

The Use of Iconic Words in Early Child-Parent Interactions

Marcus Perlman (marcus.perlman@mpi.nl)

Language & Cognition Department

Max Planck Institute for Psycholinguistics, Nijmegen, 6500 AH The Netherlands

Riccardo Fusaroli (fusaroli@cc.au.dk)

Department of Communication and Culture & the Interacting Minds Center,
Aarhus University, Jens Chr Skous Vej 2, Denmark

Deborah Fein (deborah.fein@uconn.edu) & Letitia Naigles (letitia.naigles@uconn.edu)

Department of Psychological Sciences
University of Connecticut, Storrs, CT

Abstract

This paper examines the use of iconic words in early conversations between children and caregivers. The longitudinal data include a span of six observations of 35 children-parent dyads in the same semi-structured activity. Our findings show that children’s speech initially has a high proportion of iconic words, and over time, these words become diluted by an increase of arbitrary words. Parents’ speech is also initially high in iconic words, with a decrease in the proportion of iconic words over time – in this case driven by the use of fewer iconic words. The level and development of iconicity are related to individual differences in the children’s cognitive skills. Our findings fit with the hypothesis that iconicity facilitates early word learning and may play an important role in learning to produce new words.

Keywords: iconicity; vocabulary development; child-directed speech; sound symbolism

Introduction

How do young children learn to understand and use their first words? Philosophers have pointed out the inductive challenge of learning to associate the sound of a word with its meaning (Quine, 1960), and developmental psychologists observe that this challenge is compounded for an infant (Imai & Kita, 2014). Not only must infants isolate the meaning of a word from a noisy, complex environment and learn to generalize it to new contexts, they must grasp the very concept of a symbol in the first place.

One cue infants may utilize to facilitate early word learning is *iconicity* – a degree of resemblance between the form of a signal and its meaning. For example, a person might represent ‘small size’ with an index finger-to-thumb pinching gesture, or in speech, by raising the pitch of their voice as they articulate the small-sounding word “itty-bitty”. One proposal for how iconicity can help early word learning in spoken languages is the sound symbolism bootstrapping hypothesis (Imai and Kita, 2014). (The term “sound symbolism” is often used to refer to iconicity in spoken words.) On this idea, children are biologically endowed with a bias to recognize various cross-modal correspondences between sound and phenomena of the other senses – for example, between pitch and size or brightness, or between

the duration of a sound and the visual extension of a line (see Spence, 2011 for a review of crossmodal correspondences). These biases, which may also be learned by experience, might bootstrap children into the connection between the sounds of iconic words and their corresponding meanings (Imai & Kita, 2014; Perniss & Vigliocco, 2014). The sound of a word could help children identify its intended referent from a complex scene, recognize the invariance of its meaning across contexts, and apply it productively to new contexts. By helping children connect spoken words with their meanings, iconicity may help children gain the “referential insight” that speech sounds refer to entities and properties in the world.

Laboratory studies of iconicity in word learning

Laboratory studies show that young children are indeed sensitive to iconicity in spoken words, and some studies suggest further that this iconicity can facilitate word learning. Maurer et al. (2006) found that 2.5-year-old children were more likely to match nonsense words containing rounded vowels (e.g. *bouba*) with rounded shapes, and words containing unrounded vowels (*kiki*) with pointed shapes. Another study, using a preferential looking paradigm, found that infants as young as four months are sensitive to this *bouba-kiki*-type iconicity (Ozturk et al., 2012). There is also evidence that sound-shape correspondence can more directly facilitate word learning in infants (Imai et al., 2015). 14-month-old infants were habituated to combinations of a novel word and a picture of an object, in either an iconically matching or mismatching condition. When the children were then presented with the novel words along with a picture of the correct object and a distractor, they looked more at the correct object when its sound and shape were matching.

The sensitivity of infants to sound-shape iconicity has also been demonstrated using electroencephalography (Asano et al., 2015). Event related potentials were measured as 11-month-old infants were presented with pictures of shapes followed by novel words that matched or mismatched the shape in iconicity. With mismatching word-shape pairs, subjects showed a response similar to the N400 effect, typically an index of difficulty with semantic

integration. Analysis of brain oscillations found an increase in early γ -band oscillations in the matching condition, which might indicate increased cross-modal integration between the sound of the word and its visual referent.

