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# Looking for the bouba-kiki effect in prelexical infants

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## Abstract

Adults and toddlers systematically associate certain pseudowords, such as ‘bouba’ and ‘kiki’, with round and spiky shapes, respectively. The ontological origin of this so-called bouba-kiki effect is unknown: it could be an unlearned aspect of perception, appear with language exposure, or only emerge with the ability to produce speech sounds (i.e., babbling). We report the results of three experiments with five- and six-month-olds that found no bouba-kiki effect at all. We discuss the consequences of these findings for the emergence of cross-modal associations in infant speech perception.

**Index Terms**: sound symbolism, bouba-kiki effect, prelexical infants, early language acquisition

## 1. Introduction

The link between a speech sound and its meaning is supposed to be arbitrary [1]. However, most languages contain sound-symbolic words (e.g., English: [2, 3]; Japanese: [4, 5]). For instance, the English lexicon has several sets of verbs in which a shared initial consonant cluster seems to reflect a common part of the verbs’ meanings (e.g., /kr/ is associated with “noisy impact” in verbs like *crash, crack,* and *crunch*). Moreover, adults and toddlers are sensitive to sound symbolism: They more easily learn novel sound-meaning mappings when the words are sound-symbolic compared to when they are not [4-6]. In various sound-shape matching tasks, they also consistently associate certain pseudowords, such as ‘bouba’ or ‘maluma’, with round shapes, and others, such as ‘kiki’ or ‘takete’, with spiky ones [7-9]. This so-called bouba-kiki effect holds across different cultures and languages [3, 10], and hence it may well be universal.

One question concerning these spontaneous sound-symbolic associations concerns its ontological origin. Indeed, whether the bouba-kiki effect is an unlearned aspect of perception or rather emerges with language exposure is largely unknown. Its presence could depend upon the acquisition of sound-symbolic words in the native language, or upon direct experience with one’s own vocal tract gestures when producing speech sounds. Still other possibilities are that it arises with passive exposure to speech sounds, or even that it is present at birth. The goal of the present research is to explore whether prelexical infants who have neither lexical knowledge nor experience with babbling already show a bouba-kiki effect.

To our knowledge, only one study has reported a bouba-kiki effect in infants [11]. In a preferential listening procedure, four-month-olds looked longer at a shape when the accompanying speech sound is judged as incongruent by adults (round shape + /kiki/ or spiky shape + /bubu/) than when it is judged as congruent (round shape + /buba/ or spiky shape + /kiki/). This study used only two stimulus pairs, and the effect was limited in scope: contrary to adult control subjects, the infants failed to show a preference in two additional experiments in which either the consonants (/kiki/ vs. /kuku/) or the vowels (/bubu/ vs. /kuku/) were held constant.

In the present research, we further explore the presence of a bouba-kiki effect in prelexical infants. Moreover, we investigate whether consonants and vowels might play differential roles. The bouba-kiki effect has often been claimed to be mostly driven by the influence of vowels [7, 8], possibly because perceivers match the visual shape with the shape of the lips when producing the vowels within the speech stimuli (e.g. presence of lip rounding in /u/, as in /maluma/ and /buba/, vs. absence of lip rounding in /i/ and /e/, as in /takete/ and /kiki/). Prelexical infants are sensitive to this cue: as early as two months of age they can match auditory /i/ and /u/ onto silent videos of a talking face showing the corresponding articulatory gestures [12]. However, consonants have also been shown to play a role in the bouba-kiki effect [13, 14], and recent data even provide evidence for a stronger influence of consonants than of vowels [11, 15, 16]. For instance, French adults map CVCV pseudowords systematically onto round shapes when the consonants are /m/ and /l/ and onto spiky shapes when they are /k/ and /t/, regardless of the vowels (e.g., both /lumu/ and /limi/ are mapped onto round shapes and both /koto/ and /kiti/ onto spiky shapes). By contrast, their mapping of CVCV pseudowords onto round shapes when the vowels are /o/ and /u/ and onto spiky shapes when the vowels are /e/ and /i/ is less systematic: depending on the consonants, they sometimes prefer the reverse mappings (e.g., while both /pipe/ and /dedi/ are consistently mapped onto a spiky shape, /bibe/ and /memi/ are mapped onto a round shape) [16]. Thus, in addition to exploring the presence of a bouba-kiki effect in prelexical infants, we examine whether, like adults, infants are more sensitive to consonants than to vowels in this type of sound symbolic matching.

