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Proceedings of the Annual Meeting of the Cognitive Science Society

Title
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Permalink
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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 36(36)

ISSN
1069-7977

Authors
Flumini, Andrea
Ranzini, Mariagrazia
Borghi, Anna Maria

Publication Date
2014

Peer reviewed

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Sound-symbolic correspondences with figures of known entities

Andrea Flumini (andrea.flumini2@unibo.it)
Department of Psychology, University of Bologna
Viale Berti Pichat 5, 40127 Bologna, Italy

Mariagrazia Ranzini (mari.ranzini@gmail.com)
FNRS, CRCN, Université Libre de Bruxelles (ULB)
Avenue Franklin Roosevelt 50, 1050 Bruxelles, Belgium

Anna M. Borghi (annamaria.borghi@unibo.it)
Department of Psychology, University of Bologna
Viale Berti Pichat 5, 40127 Bologna, Italy
ISTC-CNR, Institute of Cognitive Sciences and Technologies
National Research Council, Via S. Martino della Battaglia, 44 00185 Roma, Italy

Abstract

The existence of sound-to-shape correspondences has been demonstrated in the literature on sound-symbolism using double forced-choice paradigms and ad hoc figures. In two experiments, we tested if the sound-shape correspondence effect would be observed when participants were required to name one by one figures of every-day entities. Additionally, as stimuli represented known entities, we hypothesized that the sound-symbolic effect would be influenced by the entities' category (i.e., natural, artificial). Results confirmed the sound-shape correspondence in both experiments. Furthermore, in Experiment 2 a modulation due to the category was observed while participants, both adults and children, named agents (i.e., animals, anthropomorphous robots). Results are discussed in the framework of embodied cognition theories.

Keywords: sound-symbolism; embodied cognition; shape; referent; natural object; artifact; agent.

Introduction

Embodied and grounded cognition theories (reviews in Barsalou, 2008; Borghi & Pecher, 2011) affirm that linguistic symbols are grounded in the same systems used by perception, action and emotion. According to this perspective, during language processing we would re-activate previous experiences with words referents (e.g., Barsalou, 2008). For example, the word "car" would elicit a simulation of sitting in it, driving it, and so on. In the present study, we intended to investigate the word-referent relation by focusing on the direct bindings between the word sound and certain aspects of the referent appearance (i.e., shape). By word sound we refer to a multimodal experience, including both the acoustic experience during language comprehension and the phono-articulatory experience of word production, showing that verbal labels can entertain a non-arbitrary relation with their referents. This kind of relation has already been identified in speech and has been called sound-symbolism or phonosemantics (Hinton et al., 1994), being thought to be the verbal counterpart of iconicity in sign languages (e.g., Corballis, 2002, 2009; Pietrandrea, 2002; Pizzuto & Volterra, 2000).

The psychological literature on sound-symbolism is longstanding, dating the first decades of the XX century (e.g., Sapir, 1929; Köhler, 1929). In the last years, much research has been conducted on speakers of different languages, either children and adults. The data collected support the idea that sound-shape correspondences are at work in a number of cognitive tasks (e.g., Arata et al., 2010; Asano et al., 2011; Kovic et al., 2009; Iwasaki et al., 2007; Nielsen & Rendall, 2011; Nygaard et al., 2009a, b; Spector & Maurer, 2008; Westbury, 2005). For example, Maurer et al. (2006) asked 2.5-years-old children and adults to couple two invented names, one sonorant and one strident, with two invented figures, one rounded and one jagged-shaped. Results showed that both groups assigned sonorant words to rounded shapes and strident words to jagged ones. These results confirmed the sound-shape correspondence effect, suggesting that it plays a role at the earliest stages of language development.

Despite their interest, a number of studies adopting labeling tasks with a double forced-choice paradigm has some methodological limitations. These experiments typically used forced-choice tasks where two words (one sonorant and one strident) were simultaneously presented together with two figures (one rounded and one jagged-shaped). In this way, the subjects' second-choice was automatically determined by the first coupling, with no possibility of disentangling if two matches are effectively at work, one for strident sounds/jagged shapes and another for sonorant sounds/rounded shapes, or if there is only a match in one direction. In addition, the ad hoc figures typically used magnify the properties that are under investigation (e.g., roundness, jaggedness). These two aspects might therefore induce an enhancement of the results. A further problem that derives from them is the risk for this design to be too transparent (see Nielsen & Rendall, 2011, for a similar critique). Finally, this kind of setting is poorly ecological, and might not reflect what happens in every-day life.

