The Mechanism of Sound Symbolism Generation —A Nature-Nurture Interaction Model Based on the Sensitive Period

Authors: Ma Yanan, Huang Yanli, Yujing Shi, Xie Jiushu, Huang Yanli, Xie Jiushu

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Abstract

The Bouba-Kiki effect (abbreviated as the BK effect) refers to the mapping relationship between speech sounds and shape features. Regarding the underlying mechanism of the BK effect, there is intense debate between nativist and empiricist theories. The nativist perspective holds that human sensitivity to sound symbolism is a linguistic mechanism present from birth, whereas the empiricist perspective emphasizes that sound symbolism is a product of linguistic experience. Both theories have received substantial support from research evidence, and neither can completely refute the other. This suggests that neither theory may have fully elucidated the mechanism underlying sound symbolism. In light of this, regarding the mechanism of the BK effect, this paper reviews supporting evidence for both nativist and empiricist theories and proposes, for the first time, the hypothesis of a language-related sensitive period for the BK effect. Additionally, it reviews preliminary research evidence supporting the sensitive period for the BK effect and potential influencing factors. Furthermore, based on the hypothesis of a language-related sensitive period for the BK effect, it proposes an interactionist model of nature and nurture in the emergence of sound symbolism to reconcile contradictions in previous research. Finally, it outlines future research advances and directions in sound symbolism.

Full Text

The Mechanism of Sound Symbolism: An Innate-Acquired Interaction Model Based on the Sensitive Period

Ma Yanan, Huang Yanli, Shi Yujing, Xie Jiushu
School of Psychology, Nanjing Normal University, Nanjing 210097, China

Abstract

The Bouba-Kiki effect (BK effect) refers to the systematic mapping between speech sounds and shape features. Regarding its underlying mechanism, the innate and acquired theories have engaged in heated debate. The innate theory posits that sensitivity to sound symbolism is an inborn linguistic mechanism present at birth, whereas the acquired theory emphasizes that sound symbolism emerges from linguistic experience. Both perspectives have garnered substantial empirical support and neither can fully refute the other, suggesting that neither theory alone completely captures the mechanism of sound symbolism. This review systematically examines evidence for both the innate and acquired theories of the BK effect and, for the first time, proposes the hypothesis of a language-related sensitive period for the BK effect. We also review preliminary research supporting this sensitive period hypothesis and explore potential influencing factors. Building on this hypothesis, we propose an innate-acquired interaction model of sound symbolism to integrate previous contradictory findings. Finally, we outline future research directions for the study of sound symbolism.

Keywords: Sound Symbolism, Bouba-Kiki Effect, Sensitive Period, Linguistic Arbitrariness, Crossmodal Correspondences

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Sound symbolism refers to non-arbitrary mappings between speech sounds and the perceptual properties of their referents, such as size and shape (Dingemanse et al., 2015). The study of sound symbolism traces back to Plato' s *Cratylus*, which debated conventionalism versus naturalism in language (Sedley, 2003). In the early twentieth century, Saussure (1959) proposed the principle of linguistic arbitrariness, emphasizing that the relationship between sound and meaning is arbitrary. However, recent research has revealed that two-thirds of the world' s languages exhibit systematic sound-meaning mappings (Blasi et al., 2016). These mappings manifest in various forms, including associations between pitch and frequency, sound and shape, and sound and size. Investigating the cognitive mechanisms of sound symbolism thus holds significant theoretical value for understanding language origins and development, as well as practical implications for language construction and pragmatic competence.

The most representative example of sound symbolism is the Maluma/Takete effect discovered by psychologist Köhler (1947). In this classic experiment, participants viewed novel spiky and rounded shapes (see Figure 1 [Figure 1: see original paper]) while hearing two non-words, "Takete" and "Maluma." Most participants matched "Takete" with the spiky shape and "Maluma" with the rounded shape. Ramachandran and Hubbard (2001) replicated Köhler's findings using "Bouba" and "Kiki" and formally named this phenomenon the "Bouba-Kiki effect" (BK effect). Because the BK effect demonstrates non-arbitrary associations between sound and meaning, it provides compelling evidence for sound symbolism and challenges purely arbitrary theories of language. Moreover, numerous studies have shown that the BK effect facilitates children' s vocabulary learning and memory, offering novel approaches to language pedagogy (Imai et al., 2015; Sonier et al., 2020). Since Köhler' s discovery in 1947, the BK effect has attracted widespread academic and public interest, with extensive research confirming its presence across different ages, languages, and cultures (D' Anselmo et al., 2019; Fort et al., 2018).

