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REPORT

Young children make scale errors when playing with dolls

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Abstract

Prior research (DeLoache, Uttal & Rosengren, 2004) has documented that 18- to 30-month-olds occasionally make scale errors: they attempt to fit their bodies into or onto miniature objects (e.g. a chair) that are far too small for them. The current study explores whether scale errors are limited to actions that directly involve the child's body. We investigated whether children would also make scale errors with a doll and objects that were much too small for the doll (e.g. a chair, a bed). Many participants did try to fit the doll into or onto the miniature objects. Thus, the previously documented phenomenon of scale errors extends to situations in which the relevant size difference is between two objects. This finding supports the view that scale errors occur when visual information about object size fails to influence the decision to act on an object. The results are discussed in terms of the use of visual information for the planning and control of actions.

Introduction

Young children occasionally try to fit their bodies into or onto objects that are far too small for them (DeLoache, Uttal & Rosengren, 2004). For example, a young child may try to sit in a doll-sized chair, put on a doll's shoe or get into a tiny toy car. DeLoache *et al.* (2004) called these behaviors *scale errors*. During a scale error, a child attempts to perform an action that is commonly associated with a larger version of the object or the general category of objects despite extreme differences between the relative size of the child's body and the size of the object. In other words, the child attempts to interact with the miniature object as if it were a full-sized version.

Participants in DeLoache *et al.*'s (2004) study initially played with child-sized versions of a chair, an indoor slide and a toy car. These objects were large enough for the children to interact with them in a conventional manner. For example, they could easily sit in the chair, slide down the slide and get into the car. The three large objects were subsequently replaced with miniature replica objects while the child was out of the room. The three replicas were virtually identical to the larger objects except for size. Nearly half of the 18- to 30-month-old participants (25 of 54) made at least one scale error with one or more of the miniature objects. For example, they made serious efforts to get into the miniature car, attempting to get their foot through the open door as they had done with the larger version. The children also attempted to sit in the chair or go down the slide, often falling off in the process. The children's efforts were judged to be serious attempts to perform the actions, rather than acts of pretense. This research provided the initial documentation of the phenomenon of scale errors.

It is important to note that young children commit scale errors in everyday life. Indeed, the impetus for the original study (DeLoache *et al.*, 2004) came from informal observations of scale errors made by young children in the researchers' own homes and labs, as well as from anecdotal accounts from other parents and researchers. Thus, although recent exposure to similar large objects presumably increases the likelihood of scale errors, it is not required for their occurrence.

Why do scale errors occur? DeLoache *et al.* (2004) suggest that scale errors stem from a momentary breakdown in the use of visual information for action planning. When a child sees a replica of an object from a familiar category, visual input activates a stored

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mental representation of that object or of the category of larger objects that the replica denotes. This representation includes a motor plan for interacting with a larger version of the object (Barsalou, Simmons, Barbey & Wilson, 2003; Tucker & Ellis, 1998, 2001). Normally, visual information about the size of the miniature object will inhibit the motor plan that is associated with a full-sized version. In these situations, the child will not commit a scale error but instead might treat the replica as a toy or choose not to play with it all together. Occasionally, however, the relevant size information fails to inhibit the activated motor routine. This leads to the execution of an action plan that derives from the category of larger objects that the replica stands for. Thus, a scale error occurs when a child encounters a miniature object and visual registration of the object's size does not serve to inhibit a prepotent motor plan that is associated with a full-sized version of that object.

Scale errors do not occur because young children have difficulty discriminating between the sizes of large and miniature objects. The ability to distinguish between two objects on the basis of size emerges as early as 4.5 months of age (Wilcox, 1999). Furthermore, DeLoache *et al.* (2004) showed that children of the same age as those in the original scale error study were aware of the size differences between the large and miniature objects used in that study. Participants were shown the large and miniature objects simultaneously and were asked to perform a relevant action (e.g. 'Come and sit in the chair'). They always chose to interact with the object that afforded the requested action (e.g. the large chair). This preference to interact with the large objects demonstrates that the children could perceive the size differences between the large and miniature objects.

In addition, children's behavior during scale errors provides evidence that, at some level, they are aware of the small size of the object. Specifically, DeLoache *et al.* (2004) report that size information influenced the on-line control of actions during the commission of scale errors. That is, while attempting to act on the replicas, the children's individual movements were adjusted to the small size of the miniature objects. For example, during scale errors with the miniature chair, the children approached the chair, turned around, bent their knees, and carefully squatted down over the chair until they came into contact with it. The general motor plan was similar to actions directed towards the large chair, but the individual movements were calibrated to the actual size of the replica chair. Thus, even though size information did not influence the children's initial decision to sit in the chair, their actual movements were affected by the small size of the chair.