The methodological flaws of this kind of research, evidenced by some authors (e.g., Nielsen & Rendall, 2011), has led to the underestimation of the role played by

sound-symbolic correspondences in real languages. A pervasive skepticism has grown along the years, and sound-symbolism has often been treated as a peripheral phenomenon in psycholinguistics (Nielsen & Rendall, 2011). To highlight the role of the sound-shape correspondence effect, in the present study we decided to investigate it trying to elude some limitations of the previous literature. To this aim, we avoided a double forced-choice design, and used visual stimuli depicting every-day entities (e.g., animals, tools). The choice of using every-day stimuli has a further advantage, as it gave us the possibility of investigating the eventual modulations on the sound-symbolic effects due to the category of the stimulus (i.e., artificial, natural). To the best of our knowledge, no study so far has taken into account the possible effects of categorical differences on sound-symbolic correspondences. Instead, the literature on concepts has provided evidence that artifacts and natural objects, as well as living and not living entities, are differently represented. This was observed in studies on categorization with brain imaging techniques (a review in Martin, 2007), in neuropsychological studies (e.g., Humphreys & Forde, 2001), as well as in behavioral studies on both children (e.g., Rakison & Oakes, 2003) and adults (e.g., Borghi et al., 2007). For example, some research has highlighted that categorization in infants may be based on perceptual as on motion cues, and that motion cues differ for animals and artifacts. In fact, animals are characterized by self-propelled movements and nonlinear, smooth motion paths, while artifacts are characterized by induced movements and linear motion paths (e.g., Mandler, 1992, 2004). Thus, we reasoned that it would be possible that natural objects not only have a smoother motion path, but that their shape might be represented as smoother in comparison to that of artifacts. In light of these considerations, we created a design that allowed us to investigate the development of the symbolic correspondence between word sounds and properties of every-day entities belonging to different categories, using a novel paradigm also in respect to the literature on categorization.

To summarize, in this study we hypothesized that the sound-shape correspondence effect would be conserved if the figures represent every-day entities, and if they were presented one by one. Furthermore, we hypothesized that the effect would be modulated by the category of visual stimuli. To this aim, in Experiment 1 stimuli figures represented every-day objects which could be natural or artificial, in order to verify if natural objects are represented as rounder in shape and associated to smoother sounds compared to artifacts.

Experiment 1

Method

Participants Twenty-four undergraduate students from the University of Bologna participated in the experiment for course credits (9 males; mean age = 20.79 (2.23); 2 left-handed by self-report). All participants had normal or corrected-to-normal vision and were naive as to the purposes of the experiment.

Materials 24 black-and-white line figures were chosen from the graphic database by Lotto, Dell'Acqua and Job (2001), 12 natural objects and 12 artifacts. Each set was composed by 6 rounded and 6 jagged-shaped figures. The pictures were rated by each subject after the experimental session on a 7-point Likert scale for sharpness/roundness (1: "very sharp" – 7: "very rounded"). A 2 x 2 ANOVA on ratings with the within factors Figure Type (Artificial vs. Natural) and Figure Shape (Rounded vs. Jagged) revealed as significant both the main effects of Figure Type, $F(1, 5) = 24.98$, $MSe = 0.17$, $p < .01$, $\eta_p^2 = .833$ (Natural $M = 4.21$, Artificial $M = 3.37$), and Figure Shape, $F(1, 5) = 134.23$, $MSe = 0.41$, $p < .001$, $\eta_p^2 = .964$ (Rounded $M = 5.31$, Jagged $M = 2.26$). The interaction was not significant.