Importantly, children can benefit from iconicity in learning to associate sounds and meanings in domains outside of shape. Imai et al. (2008) presented 25-month-old Japanese toddlers with novel words along with two video clips of people performing two different manners of walking. Norming with adult Japanese and English speakers had determined that one of the videos, but not the other, was iconically congruent with the verb. Similarly, when the children were asked to select the manner of walking to which they thought the word referred, they were more likely to choose the one that matched the verb. A subsequent experiment found that 3-year-old Japanese children were able to correctly generalize the iconic verbs to new agents, but were unable to generalize non-iconic verbs. Further work replicated the finding with 3-year-old English learners, indicating at least some level of universality in the iconicity of the sound-referent pairings (Kantaris et al., 2011). A study by Yoshida (2012) found similar results with Japanese- and English-speaking toddlers.

Iconicity in natural word learning

These laboratory studies show that young children are sensitive to certain forms of iconicity in spoken words, and under some conditions, they can learn iconic words faster than non-iconic words. However, if iconicity does play an important role in early word learning in the wild, then there should be evidence of this in natural language learning. In particular, children should learn more iconic words earlier, and caregivers should be more inclined to use iconic words with early learners.

A recent study of English and Spanish found that children do tend to learn more iconic words earlier (Perry et al., 2015). Perry et al. collected native speaker iconicity ratings of roughly 600 English and Spanish words that are learned earliest by children according to the respective MacArthur-Bates Developmental Inventories (MCDIs). They asked participants to rate the degree to which the words “sound like what they mean”. The age of acquisition (AoA) of words was indexed by the proportion of children using the word at 30 months according to the MCDI database. Over multiple experiments in both languages, the results showed that words rated as more iconic were acquired earlier by children.

Notably, this relationship held after controlling for the systematicity of words as measured by Monaghan et al. (2014). Systematicity is an index of the degree to which similar meanings have similar forms in the lexicon of a language. Monaghan et al. found that, from the age of 2 to 13+ years, children tended to learn more systematic words earlier. According to Monaghan et al., in theory, iconicity and systematicity are orthogonal properties. Words can be systematic but not iconic – a point they illustrate with the English consonant cluster *sl-* (e.g. *slime*, *slow*, *slur*, *slum*),

which systematically refers to negative or repellent properties, but bears no clear resemblance to this meaning. Yet, it is questioned whether spoken languages afford sufficient articulatory freedom for words to be iconic but not systematic. For instance, Monaghan et al. offers the example of onomatopoeic words for the calls of small animals (e.g. *peep*, *cheep*) compared to calls of big animals (*roar*, *grrr*), which both iconically and systematically reflect the animals’ size. However, Perry et al.’s (2015) finding that the iconicity-AoA relationship held after controlling for systematicity shows some limited support for the independence of these properties in English – at least for the roughly 300 words for which these measures overlapped. In further support for their independence, Winter et al. (in press) examined the relationship between iconicity ratings and Monaghan et al.’s systematicity index for 1,104 words, and found only a weak correlation of $r = 0.06$.

Following the study of Perry et al. (2015), a couple of subsequent studies have found comparable results. Massaro and Perlman (2017) used the same procedure to collect new iconicity ratings for the English MCDI words. They used these to examine the relationship between iconicity and the frequency with which children used the words from 6 to 47 months of age. The study found a gradual decrease in the influence of iconicity on children’s production vocabulary with increasing age. An analysis of children’s receptive and productive vocabularies with respect to increasing vocabulary size showed that the average iconicity of their vocabulary declined with increasing size.

Massaro and Perlman (2017) observed that the very first words that children produced were especially high in iconicity and included a relatively high number of onomatopoeic words. This observation is consistent with some other studies of early vocabulary, which indicate that a high proportion of children’s first words are onomatopoeic or mimetic words. As reported by Laing (2015), a study of children’s first five words across various languages found that about 20% were onomatopoeic (Menn & Vihman, 2011). Another study found that 3-year-olds used more mimetics to describe motion events than 5-year olds (Kita et al., 2010).

