Journal of Visualized Experiments

Children Touching Words: Studying Tactile Sound Symbolism in Young Children

--Manuscript Draft--

Article Type:	Invited Methods Article - JoVE Produced Video
Manuscript Number:	JoVE61000R3
Full Title:	Children Touching Words: Studying Tactile Sound Symbolism in Young Children
Section/Category:	JoVE Behavior
Keywords:	tactile sound symbolism; young children; crossmodal correspondences; bouba-kiki effect.
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Additional Information:	
Question	**Response**
Please indicate whether this article will be Standard Access or Open Access.	Standard Access (US$2,400)
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TITLE:

Children Touching Words: Studying Tactile Sound Symbolism in Young Children

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SUMMARY:

Sound symbolism in the tactile modality has been scarcely studied, and only in adults. This article presents a protocol to study tactile sound symbolism in young children by using play, toys, and touch-appropriate materials. The protocol has been tested with Spanish speaking children.

ABSTRACT:

This article presents a protocol for investigating the existence of tactile sound symbolism in young children. Sound symbolism is the systematic correspondence between the sound of a word and physical features of the object to which the word refers. Tactile sound-symbolism has been scarcely studied. Moreover, it has been studied only in adults. Studying tactile sound symbolism in children should offer novel insights that may be relevant not only for understanding the nature of sound symbolic correspondences, but also for understanding the development and origin of the phenomenon. The protocol adapts a forced choice paradigm to make it accessible to 3-4 year old children by using toys, play, and touch-appropriate materials. The protocol consists of two experiments: a pointing selection task, and a naming task. Sound symbolic associations were found in the naming task with Spanish speaking children.

INTRODUCTION:

The protocol presented in this article aims to determine the presence of tactile sound symbolism (i.e., word-tactile systematic correspondences) in young children. The rationale underlying the protocol is to use play to engage children's participation in two tasks that tap into word-tactile associations. Briefly, the first task presents children with a nonword and asks them to point to a corresponding texture. The second task presents a texture and asks them to name it with a corresponding nonword. The protocol can be utilized with a wide variety of populations, since it only requires unbiased samples of neurotypical monolingual children. The protocol has been tested with 3-4 year old children but it can be easily adapted for older populations by using more age-appropriate props. For instance, the experimenter can choose to rely solely on storytelling instead of using a puppet. Also, materials can be colored with a variety of colors, expecting that the variation in visual stimulation can be used to minimize the impact of colors on the test.

Tactile sound symbolism has been scarcely studied and only in adults (Sakamoto and Watanabe[1], Fryer et al.[2], Etzi et al.[3] and Domínguez-Gallegos[4]). One advantage of studying the phenomenon in young children is that the results should help to clarify whether sound symbolism possesses a developmental profile and whether factors such as age, or linguistic development have an impact on the phenomenon. Thus, unlike studies in adults, one of the advantages of the presented protocol is that it allows researchers to explore developmental aspects of sound symbolism. Finally, the protocol can be easily extended to investigate other tactile dimensions such as hard-soft, hot-cold, bumpy-flat, etc.

It must be pointed out that in the literature there is no protocol to test tactile sound symbolism in children. Working with children pose special challenges to develop an adequate protocol for testing tactile sound symbolism. The first challenge is to engage the continuous cooperation of children. In studies with adults, cooperation can be engaged simply by giving clear instructions to the consenting participants. By contrast, with child participants, in addition to clear guidelines, the experimenter must use devices such as play, toys and storytelling to engage participants. One difference between the presented protocol and protocols used with adults is the usage of age-appropriate play, toys and storytelling to recruit the attention of participants.

A second challenge is to isolate tactile input from other modes of input. It is important that children have mainly tactile and not visual sensations during the test. In studies with adults, this is usually achieved by the participants consenting to use blindfolds or earphones in order to isolate tactile stimuli. In the presented protocol, we devised props appropriate to the play and storytelling in order to provide tactile stimulation while blocking visual stimulation. These features provide a nonintrusive and child-friendly way of isolating tactile stimulation. Thus, another difference between the presented protocol and protocols used with adults is the usage of specially constructed materials to ensure that the tactile input is not confounded with input from other modalities.

The idea of using toys and play to make the task child-friendly has been adapted from Maurer's study[5] of visual sound symbolism in children. Thus, the closest referents are the studies of tactile sound symbolism in adults: Sakamoto and Watanabe[1], Fryer et al.[2], Etzi et al.[3] and Domínguez-Gallegos[4], and Maurer[5]. Even though there is no previous referent in studying tactile sound symbolism in children, to assess the merit of the protocol, results from its application are presented in the Representative Results section.

One potential problem with the protocol is the use of nonwords. Nonwords should not be biased by, for instance, resembling words related to tactile perceptions. Hence, step 3.1 of the protocol includes a method to produce nonwords that avoids these biases. Another limitation is the time-consuming nature of the protocol, which may result in children becoming tired. The protocol has been devised to appeal specially to younger children (around 3 years old), and thus it devotes a great deal of time in recruiting children's interests and in verifying that the child can deal with the task.

The presented protocol is suitable for experimenters interested in the developmental aspect of sound symbolism. Experimenters should consider that the protocol is appropriate for application when they are interested in studying children with 3 years of age and older. The method has been tested with children being neurotypical, monolingual and with typical linguistic development. They should also consider other constraints: the procedure is more time consuming than studies with adults, moreover, the time the experiments take for completion depends on the child. Toys and props need to be constructed or suitably adapted.