Recent advances in psycholinguistics, cognitive linguistics, and neurolinguistics have made sound symbolism a major research focus. Sound symbolism not only promotes early language comprehension and word learning in infants (Imai et al., 2015; Kantartzis et al., 2019; Nielsen & Dingemanse, 2020) but also enhances associative memory, particularly for words (Preziosi & Coane, 2017; Sonier et al., 2020). Furthermore, sound symbolism has been widely applied in brand image design and product development (Pathak & Calvert, 2020; Park et al., 2021).

However, the mechanism underlying sound symbolism remains unclear, hindering its application across domains. The innate and acquired theories of sound symbolism hold opposing views, each supported by substantial evidence. The innate theory argues that sensitivity to sound symbolism is an inborn linguistic mechanism rooted in the brain's intrinsic properties (Ramachandran & Hubbard, 2001; Spector & Maurer, 2013; Yang et al., 2019). In contrast, the acquired theory stresses the role of linguistic experience, suggesting that sound symbolism develops gradually through language learning (Lewkowicz & Ghazanfar, 2009; Pejovic & Molnar, 2017).

This review first examines evidence for both the innate and acquired theories of sound symbolism. Building on this foundation, we propose the novel hypothesis of a language-related sensitive period for the BK effect. We then review preliminary findings supporting this sensitive period and discuss relevant influencing factors. Subsequently, we present an innate-acquired interaction model of sound symbolism based on the sensitive period hypothesis. Finally, we outline future research directions for investigating the sensitive period of sound symbolism.

2. The Innate Theory of Sound Symbolism

Numerous studies suggest that sensitivity to sound symbolism is an innate linguistic mechanism present at birth (Ramachandran & Hubbard, 2001; Yang et al., 2019). Evidence for the innate theory primarily comes from research on infants' BK effect and crossmodal correspondence phenomena in animals.

2.1. The BK Effect in Infants

If the BK effect is innate, it should be present before language acquisition. Supporting this hypothesis, studies have found that four-month-old infants exhibit the same sound-shape mappings as older children and adults. Specifically, in visual preference tasks, infants look longer at incongruent sound-shape pairings than at congruent ones (Ozturk et al., 2013).

Research using functional near-infrared spectroscopy (fNIRS) and event-related potentials (ERPs) has also documented the BK effect in infants. Asano et al. (2015) used ERPs to investigate eleven-month-olds' performance in a sound symbolism task. They found significantly increased gamma power within 300 ms of stimulus onset under congruent sound-shape conditions, indicating that eleven-month-olds already show the BK effect. Additionally, Yang et al. (2019) used fNIRS to demonstrate that when sounds and shapes matched, eleven-month-olds exhibited significantly increased blood flow in the right posterior superior temporal sulcus (rSTS), but only when "Moma" sounds co-occurred with rounded shapes.

These findings suggest that infants display sensitivity to sound symbolism before acquiring language. However, some researchers argue that these studies do not rule out the influence of statistical co-occurrence between sounds and shapes. Infants might internalize these associations through associative learning based on frequent pairings of sounds like "Moma" with rounded shapes (Sidhu & Pexman, 2018). To control for this possibility, researchers have turned to animal studies.

2.2. Crossmodal Correspondence in Animals

Crossmodal correspondence refers to associations formed between features or attributes across different sensory modalities (Parise, 2016). Evidence of cross-modal correspondence in animals provides crucial support for the innate theory. Ludwig et al. (2011) asked human adults and chimpanzees to classify black and white squares while listening to high- and low-frequency sounds. Both humans and chimpanzees performed best when color and sound matched (i.e., "white-high pitch" or "black-low pitch"), indicating that chimpanzees exhibit sound symbolism.

Researchers have also examined similarities between animal and human sound symbolism. Rendall and Owren (2010) noted consistent affective-semantic associations in animal communication systems that may provide a foundation for complex human semantic systems. For instance, animals produce sharp sounds in hostile, high-arousal states and soft sounds in positive, low-arousal states (Owren & Rendall, 2001). This pattern resembles infants' production of harsh versus smooth vocalizations in dangerous versus satisfying situations. These phenomena may have evolved during development into sonorants and stops, manifesting as the Maluma/Takete effect—associations between sonorants and rounded shapes and between stops and spiky shapes.