The 8 words, used as names for the 24 pictures, were taken from the study by Maurer et al. (2006) and manipulated to obtain in Italian the same sound they have in English (e.g., the English *bouba* was changed in the Italian *boba*). The 8 words were coupled as in Maurer et al. (2006), with each pair being composed by a sonorant, round-sounding name (e.g., *maluma*) and a strident, sharp-sounding name (e.g., *takete*). Each word pair was presented visually, right under the picture to name on a computer screen. Thus, depending on the object appearance in the figure (Figure Shape: Rounded vs. Jagged) and on the phonological characteristics of the name (Response Type: Rounded vs. Jagged), in each trial it was possible to observe a sound-symbolic response (e.g., *maluma* assigned to a round-shaped figure) or not (e.g., *maluma* assigned to a jagged-shaped figure). For sake of simplicity the two levels of both the factors Figure Shape and Response Type were defined as Rounded vs. Jagged.

Procedure Participants sat 50 cm from the computer screen. Each trial began with a fixation point (+) lasting for 500 ms. Then, the stimulus picture was displayed centrally and remained on the screen for 5 seconds or until a response was made. The two names were simultaneously presented under the picture, one on the left and the other on the right (the names order was counterbalanced between subjects). Participants were required to decide which of the two names was more suitable for the picture simultaneously displayed by pressing two keys on the keyboard. The keyboard was positioned just below the screen, so that each of the two names was located perfectly above the key to which it corresponded ("5" for the name on the left, "9" for the one on the right). At the beginning of the experiment participants were instructed to decide as quickly as they could, without any feedback about their responses. As each of the total 24 pictures was presented once with any of the 4 word pairs, overall the experiment consisted of 96 experimental trials (plus 8 training trials).

Design and Analysis Missing responses (i.e., responses that required more than 5 seconds to be given) were removed. Their very low rate (0.17%) testified that the task was easy to perform. All the remaining responses were transformed in percentage of choosing a response (rounded or jagged) and entered in a 2 x 2 x 2 ANOVA with the within factors Figure Type (Natural vs. Artificial), Figure Shape (Rounded vs. Jagged) and Response Type (Rounded vs. Jagged). Fisher's LSD *post hoc* tests were conducted on significant interactions.

Results

The ANOVA on the percentage of responses did not show any reliable main effect, but the expected Figure Shape x Response Type interaction was significant, $F(1, 23) = 19.93$, $MSe = 43.02$, $p < .001$, $\eta_p^2 = .46$. In fact, Jagged shapes were more frequently associated to Jagged sounding names ($M = 13.77\%$) than to Rounded sounding ones ($M = 11.20\%$) (LSD $p < .05$), whereas for Rounded shapes the opposite was true (Rounded response $M = 15.46\%$, Jagged response $M = 9.56\%$) (LSD $p < .01$) (see Figure 1).

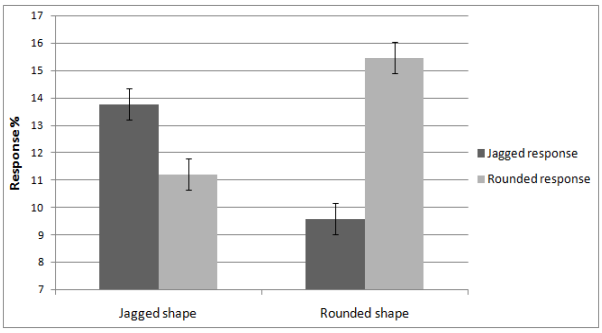

Figure 1. Experiment 1 - Interaction between Figure Shape and Response Type (error bars show S.D.)

Discussion

As predicted, participants more frequently chose rounded words (e.g., *maluma*) as names for figures of rounded-shaped objects (e.g., compass) and jagged words (e.g., *takete*) as names for figures of jagged-shaped objects (e.g., pineapple). They revealed a high sensitivity to the correspondence between words sounds and visual shapes even if the figures to name represented familiar objects. This result confirms evidence on the sound-shape correspondence effect and extends it. First, it suggests that assigning labels to external entities is not necessarily an arbitrary activity, also in the case of every-day objects that are not characterized by ad hoc properties. Second, the effect was observed while presenting stimuli one by one. Thus, we were able to avoid the potential limitations of previous studies. However, despite the fact that results from participants' ratings predicted it, the effect of the object category (artificial vs. natural) was not present.

