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Articulatory features of phonemes pattern to iconic meanings: evidence from cross-linguistic ideophones

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Abstract

Iconic words are known to exhibit an imitative relationship between a word and its referent. Many studies have worked to pinpoint sound-to-meaning correspondences for ideophones from different languages. The correspondence patterns show similarities across languages, but what makes such language-specific correspondences universal, as iconicity claims to be, remains unclear. This could be due to a lack of consensus on how to describe and test the perceptuo-motor affordances that make an iconic word feel imitative to speakers. We created and analyzed a database of 1,888 ideophones across 13 languages, and found that 5 articulatory properties, physiologically accessible to all spoken language users, pattern according to semantic features of ideophones. Our findings pave the way for future research to utilize articulatory properties as a means to test and explain how iconicity is encoded in spoken language.

Keywords: iconicity; ideophones; systematicity; sound symbolism; phonology; semantics

Introduction

Iconicity in spoken language can be summed up as the relation of a linguistic form (or sound) to its meaning (Hinton, Nichols, & Ohala, 1994). One fundamental example is onomatopoeia, as in the English *woof woof* for the sound of a dog bark or *vroom vroom* for the reving a car engine. Sound mapping to meaning in an imitative way is also called sound symbolism. An implicit assumption underlying the term sound symbolism is that phonemes, or clusters of phonemes, map onto meaning below word or morpheme level thus acting as affordances which together allow the sound symbolic word to take on meaning. For example, the /ŋ/ in English /dɪŋ.dɒŋ/ seems to be characteristic of the reverberating echo of a bell tolling, while the alternating /i/ and /o/ seems characteristic of movement or a fluctuation in pitch as the bell tolls. While various studies have worked to elicit sub-phonemic sound-to-meaning correspondences (Aryani, 2018; Blasi, Wichmann, Hammarström, Stadler, & Christiansen, 2016; De Carolis, Marsico, & Coupé, 2017; Kawahara, Noto, & Kumagai, 2018; Shih, Ackerman, Hermalin, Inkelas, & Kavitskaya, 2018; Kwon & Round, 2015; Ofori, 2009; Hamano, 1998; Maduka, 1988; Oswalt, 1994; Akita, Imai, Saji, Kantartzis, & Kita, 2013; Ayalew, 2013; McCune, 1985; Assaneo, Nichols, & Trevisan, 2011; Strickland, J, Schlenker, & Geraci, 2017), the underlying mechanisms of such correspondences are unclear. To begin rectifying the issue of what exactly makes a sound symbolic word iconic, and so the field of iconicity can move toward a unified understanding of what affordances in the spoken modality should be classified as iconic, this paper attempts to reveal the gestural affordances underpinning imitative words, i.e., ideophones. Ideophones are marked words which depict sensory meaning and belong to an open lexical class (Dingemanse, 2012, in press). Recent studies have likened ideophones to oral gestures considering that they co-occur with other visual forms of communication so frequently in spontaneous speech (Dingemanse, 2015; Hatton, 2016; Mihas, 2013; Dingemanse, 2013; Nuckolls et al., 2000). This speaks to the importance of analyzing (articulatory) movement in order to understand how ideophones mean what they mean. Ideophones have been shown to be easily learnable by speakers from different language backgrounds, which may also speak to their imitative, gestural nature encoded despite language-specific differences such as phonotactics, phonological inventory, or lexical associations (Lockwood, Hagoort, & Dingemanse, 2016; Dingemanse, Schuerman, Reinisch, Tufvesson, & Mitterer, 2016; Iwasaki, Vinson, & Vigliocco, 2007a, 2007b). Thus, ideophones are an ideal testing ground for how articulatory properties pattern to meaning. Vocal imitations and onomatopoeia created spontaneously by participants in experimental settings have been shown to exhibit sound-meaning correspondences which can be attributed to patterns of oral articulation (Assaneo et al., 2011; Taitz et al., 2018). This leads us to our investigative focus on the articulatory gestures of consonants in imitative words. In a methodological vein similar to Blasi et al. (2016), this study looks at whether articulatory feature (e.g., plosive, fricative, nasal, velar, labial) is more or less found in certain semantic domain (e.g., telic events, human vocal sounds, motion, appearance) following cross-linguistic descriptions of ideophone meaning (Dingemanse, 2012; Hamano, 1998; Van Hoey, 2018; Nuckolls, Swanson, Sun, Rice, & Ludlow, 2017). However, unlike Blasi et al. (2016) who focused on identifying sound-to-meaning mappings in arbitrary words, this study focuses on words which are explicitly iconic in nature. If an oral articulation is more attested in one semantic domain of ideophones than another this could explain why some phonosemantic mappings might be perceived as imitative and therefore iconic of a given percept. Such mappings are therefore explainable as perceptuo-motor affordances grounded in gestural means, e.g., total closure of plosive articulation, affords the semantic category of telic events and their percept coming to an abrupt stop. We created a database of ideophones from 13 languages (in total, 1888 ideophones) to carry out our investigation on how articulatory properties of consonants pattern with ideophone meaning.