Antecedents

The connection between a word and its meaning is usually conceived as being arbitrary. Words are associated with their referents by convention, and any word can have any meaning, as long as there is a convention in place. The arbitrariness of words implies that the sounds of words have no systematic connection to the objects they refer to. However, since the early 20th Century, there exists evidence that challenges this idea. Evidence shows that nonwords such as "bouba" or "kiki" exhibit a systematic association with features such as size, roundness or spikiness of the object they refer to. This phenomenon is called *sound symbolism*.

Sound symbolism was first demonstrated by Sapir[6], who found that most people associate words with the vowel *a* (e.g., *mal*) to large objects; and words with *i* (e.g., *mil*) to small objects. Kohler[7] introduced the nonword forced choice paradigm that has become the standard experimental design in the study of sound symbolism. In this paradigm, participants hear two distinct nonwords (e.g., *mal/mil* or *bouba/kiki*) and are tasked with choosing which two visually presented shapes, one rounded and one pointy, correspond with each nonword.

Sound symbolism seems to appear in early stages of development. Asano et al.[8] found neurophysiological correlates in the integration of visual and spoken-word stimuli with 11-month-old infants. They presented infants to a round or spiky shape whilst one of two words, (i.e., *moma* or *kipi)*, was heard. Neural markers of sensory integration were found in the expected match condition (round-*moma*; angular-*kipi*). It was also found that the markers of heightened processing effort were present in the mismatch condition. Ozturk et al.[9] utilized a preferential looking paradigm, presenting a shape and a nonword. Also, visual-auditory correspondences were observed in 4-month-old infants. Similar visual-auditory correspondences were found by Peña[10]. Maurer et al.[5] observed visual sound symbolic correspondences in 2.5-year-old children. Tzeng et al.[11] researched how children's sensitivity to sound symbolism develops with age. They presented nonwords to three-, five-, and seven-year-old children and tasked them with choosing which of either a round or pointy picture corresponded to each word. Accuracy and performance were shown to improve with age, suggesting that sound symbolism emerges with experience. Now, although sound symbolism seems to change with development, some studies show that sound symbolism is sensitive to task difficulty: Fort et al.[12] tested 5 and 6-month-old old prelexical infants. They used a preferential looking paradigm presenting round and spiky shapes, expecting to find preferences according to the standard sound symbolic correspondences. However, no sound symbolic effect was observed. Fort et al. suggested that the difficulty of the task might be the explanation of such results.

Regarding *tactile* sound symbolism, research is scant. This is noteworthy, since seminal investigations into sound symbolism addressed sound-size and sound-shape correspondences. Sight and touch can perceive size and shape. An object's round or angular shape can be seen and touched. Hence, *tactile* sound symbolism should be among the first targets of non-visual modality investigations. However, as we mentioned, the investigation of tactile sound symbolism is sparse. Among the few studies, Sakamoto and Watanabe's found sound symbolism in testing Japanese ideophones[1]. Tactile materials were tested for associations with Japanese ideophones, and with adjective pairs such as comfort/discomfort, bumpy/flat, rough/smooth, and so forth. Significant correspondences were found. For example, positive ratings corresponded to /u/ and negative ratings to /i/ and /e/. Voiced consonants were associated with roughness, while voiceless consonants with smoothness.

Correspondence between angular or round tactile sensations and nonwords was investigated by Fryer et al.[2]. Participants touched paper and 3D models of angular or round shapes. Then, they were asked to use *bouba* or *kiki* to name the models. The correspondences round-*bouba* and angular-*kiki* were observed. Etzi et al.[3] studied correspondences between nonwords, various adjectives and the textures of cotton, satin, tinfoil, sandpaper and abrasive sponge. Rating scales anchored in word pairs such as *bouba/kiki* or *light*/*heavy* were given to participants in order to rate the materials after being stroked with them. Sound symbolic associations were observed. Now, Etzi et al. themselves point out that they did not use auditory stimuli in their study, but only written words, and thus that there are issues about tactile-auditory associations still to be properly addressed. Domínguez-Gallegos[4] did address auditory-tactile associations. Domínguez-Gallegos observed that fricative-rich nonwords are associated with rough stimuli, and fricative-free nonwords with smooth perceptions.

The cited studies by Fryer et al.[2], Etzi et al.[3], and Domínguez-Gallegos[4] seem to be among the few studies reporting tactile sound symbolism. These studies were conducted in adults. Sound symbolism both in the tactile modality *and* in children has only been addressed by the presented protocol. Now, tactile sound symbolism in young children is specially challenging. For, as we mentioned (Fort et al.[12]), sound symbolism in children is sensitive to task difficulty.

In the present protocol, we implemented a child-friendly forced choice task to test for tactile sound symbolism. The protocol uses toys and storytelling to engage children's interest. Procedures in the protocol have been adapted from Maurer et al.[5]. Three significant differences with Maurer were implemented: firstly, toys, story, stimuli and materials were designed to test for the rough-smooth tactile dimension. Secondly, the protocol includes pre-validated unbiased nonwords (tested with Spanish speaking adults). Thirdly, the presented protocol includes two experiments: a pointing task and a naming task.