In summary, humans and animals share similar crossmodal correspondence phenomena, suggesting that linguistic iconicity may be innate.

3. The Acquired Theory of Sound Symbolism

Despite substantial support for the innateness of the BK effect, numerous studies challenge this view. Fort et al. (2013) found that five- to six-month-old infants do not show sensitivity to sound symbolism. Consequently, proponents of the acquired theory argue that the BK effect depends on postnatal linguistic and audiovisual experience. Evidence for this perspective comes from several sources.

3.1. The BK Effect in Animals

Some researchers have failed to find the BK effect in animals. Margiotoudi et al. (2019) used the classic "Takete-Maluma" paradigm to investigate whether both humans and gorillas exhibit the BK effect. No BK effect was found in gorillas, leading the researchers to conclude that a linguistic system may be a prerequisite for sound symbolism.

3.2. The Role of Visual Experience in the BK Effect

Other researchers emphasize the importance of visual experience in the BK effect. Studies testing congenitally blind and late-blind participants on haptic-auditory BK tasks found that both groups exhibited weaker BK effects (Fryer et al., 2014). Sourav et al. (2019) reported similar findings with late-blind participants, suggesting that sound-shape associations require specific visual experiences, such as observing lip movements during speech production.

Researchers have also investigated the BK effect from the perspective of visual attributes, finding that visual features play a critical role. Chow and Ciaramitaro (2019) discovered that six- to eight-year-old children form BK effects based on the number of protruding spikes in visual figures rather than sharpness of contour, whereas adults rely on contour sharpness. Cuskley et al. (2017) examined the role of orthography, finding that curved letters are more easily matched with rounded shapes. These findings suggest that the BK effect may depend on directed extraction of auditory and visual features.

3.3. The Role of Linguistic Experience in the BK Effect

Numerous studies demonstrate that the BK effect is modulated by linguistic experience. For example, non-words that violate the phonetic properties or structures of participants' native language do not produce BK effects. Rogers and Ross (1975) used non-words "Takete" and "Maluma" as auditory stimuli, which contained phonemes /th/ and /l/ absent from Papuan New Guinean adults' native language. No BK effect was found in these participants. Similarly, Styles and Gawne (2017) used "Bubu" and "Kiki," which included the phoneme combination /k/ and /u/ absent from Nepali participants' native language, and likewise found no BK effect. Styles and Gawne hypothesized that phonological plausibility is a prerequisite for the BK effect. Delgado et al. (2020) systematically investigated this hypothesis and found that non-words violating adults' native phonological structure disrupted the BK effect. These results indicate that the BK effect is modulated by linguistic experience.

4. Sensitive Periods in Language Development

To better understand the mechanism of the BK effect, we draw on research regarding language-sensitive periods to integrate the innate-acquired debate. A sensitive period refers to a developmental window during which the brain exhibits enhanced plasticity for encoding specific environmental experiences, potentially altering brain structure and function (Gabard-Durnam & McLaughlin, 2020). Sensitive periods differ from critical periods: critical periods involve irreversible changes in brain function and structure that cannot occur if missed, whereas sensitive periods affect the intensity of plasticity. After a sensitive period, the brain retains some plasticity, albeit reduced (Gabard-Durnam & McLaughlin, 2020).

Experimental evidence for language-sensitive periods primarily comes from environmental deprivation paradigms (Hensch, 2018). For example, researchers have systematically examined differences in language processing among late-blind, congenitally blind, and sighted but blindfolded participants to investigate whether congenital blindness affects neural plasticity for language. Results showed reduced left lateralization in frontotemporal language areas in congenitally blind individuals, indicating that visual input influences language development according to a sensitive period hypothesis (Pant et al., 2020).

Changes in language learning ability represent classic evidence for human developmental sensitive periods (Kuhl, 2010; Mayberry & Kluender, 2018). During language-sensitive periods, enhanced neural plasticity enables superior language learning. After these periods, reduced plasticity leads to diminished language learning capacity (Werker & Hensch, 2015). Since sound symbolism involves language processing, it may also follow a sensitive period pattern.

5. The Language-Related BK Effect Sensitive Period Hypothesis

5.1. Preliminary Evidence for the BK Effect Sensitive Period

Drawing on language-sensitive period research, we propose the novel hypothesis of a language-related sensitive period for the BK effect. This hypothesis posits that a sensitive period exists for BK effect development, during which individuals readily form sound-symbolic associations, while efficiency declines significantly outside this window.