Background

Phonosemantics

Sub-phonemic sound-to-meaning mappings have been proposed for a number of languages (Maduka, 1988; Waugh, 1994; Hamano, 1998; Oswalt, 1994; Assaneo et al., 2011; Akita et al., 2013; Ayalew, 2013; Kwon & Round, 2015; Blasi et al., 2016). The general assumption is loosely encapsulated by a broad hypothesis that every phoneme is meaning-bearing, and that this meaning is rooted in its articulation (Diffloth, 1979, 1994; Hamano, 1998; Dingemanse, 2018). Though this study does not assume all phonemes to be meaning bearing in all contexts, we do subscribe to the notion that the meaning of a phonosemantic mapping for iconic word should be rooted in its articulation following previous studies (Diffloth, 1979, 1994; Oda, 2001; Assaneo et al., 2011; Taitz et al., 2018; Strickland et al., 2017).

Ideophone Database

Database

Currently there is no cross-linguistic database dedicated solely to ideophone inventories. We created a database of 13 languages[1] which were selected with the aim of being as typologically diverse as possible despite the limited number of linguistic descriptions for ideophone inventories in the world[2]). The languages are as follows with their number of ideophones in brackets: Manyika Shona (Niger-Congo) [112] , Uyghur (Turkic) [49], Manchu (Tungusic) [91], Chaoyang Southern Min (Sino-Tibetan) [248], Ma'ai Zhuang (Kra-Dai) [232], Kam (Kra-Dai) [223], Akan (Niger-Congo) [190] , Kisi (Niger-Congo) [98], Kuhane (Niger-Congo) [64], Pastaza Quichua (Quechuan) [283] , Upper Necaxa Totonac (Totozoquean) [146], Temne (Niger-Congo) [76] , Yakkha (Sino-Tibetan) [76]. Due to their depictive nature, and the various methods of elicitation, the ideophone inventory numbers reported above are not absolute, but instead reflect a general picture about the semantic "visibility" of ideophones per language. This is in line with a claim recently put forth by Dingemanse (Dingemanse, in press) that ideophones form an open class, speaking to the creative potential for newly coined ideophones.

Total number of ideophones was 1,888. Ideophones were entered into the database with their orthography (if available), International Phonetic Alphabet (IPA) transcription, and reported translation. A phonetically trained transcriber provided IPA transcription of words when original resources do not provide IPA transcriptions. To analyze the phonetic properties of words, the transcriber also provided with place (labial, coronal, dorsal, pharyngeal, laryngeal), manner (sonorant, continuant, nasal, lateral, delayed release), and laryngeal features (voice, spread glottis, constricted glottis) of

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Table 1: Semantic features

Semantic Feature	Description of [+] feature
[+/- animal]	vocalization made by animals
[+/- appearance]	depicts visual information, i.e., how something looks or degrees of visibility
[+/- friction]	depicts rubbing together or rough contact of surfaces (not necessarily active movement), i.e., grinding, rustling, sharpening, hacking up phlegm, tearing cloth
[+/- human]	vocalization made by people, i.e., laughter, crying, talking
[+/- loud]	auditory information of inherently high amplitude, i.e., explosion, screaming, shattering
[+/- motion]	depicts active (the act of X) movement, i.e., walking, chopping, splashing, sneaking, flapping, water boiling, bumping, spitting, firecrackers exploding
[+/- sound]	depicts auditory information (the sound of X)
[+/- telic]	depicts an event which reaches completion
[+/- wind]	depicts movement of air, i.e., blowing, coughing, gales

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consonants for each ideophone. An independent transcriber checked the validity of the transcriptions as well as featural descriptions of ideophones. Ideophones were then coded for semantic features following criteria below (Table 1).

