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Sound-Symbolism Boosts Novel Word Learning

Gwilym Lockwood and Mark Dingemanse
Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands

Peter Hagoort
Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, and Donders Institute for Brain, Cognition, and Behaviour, Radboud University

The existence of sound-symbolism (or a non-arbitrary link between form and meaning) is well-attested. However, sound-symbolism has mostly been investigated with nonwords in forced choice tasks, neither of which are representative of natural language. This study uses ideophones, which are naturally occurring sound-symbolic words that depict sensory information, to investigate how sensitive Dutch speakers are to sound-symbolism in Japanese in a learning task. Participants were taught 2 sets of Japanese ideophones; 1 set with the ideophones' real meanings in Dutch, the other set with their opposite meanings. In Experiment 1, participants learned the ideophones and their real meanings much better than the ideophones with their opposite meanings. Moreover, despite the learning rounds, participants were still able to guess the real meanings of the ideophones in a 2-alternative forced-choice test after they were informed of the manipulation. This shows that natural language sound-symbolism is robust beyond 2-alternative forced-choice paradigms and affects broader language processes such as word learning. In Experiment 2, participants learned regular Japanese adjectives with the same manipulation, and there was no difference between real and opposite conditions. This shows that natural language sound-symbolism is especially strong in ideophones, and that people learn words better when form and meaning match. The highlights of this study are as follows: (a) Dutch speakers learn real meanings of Japanese ideophones better than opposite meanings, (b) Dutch speakers accurately guess meanings of Japanese ideophones, (c) this sensitivity happens despite learning some opposite pairings, (d) no such learning effect exists for regular Japanese adjectives, and (e) this shows the importance of sound-symbolism in scaffolding language learning.

Keywords: ideophone, sound-symbolism, synaesthesia, iconicity, word learning

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The classical view that the relation between the sound and meaning of lexical items is arbitrary is at odds with growing evidence from sound-symbolism research (Lockwood & Dingemanse, 2015; Perniss, Thompson, & Vigliocco, 2010). Sound-symbolism has mostly been investigated with variations on the *kiki/bouba* paradigm, where participants associate spiky shapes and round shapes with the nonwords *kiki* and *bouba* respectively in a forced choice task. Original forced choice experiments established that regardless of language background, people associate specific sounds with specific sensory properties, such as object roundness with vowel roundness and object size with vowel height and backness (Davis, 1961; Köhler, 1947; Newman, 1933; Ramachandran & Hubbard, 2001; Sapir, 1929). More recent behavioral experiments have probed how these effects vary when accounting for individual vowels and consonants (Nielsen & Rendall, 2013), increasing the number of choices available (Aveyard, 2012), setting the experiment up as a gradient of choice rather than alternative choices (Thompson & Estes, 2011), and replicating the paradigm with non-WEIRD (Western, educated, industrialized, rich, and democratic) (Henrich, Heine, & Norenzayan, 2010) participant groups to examine the effects of culture, orthography, and specific neurological condition (Bremner et al., 2013; Drijvers, Zaadnoordijk, & Dingemanse, 2015; Occelli, Esposito, Venuti, Arduino, & Zampini, 2013).

These studies have been instrumental in establishing that people can reliably make certain sound-meaning associations. However, the stimuli used in these experiments are nonwords that, in most cases, are deliberately constructed to maximize contrasts. This does not guarantee that findings from these experiments are representative of sound-symbolism in natural language, and therefore these findings may not directly address the processes at play in natural language learning and use.

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Gwilym Lockwood, Neurobiology of Language Department, Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands; Mark Dingemanse, Language and Cognition Department, Max Planck Institute for Psycholinguistics; Peter Hagoort, Neurobiology of Language Department, Max Planck Institute for Psycholinguistics, and Donders Institute for Brain, Cognition, and Behaviour, Radboud University.

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Correspondence concerning this article should be addressed to Gwilym Lockwood, Neurobiology of Language Department, Max Planck Institute for Psycholinguistics, Wundtlaan 1, 6525XD Nijmegen, The Netherlands. E-mail: gwilym.lockwood@mpi.nl

Sound-symbolism in natural languages is more common than often assumed (Dingemanse, Blasi, Lupyan, Christiansen, & Monaghan, 2015; Hinton, Nichols, & Ohala, 1994), and offers many possibilities for experimental investigation. Most strikingly, many of the world's languages—though not the small set of Western languages commonly studied in psycholinguistics (Majid & Levinson, 2010)—feature sizable classes of ideophones, sound-symbolic words with vivid sensory meanings (Voeltz & Kilian-Hatz, 2001; Dingemanse, 2012). Japanese, for instance, has thousands of these words (also known as "mimetics"), and their phonological, morphological, syntactic, and semantic properties are well documented (Akita, 2009; Hamano, 1998; Shogakukan, 2001). Sound-symbolism research that uses ideophones has broadly confirmed the effects from nonword experiments, showing that participants are able to guess the meaning of sound-symbolic real words at above-chance accuracy (Iwasaki, Vinson, & Vigliocco, 2007a, 2007b; Nygaard, Herold, & Namy, 2009; Oda, 2000; Revill, Namy, DeFife, & Nygaard, 2014). While two-alternative forced-choice (2AFC) experiments with ideophones have replicated findings from the nonword literature using natural language stimuli, the restricted nature of such tasks does not allow strong inferences about the strength of sound-symbolism in ideophones beyond the 2AFC context, or about the functions of sound-symbolism in language learning.