The initial demonstrations of scale errors reveal that visual information about object size sometimes is not integrated into young children's action planning for actions directed towards miniature objects. The research conducted thus far has only documented the occurrence of scale errors; it has not tested the limits of this phenomenon. One question of particular interest is whether the occurrence of scale errors is limited to actions that directly involve the child's own body. It may be that scale errors arise from specific difficulties in integrating visual size information with action plans that involve large motor activity. Alternatively, it is possible that breakdowns in the use of visual information for action planning that underlie scale errors also occasionally occur during the formation of motor plans that involve combining two objects.

To explore whether scale errors are limited to actions that directly involve the child's body, we asked if young children commit scale errors in which the size discrepancy is not between their own body and an object, but between two objects. Specifically, we looked for scale errors in young children's play with a doll and doll-related toys that were either appropriate or miniature with respect to the doll's size. Otherwise, the situation was as similar as possible to the original scale error study (DeLoache *et al.*, 2004). If scale errors reflect a general problem integrating visual information for planning and executing actions, as DeLoache *et al.* have suggested, then young children might also make scale errors with a doll and objects that are too small for the doll. If, however, scale errors stem at least in part from some sort of body-image problem, then scale errors should not be observed in the current study.

Method

Participants

The participants were 24 16–24-month-olds ($M = 20.54$), 24 29–32-month-olds ($M = 30.46$), and 26 35–40-month-olds ($M = 37.08$).[1] There were an equal number of boys and girls in all three age groups. Participants were recruited through direct mail and telephone calls to their parents.

[1] Eleven 16–24-month-olds, six 29–32-month-olds, and four 35–40-month-olds were tested but were not included in the final sample due to: fussiness or lack of interest in playing with the toys ($N = 16$) and parent or sibling interference ($N = 5$). Of the 16 children who were dropped because of fussiness or level of interest, 11 were boys. This difference might reflect the boys' reluctance to play with the doll and related toys.

Materials

Materials included a 42-cm baby doll and five pairs of objects (bathtubs, beds, rocking chairs, hats and wagons), each pair consisting of a large object and a physically similar miniature version of it. The dimensions of the large and miniature objects were, respectively: bathtub – $41 \times 28 \times 19$ cm and $15 \times 10 \times 7.5$ cm; bed – $46 \times 28 \times 30.5$ cm and $16 \times 10.5 \times 9.5$ cm; chair – $24.5 \times 21 \times 37$ cm and $7 \times 5.5 \times 9.5$ cm; wagon – $32 \times 19 \times 13$ cm and $7 \times 4 \times 3$ cm; hat – 6 cm height, 17 cm diameter and 3 cm height, 7 cm diameter. Thus, roughly speaking, the large objects were between 2 and 4 times larger than their miniature counterparts. The doll fit into the large objects but was much too big to fit into the miniature objects. For example, the miniature chair was too small for the doll to sit in, and the miniature hat was too small to fit around the doll's head. The miniature objects were similar in size to those used in DeLoache *et al.*'s (2004) study, but the large objects in the current study were somewhat smaller than those in the previous research because of the need to use doll-sized objects. As a result, the difference between the sizes of the large and miniature objects was smaller than the size differences between the objects in DeLoache *et al.*'s study.

Procedure

Each child participated in a single testing session that lasted approximately 15–20 minutes. The experimenter interacted with the child throughout the session and an assistant videotaped the child's interactions with the objects. The session consisted of three phases that lasted approximately 5 minutes each.

In the initial play period participants played with the doll and the five large toys. Following this play period, the child was taken from the room. In the child's absence, three of the large toys were replaced with their miniature counterparts. For the second phase, the child returned to the room, where two of the original large objects were still present, but three had been replaced with miniature versions (e.g. the child might find the large bathtub and bed, with the miniature chair, hat and wagon). In the third and final phase, all five objects currently in the room were switched with their larger or smaller counterparts (e.g. the stimuli now included the miniature bathtub and bed, and the large chair, hat and wagon). Thus, there were always some large toys and some miniature toys available for the child to play with, but both sizes of the same object were never present simultaneously. The procedure of changing only some of the toys at one time was followed to make the current study similar to the original study conducted by DeLoache *et al.* (2004).[2]

During each phase of the testing session, the children were free to play with whatever toys they wanted; however, the experimenter used a specific prompt to encourage the child to interact with an object if the child had not spontaneously interacted with the object at least twice (e.g. 'Does the baby want to go night-night in the bed?', 'Does the baby want to go for a ride in the wagon?'). The experimenter was not blind to the purpose of the study but always phrased the prompts in question format and never commented on the sizes of the objects. At the end of each of the three phases, the child had either interacted twice with each of the five available objects or had been encouraged to do so by the experimenter.