The presented protocol employs a forced choice paradigm, made accessible to children as young as 3.5 years of age, by using toys, play, and touch-appropriate materials. It consists of two experiments: a pointing selection task, and a naming task. In the pointing selection task (Experiment 1), children are asked to pick the texture corresponding to a heard nonword (children must hear the word and point to the texture, hence the task is labeled *pointing task*). In the naming task (Experiment 2), children are asked to name with one of two nonwords an indicated texture (hence *naming task*). By using these two tasks the protocol addresses several issues: first, allows exploring if there exist differences induced by the type of task (hearing words and pointing in the first experiment, and pronouncing words in the second). The second issue is to determine whether the difficulty of the task has an impact on any putative sound symbolic effect. The two tasks represent two different levels of cognitive and response demands. The rationale is that differences in demand may reveal the influence of cognitive load in sound symbolism. The naming task should be more demanding than the pointing task, at least in principle. The act of naming a texture involves making a decision that taps into cross-modal associations, as well as maintaining in mind nonwords (which are difficult to remember, since they are unfamiliar) and their correct pronunciation. Naming is more demanding than pointing. Hence, the naming task may elicit an *attenuated* sound symbolic effect. A third issue is to determine whether differences in phonological processes may play a role in sound symbolic correspondences. Experiment 1 involves covert phonological processing, whereas Experiment 2 involves overt processing, with its accompanying sensorimotor processes.

PROTOCOL:

The presented protocol was approved by the Research Ethics Committee of the Faculty of Human Communication, Universidad Autónoma del Estado de Morelos, México.

1. Participants

1.1. Recruit neurotypical monolingual young children. Obtain consent from their parents. The protocol has been tested with children 3.5-4.5 years of age. Thus, children as young as 3.5 years of age can complete the task. The protocol is based on play and storytelling to engage the cooperation of young children, but it can be applied with older children.

1.2. Assign participants to two experimental groups. In order to reduce the possibility of obtaining unbiased samples, make sure that participants are randomly assigned to the two groups. Variables that may induce a bias in linguistic or perceptual performance may be considered (e.g., differences in socio-economic status, age, previous experiences, IQ, vocabulary sizes, etc.).

NOTE: Representative results are based on a sample of 29 children for Experiment 1 and 30 children for Experiment 2.

1.3. Conduct Experiment 1 as described in step 4 with the first group. Conduct Experiment 2 as described in step 5 with the second group.

2. Stimuli and materials

2.1. Generate and select nonwords.

2.1.1. If available, make use of nonwords previously validated in tactile crossmodal correspondence studies in the mother tongue of children, such as *bouba/kiki* in English, or *krexis/nunum* in Spanish.

2.1.2. If no validated nonwords are available, use *Random Word Generator* software (or another method for generating random nonwords) to generate a large pool (e.g., 500 words) of two-syllable nonwords.

2.1.3. From the pool, select two sets of around 20 words. Have each set of words correspond to either a smooth or rough tactile stimulus; thus, use experience and knowledge to choose words that may be associated to the tactile stimuli. Testing the words, see 2.1.5, will refine this rough procedure.

2.1.4. Make sure that the nonwords do not resemble the words for smooth or rough in the children's mother tongue (or at least make sure that the nonwords have no bias towards any of the words for smooth or rough).

2.1.5. Test with adults which nonwords in each set exhibit the best correspondences with smooth and rough tactile stimuli. Choose the nonwords that show the strongest associations to smooth and rough tactile stimuli.

2.1.6. Once the two nonwords have been selected, generate counterbalancing alternatives by rearranging the order of the syllables in the nonwords. For example, from /krexis/ generate the counterbalancing alternative /xikres/; from /nunum/ generate /munmu/.

2.2. Produce tactile material.

2.2.1. Produce material for storytelling and play. Use toys and props to narrate a story about a zookeeper who needs help finding some escaped animals. Make use of a variety of plastic toys.

2.2.2. To keep the interest of children engaged along the four blocks of play and experimental trials, use a variety of toy animals. For instance, in addition to a pair of toy tigers, add a pair of elephants. The variety also helps to prevent possible bias associated with the specific details of each type of toy, for instance the different color, size, or type of animal toys. Thus, at least two different pairs of animals are recommended, and since there are four blocks of trials, the best practice is to use four different pairs of toys, one pair for each block.

2.2.3. Use 4 pairs of plastic animal toys (e.g., 2 tigers, 2 elephants, 2 lions and 2 zebras), which will play the part of animals in a zoo. The bottom of the toy animals should be flat and wide enough so that a flat layer of tactile materials can be glued to them. To aid in storytelling use a hand puppet to capture children's attention. The puppet will play the part of the zookeeper who tries to find animals that escaped from the zoo.

2.2.4. To provide rough stimuli use black aluminum oxide sandpaper, grit 40 (**Figure 1**, left). To provide smooth stimuli use black polar-fleece fabric (**Figure 1**, right). The purpose of the color black is to minimize the visibility of the tactile materials.

[FIGURE 1, HERE]

2.2.5. For each pair of toy animals (four pairs), apply tactile material on the flat bottom, so as to obtain four pairs of visually identical animals that can be distinguished only by touching the bottom (e.g., two identical tigers, one with sandpaper bottom and one with fabric bottom; two elephants, one with sandpaper bottom and one with fabric bottom, and so forth). Make sure that the tactile materials are not visible when the toys are in upright positions.