Developmental studies have shown that natural sound-symbolism scaffolds word learning in infants (Imai, Kita, Nagumo, & Okada, 2008[1]; Laing, 2014; Yoshida, 2012), perhaps by facilitating multisensory integration of linguistic form and the sensory properties of the referent (Asano et al., 2015). Previous experiments on word learning in adults have shown that adults also look for sound-symbolic cues (Nygaard, Cook, & Namy, 2009), and this suggests that natural sound-symbolism can be identified outside a 2AFC paradigm and exploited during word learning.

Nygaard et al. used a set of real words in a sound-symbolism experiment, which is a welcome departure from the typical nonword 2AFC experiments that tend to dominate the sound-symbolism literature (Lockwood & Dingemanse, 2015). The words they used are mostly adjectives, some verbs, and even a couple of nouns—all categories considered to be arbitrary in the Japanese linguistic literature. They found judgment accuracy and reaction time (RT) differences between words learned with their real translations and with random translations, with participants responding to words learned with their real translations more accurately and more quickly. They use this to support their argument that sound-symbolically congruent mappings between sound and word meaning facilitate word learning. However, they found no difference in either judgment accuracy or RT between words learned with their real and opposite translations.

While there may well be sound-symbolic traces or informative prosodic contours in the words (Kunihira, 1971), the nature of the sound-symbolic links is uncertain, and may be best described as *covert* sound-symbolism. Ideophones, on the other hand, are an example of *overt* sound-symbolism. Ideophones stand out from other words due to their morphophonological patterns, and work in linguistics and psychology has found consistent links between the sounds of the ideophones and their cross-modally congruent meanings (Vigliocco & Kita, 2006; Dingemanse et al., 2015). A learning study based on overtly sound-symbolic ideophones rather than covertly sound-symbolic regular words can clarify the role of sound-symbolism in language learning.

This study was designed to investigate whether adult participants learn words better when form and meaning match. We designed a learning and recognition experiment where Dutch participants learned Japanese ideophones with either their real translation (i.e., where the Japanese ideophones are sound-symbolically congruent with the Dutch translations) or their opposite translation (i.e., where the Japanese ideophones are sound-symbolically incongruent with the Dutch translations). We hypothesized that participants would learn the real translations better than the opposite translations because for real translations, sound-symbolic cues in ideophones would highlight perceptual analogies between form and meaning and thereby facilitate learning. We also tested the participants on a 2AFC task afterward because we hypothesized that participants would still be sensitive to the sound-symbolic cues in ideophones despite the learning task. If participants are unable to guess the meanings of the ideophones in a 2AFC task afterward (or if participants just selected the options that they learned earlier), then learning a word can suppress participants' sensitivity to sound-symbolic cues; if participants were able to disregard their earlier learned associations and guess the real meanings of the words at above chance level, then sound-symbolic cues are still available to participants despite learning a specific word-to-word mapping. Finally, we hypothesized that in a control experiment with regular adjectives, there would either be a much smaller learning effect or no learning effect at all when learning the real translations compared to the opposite translations, because overt sound-symbolic cues are not available.

Material and Method

Stimuli Selection

First pretest. We made a list of 376 reduplicated CVCV-CVCV Japanese ideophones, and translated a systematic selection of them in Dutch. Translations were agreed upon by G. L., M. D. (a native Dutch speaker and ideophone expert), and a native Dutch speaker who is fluent in Japanese. We filtered out ideophones that had strongly similar forms and meanings (e.g., *bakibaki* and *bokiboki*, both of which mean a cracking sound like of tree branches or knuckles), and kept the most frequent or canonical ideophone only. We also filtered out ideophones where a simple Dutch translation couldn't fully distinguish between different concepts (e.g., *hatahata*, *batabata*, and *patapata*, all of which mean "flapping" but to a greater or lesser degree). Finally, we aimed for translations that were as short and as uniform across opposites as possible, so we filtered out ideophones where it was not possible to get a good translation of its opposite meaning (e.g., we could not find an opposite to *muzumuzu*, meaning "itchy," other than "not itchy").