Several studies provide preliminary support. For instance, when controlling for language proficiency, hearing-impaired adults showed reduced BK effects. Moreover, the magnitude of BK effects in hearing-impaired participants correlated with the duration of auditory deprivation during childhood: children fitted with hearing aids before 23 months performed better on BK tasks than those fitted after 23 months. This suggests a sensitive period for forming sound-shape associations; auditory impairment during this window impedes BK effect development even after years of subsequent training (Gold & Segal, 2020). However, this study did not rule out the possibility that reduced auditory ability itself weakened the BK effect. Thus, the BK effect sensitive period may be related to the phonological sensitive period (which emerges around 12 months).

Similar findings come from visually impaired participants, who show weaker BK effects than sighted controls (Fryer et al., 2014; Graven & Desebrock, 2018). These results suggest that BK effects may have a sensitive period during which early visual and auditory input is essential for development, while deprivation after the period has minimal impact (Bottini et al., 2019; Hamilton-Fletcher et al., 2018; Sourav et al., 2019).

Research with visually impaired participants suggests the BK effect sensitive period ends around age 12. One study found that adults with late-onset permanent blindness and sighted controls showed strong BK effects, whereas congenitally blind adults and those with developmental cataracts (onset around age 13, with vision deteriorating before age 12) showed no BK effect. Crucially, participants who experienced vision loss before age 12 failed to show BK effects, while those with intact vision until after age 12 did. Additionally, adults with transient congenital blindness from bilateral cataracts (surgically corrected at a mean age of 58 months) failed to acquire BK effects despite subsequent learning opportunities. This indicates that visual experience before age 12 is critical, implying that missing the BK effect sensitive period makes it difficult to acquire these associations even with extensive audiovisual exposure (Sourav et al., 2019). Notably, visual deprivation before age 12 also disrupts normal visual input during the visual sensitive period (which ends around age 10), potentially contributing to reduced BK effects. Therefore, it remains unclear whether the BK effect sensitive period is independent from phonological and visual sensitive periods.

5.2. Factors Influencing the Sound Symbolism Sensitive Period

The BK effect sensitive period influences the emergence of sound symbolism, but the period itself may be affected by other factors, particularly language-related ones.

5.2.1. Language Experience Accumulation The BK effect is influenced by language experience. On one hand, early language learning enhances infants' sensitivity to the BK effect. Pejovic and Molnar (2017) assessed BK effects for non-repeating syllable non-words ("Buba" and "Kike") paired with rounded or spiky shapes in four- and twelve-month-old Basque monolingual and Spanish-Basque bilingual infants. Both monolinguals and bilinguals showed increased sensitivity after twelve months of language exposure, indicating that early language experience is crucial for BK effect development.

On the other hand, adults'sensitivity to sound symbolism gradually declines with age and linguistic experience. While infants are sensitive to sound symbolism across languages, older individuals become sensitive only to sound symbolism in their native language (Imai & Kita, 2014). Katerina and Kantartzis (2011) tested English- and Greek-speaking adults and two-year-olds with universal and English-specific sound-symbolic stimuli. Children performed similarly on all stimuli, whereas Greek-speaking adults performed poorly on English-specific items. This suggests that children are sensitive to all sound-symbolic relations, while adults lose sensitivity to non-native associations. Similar findings emerge in tone-shape mapping research: Mandarin speakers map flat tones to rounded shapes and contour tones to spiky shapes based on tonal variation, whereas English speakers map high tones to spiky shapes and low tones to rounded shapes based on pitch height. Mandarin-English bilinguals attend to both dimensions, demonstrating that adult tone-shape mapping is shaped by linguistic background and reduced sensitivity to unfamiliar patterns (Shang & Styles, 2017).

Thus, the BK effect sensitive period is dynamically modulated by language experience. In early language acquisition, language experience and the sensitive period work synergistically to promote sound symbolism development. In later stages, language experience may maintain BK effects for the native language while gradually diminishing sensitivity to other languages. However, whether language experience accumulation terminates the sensitive period or vice versa requires further investigation.