Coding

The experimental sessions were videotaped. Two coders independently evaluated each session, focusing on whether children's interactions with the doll and the miniature objects constituted scale errors. Actions were coded as scale errors if a child made a serious attempt to fit the doll into or onto one of the miniature objects in the same manner that he or she would place the doll into or onto the large version of that object. Scale errors involved physical contact between the doll and the relevant part of the miniature object (e.g. attempting to lower the doll's feet or bottom into the interior of the miniature bathtub). Coders rated the seriousness of children's attempts to place the doll into or onto the objects, using a 5-point scale that ranged from 1 (definitely serious) to 5 (definitely pretending). Smiling, laughing and certain verbal comments were considered to be indicators of pretense. An event was counted as a scale error only if both coders rated the participant's efforts as probably or definitely serious. Finally, each scale error was coded as prompted or unprompted. Prompted scale errors were those that had been immediately preceded by an experimenter prompt.

Results

More than half of the participants (46 of 74) made at least one scale error involving the doll and one of the

[2] DeLoache *et al.* (2004) combined the results from two separate studies because there was no difference in the rate of scale errors as a function of whether all or only some of the larger items were replaced with miniature versions.

miniature objects. The children made a total of 104 scale errors, for an average of 1.4 scale errors per child (SD = 1.65). Over half of the scale errors (62) were unprompted, and 32 of the 46 children who made scale errors made at least one unprompted scale error. In a repeated measures ANOVA with prompt as a within-subjects factor, there was no difference between the number of prompted and unprompted scale errors that participants made. Thus, the children were just as likely to make spontaneous scale errors as they were to make scale errors following an experimenter prompt.

There were no significant effects or interactions involving gender, so it was not included in the following analysis. A one-way ANOVA revealed a significant effect of Age on the number of scale errors that children made, $F(2, 71) = 4.37$, $p < .05$. Pairwise comparisons showed that the 35–40-month-olds made significantly more scale errors ($M = 2.12$) than the 16–24-month-olds ($M = 1.21$, $p < .05$) and the 29–32-month-olds ($M = .83$, $p < .05$), but the two younger groups did not differ.

The age difference in the number of scale errors may be due in part to the degree to which the children were engaged and interested in playing with the doll and the toys that we provided. The older children spent almost twice as much time playing with the doll and the large toys during the initial play period than did the other two groups. The effect of Age on the amount of time spent playing with the doll and toys during initial play was significant, $F(2, 71) = 8.75$, $p < .05$. The 35–40-month-olds ($M = 146.1$ sec) played more than both the 16–24-month-olds ($M = 66.92$, $p < .05$) and the 29–32-month-olds ($M = 87.02$, $p < .05$). No other comparisons were significant.

In addition, there was a significant correlation between the amount of time spent playing with the doll and the large toys during the initial play period and the occurrence of doll scale errors involving the miniature objects ($r = .27$, $p < .05$). Children who had played more with the doll and the large toys during the initial play period made more scale errors with the miniature objects during the test phases. Taken together, these results suggest that the oldest children may have made more scale errors because they were more interested and engaged in playing with the doll and the toys; they made more scale errors because they had more opportunities to do so.

Discussion

The results of the research reported here establish that young children commit scale errors involving a doll and miniature objects. The children made serious attempts to fit a doll into and onto various objects that were far too small for the doll, trying to stuff it into a tiny bathtub or onto a very small bed. More than half of the scale errors were spontaneous, with no prompting from the experimenter. Thus the results cannot be explained in terms of the experimenter influencing the children's behaviors. The scale errors involving a doll that occurred in the current study are comparable to the efforts made by the children in the original report of scale errors, in which they attempted to fit their own bodies into and onto objects that were far too small to afford what they were trying to do (DeLoache *et al.*, 2004).

The present research extends the earlier findings in an important way by showing that scale errors are not limited to actions that directly involve a child's body. Young children also commit scale errors in which the relevant size discrepancy is between two objects. Thus, scale errors are not restricted to interactions that involve judgments about relations between the size of one's body and the size of a target object. A recent unpublished study by Brownell, Zerwas, Balaraman, Adalja and Sanckatar (2004) also reports that young children commit scale errors with dolls, providing further support for the current findings.

The children in the present study (like those in the original documentation of scale errors) were induced to interact with the larger objects immediately before being presented with their miniature counterparts. The motivation for this initial play period with the large objects was to increase the likelihood of observing and documenting scale errors. We assumed that experience with the large objects would activate the children's mental representations of the particular target objects as well as the general category of objects to which they belong. Activation of the object representations would simultaneously activate the children's motor routines associated with those objects (e.g. the actions the child used to lay the doll on the large bed or insert it into the large bathtub). The recent activation of these motor routines was assumed to increase the chance that the children would commit scale errors when presented with the miniature versions. However, as noted earlier, scale errors on miniature objects do not require immediately prior experience with larger objects; many informal reports and some formal observations testify that young children commit scale errors, including scale errors with dolls, without any recent priming (DeLoache *et al.*, 2004).