This left us with 95 ideophones that had good Dutch translations for both their real and opposite meanings. We used the CELEX database to ensure that there was no difference in word frequency between the real and opposite translations. There were also no differences between conditions in terms of word length and the

[1] While Imai et al. (2008) used nonwords for this experiment, they did so based on standard Japanese ideophonic templates, which were then approved as acceptable, naturalistic words by adults. The use of nonwords in Imai et al. (2008) is far more like the use of real ideophones than the use of *kiki/bouba*-esque materials.

number of letters in common between the translation and the ideophone. We recorded a female native Japanese speaker, unaware of the experimental manipulation, reading aloud each ideophone in a soundproof booth. Recordings were then checked with another native Japanese speaker to ensure that intonation and pitch accent were natural.

We conducted a stimuli selection pretest with 26 native Dutch speakers (nine male, 15 female, 22–35 years old) to see whether participants could guess the meaning of the ideophone at above chance levels. This was a 2AFC task, where participants saw and heard the ideophone, then saw two possible Dutch translations; the real translation and the opposite translation (although 2AFC tasks have their limitations—as we point out above and elsewhere [Lockwood & Dingemanse, 2015]—we find they can be useful when supplemented with other methods, as here). Participants were instructed to pick the translation that best matched the ideophone by pressing the left CTRL key to select the word on the left, and the right CTRL key to select the word on the right. The procedure is shown in Figure 1.

We used Presentation software to present stimuli and record responses. Participants guessed the ideophones correctly 63.1% of the time, which was above chance (95% confidence intervals [CIs] [60.6%, 65.7%], $\mu = 0.5$, $p < .001$). Even though this was a stimuli selection pretest, it is of interest to show that people with no knowledge of Japanese can guess the meanings of a large selection of ideophones at above chance accuracy. This is generally taken for granted, but our study is, to our knowledge, the most extensive demonstration of this beyond Iwasaki et al. (2007b), who only tested two semantic domains by using 24 mimetic words for laughing and 28 mimetic words for walking.

Afterward, we asked participants whether there were any ideophones that resembled related Dutch words. This filtered out confound words like *wakuwaku* (meaning "excited," but also a Dutch children's TV show), *iraira* (meaning "angry," but too close to English words such as *irate* and *irritated*), and *pikapika* (meaning "bright, flashing," but also the battle cry of Pikachu, a character who attacks using flashes of electricity (Oak, 1996), from the Pokémon video game and TV show that was popular with participants of this generation). We selected the 50 ideophones that were guessed most accurately in the pretest (which was over 63% of the time). The entire 2AFC test showed that ideophones are, on the whole, sound-symbolically informative to Dutch speakers, but to home in on potential learning effects, we used the individual ideophones that were most obviously sound-symbolic.

We removed 12 ideophones from these 50: *pikapika*, *iraira*, and *wakuwaku* due to world knowledge confounds; four others due to the fact that one of the translations shared the same first letter as the ideophone; *suyasuya*, meaning "sleeping peacefully," which we could not find a one-word translation for; and four more ideophones that were guessed at under 50% accuracy in the second pretest, which was used to pilot the learning task.

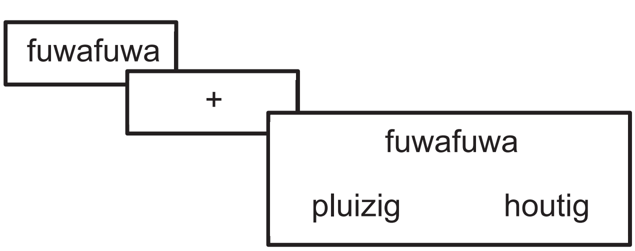

Figure 1. Stimuli selection pretest two-alternative forced-choice procedure.

Second pretest. This second pretest was actually intended as the main experiment, and involved participants learning the ideophones by making 2AFC decisions and then receiving feedback about whether they were correct. Participants saw and heard an ideophone, and then saw two Dutch translations; the real translation and the opposite translation. When they selected one, they were informed whether they were "correct" (i.e., if they had chosen the real translation in the real condition, or the opposite translation in the opposite condition) or "incorrect." This continued for three rounds or until participants could choose the correct word over 80% of the time (which occasionally took four or five rounds). They then performed one final 2AFC test. We hypothesized that participants would find it harder to remember the Dutch translations for ideophones in the opposite condition, and this is indeed what we found; participants made significantly more mistakes in the final 2AFC test when choosing the translations for the ideophones in the opposite condition than ideophones in the real condition. However, there was a major confound: We used the same real and opposite translations in each learning round, which meant that about a third of the participants realized that they could ignore the ideophone and just remember which of two Dutch words to choose each time. This is the point at which we decided that moving beyond 2AFC experiments was essential. Despite this, though, the participants still made more mistakes in the opposite condition. The participants in this second pretest were divided into two groups where the ideophones in real and opposite conditions were counterbalanced. Participants in Group 1 made an average of 9.33 mistakes in the real condition and 14.07 mistakes in the opposite condition; participants in Group 2 made an average of 9.4 mistakes in the real condition and 15.33 mistakes in the incorrect condition. As both groups recalled the real translations better than the opposite translations, we did not counterbalance the ideophones across conditions in the full experiment; each participant learned half the ideophones in the real condition and half the ideophones in the opposite condition, and these were the same across participants.