In addition to the high level of iconicity in children’s early spoken words, Perry et al. (in press) examined whether parents use more iconic words in child-directed speech. The study included iconicity ratings for approximately 2000 English words including Perry et al.’s (2015) prior ratings. First, the study replicated the finding of a relationship between the iconicity of words and their age of acquisition, which was indexed by norms based on adults’ subjective ratings (Kuperman et al., 2012). Second, the study examined how iconicity influenced the frequency of words used in children’s speech, as well as in the child-directed and adult-directed speech of adults. Word frequencies in child-produced and child-directed speech were calculated from the Child Language Data Exchange System (CHILDES), and word frequencies of adult-adult speech were from the American National Corpus. The results showed that younger

children tended to use higher iconicity words more frequently, but with age, they increasingly favored lower iconicity words. Analyses of adult speech found that adults used higher-iconicity words more frequently when talking to children, but used lower iconicity words more frequently with adults. Thus, as children became older and their vocabulary grew in size, their speech became more adult-like in the use of iconic words.

The finding that parents used more iconic words in child directed speech fits with some previous observations of Japanese-speaking parents. Imai and Kita (2014) described two studies published in Japanese that found that caretakers used more mimetics and onomatopoeia with younger children, but used these words less frequently as children became more language proficient (Saji & Imai, 2013; Suzuki, 2013). However, caution should be applied in generalizing across languages: Japanese-speaking parents have been shown to use more onomatopoeia and mimetics than English speaking parents, who nevertheless do use some onomatopoeia and especially sound effects (Fernald & Morikawa, 1993; Yoshida, 2012).

Current study

In the current study, we examined how the use of iconic words in early conversations between children and caregivers develops within individual children-parent dyads, while controlling for production setting and individual differences in the children's verbal and nonverbal skills. The longitudinal data include about six observations for each of 35 dyads within the same semi-structured activity across children and ages. We examine the change in the use of iconic words in children's speech in comparison to the speech of their parents, allowing us to investigate how parents adapt their level of iconicity to their children's language proficiency. We also explore how individual differences of the children (verbal and nonverbal IQ) relate to the use of iconic words by children and parents over development.

Methods

Participants

As part of an ongoing longitudinal study investigating language acquisition in young children with autism spectrum disorder (Goodwin, Fein, & Naigles, 2012; Tek, Mesite, Fein, & Naigles, 2014), we recruited 35 typically developing children (6 girls, mean age at onset = 20.27 months, 95% CIs: 19.78 20.93). All children were monolingual English learners. Their average verbal IQ at visit 1 (as measured by MSEL-EL, cf. below) was 19.89 (95% CIs: 18.4 21.76) and perceptual IQ at visit 1 (as measured by MSEL-VR, cf. below) 26 (95% CIs: 24.83 27.09).

Iconicity, systematicity, and concreteness

Iconicity ratings were taken from two previous studies, which collected ratings for 3001 English words (Perry et al.,

2015; Winter et al., in press). Approximately 600 of the words were selected from the MCDI (Fenson et al., 1994), and additional words were chosen to maximize coverage with relevant psycholinguistic datasets of age of acquisition and concreteness norms. Complete methodological details can be found in Perry et al. Native English speakers on Amazon Mechanical Turk rated the iconicity of the words on a scale from -5 to 5, where 5 indicated that a word was highly iconic and sounds like what it means, -5 that it sounds like the opposite of its meaning, and 0 that it is completely arbitrary. The words "slurp" and "teeny" were suggested as examples of highly iconic words, "cat" and "dog" as arbitrary words (Pinker & Bloom, 1989), and "whale" and "microorganism" as opposite-sounding words (Hockett, 1960). Each word was rated by at least 10 participants. The average iconicity rating across all words was 0.92 (SD = 1.13).

Systematicity measures were taken from Monaghan et al. (2014). This study computed systematicity for a large set of monosyllabic English words by measuring the overall correlation between the degree of similarity between the forms of any two words in the set, and the degree of similarity between their corresponding meanings. Ratings for individual words consisted of their contribution to the overall form-meaning correlation across all the words. Concreteness ratings were taken from Brysbaert et al. (2014), which were collected for 40 thousand English words and short phrases via Amazon Mechanical Turk. Words were rated 1 'abstract' to 5 'concrete'.

