what is predicated about the discourse referent over perceptual similarity. Consistent with this interpretation, Bosco et al. (2006) found that children as young as 16 months of age performed equally well in pretend and reality versions of structurally identical tasks, such as drinking from an empty versus a full cup. Functionally, an empty cup in this task serves as a symbol for a full cup, so understanding the pretense action implies dealing with objects as symbols.

The scale-model task: Accounts

DeLoache's interpretation of the demands of the scale-model task is the following: The miniature objects in the model play the roles of symbols that stand for specific referents: the actual objects in the real room. In addition, the spatial arrangement of the symbols is analogous to the layout of the room; thereby, the scale model (which consists of symbols and their arrangement) represents the situation of a specific spatio-temporal segment of reality involving the referents. See Figure 1a.

Compare this interpretation of the scale-model task to that of pretense. A recent account of the cognitive apparatus needed to understand pretense actions posits stand-for relations, but such relations are stipulated not between symbols and (real-world) referents but between symbols and *discourse referents* (Revencu, 2026). Discourse referents are internal representations of entities under discussion, which are created and maintained in communicative contexts to track and store information about the entities that participate in the episodes conveyed by the discourse (Heim, 1982; Brody & Csibra, 2026). Discourse referents normally receive descriptions that specify what kind of entities they are or what roles they play in the episode. In the case of talking to a banana while it is held to the ear of the communicator, one of the internally represented discourse referents is "a telephone," while the banana is represented as a perceptually available object that acts as a symbol standing for this

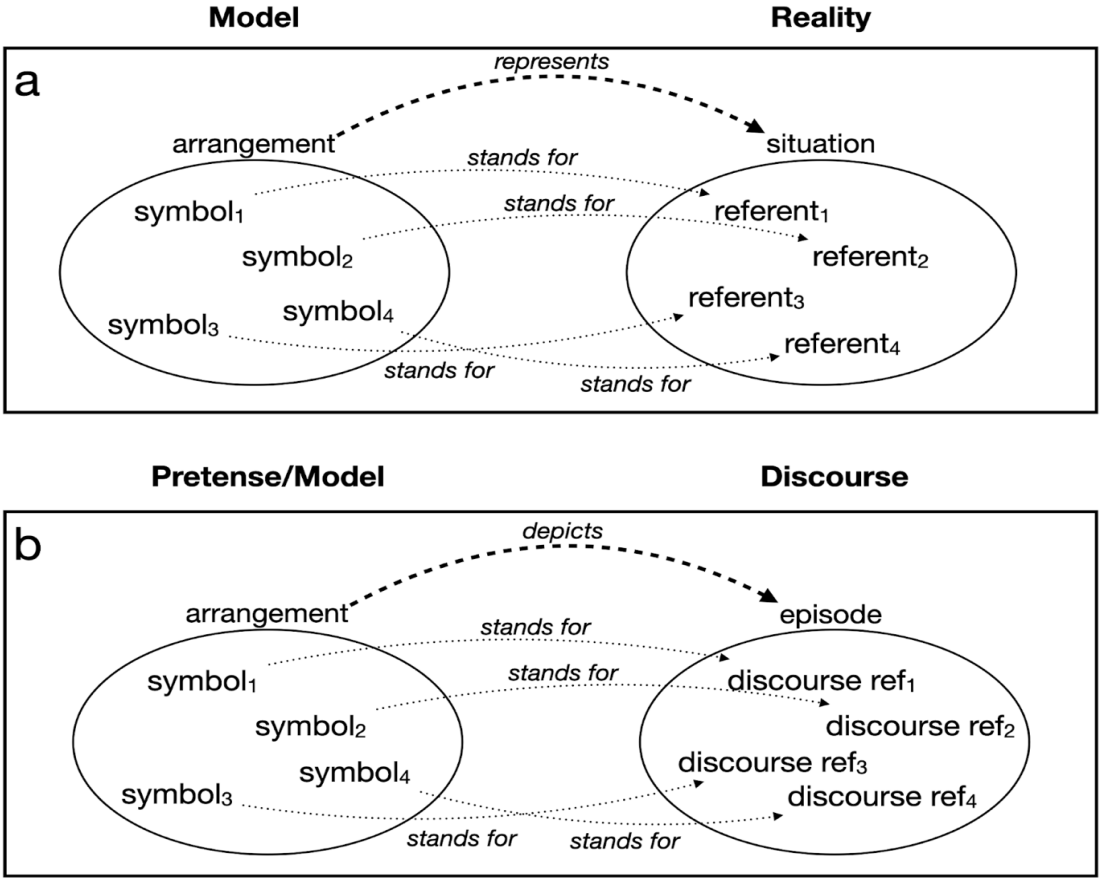

Figure 1: Simplified illustration of the relations implied in DeLoache's (2004) account of the scale-model task (a) and in Revencu's (2026) interpretation of pretense (b), which could also be applied to the scale-model task.