Experiment Procedure: Experiment 1

We used the 38 ideophones from the pretest for Experiment 1, where we tested 32 participants (10 male, 22 female). As in the pretest, there were no differences in the number of letters in common between the ideophones and between the Dutch words across conditions. We used the CELEX database to additionally ensure that there was no difference in word frequency between the Dutch words that the participants learned in the real and opposite conditions. Two participants were discarded; one for pressing the wrong response buttons throughout the experiment, the other for taking an abnormally long time during the self-paced learning sessions (RTs were not recorded for this part, but lab notes taken at the time noted that the participant took a lot longer to complete the task). This resulted in 30 participants whose data we analyzed.

Participants learned the real translations to 19 ideophones and the opposite translations to the other 19 ideophones. In one learning round, participants saw each ideophone and translation once, and then saw the ideophone and translation together. There were two learning rounds in total. The order of Dutch words and ideophones was randomized for each round and for each participant, but the items and conditions were fixed across participants (Table 1).

In the learning round, the initial Dutch word was presented for 1,000 ms with 100 ms of jitter, followed by a fixation cross for 1,000 ms with 100 ms of jitter. As the ideophone was played over the speakers, the ideophone was presented visually for 2,000 ms with 200 ms of jitter. This was again followed by a fixation cross. The final screen with the ideophone and its Dutch meaning was presented until participants were happy to move onto the next item. Between trials, a blank screen was presented, followed by a fixation cross to announce the beginning of the next trial. The set-up of the learning stage can be seen in Figure 2.

In the test round, participants were presented with either the word pairs that they had learned, or a pseudorandomized pairing of ideophones and translations that they had not seen paired together before. These pairings were pseudorandomized to ensure that the meanings were semantically unrelated (e.g., the Japanese *fuwafuwa*, learned as "fluffy," and the Dutch *kortaf*, meaning "curt"). Participants were instructed to answer "yes" (indicating that this was a word pair that they had learned) or "no" (indicating that this was not a word pair that they had learned) using the left CTRL key for yes and the right CTRL key for no. Pairs requiring a yes response made up 50% of the trials. As in the learning round, participants saw the Dutch word first, then saw and heard the Japanese ideophone, but this time they were asked to respond as soon as possible after seeing and hearing the Japanese ideophone rather than waiting for a screen where both words were presented at the same time. Timings in the test stage were identical to the learning stage. The fixation cross was displayed until participants responded, at which point a blank screen was presented, followed by a fixation cross to announce the beginning of the next trial. This is illustrated in Figure 3.

After the test round, we told the participants that half the words they had learned had the real meanings, but half actually had the opposite meaning. We asked them to forget everything they had learned, and instead to choose which translation they felt was more natural for each ideophone. Participants saw and heard the ideophone, and then saw two possible Dutch translations; the real one and the opposite one (i.e., they saw the translation they had learned, and the opposite of that translation). They selected what they felt was the most natural translation by pressing the left CTRL key for the translation on the left and the right CTRL key for the translation on the right. As in the pretest, there were no differences between the frequencies of the real and opposite Dutch words. Timings were identical to the earlier stages. The final screen was displayed until participants responded. This was identical to the stimuli selection pretest, and is illustrated in Figure 4.

Experiment 2: Stimuli Selection and Experiment Procedure

We ran a second experiment with regular adjectives—that is, presumably non-sound-symbolic words—to investigate to what extent behavioral effects found were due to the sound-symbolic nature of ideophones. This experiment was done with a separate group of 30 participants.

Stimuli were selected in a similar way to Experiment 1. We created a list of 87 Japanese adjectives and translated them into Dutch for both their real and opposite meanings. We used the CELEX database to ensure that there was no difference in word frequency between the real and opposite translations, nor was there a difference in word frequency between the words that the participants learned in real and opposite conditions. There were also no differences between conditions in terms of word length and the number of letters in common between the translation and the regular adjective. The same female native Japanese speaker provided the recordings.