Experiment 2

In Experiment 1 we asked participants to choose a name for pictures of already known objects. We found the predicted sound-symbolic correspondence between names and shapes, but no effect of the category of visual stimuli was observed. One possible reason for the absence of a category effect is that very different items were compared. Considering this, in Experiment 2 we investigated whether the effect would be found using more homogeneous categories of artificial and natural entities, i.e., the category of *agents*. We define an *agent* as an entity possessing the ability to autonomously *act* or *move*, and endowed with features typically linked to animacy (e.g., mouth; see Backscheider et al., 1999). In contemporary societies, robots have become a quite credible kind of agent for the role they play in popular culture (e.g., science fiction books, comics and movies). In this sense, we consider as agents both animals and anthropomorphous robots.

In addition, we decided to test in Experiment 2 a sample composed by both adults and children, in order to investigate the sound-symbolic phenomenon related to every-day categories also in function of age. Indeed, an ontogenetic continuity of sound-symbolism has already been shown in the literature, but only with ad hoc stimuli (e.g., Maurer et al., 2006).

To summarize, we predicted that, using the more specific and compact subcategory of agents (i.e., animals, anthropomorphous robots), we would find a modulation of the sound-symbolic effect in function of both category and age. In particular, we expected a more marked effect of category on the label choice for adults, as they may have a more clear distinction between natural and artificial agents due to experience, and because the category of animated entities might be broader in children, including artificial agents as well.

Method

Participants Twenty-four children (15 males; mean age = 8.79 (1.06); all right-handed) participated to the experiment as volunteers, and twenty-four students from the University of Bologna (10 males; mean age = 21.04 (2.91); 3 left-handed by self-report) participated for course credits. All participants had normal or corrected-to-normal vision and were naive as to the purposes of the experiment.

Materials and procedure The materials consisted of 24 black-and-white pictures of manmade drawings, of which 12 represented animals (6 rounded and 6 jagged-shaped) and 12 robots (6 rounded and 6 jagged-shaped). The same eight words of Experiment 1 were used. As in Experiment 1, after the experimental session pictures were rated on a 7-point Likert scale for roundness/sharpness by each subject. A mixed 2 x 2 x 2 ANOVA on ratings with the between factor Group (Children vs. Adults), and the within factors Figure Type (Animal vs. Robot) and Figure Shape (Rounded vs. Jagged), revealed a main effect of Figure Type, $F(1, 10) = 31.14$, $MSe = 0.40$, $p < .01$, $\eta_p^2 = .757$ (Animal $M = 4.23$, Robot $M = 3.21$), and of Figure Shape, $F(1, 10) = 331.59$, $MSe = 0.24$, $p < .001$, $\eta_p^2 = .971$ (Rounded $M = 5.01$, Jagged $M = 2.42$). No other main effects or interactions reached significance.

Design and Analysis The design and the procedure were exactly the same of Experiment 1, except for the fact that the stimuli used, instead of pictures of natural objects and artifacts, were pictures of animals and robots.

Results

Missing responses were removed (1.28%), and the remaining responses were entered as percentages in a mixed 2 x 2 x 2 x 2 ANOVA with the between factor Group (Children vs. Adults) and the within factors Figure Type (Animal vs. Robot), Figure Shape (Rounded vs. Jagged), Response Type (Rounded vs. Jagged). Fisher's LSD *post hoc* tests were conducted on significant interactions.

The ANOVA showed no reliable main effects, whereas three interactions were significant. First, similarly to Experiment 1, the Figure Shape x Response Type interaction was significant, $F(2, 92) = 10.65$, $MSe = 16.26$, $p < .01$, $\eta_p^2 = .19$, indicating that Jagged shapes more frequently evoked Jagged responses ($M = 13.23\%$) than Rounded ones ($M = 11.70\%$) (LSD $p < .05$), while the opposite was true for Rounded shapes, which elicited less Jagged ($M = 11.85\%$) than Rounded responses ($M = 13.14\%$) (LSD $p < .05$) (see Figure 2). This confirmed and extended the results on the sound-shape correspondence effect observed in Experiment 1.