discourse referent. Importantly, there is no requirement to conceive of discourse referents as corresponding to particular entities in the real world. "A telephone" here is a description that specifies the kind of entity that the banana stands for, but it does not map onto any specific phone in the world. The spatio-temporal arrangement of objects in a pretense situation (e.g., the banana being held to the ear of the adult) depicts the episode in which the discourse referents participate (i.e., "a person is listening to a telephone").

This scheme can also be applied to the scale-model situation (Figure 1b), which is analogous to the previous one (Figure 1a) with some crucial differences. Most importantly, the terminological distinction between referents and discourse referents is meant to express the difference in the targets of the symbolic relations: referents are externally defined real particulars of the world, while discourse referents are internally represented entities that are described by the role they play in the situation. An important consequence of this difference is that the relation between arrangements of the symbols and situations in the real world (Figure 1a) is *representational* in the strong sense: it is subject to a truth condition that is in principle verifiable. In the scale-model task, if the relative location of the hidden object in the room matches that of its symbol in the model, the truth condition is satisfied: the model does represent the actual situation. But it is also possible that there is a mismatch between the relative locations, in which case this truth condition is not satisfied, and the model *misrepresents* the situation. In contrast, when symbols stand not for real particulars but for (possibly fictional) entities under discussion (Figure 1b), such a truth condition does not apply. In this case, the arrangement of the symbols depicts an episode with discourse referents, which, however, does not necessarily correspond to any real-world situation, and so its correctness cannot be verified. For example, if the model depicts a princess dancing in her castle, it does not entail that somewhere a specific princess is dancing in her castle, and it would be futile to seek for verification for this episode in the real world. The terminological distinctions between representation and depiction, on the one hand, and between situation and episode, on the other, are meant to express these crucial differences. While the arrangement of a set of symbols can represent or misrepresent a situation among referents, it can only depict an episode among discourse referents, but it cannot "misdepict" it.

The main point of this account is that if young children interpret the scale model as a depictive medium (implying a discourse conveyed by it), they can set up discourse referents standing for each object in the model and can interpret their arrangement as a depiction of an imaginary episode the same way as they interpret pretense actions. However, while this interpretation includes symbols and requires the establishment of stand-for relations, it would not help children in succeeding in the search task because no external situation is linked to the internal representation of the episode (Figure 1b). This might explain why young children, who are competent users of symbolic relations in pretense and in other contexts, are unable to find the hidden object in the room even if they conceive of the objects in the scale model as symbols. In other words, young children's failure in the scale model task may indicate not a deficit in capturing symbolic relations but the immaturity of the additional cognitive operations needed to map discourse referents onto real-world particulars and depicted episodes onto real-world situations. The absence of this additional operation may also explain why young children do not comprehend when adults use a replica object (e.g., a toy hammer) to request a real target object (an actual hammer), despite their recognition of what