2.2.6. Apply each tactile material on an 8 cm long styrofoam rolls, so as to obtain one roll covered with sandpaper and one covered with fabric, as shown in **Figure 1**. In order to use a different prop in each of the four experimental blocks, four pairs of these rolls will be needed.

2.2.7. Construct a pair of colored cylinders to make them attractive to children and large enough to contain the rolls with tactile materials constructed in step 2.2.6. The purpose of these pairs of cylinders is to provide tactile but not visual stimulation.

NOTE: The cylinders are intended to enclose the two tactile textures, one texture in each cylinder. They must keep the textures out of the child's sight, but must also allow the child to place his fingers inside and have a tactile access to the textures. Hence, the long side of the cylinders must feature an orifice to allow the textures to be touched by children. The texture rolls constructed in step 2.2.6 must be placed inside these colored cylinders and glued so that they do not move when the child touches them. Each pair of cylinders must enclose a sandpaper roll on the left cylinder and a fabric roll on the right cylinder. In order to minimize the possible bias induced by the color of the cylinders, maximize the variation of the color of the cylinders. Since there are four blocks of trial, use four pairs of container cylinders with widely different colors (see **Figure 2**).

[PLACE FIGURE 2 HERE]

2.2.8. To play the role of the two weird creatures (e.g., Krexis and Nunum), construct a pair of exuberant toys. The purpose of these toys is merely to be introduced to the child at the end of the experiment, in order to satisfy his curiosity and conclude the experiment.

2.2.9. Prepare toys and prop for storytelling. When possible, prepare props that aid in playing with the child, for instance use props to simulate the zoo where story is taking place. Make sure that these props are not too distracting so that the child focuses on the smooth- and rough-feet animals.

2.2.10. To minimize distraction, when possible, keep out of sight the props that are not playing a role in the current stage of the story-telling (e.g. if you narrate the story on top of a table or desk, keep the unused props hidden, below the table or desk)

3. Design and pre-experimental procedure

3.1. Prepare a quiet room. Make sure that there are no distractions during the play and the experimental sessions. Conduct individual play and experimental sessions for each child.

3.2. Conduct two experiments with two groups of young children. Each child must participate only in one of the two experiments. Note that Experiments 1 and 2 share the same procedures for pre-experimental session and validation trials and differ only in the test trials.

3.3. Before the experimental session, conduct a pre-experimental 5 min storytelling and interactive play session. Note that the play session is intended to engage children cooperation in the tasks. Thus, play sessions are the same for Experiments 1 and 2.

3.3.1. Before starting with the validation and test trials, use the toys constructed in step 2.2 (e.g., **Figure 3**, bottom) to play with the child for 5 min. Narrate the story of a zoo whose animals have either *rough* or *smooth* feet. Each pair of toys consists of one animal with rough feet and the other with smooth feet (**Figure 3**, top right). Use an attractive prop as an auxiliary to tell the story (e.g., a puppet). This auxiliary will play the part of the zookeeper, thus make sure that the puppet or another auxiliary can be manipulated to simulate a conversation with the child.

3.3.2. Introduce the auxiliary prop (puppet) by naming it with a child-appropriate name and that also distinguishes it from the rest of the props (e.g., a moose hand puppet may be called *Mr. Moose,* see **Figure 3,** top left).

3.3.3. Use the following script, or an appropriate adaptation, to play with the child. The experimenter says: ‘Hi, my name is Mr. Moose! I can’t move that well, as my arm is hurting. Some animals have escaped from the zoo, and I must get them back into their kennels. Would you help me find them and get them back? Would you? Very Good!’

4. Experiment 1 Procedure

4.1. Perform a pre-experimental session as in step 3.3.

4.2. Conduct Experiment 1 validation trial with one experimental group. Note that the purpose of this validation trial is to make sure children know the meaning of rough and smooth, and also that they are able and willing to show they distinguish between textures. Hence, the procedure for Validation Trials is the same for Experiments 1 and 2.

4.2.1. Ask the child to identify the tactile textures by picking the appropriate toys. Validation trials are intended to familiarize children with the textures, to make sure that children's vocabulary knowledge is sufficient to perform the task, to observe that children are motivated to cooperate and that they can distinguish between textures.

4.2.2. To assess whether the child understands the question and identifies the textures, use a script along the following lines (using the puppet, the experimenter says to the child): 'Let's see, I have a friend who is a lion (or another toy) with rough feet. Can you bring the rough-feet lion to me?' Repeat the script with the remaining toys, presenting the toys in a counter-balanced manner.

4.2.3. When the child picks the correct animal, have the experimenter say, 'Very Good. I'm happy you found my friend!'. If the child picks the incorrect animal, have the experimenter say, 'Are you trying to trick me? You're funny! Try again. Can you bring the rough-feet lion to me?'

4.3. Conduct Experiment 1 test trial.

4.3.1. Before the first test trial, present to the child a pair of cylinders containing the tactile stimuli. To avoid possible bias induced by the color of the cylinders, use different colors in each of the four experimental blocks.

4.3.2. With the cylinders in front of the child, tell a new part of the script: 'Mr. Moose has given us another mission: we must find some weird creatures. These creatures have funny names. One creature is named "*krexis*" (use here the word for rough stimuli). The other creature is named "*nunum*" ' (use here the word for smooth stimuli).

4.3.3. To avoid presentation-order bias, use the counterbalancing pair of words (e.g., *xikres* and *munmu*) in the subsequent test trial.