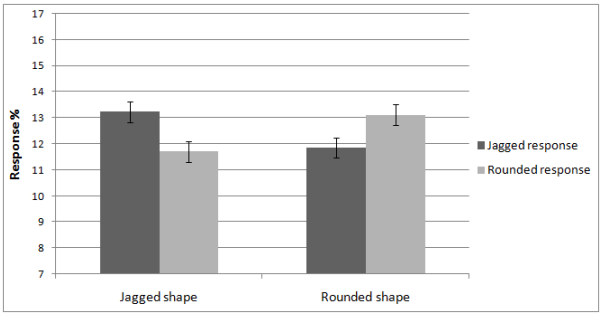

Figure 2. Experiment 2 - Interaction between Figure Shape and Response Type (error bars show S.D.)

The Group x Figure Type x Response Type interaction was also significant, $F(2, 92) = 5.56$, $MSe = 136.51$, $p < .05$, $\eta_p^2 = .11$. While in the children group there was no difference between Animal (Rounded response $M = 11.98\%$, Jagged response $M = 12.93\%$) and Robot figures (Rounded response $M = 12.56\%$, Jagged response $M = 12.52\%$), in the Adults group Animal figures were more frequently associated to Rounded ($M = 15.12\%$) than to Jagged responses ($M = 9.89\%$) (LSD $p < .05$), with the opposite being true for Robots figures (Rounded response $M = 9.97\%$, Jagged response $M = 15.01\%$) (LSD $p < .05$) (see Figure 3).

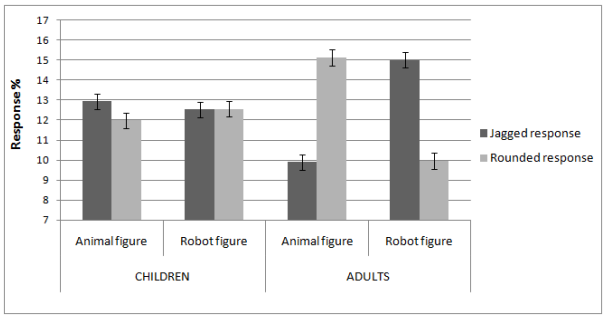

Figure 3. Experiment 2 - Interaction Group x Figure Type x Response Type (error bars show S.D.)

The last significant interaction, the Figure Type x Figure Shape x Response Type, $F(2, 92) = 23.69$, $MSe = 11.43$, $p < .001$, $\eta_p^2 = .34$, showed that Robot figures were more frequently assigned with a Jagged sounding name when the shape of figures was either effectively Jagged (Rounded response $M = 11.39\%$, Jagged response $M = 13.56\%$) (LSD $p < .01$) or Rounded (Rounded response $M = 11.13\%$, Jagged response $M = 13.97\%$) (LSD $p < .01$). On the other side, for Animal Jagged shapes no significant difference was observed between Jagged ($M = 12.90\%$) and Rounded responses ($M = 12.01\%$) (LSD $p = .20$), while for Animal Rounded shape Jagged responses ($M = 9.93\%$) were fewer than Rounded responses ($M = 15.09\%$) (LSD $p < .001$) (see Figure 4).

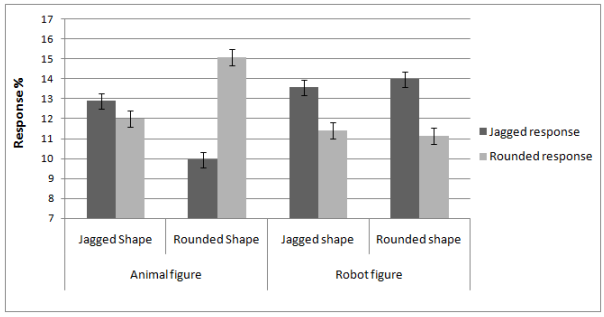

Figure 4. Experiment 2 - Interaction Figure Type x Figure Shape x Response Type (error bars show S.D.)

Discussion

The results observed in Experiment 1 with natural objects and artifacts were replicated during the labeling of natural and artificial agents (i.e., animals, robots). Furthermore, in Experiment 2 we found also an effect due to the stimulus category that confirmed our main prediction. As to the developmental pattern, we found in the adults group a clear interaction between sound and category that was not present in children: a sonorant word more frequently labeled an animal, and a strident word more frequently labeled a robot. This result shows, with a paradigm never used in studies on categorization, that natural and artificial agents may differ also for some general characteristics related to sounds. If natural entities are characterized by a smoother motion path compared to artifacts, as already demonstrated in the literature, they seem to be also represented as having smoother sounds, at least when compared with robotic agents.