Semantic Features

Feature were created to correspond to Dingemanse (2012) implicational hierarchy of ideophones which lists the following semantic categories: sound <movement <visual patterns <other sensory perceptions <cognitive states. Additional categories were created based on observations of what ideophones depict cross-linguistically (Hamano, 1998; Hinton, Nichols, & Ohala, 2006; Van Hoey, 2018; Nuckolls et al., 2017). It is important to note that semantic features are not mutually exclusive. An ideophone may be coded for multiple. For example, the Chaoyang ideophone /hu.hu/ wind blowing was coded with [+sound] (because this ideophone depicts an auditory percept), [-telic] (because this ideophone does not involve a perceived endpoint of an event), [+wind] (because this ideophone involves a percept created by the movement of air), and [-motion] (because this ideophone is not depictive of an action plus its resulting sound or manner thereof). In total 18 features in Table 1 were considered.

Articulatory Features

We categorized place, manner and laryngeal features in our phonetic transcriptions of ideophones into 7 groups (see Table 2), based on how the articulators (lips, tongue) and airflow are

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[1](Franck, 2014; Gerner, 2005; Beck, 2008; Schackow, 2016; Kanu, 2008; Childs, 1988; Ofori, 2009; Nuckolls et al., 2017; Xiao, 2015; Wang & Tang, 2014; Mathangwane & Ndana, 2014; ?, ?)

[2]Ma'ai Zhuang ideophones were collected during ongoing fieldwork.

Table 2: Articulatory features

Articulatory Feature	Description
[+labial]	usage of one or both lips
[+tongue resting]	tongue is in resting/neutral position and not raised
[+tongue root]	usage of back of tongue (dorsum)
[+airflow]	air is forced out through a narrow channel in the mouth, i.e., fricatives
[+velum] (nasal)	velum is lowered and air escapes through the nasal passage
[+oral contact]	lips and/or tongue make constriction
[+vocal folds]	vibration of the vocal folds

involved in their production[3].

While some features can be subsumed by another, such as [+labial] by [+oral contact], which is relevant to both the lips and the tongue, the decision to test a more specific feature is to keep distinctive place features that are frequently contrastive among ideophones; for example, in Chaoyang, we have [+labial] [+oral contact] ideophone /pu.pu/ meaning rapid movement and [-labial] [+oral contact] ideophones /tsu.tsu/ whispering. Likewise, in Pastaza Quichua we have [+labial] [+oral contact] /pɑw/ manner of being turned downward and [-labial] [+oral contact] /kw/ sound of stepping on dry leaves. We also include [+tongue root], which is specific to a particular part of an articulator given their frequent contrastiveness among ideophones. For example, in Akan we have [+tongue root] /kuu/ call of a large bird and [-tongue root] /tuu/ manner of hitting with the fist. The reason we created encompassing features, i.e., [+oral contact] or [+tongue resting], was so that general manner of the consonant is described regardless of place in the oral tract. There are 14 articulatory features when counting the negative counterparts of Table 2. If properties of iconicity are truly universal, then we predict that the universally accessible properties captured by our articulatory features should bear the explanatory power for what perceptuo-motor affordances underpin iconicity and its notions of (analogical) depiction.

We coded semantic and articulatory features in Table 1 and 2 for all consonants found in the ideophones in our database using binary features. Our coding did not consider syllable structures or semantic hierarchy of ideophones, treating all consonants in all ideophones equally. We measured the ratio of each semantic feature given each articulatory feature to see if a semantic feature is more likely to co-occur specifi-

cally with certain articulatory features. We used chi-squared tests to see if the distributions of a binary articulatory feature differ between two samples: ideophones that have the semantic feature **X** and those that do not in a given language. The ratios then entered into a Wilcoxon's sign rank test.