4.3.4. Continue with the script: 'We cannot see the creatures, but we can touch them. You can put your hands inside (referring to the cylinders) and touch them. Go ahead, touch them, take your time'.

4.3.5. Make sure that the child remembers the nonwords by asking them to repeat them. Hence, after the child has touched the textures inside the cylinders, the experimenter continues 'Very good'. The experimenter then asks, 'Do you remember what they are called?' Have the experimenter wait for the answer. If the child does not respond, have the experimenter repeat the names (e.g., *krexis* and *nunum*) and ask the child to repeat both names. The experimenter continues 'Yes, all right, one is called *krexis,* the other *nunum*'.

4.3.6. Counterbalance the testing order of the nonwords.

4.4. In the response phase, have the experimenter continue 'Can you tell me where is *krexis*?' (use each of the four nonwords, in a counterbalanced manner). Have the child respond by taking their fingers out of the cylinder, and pointing to the left or right cylinder. Make sure that the cylinders in the first and second trials differ in color from the third and fourth trials. Place the textures in front of the child (left and right) in a counterbalanced order.

4.5. Conduct four sets of validation and test trials in this order: validation trial 1 (VT1), test trial 1 (TT1), validation trial 2 (VT2), test trial 2 (TT2), validation trials 3 and 4 (VT3 and VT4) and test trials 3 and 4 (TT3 and TT4).

5. Experiment 2 Procedure

5.1. Conduct Experiment 2 with a different experimental group. Recall that the procedure is the same as in Experiment 1 for pre-experimental and validation trials; test trials in Experiment 1 and 2 are different in the response phase. Use the same stimuli, materials and pre-experimental play as in Experiment 1.

5.2. In the response phase, indicate a tactile stimulus (rough or smooth) to the child and ask him to use one of the nonwords to name the stimulus. Use a script along the following lines (the experimenter refers to the weird creatures inside the cylinders): 'I don't know which creature is which, but you do, because you have already touched them'.

5.2.1. Have the experimenter point to one of the two cylinders, and ask 'Can you tell me who this is?' The child should respond verbally. After the response, the experimenter continues 'Very good'.

5.2.2. Make sure that there is no bias in the child's response. Hence, continue with the following script: the experimenter points to the other cylinder, asking 'And who is this?' The purpose of this question is to avoid or detect biases induced by familiarity, difficulty or undetected developmental problems. The question ensures that the child uses and remembers both words, despite how familiar or difficult they may find them.

5.3. Conduct four sets of validation and test trials. Present the validation and test trials in the same order as in Experiment 1.

5.4. At the end of the experiment introduce the two weird creatures constructed in 2.2.9, Krexis and Nunum, to the child, in order to satisfy his curiosity and give final closure to the experiment.

6. Scoring

NOTE: To be included in the final analysis of either Experiment 1 or Experiment 2, participants must correctly answer all of the four *validation* trials of the experiment.

6.1. Code the children's responses as follows: In Experiment 1, for each of the four trials, give the child a score of 1 when they respond in accordance with the expected correspondence, that is, by pointing to the expected texture. The rough stimulus corresponds to the rough words (e.g. /krexis/ or /xikres/), likewise for the smooth stimulus (e.g., /nunum/ or /munmu/). Give a score of 0 when the child points to the wrong texture. Register whether the child chooses the rough or smooth texture.

6.1.1. In case the child does not respond, code the trial as “No Response” or “Not Available”. If the child responds with a different answer, for instance a different word or nonword, make a note describing the answer.

6.2. For Experiment 2, code the child's responses as follows: for each of the four trials, give the child a score of 1 when he pronounces the target word. That is, the word corresponding to the indicated texture (e.g. /krexis/ or /xikres/ correspond to rough, while nunum/ or /munmu/ to smooth). Give a score of 0 if the child pronounces the distractor word. Also code the word pronounced by the child.

6.2.1. In case the child does not respond, code the trial as “No Response” or “Not Available”.

REPRESENTATIVE RESULTS:

Results of the study[13] with children ranging from 3.5 to 4.5 years of age illustrate the range of possible results of the protocol, since sound symbolism was found in Experiment 2, but not in Experiment 1. Moreover, the results also illustrate how nonsound symbolic biases can be identified, since a nonsound symbolic bias towards smoothness was found in Experiment 1.

Experiment 1

We applied Experiment 1 to a sample of 29 neurotypical monolingual Spanish-speaking children. Sample average age was 3 years 11 months (SD = 3 months and 17 days; range = 3.5-4.5 years). Children from two public schools participated in the study. One school was a rural school in Morelos, Mexico. The other was an urban school in Cuernavaca City in Morelos, Mexico. Parents and school authorities provided informed consent on behalf of the participants.

Variables in Experiment 1 were categorical; hence responses were analyzed via a mixed-effects logit model (other categorical variable tests can be utilized, for instance, Person's chi-square test or a binomial test). Analysis revealed no significant difference between children’s predicted associations (M = 2.03; SD = 1.26) and chance (likelihood ratio = .036, χ^2 = .036, df = 1, p = 0.849). To determine whether children exhibited texture bias, similar analyses were conducted.

Children showed a preference for the smooth stimulus (M = 2.44; SD = .90) compared to the rough stimulus (M = 1.55; SD = .90), independently of the word pronounced by the experimenter. Logit model showed a significant difference (likelihood ratio = 5.879, χ^2 = 5.829, df = 1, $p < 0.05$). In conclusion, Experiment 1 showed no sound symbolic effect, but a significant preference for smoothness (**Table 1**).