We conducted a stimuli selection pretest with 28 native Dutch speakers (nine male, 17 female, 20–40 years old) in order to see whether participants could guess the meaning of the words at above chance levels. The procedure was identical to the first pretest for Experiment 1. We used Presentation software to present stimuli and record responses. Participants guessed the words correctly 55.3% of the time, which was above chance (95% CIs [53.4%, 57.2%], $\mu = 0.5$, $p < .001$). We asked participants afterward whether there were any ideophones that resembled related Dutch words. The word *kawaii* (meaning "cute") was filtered out, because this is a well-known word in popular culture. We also excluded words that were shorter than three syllables to keep the Japanese word length consistent across the two experiments. We selected the 38 most correctly guessed regular adjectives in order to remain consistent with Experiment 1. All were guessed above 53.6% (average 55.3%). In Experiment 2, we tested 30 participants (eight male, 22 female), and the procedure was exactly the same as in Experiment 1.

Results

Experiment 1: Ideophone Learning

Participants made more recognition mistakes in the opposite condition than in the correct condition; participants correctly remembered the real word pairing 86.1% of the time, but correctly

Table 1
Two Example Stimuli for Each Condition

Real condition		Opposite condition	
Ideophone	Translation	Ideophone	Translation
fuwafuwa ("fluffy")	*pluizig* ("fluffy")	*kibikibi* ("energetic")	*futloos* ("tame, tired")
boroboro ("worn out")	*versleten* ("worn out")	*ukiuki* ("happy")	*verdrietig* ("sad")

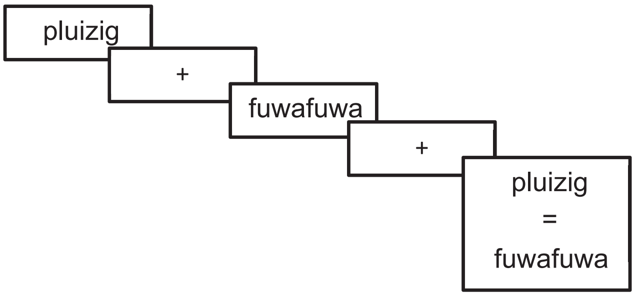

Figure 2. Learning stage procedure.

remembered the opposite word pairing only 71.1% of the time (see Figure 5).

As the dependent variable was binary—correct or incorrect—we analyzed the responses using a mixed-effects logit model with the glmer function of the lme4 (Versions 1.1–8) package in R. The data was modeled by including a per-participant and per-item random adjustment to the fixed intercept with a condition random slope for the fixed effect by participant. The condition was sum contrast coded.

Model comparison showed that a random effect by ideophone did explain some variance in the data (log-likelihood difference = 7.12, $\chi^2 = 14.24$, $df = 1$, $p < .001$). That means that some ideophones were answered correctly more often than others. However, even when controlling for this random effect by ideophone, model comparison still showed a significant fixed effect of condition ($\beta = -0.5978$, log-likelihood difference = 8.85, $\chi^2 = 17.695$, $df = 1$, $p < .001$). The model estimated that ideophones learned in the real condition were answered 9.53 percentage points more accurately than ideophones learned in the opposite condition.

There were also significant differences in RTs between conditions, with participants responding faster to ideophones in the real condition (mean RT = 1,794 ms) than the opposite condition (mean RT = 2,280 ms). The data was modeled by including a per-participant and per-item random adjustment to the fixed intercept with a condition random slope for the fixed effect by participant. The condition was sum contrast coded. The model showed a significant fixed effect of condition ($\chi^2 = 13.92$, $p < .001$). This difference existed even when only analyzing correctly answered trials ($\chi^2 = 8.10$, $p = .0044$), and so is not just a speed/accuracy trade off. There was also a strong correlation between the number of correct responses per ideophone and the speed of the reaction to that ideophone; the better an ideophone was remembered, the faster it was responded to ($r = -0.67$, $p < .001$). However, there was no correlation between the number of correct responses per

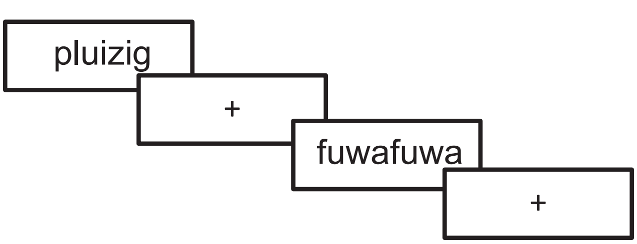

Figure 3. Test stage procedure.

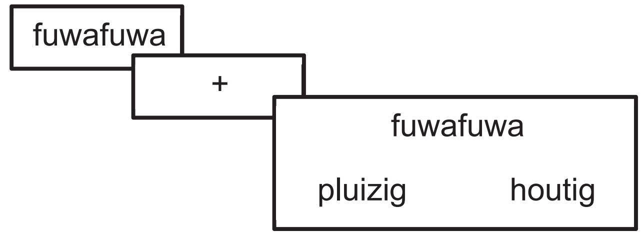

Figure 4. Post-test sound-symbolic sensitivity check procedure.

participant and RTs, meaning that more accurate participants were not necessarily faster at responding.