General Discussion

The results of Experiment 1 revealed that sound-shape correspondences can be observed also with every-day objects, but no effect of the category (natural vs. artificial) was found. In Experiment 2 we rendered the two natural and artificial categories more comparable using the subcategory of agents: stimuli were figures of animals and anthropomorphous robots. The development of the effect was investigated as well, by testing a sample of participants composed by both adults and children. The results of Experiment 2 not only confirmed what observed in Experiment 1, as an effect of the category (natural vs. artificial agents) on the labeling emerged as well. In particular, adults only more frequently assigned rounded sounding names to animals than to robots, with the opposite being true for sharp sounding names. Furthermore, the category also interacted with the takete-maluma effect, as the classic sound-shape correspondence was observed only with animals, whereas with robots a jagged response was always preferred independently of shape. Finally, this interaction was drawn from the overall data, clearly indicating that the modulation of the category was present in both adults and children.

Our results allow us to address the predictions made. First, we were able to demonstrate that the sound-shape correspondence effect is present with figures of every-day entities, that is with more ecological stimuli. Second, the name pairs we used (taken from Maurer et al., 2006) showed the predicted sound-symbolic effect when the figures were presented one by one. These two results strengthen the evidence on sound-shape correspondence collected by previous studies.

Third, modulations of the stimulus category were found in Experiment 2, as the sound-shape correspondence was not observed with robots, that were always associated to jagged names independently of variations in their shape. One possible reason why we found the effect in Experiment 2, with the more compact and apparently less differentiated category of agents, but not in Experiment 1, can depend on the special "naming habit" used by children and adults in their interactions with biological agents (e.g., animals), as with any entity presenting animacy cues (e.g., eyes, mouth), hence perceived as able to autonomously act (e.g., robots). In fact, entities perceived as agents are usually renamed during the interactions with them: if adults typically use a special name for their pets, children do it for teddy-bears and robot toys as well. In contrast, it is more difficult to associate proper names to entities endowed only with generic names, like the objects of Experiment 1. In support of this explanation, research on the mutual exclusivity or lexical contrast constraint (Markman, 1989, 1992) has showed that during language acquisition children experience difficulties in using more names, for example a basic and a superordinate one (e.g., "apple" and "fruit", respectively), to indicate the same referent.

Finally, if the takete-maluma effect and its modulation due to the category were stable across ages, the interaction between sound and category changed with development. In fact, adults only showed the tendency to associate a jagged name to a robot and a rounded name to an animal *independently of their shape*. One could speculate that the emergence of sound-symbolic correspondences at the semantic level requires the acquisition of linguistic and cultural aspects related to categories. We think it is possible that adults have more experience in listening to or in actively associating nouns to agents such as pets and toys. This experience might have created associations between sounds and categories (i.e., animal more rounded, robot more jagged) which go beyond the sound-symbolic correspondence between shapes and names based only on perceptual aspects of the stimulus. This result also suggests that children categories are more perceptually grounded than adults ones. In general, our interpretation follows the idea that, once the mapping between perceptual and linguistic aspects is established, subjects can rely on language as a shortcut (for discussion on this topic see Barsalou et al., 2008; Borghi et al., 2011).

Taken together, these results strengthen and extend previous evidence on sound-symbolism, indicating that correspondences may arise at both perceptual and semantic levels. On the whole, our results bolster the hypothesis of a natural relation between the structure of words and the meanings they convey, extending prior findings in the literature about sound-symbolism to entities taken from every-day life. This has interesting implications for the ongoing debate about the arbitrariness of verbal language. Furthermore, our evidence provides some suggestions to speculate about a possible origin of contemporary lexicons from more iconic ones, in keeping with those perspectives on cognition which hypothesize a direct, natural line of evolution from gestures to speech (e.g., Corballis, 2002, 2009; Flumini, 2014; Gallese, 2008; Gentilucci & Corballis, 2006; Rizzolatti & Craighero, 2004).

Acknowledgments

This research was supported by the EU funded Projects "ROSSI – Emergence of communication in RObots through Sensorimotor and Social Interaction", contract no. FP7-STREP-216125.

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