In the following, we report on three experiments with five- and six-month-old infants. In order to test the robustness and the possible generalization of infants’ sound-symbolic matching between speech sounds and visual shapes, we use at least six different pairs of auditory and visual stimuli in each of them.

## 2. Experiment 1

We use an intermodal preferential looking procedure with five-month-old infants. Infants hear both homogeneous stimuli, where both consonants and vowels are consistently matched to round (e.g., /lomo/) or spiky shapes (e.g., /tiki/) by French adults [16], and heterogeneous stimuli that combine either round consonants with spiky vowels (e.g., /limi/) or spiky consonants with round vowels (e.g., /toko/). The latter type of stimuli allows us to investigate whether infants are more sensitive to consonants or to vowels when performing sound-shape mappings.

## 2.1. Methods

### *2.1.1. Participants*

Twenty-four five-month-old infants (range: 4;24-5;28; mean: 5;14; 16 girls) participated. The data from ten more infants were excluded from the analyses due to fussiness (N=8) or strong side bias (N=2).

### *2.1.2. Stimuli*

The auditory stimuli consisted of 28 CVCV disyllabic sequences. They were constructed by combining two consonants that are both consistently associated with either round or spiky shapes by French adults [16] ("round": /l,m/; "spiky": /k,t/) and two vowels that are likewise both associated with either round or spiky shapes ("round": /o,u/; "spiky": /i,e/; see Appendix A). Thus, half of the stimuli contained vowels and consonants that are all judged as either round (e.g., /lumu/) or spiky (e.g., /kiti/). The other half contained either round consonants and spiky vowels (e.g., /mili/) or round vowels and spiky consonants (e.g., /tuku). The stimuli were recorded by a French female speaker in infant-directed-speech. Their mean duration, minimum F0 and maximum F0 - averaged for the items within each condition - were not significantly different among the four conditions (all $p > .05$).

To construct the visual stimuli we created two pairs of black outlined shapes (one round, one spiky for each pair); within each pair, the shapes were matched in surface but not in number of curves and spikes. We filled both pairs with 7 different colors (yellow, red, brown, blue, pink, green, purple), and finally mirrored each pair of shapes to increase the total number of pairs to 28 (2 shapes x 7 colors x 2 mirror-image versions). Color-filled examples of each pair are shown in Figure 1.

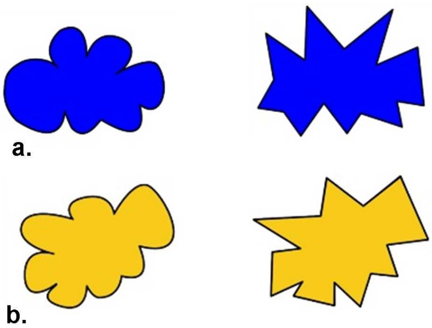


Figure 1. *Example of the first (a) and the second pair (b) of round and spiky shapes used in Experiment 1.*

### *2.1.3. Procedure*

Infants were held in the lap of a parent and tested in a quiet room. Their eye gazes were monitored and recorded on video. The parents wore headphones with masking music that prevented them from hearing the auditory stimuli. Each trial started with the presentation of an attention getter, a colorful moving image, on a television screen. As soon as the infant had fixated it for 1 s., it was replaced by a pair of still shapes (one round, one spiky) presented side-by-side on a white background, followed after 500 ms by the presentation of five repetitions of a single token of one auditory stimulus. Each trial lasted 10.5 s. The order of the stimuli and the sound-shape pairing was pseudo-randomized across four different lists. Each infant was presented with only one list, consisting of 28 different trials divided into two blocks. Within each block, the round shape appeared at the left side half of the times. Trials with the same type of auditory stimulus or with the same color of the visual stimulus were presented not more than twice in a row.

## 2.2. Results and discussion

Infants' eye gazes were coded off-line frame-by-frame. Frames in which the infant looked towards the round shape were coded "1" and those in which they looked towards the spiky shape were coded "-1". Figure 2 shows these scores averaged across all infants in intervals of 1 second from the beginning of the auditory stimulus until its end, and separated for the homogeneous and the heterogeneous auditory stimuli. A positive mean score indicates a preference for the round shape, a negative one a preference for the spiky shape.