In the sound-symbolism sensitivity check after the experiment, participants guessed the real meanings of the Japanese words with 72.3% accuracy, which was comfortably above chance ($\mu = 0.5$, $t = 10.51$, $df = 29$, $p < .001$). Only one participant guessed the meanings at below 50% accuracy, one ideophone (*tsuyatsuya*) was guessed at 50% accuracy, and only one ideophone (*gowagowa*) was guessed at below 50% accuracy (although it was guessed at 69% accuracy during the pretest). We checked if participants who guessed more accurately also guessed faster, but there was no link between RTs and accuracy ($r = .13$, $n = 30$, $p = .49$). We also checked if ideophones that were guessed more accurately were also guessed more quickly. There was a correlation between RT and the mean accuracy at which the ideophone was guessed ($r = -0.39$, $n = 38$, $p = .015$), and this was not a speed/accuracy trade off.

Experiment 2: Regular Adjective Learning

In contrast to Experiment 1, there was no learning effect present in Experiment 2, which used regular adjectives instead of ideophones: Participants correctly remembered the real word pairing 79.1% of the time, and the opposite word pairing 77% of the time (see Figure 6).

We analyzed the responses using the same mixed-effects logit model and modeling procedure as in Experiment 1. Model com-

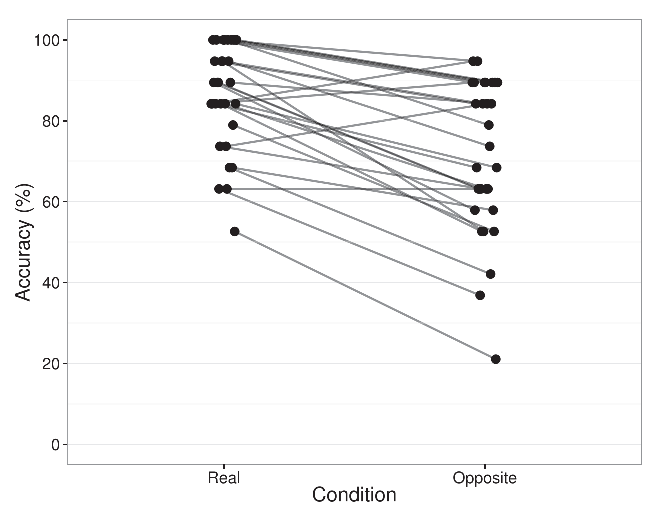

Figure 5. Ideophone recognition accuracy per condition.

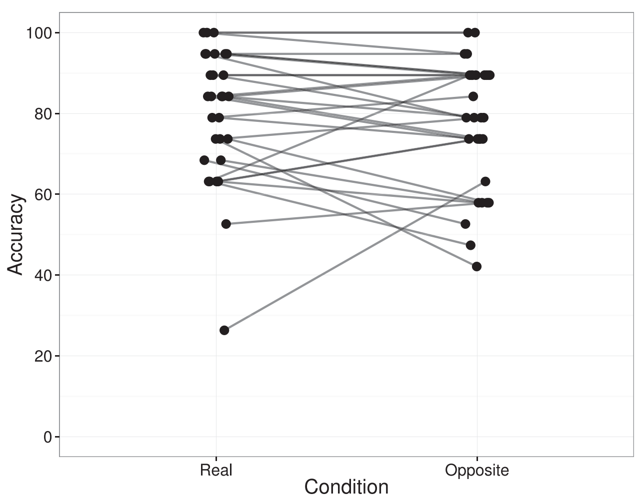

Figure 6. Regular adjective recognition accuracy per condition.

parison showed a random effect by regular adjective did explain some variance in the data (log-likelihood difference = 12.86, $\chi^2 = 25.718$, $df = 1$, $p < .001$). That means that some regular adjectives were answered correctly more often than others. However, when controlling for this random effect by regular adjective, model comparison showed no fixed effect of condition ($\beta = -0.1256$, log-likelihood difference = 0.38, $\chi^2 = 0.7739$, $df = 1$, $p = .379$). The model estimated that regular adjectives learned in the real condition were answered 1.81 percentage points more accurately than regular adjectives learned in the opposite condition.