[PLACE TABLE 1 HERE]

Experiment 2

We applied Experiment 2 to a sample of 30 neurotypical monolingual Spanish-speaking children. Sample average age was 4 years and 1 month (SD = 4 months; range = 3.5–4.5 years). Results for Experiment 2 were analyzed using a mixed-effects logit model. Children's performance was significantly above chance (M = 2.33; SD = .80) as shown in the model (likelihood ratio = 4.085, χ2 = 4.062, df = 1, $p < 0.05$). The correspondences rough-*krexis* (-*xikres*) and smooth-*nunum* (*munmu*) were observed (**Table 2**). As with Experiment 1, word-bias was investigated. Fricative-rich word naming rate (M = 2.2; SD = .84) and fricative-free word naming rate (M = 1.83; SD = .79) exhibited no significant difference (likelihood ratio = .549, χ^2 = .549, df = 1, $p = 0.459$).

[PLACE TABLE 2 HERE]

FIGURE AND TABLE LEGENDS:

Figure 1. Tactile Stimuli for test trials. Coarse grain sandpaper (left) and fleece fabric (right). Textures were not visible for children. This figure has been published in Falcón et al.[13].

Figure 2. Materials for test trials. Cylinders containing hidden rough and smooth stimuli. Each cylinder encloses one type of stimulus, counter-balanced distributed to the left or right. This figure has been published in Falcón et al.[13].

Figure 3. Materials for validation trials. Stuffed puppet that interacted with children (top left). Sample of toys with stimuli on their feet (top right). Toys and props that supported the story (bottom). This figure has been published in Falcón et al.[13].

Table 1. Results of Experiment 1. Responses pointing to rough and smooth textures ([a]correct and [b]incorrect) per nonword stimulus and total. *Indicates a significant difference between responding (pointing) to a smooth vs. a rough texture, $P < .05$.

Table 2. Results of Experiment 2. Responses uttering fricative-rich and fricative-free words ([a]correct and [b]incorrect responses) per tactile stimulus and total of correct responses. *Indicates significantly more correct (expected) responses, $P < .05$.

DISCUSSION:

The presented protocol is appropriate for exploring tactile sound symbolic correspondences in young children. Moreover, due to the fact that it incorporates two tasks that tap into the tactile and auditory modalities of children, it is also appropriate for identifying bias in the auditory or tactile modalities. The two tasks in the protocol allow experimenters to identify possible bias induced by the tactile or auditory modality, by the difficulty of the task, or by the covert and overt phonological processing. Application with Spanish speaking children indeed revealed that different difficulty conditions determine the presence of a sound symbolic effect, since no sound symbolic effect was found in Experiment 1. In this way, the protocol allowed to uncover unexpected evidence. As mentioned in the representative results section, no sound symbolic effect was observed in Experiment 1. This finding is intriguing, since Experiment 1 consisted of the simpler pointing task. In principle, it was anticipated that the higher cognitive load of the naming task (Experiment 2) might attenuate the effect. The contrary was the case, tactile-auditory correspondences showed in the more demanding task.

These results are significant, since they illustrate the importance of studying sound symbolism in an early developmental stage. Sound symbolism tends to manifest itself in a more robust manner in adults. The fact that children show less robust evidence, as illustrated by the results using this protocol, indicates that development and experience probably have an impact on sound symbolism and thus that it cannot be studied solely based on its biological foundations, but rather that environmental variables are determinant. The protocol has also been appropriate to identify nonsound symbolic biases, thus broadening avenues for research and theorizing.

If needed, the protocol can be easily modified to investigate correspondences between phonological elements and tactile dimension. For instance, the effect of different phonological groups can be investigated, by replacing the nonwords with words containing the phonological units of interest. The protocol can also be readily modified to test further dimensions in the tactile modality. Since the tactile materials are hidden from sight, the rationale to test, for example the bumpy/flat dimension, is the same. The tactile materials feature only on the bottom of the animal toys and inside the enclosing cylinders. Therefore, the only changes necessary are the replacement of tactile materials on the bottom of the toys and the material-holding rolls hidden in the cylinders. Possible problems in modifying the protocol may be, for instance, that the bumpy material needs a larger surface due to the size of the bumps. In such cases, toys with larger bottom sides and rolls with larger diameters can be utilized. We have mentioned that the time-consuming nature of the protocol can be a problem, since it may be tiring for certain children. Thus, another possible modification is to simplify the protocol. For example, the play session and validation trials can be shortened by telling the story with fewer details and in a faster pace. If the protocol is used with older children, it may even be possible to eliminate play and storytelling altogether and utilize simply the child-appropriate materials in story-free validation and experimental trials. We have provided brief explications of the purpose of the main steps in the experiments, thus the steps and procedures intended to aid in storytelling can be identified and simplified if needed.

As the results showed, no sound symbolism was found in Experiment 1. Although we found a smooth-preference effect that helps us to propose a possible explanation for the absence of sound symbolism, it is possible that no effects whatsoever might be found. Due to the young age of the children, another explanation for the absence of effect is that the procedure is too long and complicated, thus resulting in masking due to tiredness. This is a limitation of the protocol that may be addressed by simplifying the test as described above. In such a case, the experimenter should conduct pilot tests in order to verify that a simplified protocol can still engage the younger children. Another possible confound is that other crossmodal association may interfere with the test. For example, the color of the cylinders in the experimental sessions may results in visual-tactile associations. Since it is hard to avoid colors, the solution we have suggested in this protocol is to provide variety in colors along the test, so that any bias from color-correspondences is compensated.