Hypotheses

We have made 4 preliminary hypotheses based on observations from the phonosemantic literature. These observations are grounded in perceptuo-motor analogy but have yet to be tested for ideophone inventories across languages. (1) Stop consonants, characterized by total occlusion of airflow, i.e., [-airflow], have been observed for ideophones indicating complete, i.e., [+telic], events or events with abrupt endings (Diffloth, 1979; Hinton et al., 2006; Hamano, 1998; Alpher, 1994; Taitz et al., 2018; Strickland et al., 2017). (2) Fricatives, i.e., [+airflow], have been associated to wind or friction between two objects (Diffloth, 1979; Oswalt, 1994; Hinton et al., 2006; Ofori, 2009; Taitz et al., 2018). Improvised vocal imitations have shown that (3) labial consonants, i.e., [+labial], are associated with the sounds resulting from motion, i.e., [+motion], (4) while dorsal consonants, i.e., [+tongue root], are associated with movement itself (Taitz et al., 2018) i.e., [+motion] in our feature set.

Analysis

We analysed every semantic feature (32) against every articulatory gesture feature (16), and removed all the pairs when there were two or more languages that did not have ideophones with either the semantic feature, or the articulatory gesture considered (n=213). In total, we analysed 299 pairs of semantic features and articulatory gestures. When evaluating the significance of a mapping between an articulatory gesture and a semantic feature, we compared it against all ideophones that did not have the semantic feature. To do this, we compared on an individual-language basis the distributions of a binary articulatory feature in two samples: ideophones that have the semantic feature **X** (e.g. "human vocal" vs "not human vocal") and those that do not in a given language. We are thus testing for differences in distributions of a binary feature. We first compare these ratios for each individual language. Because the sample sizes were quite low in some comparisons (5-6 samples for e.g. the "human vocal" category in some languages), we use the chi-squared test. To test whether mappings of articulatory gesture to meaning were consistent across languages, we pooled the data from across languages. We decided not to run tests on all the agreggated ideophones across languages, as this would have been biased by the differences in sample sizes across languages. Instead, we compared the ratios from the previous analysis done at the individual language level. There were many maximum ratios (i.e. languages where all words have a given feature). We thus used a wilcoxon's sign rank test, since it is a non-parametric test and does not assume the data to be normal like e.g. a paired Student's t-test.

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[3][+airflow] applies to IPA symbols /ɸ β f v θ ð s z ʃ ʒ ʂ ʐ ç j x ɣ χ ʁ ħ ʕ h ɦ/. [+tongue root] IPA = /j c ɟ k g ɲ ŋ ç j x ɣ j ɥ ʎ ʟ/. [+labial] IPA = / p b m ʙ ɸ β ɱ v ʋ f ɓ w/. [+velum] IPA = /m ɱ n ɳ ŋ ɴ/. [+oral contact] IPA = /p b m ʙ ɸ β ɱ v ʋ v f θ ð t d n r r z ʐ ɻ l s ɬ ʃ ʒ ɖ ɳ ɽ ʐ ʂ ɽ c ɟ ɲ ç j j ʎ k ŋ x ɣɥ ʟ ɓ ɗ ʄ w/. [+tongue resting] IPA = / t ħ ʕ p b m ʙ β ɸ ɱ v ʋ f ʋ/.

Table 3: Articulatory feature to semantic feature mappings significant across 13 languages.

#	Articulatory Feature	Semantic Feature	Correlation across all languages (Wilcoxon's test p-values)	Number of individual languages,with significant chi-squared (p<0.05)
1	-airflow	+telic	0.0015	7
2	+airflow	+wind	0.0015	6
3	-airflow	+motion	0.0019	4
4	+airflow	+friction	0.0024	4
5	+labial	+motion	0.0107	4
6	-vocal folds	+telic	0.0121	4
7	-tongue resting	+telic	0.0159	4

Results

Out of 299 combinations of articulatory to semantic features, 69 combinations were significant across languages according to Wilcoxon signed rank tests. To be conservative, we used the results of the single-language chi-squared tests as a threshold for reporting Wilcoxon signed rank tests across languages. Specifically, Wilcoxon tests reported here are only those that apply to combinations which were significant ($p < 0.05$) for 4 or more languages on an individual basis. 7 articulatory feature and semantic feature, shown in Table 3, were above this threshold. The correlations in Table 3 are ordered according to the number of languages who had a significant articulatory to semantic feature correlation. The correlation of [-airflow] to [+telic] and [+airflow] to [+wind] are our most robust articulatory feature to semantic feature mapping ($z = 0.00, p = 0.0015$) across all languages, and are significant ($\chi^2, p < 0.05$) for 7 and 6 languages on an individual-basis respectively. The correlation of [-airflow] to [+motion] is significant across all languages (Wilcoxon, $p = 0.0019$).