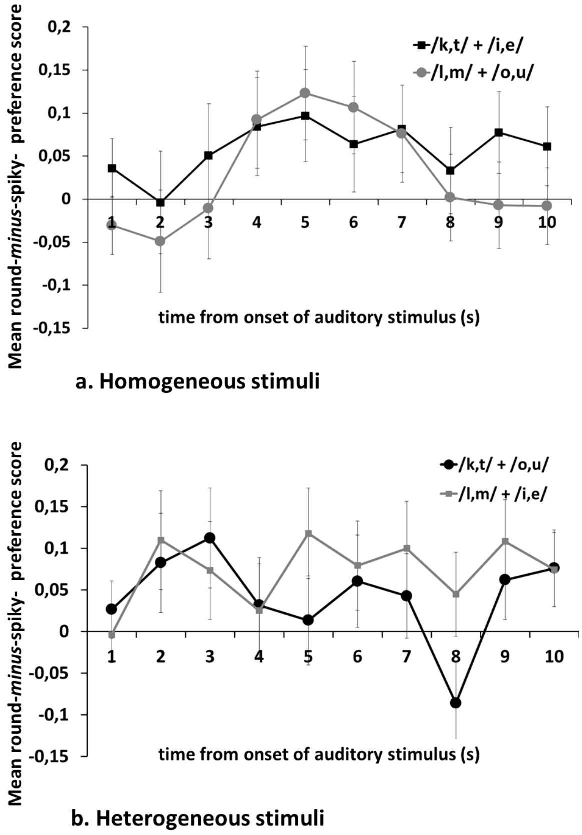


Figure 2. *Mean preference scores for the homogeneous (a) and the heterogeneous (b) auditory stimuli over time. Positive scores indicate a preference for the round shape. Error bars represent standard errors from the mean.*

Note that while infants showed an overall preference for the round shapes, they did not seem to look differentially to the round and the spiky shapes as a function of auditory stimulus, whether these were homogeneous or heterogeneous. We thus conducted our analyses over the total trial duration. Table 1 presents the mean looking times to the round shape minus the mean looking times to the spiky shapes.

Table 1. *Mean looking times to the round shape minus mean looking times to the spiky shapes (in ms) as a function of Consonant Type (/l,m/ vs. /t,k/) and Vowel Type (/o,u/ vs. /i,e/). Standard errors from the mean are shown in parentheses.*

| | /o-u/ | /i,e/ | *mean* |
|---|---|---|---|
| /l-m/ | 329 (270) | 852 (228) | *591 (180)* |
| /t-k/ | 435 (305) | 631 (386) | *533 (247)* |
| *mean* | *382 (204)* | *741 (224)* | |

These difference scores were submitted to a 2x2 repeated measures ANOVA with the factors Consonant Type (/l,m/ vs. /t,k/) and Vowel Type (/o,u/ vs. /i,e/). The analysis revealed neither a main effect nor an interaction (Consonant Type: $F < 1$; Vowel Type: $F(1,23) = 2.25$, $p = .15$; Consonant Type x Vowel Type: $F < 1$). Furthermore, planned restricted analyses of the two conditions in which both the vowels and the consonants were either round or spiky, showed no significant differences either (both $F < 1$). Overall, infants only showed positive difference scores, indicating a general preference for the round shapes ($t(23) = 3.02$, $p < .01$), in accordance with what has been reported in [17]. The same pattern of results was obtained analyzing the first and the second block separately: no significant effects in the ANOVA, (all $p > .10$), and a preference for the round shapes (first block: $t(23) = 2.33$, $p < .05$; second block: $t(23) = 2.05$, $p = .05$).

Thus, we found no sign of a bouba-kiki effect in this experiment, not even when we considered only the two conditions in which according to French adults the pseudowords were composed of consonants and vowels that are either all round or all spiky [16]. One possible explanation for the absence of an effect is that half of the stimuli contained either spiky consonants with round vowels or round consonants with spiky vowels; this might have prevented infants to perform sound-symbolic associations. Moreover, the preference for the round shapes overall might have masked the expected bouba-kiki effect. In the next experiment, we address these points as follows. First, we only use auditory stimuli in which both the consonants and the vowels are either round or spiky, hence leaving aside the question as to the relative roles of consonants and vowels in sound-shape matching. Second, we use a preferential looking procedure as in [11], where in each trial only one shape is displayed.