Speech data

The data were collected across six home visits, each separated by 4 months. For six children, data at one visit were missing. This generated a total of 204 visits. During each visit, children engaged in a 30-min semi-structured parent-child play session. All sessions were transcribed at the word-level. The 204 transcripts analyzed consisted of 465,474 words (99,210 of children's speech, CS) and 4143 unique words (2185 in CS). 1334 unique iconicity-rated words were found (899 in CS), covering 32% of all unique words used (41% in CS) and 78% of all used words (72% in CS). The systematicity coding covered 699 employed unique words (515 in CS): 17% of all employed unique words (12% in CS) and 26% of all employed words (24% in CS). Altogether, the iconicity, systematicity, and concreteness coding covered 698 employed unique words (514 in CS): 17% of all employed unique words (12% in CS) and 26% of all employed words (24% in CS).

Analysis

Separately for child-produced and child-directed speech, we produced mixed effects growth curve models assessing the development of iconicity over time in 4 steps. First we used iconicity as outcome measure, visit (linear and squared) as fixed factor, and child ID as random effect, including visit as random slope. Second, we controlled whether the results were preserved when controlling for measures of word

concreteness and systematicity by adding to the first model these measures as fixed effects. Third, we controlled for effects of verbal and nonverbal initial IQ: to the first model we added MSEL-EL and MSEL-VR at visit 1, both as main effects and as interactions with visit. Due to the high collinearity between verbal and nonverbal IQ ($r=-0.712$), high caution should be employed in interpreting the results. Finally, we tested whether significant changes of iconicity over time were due to changes in iconic or in arbitrary words. Iconic words were defined as words with an iconicity score above 1 (531 unique words), arbitrary as words with a score between -0.5 and 0.5 (421 unique words). We employed a mixed effects Poisson regression with number of iconic words as outcome, visit (linear and squared) as fixed factor, overall number of words produced by the speaker as offset and child ID as random factor including visit as random slope. This analysis was repeated for unique iconic words and for overall and unique arbitrary words. All analyses were run employing R 3.3.2, RStudio 1.0.136, lme4 1.1-12 and tidyverse 1.1.0 (Bates et al., 2014; RCoreTeam, 2016; RStudioTeam, 2016; Wickham, 2017).

Results

Children's speech

First, we analyzed whether the iconicity in children's speech changed over the six visits. We found that iconicity decreases significantly over time (linear: $b=-0.63$, $SE=0.11$, $p<0.001$; quadratic: $b=0.43$, $SE=0.09$, $p<0.001$), cf. Figure 1. When controlling for systematicity and concreteness, we still observed analogous results. Iconicity decreases over time (linear: $b=-0.19$, $SE=0.05$, $p<0.001$; quadratic: $b=0.14$, $SE=0.04$, $p<0.001$). Concreteness is a significant predictor of iconicity ($b=0.06$, $SE=0.007$, $p<0.001$), but not systematicity ($b=0.004$, $SE=0.007$, $p=0.565$).

Next, we examined whether individual cognitive skills play a role in the iconicity of children's speech. When verbal and nonverbal IQ were added to the model, we observed analogous effects, but modulated by these individual variables. Iconicity decreases over time (linear: $b=-0.63$, $SE=0.1$, $p<0.001$; quadratic $b=0.44$, $SE=0.09$, $p<0.001$). The higher the verbal IQ, the lower the iconicity ($b=-0.11$, $SE=0.03$, $p<0.001$), with only a marginal interaction with visit (linear: $b=0.23$, $SE=0.12$, $p=0.07$; quadratic: $b=-0.11$, $SE=0.11$, $p=0.3$). Nonverbal IQ did not have a main effect on iconicity ($b=-0.002$, $SE=0.03$, $p=0.95$), and it marginally modulated the effect of time: the higher the nonverbal IQ, the bigger the linear iconicity decrease ($b=-0.22$, $SE=0.12$, $p=0.07$) and the bigger the quadratic slowdown ($b=0.19$, $SE=0.11$, $p=0.08$).

Finally, we examined whether the decrease in iconicity over time resulted from a decrease in the use of iconic words or an increase in the use of more arbitrary words. We observed no significant change over time in the frequency of iconic words used, either overall uses or by unique tokens ($p's>0.17$). However, there was a significant increase over time in the overall use of arbitrary words ($b=1.07$, $SE=0.1$,

$p<0.001$), though not in unique arbitrary words used ($b=0.15$, $SE=0.09$, $p=0.08$), cf. Figure 2.