Similarly, there were no statistical differences in RTs between the two conditions, either for all trials ($\chi^2 = 0.14$, $p = .70$) or correctly answered trials only ($\chi^2 = 0.51$, $p = .48$). In the sound-symbolism check after the experiment, participants guessed the real meanings of the regular adjectives with 63% accuracy, which was again above chance ($\mu = 0.5$, $t = 7.21$, $df = 29$, $p < .001$). This is far lower than the 72.3% accuracy in the ideophone condition, but these figures cannot be compared directly as it involves two different groups of participants guessing the meanings of two different sets of words. Three participants guessed the meanings at below 50% accuracy, one word was guessed at exactly 50% accuracy, and four words were guessed at below 50% accuracy. For measures involving RTs, the correlations were reversed relative to Experiment 1. There was no correlation between the number of correct responses per ideophone and the speed with which participants responded to them ($r = -0.1$, $p = .54$), but there was a correlation for participants' accuracy and RTs, in that the more accurate participants took longer to guess the words ($r = .46$, $p = .011$).

Discussion

In Experiment 1, we taught Japanese ideophones to Dutch participants with their real and opposite translations, and we found that participants learned the sound-symbolically congruent word pairs (i.e., the ideophone and its real translation) better than the sound-symbolically incongruent word pairs (i.e., the ideophone and its opposite translation). This was corroborated by RTs, which showed that participants responded faster to the sound-symbolically congruent word pairs. We also found that, despite learning 50% incorrect mappings in the learning task, participants were still able to categorize the ideophones at above chance accuracy in a 2AFC test afterward.

In Experiment 2, another set of Dutch participants learned regular Japanese adjectives with their real and opposite translations. Here there was no learning effect at all, nor a difference in RTs, although participants were still able to categorize the regular adjectives at above chance accuracy in a typical 2AFC test afterward. The learning task results for both conditions in both experiments are shown in Figure 7. These findings show that sound-symbolism in Japanese is robustly recognizable by Dutch speakers outside a forced choice paradigm, and that it can be exploited to facilitate word learning. This provides solid empirical grounding for the developmental literature about sound-symbolic bootstrapping, which has tended to use nonwords rather than real sound-symbolic words.

These findings go beyond previous behavioral work on sound-symbolism in two key ways. First, the stimuli more accurately reflect the nature of sound-symbolism in natural language, as we use existing sound-symbolic words from a natural language as opposed to deliberately contrastive nonwords. Second, the task speaks more directly to theories about the role of sound-symbolism in learning, as we use a word learning task where participants are free to learn the ideophones and Dutch translations, rather than using a 2AFC word guessing task, which limits and shapes the cross-modal associations that participants may form.

The effect of sound-symbolism in Experiment 1 is strong and consistent: While some ideophones were answered correctly more often than others, model comparison showed that condition predicted the learning effect when controlling for random effects of ideophones. All but two ideophones were mistaken at least once in the recognition task, and only one ideophone was mistaken in the recognition task by more than half the participants (and even then, only by 17 out of 30); the rest are evenly distributed across those two points. This suggests that the sound-symbolic effect is present across all the ideophones used, affirming the sound-symbolic potential of ideophones.

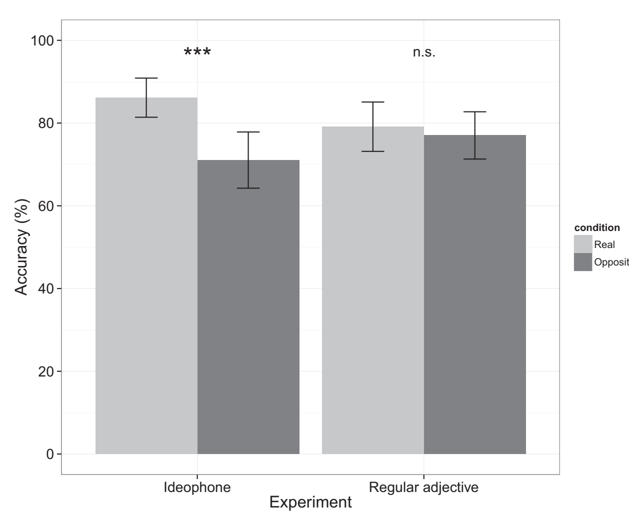

Figure 7. Recognition accuracy per condition per experiment with 95% confidence intervals.

That we obtained these results despite the open nature of the stimuli and task shows that naturally attested forms of sound-symbolism are robust beyond the classic 2AFC paradigm. Of previous studies, only Nygaard et al. (2009) use similar materials and methods. They found judgment accuracy and RT differences between words learned with their real translations and with random translations, with participants responding to words learned with their real translations more accurately and more quickly. But, they found no difference in either judgment accuracy or RT between words learned with their real and opposite translations. Nygaard et al. argue that this shows that sound-symbolically congruent mappings between form and meaning facilitate word learning. Our Experiment 2 lends support to this interpretation by replicating their finding: For regular adjectives, we find no difference in judgment accuracy and RTs between real and opposite conditions. Experiment 1, meanwhile, allows us to further explore the nature of sound-symbolic congruence: There, we find large differences in both accuracy judgments and RTs between real and opposite conditions. We expect that this difference is due to our use of overtly sound-symbolic ideophones, as the sensory sound-symbolism in ideophones makes them more transparently iconic than the technically arbitrary and covertly sound-symbolic adjectives that were used in Experiment 2 and in Nygaard et al. (2009).