# 3. Experiment 2

We use a preferential looking paradigm with six-month-old infants. Infants only hear stimuli where both consonants and vowels are consistently matched onto round (e.g., /buba/) or spiky shapes (e.g., /kike/) by French adults in a pre-test. As in [11], we manipulate the type of the shape displayed in each trial. That is, we use sound-symbolic pairings that are either congruent (e.g., round shape + /buba/; spiky shape + /kike/) or incongruent (e.g., round shape + /kike/; spiky shape + /buba/). If infants are sensitive to this type of sound symbolism, they should look differentially in the two types of trials.

## 3.1. Methods

### *3.1.1. Participants*

Twenty-four six-month-old infants (range: 5;24–6;17; mean: 6.;26; 12 girls) participated. The data from six more infants were excluded from the analyses due to parental interference (N=4), equipment failure (N=1), or failure to look away on more than half of the trials (N=1).

### *3.1.2. Stimuli*

The auditory stimuli consisted of 12 CVCV pseudo-words (cf. Appendix B). Half of them were of the bouba-type: their vowels had been chosen from among /o,u,a/ and their consonants from among /b,d,g,v,ʒ/. The other half were of the kiki-type: their vowels had been chosen from among /i,e,ɛ̃/ and their consonants from among /p,t,k,f,s/. There were no significant differences in duration, in minimum and maximum F0, or in maximum F0 difference between the bouba-type items and the kiki-type items. A female native speaker of French, different from the one used in Experiment 1, recorded all stimuli eight times in infant-directed speech.

The visual stimuli were similar to the ones used in Experiment 1 and consisted of six pairs of color pictures with black contours, one of a round and one of a spiky shape. Within pairs, the pictures had the same number of curves or spikes and they had the same color, but they were not matched for their surface. The colors were red, pink, yellow, green, light blue, and dark blue.

### *3.1.3. Procedure*

Infants were held in the lap of a parent and tested in a quiet room. Their eye gazes were monitored and recorded on video. The parents wore headphones with masking music that prevented them from hearing the auditory stimuli.

Each infant was tested on 12 trials, six congruent and six incongruent ones. There were two counterbalancing groups, such that sounds that were presented in the congruent condition for one group were presented in the incongruent condition for the other group. For instance, /ʒuvo/ was paired with the pink round shape (congruent) and /daʒo/ with the yellow spiky shape (incongruent) for one group, while the reverse pairings were used for the other group.

Each trial started with the presentation of an attention getter, a colorful moving image, on a television screen. As soon as the infant had fixated it for 1 s., it was replaced by the visual stimulus, shown on a white background, followed after 300 ms by the presentation of the auditory stimulus. The trial ended when the infant had looked away for a consecutive period of more than 2 s. or when all 8 tokens of the item had been played three times. The ISI between tokens was 1 s., and the maximum trial duration around 40 s.

Trials were presented semi-randomly, with no more than three congruent or incongruent trials in a row and with the two shapes of the same color never being presented one after the other.

### 3.2. Results and discussion

Infants' eye gazes were coded off-line frame-by-frame. The mean looking times in the congruent and the incongruent conditions are displayed in Table 2. A 2x2 repeated measures ANOVA with the factors Shape Type (round vs. spiky) and Sound (bouba-type vs. kiki-type) revealed a main effect of Shape Type ($F(1,23) = 9.16$, $p < .01$), indicating a preference for the round shapes. However, there was neither a main effect of Sound ($F < 1$) nor an interaction ($F(1,23) = 1.0$, $p = .27$). Separate analyses of the first and the second half of the experiment revealed no significant main effects or interactions at all (all $F<1$).

Table 2. *Mean looking times (in ms) as a function of Shape Type (round vs. spiky) and Sound (bouba-type vs. kiki-type) in Experiment 2. Standard errors from the mean are shown in parentheses.*

| | Round | Spiky |
|---|---|---|
| Bouba-type | 15189 (1577) | 11916 (1455) |
| Kiki-type | 13722 (1578) | 11074 (891) |

As in the previous experiment, we found no sign of a bouba-kiki effect. Moreover, despite the fact that infants no longer had to choose between a round and a spiky shape in each trial, we still obtained an overall preference for the round shapes, in that infants looked longer during trials with a round shape.