Adults' speech

Next we examined how iconicity in parents' speech changed over the six visits. Similar to children's speech, we found that iconicity decreased significantly over time (linear: $b=-0.05$, $SE=0.03$, $p=0.002$; quadratic: $b=0.03$, $SE=0.02$, $p=0.08$), cf. Figure 1. When controlling for systematicity and concreteness, we still observed analogous results. Iconicity decreases over time (linear: $b=-0.07$, $SE=0.02$, $p<0.001$; quadratic: $b=0.04$, $SE=0.02$, $p<0.001$). Like with children's speech, concreteness is a significant predictor of iconicity ($b=0.1$, $SE=0.003$, $p<0.001$). However, unlike children's speech, systematicity is also a significant predictor of iconicity ($b=-0.06$, $SE=0.003$, $p<0.001$).

Next, we examined the role of children's individual cognitive skills in the iconicity of parents' speech. With verbal and nonverbal IQ added to the model, we observed analogous effects, but modulated by the children's individual cognitive skills. Iconicity decreases over time (linear: $b=-0.06$, $SE=0.009$, $p<0.001$; quadratic: $b=0.03$, $SE=0.009$, $p=0.001$). Verbal IQ did not affect the general level of iconicity ($b=-0.004$, $SE=0.005$, $p=0.44$), but it interacted significantly with time: the higher the verbal IQ, the stronger the linear decrease in iconicity ($b=-0.03$, $SE=0.01$, $p=0.02$) and the smaller the slowdown ($b=0.03$, $SE=0.01$, $p=0.004$). Nonverbal IQ did not seem to affect iconicity ($p's>0.4$).

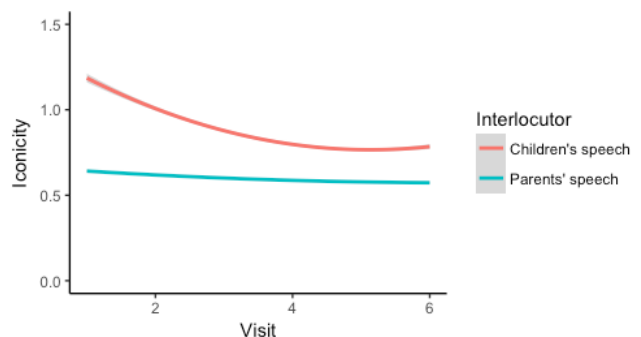


Figure 1 – Average iconicity across visits in children and adults' speech

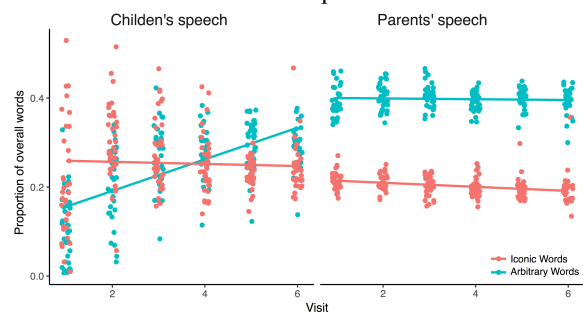


Figure 2 – Frequency across visits of highly iconic and arbitrary words in children and adults' speech

Finally, different from children, we observed a significant decrease over time in the overall frequency of iconic words ($b=-0.7$, $SE=0.03$, $p=0.012$), and a marginal decrease in the number of unique iconic words used ($b=-0.09$, $SE=0.05$, $p=0.058$), with no significant quadratic components ($p's>0.3$). In contrast, we observed no significant change over time in the frequency of arbitrary words, either overall or by number of unique tokens ($p's>0.195$), cf. Figure 2.

Table 1 shows words with iconicity ratings of 1.5 or higher from the 100 most frequent words used by children and parents during visits 1 and 6. Children produced 28 high-iconicity words during visit 1 and 18 during visit 6. Parents produced 13 such words during visit 1 and 10 during visit 6.

Table 1. Most frequent high-iconicity words.