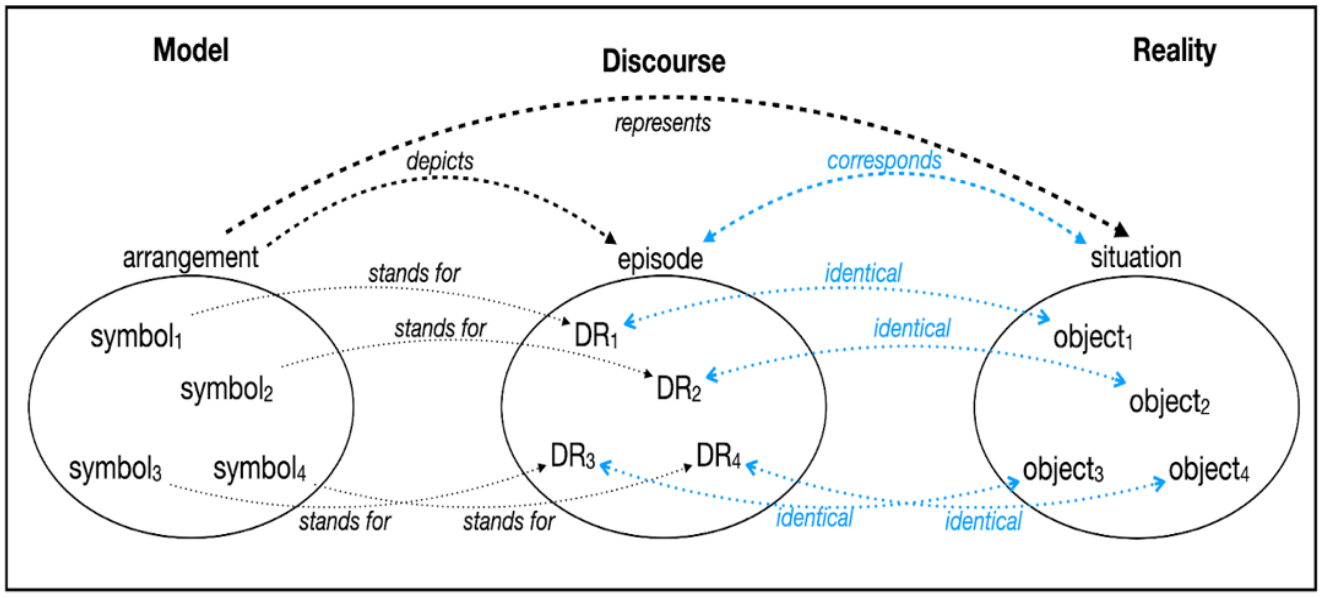

Figure 2: Illustration of the relations to be set up in order to pass the scale-model task in the proposed re-interpretation of its requirements (DR = discourse referent).

kind of object the toy stands for (Tomasello et al., 1999).

The above re-interpretation of the scale-model task suggests that conceiving the model as a symbolic depictive medium is not sufficient for passing the task. In order to succeed in the task, children would have to incorporate the actual room into their internal representation of the depicted episode (Figure 2). They can do this if they realize that the discourse referents they have posited on the basis of the scale model are meant to be the very items that populate the real room. (This may not be an easy job, especially if they have time to imagine an elaborate episode made of discourse referents that may not be similar to the real room; see DeLoache, 2000.) To represent these matches internally, they should establish identity relations between the discourse referents and the furniture items (as well as between the target object and its symbol), as seen in Figure 2. Identity relations (unlike stand-for relations) are symmetrical (as indicated by arrows on both sides of the links) and imply substitutability between the elements they link to each other. While setting up such identity relations is a necessary precondition to solve the scale-model task, it is not sufficient; to find the hidden toy, children also have to assume that the episode they have built of the discourse referents on the basis of the arrangement of the symbols in the scale model corresponds to the current situation of the room. If both conditions are met (the discourse referents are mapped onto real-world entities and actual correspondence between the depicted episode and the current situation of the real-world entities is assumed), the identity and correspondence relations together ensure that the arrangement of the symbols in the model does (or, at least, is meant to) represent the current real-world situation (Figure 2). As soon as this extension of reality is added to the scheme of depictions, children would be able to pass the scale-model task.

Conclusions

In this paper, we have argued that young children's failure in the scale-model task does not reflect a lack of symbolic competence, but a limitation in linking depicted episodes to actual situations in the world. By distinguishing between an account in which symbols stand for discourse referents and an account in which symbols represent real-world particulars (Figure 1), we suggest that scale models are initially interpreted by young children as symbolic depictions, much like the objects used in pretense. On this interpretation, children can readily establish stand-for relations between objects in the model and internally represented entities, and can understand the arrangement of those objects as depicting an episode. However, succeeding in the scale-model task additionally requires mapping these discourse referents onto specific entities in the real room and assuming a correspondence between the depicted episode and the current real-world situation. We suggest that it is this mapping, rather than symbolic understanding per se, that develops later and constrains performance in the standard task. This re-interpretation reconciles children's robust competence in pretense with their systematic failure in scale-model tasks, and reframes the task not as a test of whether children grasp the dual nature of symbols, but as a test of whether they can integrate symbolic depictions with representations of reality.

The current account of the scale-model task yields three straightforward predictions about children's performance in potential variants of the task. First, it suggests that young children who fail in the standard version of the task could nevertheless interpret models as depicting imaginary episodes. Second, it predicts that if the link between the episode involving the discourse referents and the reality of the room is not of identity and correspondence, but some other relations that are within the competence of two-year-olds, even young children may succeed in the task. Third, it predicts that when children (above 3 years of age) pass the standard scale-model task, they do not achieve this feat by mapping symbols directly onto real-world referents (like in Figure 1a) but do so via mediation of discourse referents (like in Figure 2).

Confirming these predictions would suggest that human symbolic competence more likely originates from using symbols to depict characteristic but fictional episodes than from conveying verifiable information about real states of the world.

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