One possible reason for the absence of a bouba-kiki effect is that infants might have failed to make the association between the auditory and the visual stimuli. In the next experiment, we use the same experimental design but make the visual stimuli move in synchrony with the auditory ones, thus facilitating the sound-shape association [18].

## 4. Experiment 3

As in Experiment 2, we use a preferential looking paradigm with six-month-old infants.

### 4.1. Methods

#### *4.1.1. Participants*

Twenty-three six-month-old infants (range: 5;29–6;16; mean: 6.26 month-old; 10 girls) participated in the study. Seven more infants were tested but excluded from the analyses due to fussiness (N=3), experimenter error (N=2), or failure to look away on more than half of the trials (N=2).

#### *4.1.2. Stimuli*

The auditory and visual stimuli were the same as those in Experiment 2.

#### *4.1.3. Procedure*

The procedure was the same as that in Experiment 2, with one exception: The visual stimuli moved in synchrony with the auditory ones, decreasing and increasing in size (20% of size variation); they reached their maximum size during the second, stressed, syllable of the pseudoword, and remained immobile until just before the presentation of the next token.

### 4.2. Results and discussion

Infants' eye gazes were coded off-line frame-by-frame. The mean looking times as a function of visual and auditory stimuli are displayed in Table 3. In a 2x2 repeated measures ANOVA with the factors Shape Type (Round vs. Spiky) and Sound (Bouba-type vs. Kiki-type) neither the main effects nor the interaction were significant (Shape Type: $F(1,23) = 2.16$, $p = .16$; Sound: $F < 1$; shape type x sound: $F(1,22) = 1.94$, $p = .18$). An ANOVA restricted to the first half of the experiment revealed no main effects or interaction either (all $F < 1$). For the second half, there was an effect of Sound $F(1,22) = 5.17$, $p = .03$), indicating that infants looked longer at the shapes when kiki-type stimuli were displayed, but no effect of Shape Type ($F(1,22) = 1.74$, $p = .20$) and no interaction ($F<1$)

Table 3. *Mean looking times (in ms) as a function of Shape Type (round vs. spiky) and Sound (bouba-type vs. kiki-type). Standard errors from the mean are shown in parentheses.*

| | Round | Spiky |
|---|---|---|
| Bouba-type | 16868 (1164) | 14025 (1260) |
| Kiki-type | 15451 (1256) | 15529 (1107) |

Thus, despite the fact that we facilitated the sound-shape association by making the shape move in synchrony with the auditory stimuli, we again failed to find a bouba-kiki effect.

## 5. General discussion

In three experiments, we failed to find a hint of a bouba-kiki effect in five- and six-month old infants. It is unlikely that methodological issues can explain this absence of evidence for sound-symbolic speech-shape associations in prelexical infants: We tested more than 20 infants in each experiment, using different paradigms that have been shown to be suited for testing infants' capacities to link auditory and visual stimuli at this age [19, 20]. We may also discard the possibility that infants did not discriminate between the round and the spiky shapes and therefore failed to show a bouba-kiki effect. Indeed, in two out of three experiments, infants looked longer at the round than at the spiky shapes, showing that they had no difficulty discriminating them.

Of course, our null results remain difficult to interpret, especially in light of the fact that a bouba-kiki effect was reported earlier in four-month-old infants [11]. Recall that in that study, only one pair of stimuli was used, whereas in our experiments each infant was tested on at least six different pairs. We tentatively argue that the increased complexity of our design might have masked infants' emerging sound-symbolic matching abilities. In other words, the bouba-kiki effect in infants might be weak and detectable only with the simplest designs. The fact that [11] failed to find the effect when the pair of sounds only differed by either its consonants or its vowels might be another sign of the lack of robustness of the effect in prelexical infants; specifically, they would only show it when all the phonemes in the auditory stimuli provide congruent sound-symbolic information.