Group	Visit	Words
Children	1	no (2.8), baby (2.2), <i>bye</i> (1.6), one (1.8), vroom (3.5), <u>cup</u> (1.5), snake (2.0), <u>balloon</u> (1.7), <i>help</i> (1.5), <u>pop</u> (4.1), <u>my</u> (1.5), <u>block</u> (2.4), <u>roar</u> (3.9), <u>beep</u> (4.4), <u>boom</u> (3.8), <u>fall</u> (1.5), <u>dump</u> (2.9), <u>shake</u> (2.6), <u>three</u> (1.6), <u>owl</u> (1.5), <u>hello</u> (2.1), <u>mine</u> (1.5), <u>star</u> (1.6), <u>yes</u> (2.2), <u>yum</u> (2.8), <u>crash</u> (3.7), look (1.8), <i>bee</i> (1.5)
	6	no (2.8), one (1.8), <u>three</u> (1.6), snake (2.0), baby (2.2), my (1.5), look (1.8), <u>elephant</u> (2.1), <u>yes</u> (2.2), <u>vroom</u> (3.5), <u>balloon</u> (1.7), <u>beep</u> (4.4), <u>knock</u> (3.1), <u>stop</u> (2.5), <u>pop</u> (4.1), <u>home</u> (2), <u>hiss</u> (4.2), <u>off</u> (1.9)
Parents	1	look (1.8), one (1.8), baby (2.2), no (2.8), <u>push</u> (2.3), <i>bye</i> (1.6), block (2.4), <u>snake</u> (2.0), <u>work</u> (1.7), <u>knock</u> (3.1), <u>vroom</u> (3.5), help (1.5), <u>hello</u> (2.1)
	6	look (1.8), one (1.4), no (2.8), baby (2.2), my (1.5), elephant (2.1), work (1.7), help (1.5), knock (3.1), block (2.4)

Note. Words ranked in order of frequency. Iconicity ratings in parentheses. Underlined words among the most frequent for that group during the particular visit, but not for the other group. Italicized words among the most frequent during that visit for the particular group, but not for the other visit. E.g. “yum” was used frequently by children during visit 1, but not by parents during that visit, nor by children during visit 6.

Discussion & Conclusion

Developmental psychologists have proposed that iconicity may facilitate early word learning, helping children to bridge the sounds of words with their meanings. To investigate this hypothesis, we used iconicity ratings for a large set of English words to examine iconicity in the speech of children and parents.

We found that iconicity decreases over language development in both child-produced and child-directed speech. These patterns held after controlling for concreteness and systematicity of the words. In children, the overall decrease in iconicity is driven by an increase in the use of more arbitrary words, rather than a decrease in iconic words. This contrasted to parents, who decreased their use of iconic words, but maintained the frequency of arbitrary words. Our analysis of individual verbal and nonverbal IQ showed that children’s level of cognitive ability modulated their transition to the more frequent use of arbitrary words. The results also suggest that parents may adapt their

iconicity more to the children’s actual cognitive skills than to their age.

These findings, along with several other studies, show a robust relationship between the iconicity of spoken words as garnered from native speaker ratings, and their prevalence in early communication between children and caregivers (Massaro & Perlman, 2017; Perry et al., 2015; Perry et al., in press; also see Thompson et al., 2012 for similar results with British Sign Language). They support the hypothesis that iconicity plays a role in facilitating early vocabulary learning. Additionally, they highlight the possible role of iconicity in children’s production. Iconicity of words may not just facilitate comprehension of their meaning, but also foster “thinking for speaking” during the beginning phases of learning to produce meaningful words (cf. Slobin, 2006). However, it is also important to note that young children and their parents clearly use a high proportion of arbitrary words too, even as they show a relatively higher inclination to use iconic words.

Our findings suggest several directions for future research on iconicity in early word learning. One important question is whether iconic words actually help children gain the referential insight, which would then ease the way for learning more arbitrary words. Alternatively, iconic words might simply be more readily acquired and put to use, which potentially could still facilitate subsequent word learning by bolstering early vocabulary. A second direction for future research is to investigate the more fine-grained temporal dynamics of iconicity in the unfolding interaction. Do parents and children adapt to each other’s level of iconicity, and if so, do they do that on a turn-by-turn base, or at a more general level? Finally, future research might examine how iconic words are used with other iconic devices, such as prosody and iconic gesturing. For example, parents might modulate the prosody of their speech in iconic ways, which could help children with comprehension and word learning (Nygaard et al., 2009).