5.2.2. Distribution of Linguistic Arbitrariness In early language development, iconic features dominate, but arbitrariness gradually increases and becomes predominant (Monaghan et al., 2014; Dingemanse et al., 2015; Perry et al., 2015). Children initially acquire many iconic words (e.g., onomatopoeic "quack-quack") (Kantartzis et al., 2019; Jo & Ko, 2018; Perry et al., 2018). Eye-tracking research shows that eleven-month-old infants fixate faster on onomatopoeic words in naturalistic contexts, suggesting an advantage in early word learning (Laing, 2017). Additionally, fourteen-month-olds can detect sound-shape associations and use this sensitivity for word learning (Imai et al., 2015), particularly for verbs (Kantartzis et al., 2019). Monaghan et al. (2014) analyzed English corpora and found that two- to six-year-olds acquire substantial iconic vocabulary, after which arbitrary words increase until arbitrariness peaks after age 13.

Evidence also suggests that children' s sensitivity to sound symbolism changes with age. Tzeng et al. (2017) found that sensitivity exists before age three and continues developing until age seven. How does human sound-symbolic sensitivity change with age? We propose that this relates to shifts in iconic and arbitrary features. Early vocabulary learning focuses on easily symbolized iconic words, gradually strengthening sensitivity. As vocabulary expands and arbitrary words dominate, sensitivity wanes. We hypothesize that by calculating the ratio of iconic to arbitrary words in children's lexicons (denoted as d), we can predict changes in sound-symbolic sensitivity, which should follow an inverted U-shaped curve as d increases. Previous research shows that the decline in BK effect sensitivity overlaps temporally with increasing linguistic arbitrariness

(Monaghan et al., 2014), though direct empirical verification is needed.

6. An Innate-Acquired Interaction Model of Sound Symbolism

Given that the innate theory cannot exclude the role of experience and the acquired theory does not completely deny innate factors, a new theoretical model is needed to integrate these contradictions. Classic cognitive interactionism in language development holds that cognitive structures form the basis of language development, with linguistic structures evolving alongside cognitive structures that arise from interactions between organism and environment. Cognitive development is shaped by both innate and acquired factors. Schemas are cognitive structures constructed through assimilation and accommodation. Assimilation is the process of incorporating external stimuli into existing or forming schemas, while accommodation involves adjusting schemas to adapt to novel stimuli that cannot be assimilated. Adaptation to the environment achieves a temporary equilibrium (Piaget & Duckworth, 1970).

Since sound symbolism is a linguistic phenomenon and both innate and acquired theories can be integrated within this framework, we combine the language-related BK effect sensitive period hypothesis to propose the innate-acquired interaction model of sound symbolism (see Figure 2a [Figure 2: see original paper]). This model posits that sound symbolism involves both an innate mechanism and experiential drivers, shaped by the interaction between neurodevelopmental plasticity and language experience accumulation. Specifically, children possess an innate "sound symbolism cognitive structure" enabling multimodal information integration and sensitivity to all potential sound-symbolic associations. In early language development, when iconicity dominates, children' s verbal expression triggers this structure, building iconic schemas through assimilation and enhancing brain sensitivity to sound symbolism. However, as vocabulary grows and arbitrariness increases, children accommodate by forming arbitrary schemas when the sound symbolism cognitive structure cannot assimilate new words, gradually reducing sensitivity. Assimilation and accommodation operate simultaneously, but accommodation strengthens throughout development, whereas assimilation strengthens only during the sensitive period and weakens afterward (see Figure 2b [Figure 2: see original paper]). Eventually, with age and experience, dynamic equilibrium is achieved: the sound symbolism cognitive structure changes with external input. After the sensitive period, increasing arbitrariness modifies the structure through accommodation. As language experience accumulates, the ratio of arbitrariness to iconicity stabilizes, the cognitive structure adapts to environmental information, and assimilation and accommodation reach relative balance. Reinking et al. (2000) applied Piaget and Duckworth' s concepts to digital literacy instruction and observed similar assimilation and accommodation trends, providing preliminary support for our model.

Several aspects of this model receive direct or indirect empirical support. First, previous debates provide initial evidence. For example, great apes show sensitivity to crossmodal correspondences involving perceptual properties (e.g., pitch-color patches) (Ludwig et al., 2011) but not to BK effects involving sound-meaning mappings (Margiotoudi et al., 2019), suggesting that linguistic experience may be a prerequisite for acquiring the BK effect. Additionally, four-month-olds show sensitivity to simple sound symbolism (Ozturk et al., 2013), but five-month-olds fail to show sensitivity to complex symbolic stimuli (Fort et al., 2013), indicating that while infants possess innate sensitivity, insufficient language experience impedes full sound symbolism development.