Possibly, for the bouba-kiki effect to become more robust infants need to experience their own vocal tract gestures when producing speech sounds. Thus, sound-symbolic associations should become stronger as infants gain experience with the production of speech sounds through babbling and as they recruit sensorimotor areas to decode spoken language. In line with this idea, infants' cross-modal binding has been shown to be initially broad and to become tuned with perceptual experience [21-23]. More specifically, speech motor areas in the left inferior frontal gyrus are activated by the perception of speech in 6.5 and 12-month-old infants but not in neonates, suggesting that experience producing speech sounds is required to perform sensorimotor bindings [23].

Two recent studies have examined related forms of audio-visual sound-symbolic associations in prelexical infants [19, 20]. One of them showed that three- to four-month-old infants look longer at a spiky shape when it is accompanied by a high-pitch rather than a low-pitch sound, and that conversely, they look longer at a round shape when it is accompanied by a low-pitch rather than a high-pitch sound [19]. The other study reported that four-month-old infants prefer to look at a large version of a shape rather than a small one when they hear /o/ or /a/, while they prefer to look at a small version when they hear /i/ or /e/ [18]. Thus, like adults [24, 25], infants are able to perform systematic cross-modal sound-shape and sound-size mappings only a few months after birth.

Note that both of these studies used low-complexity auditory stimuli (pure tones and isolated vowels, respectively). It would be interesting to investigate the emergence of the bouba-kiki effect using isolated vowels. Prelexical infants might have less difficulty matching isolated vowels rather than entire CVCV sequences onto visual shapes, especially in light of their spontaneous matching of vowel sounds with silent videos of a talking face showing the corresponding articulatory gestures [12, 26]. In particular, we would expect them to match rounded vowels such as /u/ and /o/ onto round shapes and unrounded ones, such as /i/ and /e/, onto spiky shapes. Such findings would be in line with the idea that at least part of the correspondences between speech sounds and shapes is due to the mappings of the shape of the lips to produce a vowel onto the visual properties of a shape. More complex cross-modal mappings between consonants and visual shapes might emerge later. Of course, if this is the case, then we have to account for the qualitative shift that takes place during development, with consonants at some point in time becoming more important than vowels for the bouba-kiki effect [11, 15, 16]. The preponderance of the role of consonants in the bouba-kiki effect in adults meshes well with studies showing that adults rely more on consonants than on vowels for the purposes of lexical processing[27, 28]. Interestingly, 12-month-old infants likewise rely more on consonants than on vowels when distinguishing among words [29]. It would thus be particularly interesting to compare younger and older infants in a simple design as the one used by [11], to see whether for the purposes of sound-shape matching they initially pay more attention to vowels and come to rely more on consonants by the time they start to learn words.

To conclude, infants' sensitivity to sound symbolism has received little attention in research on the ontological development of multimodal speech perception. The evidence for a bouba-kiki effect in prelexical infants so far is weak, and we argue that null results like the present ones should not be kept in a drawer. More research is necessary to investigate the role of experience in the emergence of the bouba-kiki effect, as well as in the differential role that consonants and vowels may play in infants' cross-modal correspondences.

## 6. Acknowledgements

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## 7. Appendices

A. *Auditory stimuli used in Experiment 1.*

| homogeneous stimuli | |
|---|---|
| /l,m/ + /o,u/ | /lumu/, /mulu/, /lomo/, /molo/, /lumo/, /mulo/, /lomu/ |
| /t,k/ + /i,e/ | /kiti/, /tiki/, kete/, /teke/, kite/, /keti/, /teki/ |
| heterogeneous stimuli | |
| /l,m/ + /i,e/ | /limi/, /mili/, /leme/, /mele/, /lime/, /mile/, /meli/ |
| /t,k/ + /o,u/ | /kutu/, /tuku/, /koto/, /toko/, /tuko/, /kotu/, /toku/ |

B. *List of the* a*uditory stimuli used in Experiments 2 and 3.*

| Pair n° | kiki-type | bouba-type |
|---|---|---|
| 1 | /pɛ̃fi/ | /buba/ |
| 2 | /tesi/ | /voga/ |
| 3 | /sitɛ̃/ | /ʒuvo/ |
| 4 | /kike/ | /gudu/ |
| 5 | /fekɛ̃/ | /bodu/ |
| 6 | /tepe/ | /daʒo/ |

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