The current study adds to accumulating research showing iconicity in the lexicons and grammars of spoken and signed languages alike (Dingemanse et al., 2015; Perniss et al., 2010). This research suggests that iconicity is a fundamental property of languages – a complement to arbitrariness. Our findings show how iconicity may play an important role in children’s earliest conversations, even in a spoken language like English that lacks a large inventory of widely recognized iconic words.

Acknowledgments

We are grateful for funding from the Language Evolution and Interaction Group at the Max Planck Institute for Psycholinguistics, and from the Interacting Minds Center (Aarhus university). We thank Padraic Monaghan for sharing his data on the systematicity of English words.

References

- Asano, M., Imai, M., Kita, S., Kitajo, K., Okada, H., & Thierry, G. (2015). Sound symbolism scaffolds language development in preverbal infants. *Cortex*, *63*, 196–205.
- Bates, D., Maechler, M., Bolker, B., & Walker, S. (2014). lme4: Linear mixed-effects models using Eigen and S4. R package version, 1(7)
- Brysbaert, M., Warriner A. B., & Kuperman, V. (2014). Concreteness ratings for 40 thousand generally known English word lemmas. *Behavior Research Methods*, *46*, 904-911.
- Dingemanse, M. Blasi, D. E., Lupyan, G., Christiansen, M. H., & Monaghan, P. (2015). Arbitrariness, iconicity, and systematicity in language. *Trends in Cognitive Sciences*, *19*, 603-615.
- Fenson, L, Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., et al. Variability in early communicative development. *Monographs of Social Research in Child Development*, *59*, i-185.
- Fernald A, Morikawa H. (1993). Common themes and cultural variations in Japanese and American mothers' speech to infants. *Child Development*. *64*, 637–656.
- Goodwin, A., Fein, D., & Naigles, L. R. (2012). Comprehension of wh-questions precedes their production in typical development and autism spectrum disorders. *Autism Research*, *5*(2), 109-123.
- Hockett, C. F. (1960). The origin of speech. *Scientific American*, *203*, 88-96.
- Imai, M., Kita, S. (2014). The sound symbolism bootstrapping hypothesis for language acquisition and language evolution. *Philosophical Transactions of the Royal Society b*, *369*, 20130298.
- Imai, M., Kita, S., Nagumo, M., & Okada, H. (2008). Sound symbolism facilitates early verb learning. *Cognition*, *109*, 54–65.
- Imai, M., Miyazaki, M., Yeung, Henny, Hidaka, S, Kantartzis, K, Okada, H., and Kita, S. (2015) Sound symbolism facilitates word learning in 14-month-olds. PLOS ONE.
- Kantartzis, K., Imai, M., & Kita, S. (2011). Japanese sound-symbolism facilitates word learning in English-speaking children. *Cognitive Science*, *35*, 575–586.
- Kita S, Ozyürek A, Allen S, Ishizuka T. (2010). Early links between iconic gestures and sound symbolic words: evidence for multimodal protolanguage. In Proc. 8th Int. Conf. on Evolution of Language, Utrecht, The Netherlands, 14–17 April 2010 (eds ADM Smith, M Schouwstra, B de Boer, K Smith), pp. 429–430. Singapore: World Scientific.
- Kuperman, V., Stadthagen-Gonzalez, H., & Brysbaert, M. (2012). Age-of-acquisition ratings for 30,000 English words. *Behavior Research Methods*, *44*(4), 978–990.
- Laing, C.E. (2014). A phonological analysis of onomatopoeia in early word production. *First Language*, *34*, 387-405.
- Massaro, D.W. & Perlman, M. (2017). Quantifying iconicity's contribution during language acquisition: Implications for vocabulary learning. *Frontiers in Communication*, *2*:4.
- Maurer D., Pathman T., Mondloch C.J. 2006 The shape of boubas: sound–shape correspondences in toddlers and adults. *Developmental Science*, *9*, 316–322.