The significance of the method is that it can be used to study tactile sound symbolism in developmental stages. Results from the application of the protocol shows that it can show the presence of tactile sound symbolism when children articulate the nonwords. Results also revealed unexpected bias towards smoothness. As we mentioned, the protocol can be modified to test the effect of phonological units and to test other tactile dimensions, thus, offering potential for investigating the development of the phenomenon in detail.

The protocol has been devised to be applied to young children. Future applications of the protocol can thus address specific ranges of age, especially younger ages (e.g., 2.5 or 3-year-old children). The study of other languages is another avenue of application; especially the more studied ones such as English and Japanese. As we have mentioned, the protocol can be suitable modified to test other aspects of the tactile modality. Future studies can test size, shape, temperature, etc.

The most important steps in the protocol are the verification of the child's competences (steps 4.2.1, 4.2.2, 4.3.2, 4.3.4 and 4.3.5) and to test the sound symbolic correspondences (step 4.4 of Experiment 1 and step 5.4 of Experiment 2). The remaining steps are mainly to provide a child-appropriate experimental environment and to ensure experimental controls. The crucial information for analysis is obtained in step 4.4 and steps 5.4.1-5.4.2.

In sum, this protocol is, as far as we know, unique in that it allows the study of tactile sound symbolism in early ages. It is possible to investigate the effects of auditory or tactile modality bias, task difficulty, and over vs. covert phonology. It can be also adapted to study other languages, phonological effects and further tactile dimensions.

ACKNOWLEDGMENTS:
The authors wish to thank the members of the Laboratory of Human Communication and Cognition (Laboratorio de Comunicación Humana y Cognición, Facultad de Comunicación Humana, UAEM, México).

DISCLOSURES:
None.