Second, infants show differential sensitivity to "rounded/Bouba-type" versus "spiky/Kiki-type" stimuli, suggesting sound symbolism emerges from innate-acquired interactions. A meta-analysis by Fort et al. (2018) of infants aged 4–38 months found higher sensitivity to "rounded/Bouba-type" than "spiky/Kiki-type" stimuli, with sensitivity to the latter emerging gradually with age. This indicates temporal dissociation in the onset of different BK effect sensitivities. Yang et al. (2019) also found that eleven-month-olds were sensitive only to "rounded/Moma-type" stimuli, not "spiky/Kipi-type" stimuli. These findings suggest that infants initially develop sound symbolism for highly iconic associations (e.g., rounded sounds and rounded mouth shapes), while more subtle cues (e.g., sharp sounds and flattened mouth shapes) require greater language experience.

Third, the model predicts that continuous integration of novel information with the sound symbolism cognitive structure enhances sensitivity and may establish new crossmodal correspondences. Empirical support includes Ernst' s (2007) finding that participants formed novel brightness-hardness associations after training, and PET studies showing that brief audiovisual co-occurrence induced crossmodal correspondences (Zangenehpour & Zatorre, 2010). Additionally, children' s BK effect sensitivity can be enhanced through learning (Pejovic & Molnar, 2017), suggesting that iconic experience integrates with the cognitive structure through assimilation, thereby increasing sensitivity.

Fourth, the model' s prediction that sensitivity wanes during accommodation is reflected in changing roles of sound symbolism in vocabulary learning. Brand et al. (2018) found that sound symbolism effectively integrates into lexical structure and facilitates learning when vocabulary is small, but serves lexical categorization when vocabulary is large. This shift may occur because increased language experience promotes accommodation, gradually reducing sound symbolism' s role. Reduced sensitivity also appears in adults' diminishing sensitivity to non-native sound symbolism compared to children (Katerina & Kantartzis, 2011), suggesting that accommodation modifies the cognitive structure and weakens sensitivity across development.

This model has broad implications for language learning. In early language development, input of iconic vocabulary facilitates speech production and comprehension. For instance, mothers' frequent use of sound-symbolic words with infants promotes language understanding (Jo & Ko, 2018). However, as arbitrariness increases with age, iconic word frequency decreases with children' s developing linguistic abilities (Perry et al., 2018), and sound symbolism' s role in word learning diminishes. When vocabulary reaches a certain size, sound symbolism may instead facilitate category learning (Brand et al., 2018). These findings suggest that sound symbolism' s function changes with age, though no study has systematically examined this developmental trajectory. Our sensitive period-based innate-acquired interaction model provides a theoretical framework for future research on this topic and offers guidance for applying sound symbolism to language learning.

7. Summary and Future Directions

This review has synthesized recent research on sound symbolism and proposed the novel hypothesis of a language-related sensitive period for the BK effect. In particular, we have advanced an innate-acquired interaction model based on this sensitive period. However, several important scientific questions remain unresolved, and future research should address the following areas.

First, researchers should develop innovative paradigms to verify the BK effect sensitive period. Previous studies have primarily used environmental deprivation paradigms, which cannot exclude effects of sensory impairment. Future work should employ experience substitution paradigms, which control the nature or type of specific experiences during sensitive periods to examine their impact (Gabard-Durnam & McLaughlin, 2020). For example, to investigate the sensitive period for face recognition, researchers provided three months of macaque face exposure training to six-month-old infants, finding that trained infants retained sensitivity to macaque faces at nine months (Ortiz-Mantilla et al., 2019). Similarly, researchers could present non-native linguistic stimuli during early childhood to track changes in sensitivity to non-native sound symbolism.

Second, future studies should investigate how orthography influences the sound symbolism sensitive period. The world' s writing systems include alphabetic (phonographic) scripts like English and logographic scripts like Chinese. In alphabetic systems, symbols closely relate to phonology, whereas in logographic systems, visual form has no clear phonological correspondence (Lewis et al., 2015; Xie et al., in press). Research shows that orthography facilitates the BK effect in alphabetic scripts through mappings between letter curvature and shape (Cuskley et al., 2017). Future research should examine which orthographic features influence sound symbolism in logographic scripts like Chinese.

Third, researchers should explore the mechanism of the BK effect in second language acquisition. Given that second languages may be represented differently than first languages, future work should investigate whether BK effects in second languages follow our proposed innate-acquired interaction model. Additionally, research should examine whether BK effects in first and second languages share common linguistic representations and explore the potential for using the BK effect to facilitate second language learning.

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