- Menn, L., & Vihman, M. (2011). Features in child phonology: Inherent, emergent, or artefacts of analysis? In Where do phonological features come from? The nature and sources of phonological primitives (Eds. N. Clements & R. Ridouane), pp. 261–301. Amsterdam: John Benjamins Publishing Company.
- Monaghan, P., Shillcock, R.C., Christiansen, M.H., & Kirby, S. (2014). How arbitrary is language? *Philosophical Transactions of the Royal Society B*, *369*, 20130299.
- Nygaard, L.C., Herold, D.S., & Namy, L.L. (2009). The Semantics of Prosody: Acoustic and Perceptual Evidence of Prosodic Correlates to Word Meaning. *Cognitive Science*, *33*, 127–146.
- Ozturk O, Krehm M, Vouloumanos A. (2012) Sound symbolism in infancy: evidence for sound–shape cross-modal correspondences in 4-month-olds. *Journal of Experimental Child Psychology*, *114*, 173–186.
- Permiss P, & Vigliocco G. (2014). The bridge of iconicity: from a world of experience to the experience of language. *Philosophical Transactions of the Royal Society B*, *369*; 20130300.
- Permiss, P., Thompson, R.L., & Vigliocco, G. (2010). Iconicity as a general property of language: Evidence from spoken and signed languages. *Frontiers in Psychology*, *1*.
- Perry, L.K., Perlman, M., Lupyan, G. (2015). Iconicity in English and Spanish and its relation to lexical category and age of acquisition. *PLoS ONE*, *10*, e0137147.
- Perry, L.K., Perlman, M., Winter, B., Massaro, D.W., & Lupyan, G. (in press). Iconicity in the speech of children and adults. *Developmental Science*.
- Pinker, S. & Bloom, P. (1990). Natural language and natural selection. *Behavioral and Brain Sciences*, *13*, 707-727.
- Quine, W.V.O. (1960). Word and object: An inquiry into the linguistic mechanisms of objective reference. Cambridge, MA: MIT Press.
- RCoreTeam. (2016). R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing; 2014.
- RStudioTeam. (2016). RStudio: Integrated Development for R. RStudio. Boston, MA. Retrieved from <http://www.rstudio.com/>
- Saji, N. & Imai, M. (2013). Goishutoku ni okeru ruizousei no kouka no kentou. In Onomatope kenkyu no shatei– chikadzuku oto to imi (Eds. K. Shinohara & R. Uno), pp. 151–166. Tokyo, Japan: Hituji Syobo.
- Slobin, D.I. (2006). The child learns to think for speaking: Puzzles of crosslinguistic diversity in form-meaning mapping. *Studies in Language Sciences*, *7*.
- Spence, C. (2011). Crossmodal correspondences: A tutorial review. *Attention, Perception, & Psychophysics*, *73*, 971–995.
- Stone, W.L., Coonrod, E.E., & Ousley, O.Y. (2000). Brief report: screening tool for autism in two-year-olds (STAT): development and preliminary data. *Journal of autism and developmental disorders*, *30*(6), 607-612.
- Suzuki Y. (2013). Intarakushon no naka de tsukawareru 'onomatope fl suru' doushi. In Onomatope kenkyu no shatei – chikadzuku oto to imi. (Eds. K. Shinohara & R. Uno), pp. 167–181. Tokyo: Hituji Syobo.
- Tek, S., Mesite, L., Fein, D., & Naigles, L. (2014). Longitudinal analyses of expressive language development reveal two distinct language profiles among young children with autism spectrum disorders. *Journal of autism and developmental disorders*, *44*(1), 75-89.
- Thompson, R.L., Vinson, D.P., Woll, B., Vigliocco, G. (2012). The road to language learning is iconic: evidence from British Sign Language. *Psychological Science*, *23*, 1443–1448.
- Wickham, H. (2017). Tidyverse: Easily Install and Load 'Tidyverse' Packages: R package version 1.1.0. Retrieved from <https://CRAN.R-project.org/package=tidyverse>
- Winter, B., Perlman, M., Perry, L.K., & Lupyan, G. (in press). Which words are most iconic? Iconicity in English sensory words? *Interaction Studies*.
- Yoshida, H. (2012). A cross-linguistic study of sound symbolism in children's verb learning. *Journal of Cognition and Development*, *13*, 232-265.