Comparing Experiment 1 and Experiment 2 (with the caveat that these were done by different sets of participants) suggests that the effect may be driven by both a sound/meaning match providing a mapping boost and a sound/meaning mismatch creating a mapping difficulty. For ideophones (Experiment 1), the difference between the real and opposite conditions is maximal: 86.1% versus 71.1% correct responses. For adjectives (Experiment 2), the difference between real and opposite conditions is minimal, indeed nonsignificant: 79.1% versus 77% correct responses. That ideophones outperform adjectives in the real condition suggests that the sound/meaning match may provide a mapping boost that helps participants remember the real words, a finding that is in line with the developmental literature on the role of sound-symbolism in learning (Imai & Kita, 2014). When this sound/meaning match is not present, participants may default to assuming word arbitrariness, which also works but not quite as well (as seen in the adjectives). That ideophones lead to worse performance than adjectives in the opposite condition suggests that the sound-meaning mismatch may create a mapping difficulty, the converse of the putative mapping boost seen in the real condition. However, it is important to stress that the two experiments featured different groups of participants learning different test items, and the hypothesis of a sound-meaning match mapping boost and a sound-meaning mismatch mapping difficulty can only be tested with the same participants learning both sets of words.[2] More research is needed to uncover the mechanism by which naïve participants come to have different expectations about ideophones versus adjectives in a language they do not speak, but the answer lies likely in a combination of the special morphophonological shapes of ideophones and their relatively specific meanings as compared to adjectives (Akita, 2011; Dingemanse, 2012).

It is possible that having the 2AFC task after the learning round could bias the participants toward just selecting the words they had learned and remembered, rather than assessing their sensitivity to sound-symbolism in general. However, participants could guess the real meanings of the words that they learned in both conditions at the same accuracy. This was the case in both Experiment 1 (75.1% guessing accuracy for ideophones previously learned in the real condition, 69.5% guessing accuracy for ideophones previously learned in the opposite condition, $t = 1.31$, $p = .2$) and Experiment 2 (65.1% guessing accuracy for regular adjectives previously learned in the real condition, 60.8% guessing accuracy for regular adjectives previously learned in the opposite condition, $t = 1.12$, $p = .27$). This suggests that a general sensitivity to sound-symbolism persists throughout, and despite, learning opposite mappings. However, it cannot be excluded that this effect may disappear with familiarity with the words, meaning that additional learning rounds and test rounds may bias participants toward selecting answers in the 2AFC task based on what they had learned rather than on their intuition.

It is interesting that the regular Japanese adjectives were also guessed at above chance level in the stimuli selection pretest (at 55.3% accuracy, compared to 63.1% accuracy in the ideophone stimuli selection pretest). This result is probably driven by a certain amount of low-level sound-symbolism in the mostly arbitrary words, and the residual levels of informative prosody in the native speaker's recordings; that is, the kind of covert sound-symbolism that is also present in Nygaard et al. (2009). It is probably too simplistic to think of sound-symbolism as a binary feature that words or word classes do or do not have; instead it is more useful to think about the *degree* of iconicity (or sound-symbolic congruency) in form-meaning correspondences (Dingemanse et al., 2015; Perry, Perlman, & Lupyan, 2015). Here, we have used ideophones as a word class with a relatively high degree of iconicity to study learning effects of sound-symbolism, and we have used regular adjectives as a word class with relatively lower degree of iconicity as a control condition to make sure the learning effects really are due to sound-symbolism.

Our finding that Dutch participants learn sound-symbolic words with their real meanings better than sound-symbolic words with their opposite meanings raises the questions of how exactly this works, and how universal this is. Future research is required into ideophones from other languages than Japanese with participants with native languages other than Dutch.

Conclusion

This study has shown that Dutch speakers are sensitive to the meanings of Japanese ideophones in both a 2AFC task and a learning task. Sound-symbolism appears to provide a mapping boost: When sound and meaning are congruent, learning the link between them is easier. A second experiment with regular adjectives found no such learning effect. This shows that the word classes of natural language may differ in the degree to which they show sound-symbolism, with ideophones being more strongly sound-symbolic than regular adjectives. Our results suggest that sound-symbolism in ideophones is universally perceivable to at least some extent, and that not only children but also adults can use sound-symbolic cues to bootstrap word learning.

[2] For the record, the difference between the two match (i.e., real translation) conditions is $t = 1.8$, $p = .076$, and the difference between the two mismatch (i.e., opposite translation) conditions is $t = 1.3$, $p = .19$. However, we provide these cross-experiment statistics only as a reference point for performing future within-subjects experiments.

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