One difference between the results presented here and in the earlier scale error report (DeLoache *et al.*, 2004) is that the mean incidence of scale errors was somewhat higher in the current study – 1.4 versus .74. One aspect of the studies that might contribute to this apparent difference is that the size disparity between the large and small objects was much greater in the previous study. The large and miniature objects were more similar in size in the current study. Presumably, the more similar a large object is to the small version of it, the more strongly the child's representation of the large object will be activated by the miniature. The more strongly the representation of the original, large object and its associated motor plan is activated, the more likely the child should be to commit a scale error. A fruitful direction for future research would be to systematically compare the rate of scale errors as a function of various aspects of similarity between the large and small objects.

The basic similarity between the nature of the scale errors reported here and in the original report of the phenomenon (DeLoache *et al.*, 2004) suggests the applicability of the same account to errors involving the relation between a child's own body and a miniature object and to those involving the child's actions on a doll and a miniature object. In both cases, scale errors involve a failure to take object size into account when planning an action. The child who has decided to put the doll into the tiny bathtub has not appreciated the impossibility of carrying out this plan. Once the plan is initiated, however, the child does take the size of the little bathtub into account by carefully aiming the doll's feet at the open area of the bathtub.

The dissociation in the use of visual information for action planning versus control is consistent with Glover's (2002, 2004) recent revision of Milner and Goodale's (1995) dual process account of visual processing. Both theories posit the existence of two neurally and functionally distinct systems underlying visual perception and action. We propose that visual information about the size of a target object is occasionally not integrated into the decision to act on the object, but is recruited for on-line guidance of the execution of the action.

The discrepancy between the influence of visual size information on planning versus control that accounts for scale errors is similar to semantic interference effects on action in adults (Gentilucci, 2002; Glover, Rosenbaum, Graham & Dixon, 2004). For example, Glover *et al.* (2004) showed that words that represent large or small objects influence the early phases of grasping movements directed towards wooden blocks. So, if participants had read a word that represented a large object (e.g. 'apple'), their initial grip aperture was larger than if they had read a word that represented a small object (e.g. 'grape'). This interference effect was corrected on-line such that the final stages of the grasping movement were adjusted to the actual target size. Similarly, a scale error is characterized by the formation of an action plan based on a stored representation of a familiar object and on-line correction of the movements that comprise this action using visually available information.

Presumably, such failures to use available information about object size when forming action plans occur only occasionally, because scale errors occur only occasionally. Most of the time, young children interact appropriately with objects – their perception of the size of a miniature object causes the motor routine associated with its larger counterpart to be inhibited. Occasionally, however, children's representation of the larger object and the actions associated with it override their visual perception of its miniature replica, and a scale error occurs.

The phenomenon of scale errors by young children thus contributes to a growing body of developmental research based on dual process theories of visual processing (Glover, 2002, 2004; Milner & Goodale, 1995) and extends it in three ways. First, the scale error phenomenon expands the developmental application of these theories to young children. Most of the existing developmental research in this area has involved infants (Bertenthal, 1996; Mareschal & Johnson, 2003; Newman, Atkinson & Braddick, 2001; Vishton, Ware & Badger, 2005; Vishton, Ware & Mayuga, 2004; von Hofsten, Vishton, Spelke, Feng & Rosander, 1998; Ware, Covington & Vishton, 2004). Second, scale errors involve actions performed on real objects – either full-body movements performed in large-scale space on real objects, as in the original report (DeLoache *et al.*, 2004), or actions on a doll and target object, as in the current research. Much of the existing research base consists of studies of reaching and grasping behaviors, often to two-dimensional visual illusions. Third, in scale errors, the dissociation in action planning versus control is observable in the behavior of individuals, rather than by comparisons across participants, as is the case for much of the existing research. A child fails to use size information in the process of formulating a faulty plan, but the same child does use it moments later in the attempt to execute the plan.

In summary, the research reported here provides the second body of evidence for the existence of a new phenomenon – scale errors in the interactions of very young children with replica objects. The present research expands on the earlier study by DeLoache *et al.* (2004) by establishing that scale errors are not body-scale errors; they are not restricted to actions that directly involve the child's body. Rather, scale errors involve a more general problem integrating visual information for planning and controlling actions. This research extends the general body of evidence of perception–action dissociations in the behavior of typically developing children.

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