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Figure 1

Figure 2

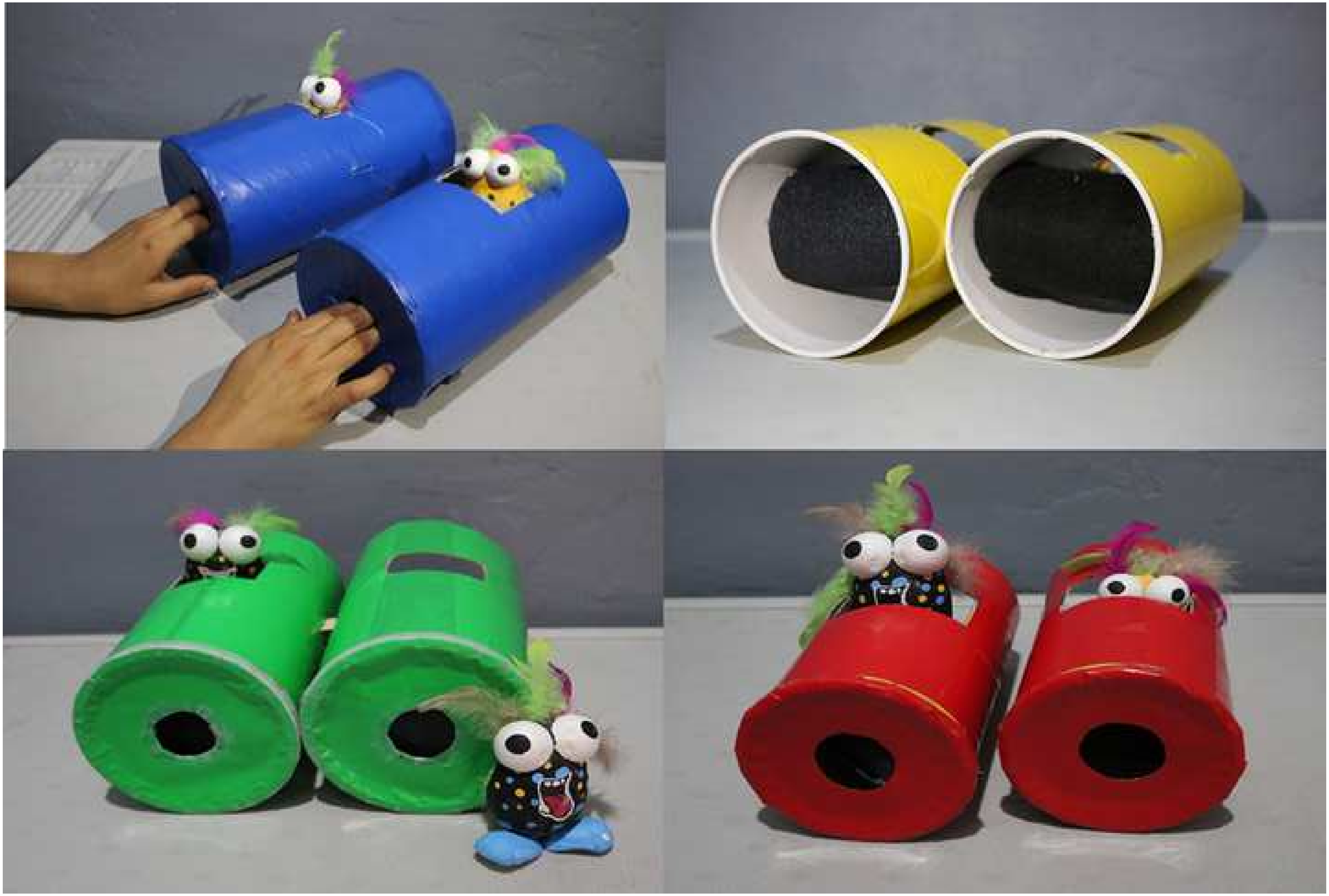

Figure 3

Click here to access/download;Figure;Fig 3.tif

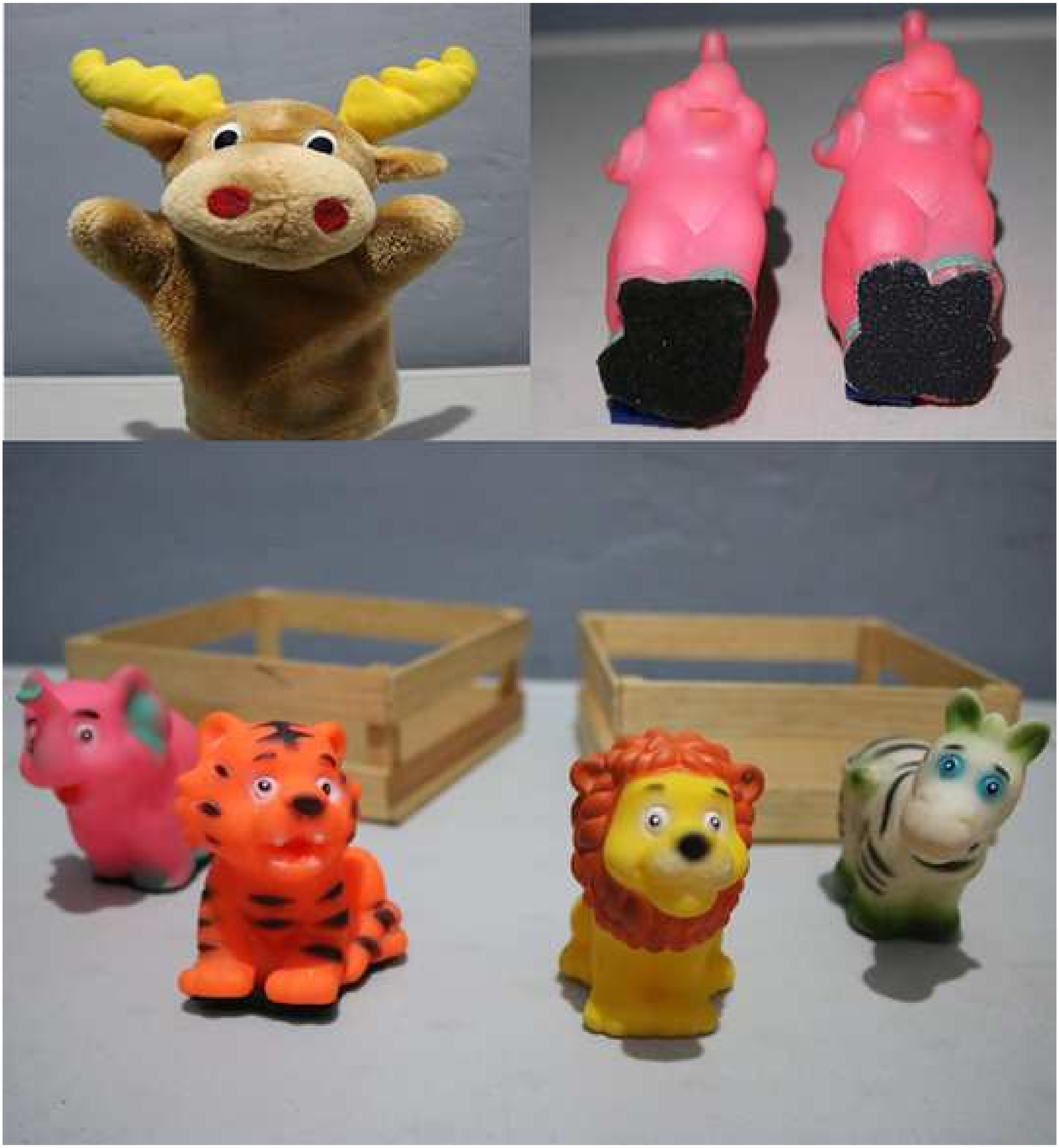

Table 1

	Rough texture (response)	Smooth texture (response)
Fricative-rich word (stimulus)	22[a]	36[b]
Fricative-free word (stimulus)	23[b]	35[a]
Total responses	45*	71*

Table 2

	Fricative-rich word (response)	Fricative-free word (response)	Correct responses
Rough texture (stimulus)	38[a]	22[b]	38
Smooth texture (stimulus)	27[b]	33[a]	33
Total			71*

Name of Material/Equipment	Comments/Description
4 pairs of cylinders with small oppenings	oat cans were used in the actual experiment
4 pairs of plastic animal toys	
coarse grain sand paper	aluminum oxide sandpaper (grit 40)
polar fleece fabric	

Rebuttal letter-R3

Requests from editor have been addressed.