Discussion

Our results overall show that certain articulatory properties map to semantic features of ideophones from 13 languages. More specifically, our results show that phonosemantic mappings as proposed in the ideophone literature (see **Hypotheses** section, hypotheses 1-3) are supported, while [+/-tongue root] was not significant for [+/- motion] as claimed by hypothesis (4). Table 3 shows that five modes of articulation create robust cross-linguistic patterns with regards to imitative meaning. These five modes are: tongue movement, lip movement, airflow, velum lowering (nasal airflow), and vocal fold vibration. This suggests that the imitative nature of ideophones is begotten from perceptuo-motor analogies afforded by such articulatory properties. That is to say, imitative words to an extent derive their imitative meaning through their ar-

ticulation, implying that articulatory properties of speech are a potential route for explaining the iconic nature of words, such as ideophones. By extension, words of contested iconic nature could thus be deemed more or less iconic depending on whether their articulatory properties support such a claim, For example, if *gl-* of *glisten*, *glimmer*, *glint* was to be proven iconic and therefore imitative, an analogy supported by articulatory features would be required to argue for its purported meaning of luminescence.

If iconicity is imitative due to perceptuo-motor analogy (Dingemanse, Blasi, Lupyan, Christiansen, & Monaghan, 2015) (relations made between sensory percepts and movements), then articulatory properties should likewise map to semantic features for reasons grounded in perceptuo-motor analogy. In Table 4, we propose the perceptuo-motor analogies that allow these articulatory properties to pattern with their semantic features and are in turn embedded in a given ideophone on a sub-phonemic level.

There are few things worth noting regarding the overlap of semantic features. First is that the articulatory feature [+airflow] corresponds to semantic features [+friction] and [+wind] but not motion, i.e., [+air flow] corresponds to [-motion]. This does not imply that [+friction] ideophones are not coded for movement related meaning (as friction must imply some kind of movement). Rather, this implies ideophones which are no to do with motion[4], and are thus beyond motion on Dingemanse (2012) semantic hierarchy for ideophones, involve [+airflow]. With that in mind, the finding that [+labial] corresponds to [+motion] would imply that some (not necessarily complete) occlusion of airflow made by contact with the articulators, is involved in the perceptuo-motor analogy of [+motion]. However, here we would argue that it is the movement of the articulators, not the blockage of air, which affords this perceptuo-motor analogy of movement. This is because [+labial] allows for labio- and labiodental fricatives which of course are consonants coded as [+airflow]. This is further supported by the fact that [-tongue resting], i.e., tongue movement rather than lip movement, also corresponds with [+telic]. Implying that the tongue is used to occlude air in the oral tract to give us the correspondence of [-airflow] to [+telic].

Another observation regarding the overlap of features is that the semantic feature [+telic] is associated with articulatory features [-vocal folds], and [-airflow]. Bear in mind that our feature airflow does not encompass nasal consonants, i.e., air escaping through the nose. We did not find the relation of [+velum] to [+telic] to be significant overall using our Wilcoxon signed rank test (p=0.0869) and thus it is unreported in Table 4. However our chi-squared tests showed it to

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[4]There are very few ideophones in our database which are [+motion] but [-sound]. If ideophones are [+motion] they are almost always [+sound], implying that the sound is resultative of the motion and somehow semantically entails it. For example, an ideophone for the sound of footsteps would be [+sound] and [+motion]. The reverse however is not true. For example, the sound of a cow or the sound of wind blowing is [+sound] but [-motion].

Table 4: Analogical justifications for articulatory feature and semantic feature correspondences across 13 languages.

#	Articulation	Corresponds	Justification (≈ analogical to)
1	-airflow	+telic	airflow occlusion ≈ cessation of an event
2	+airflow	+wind	continual airflow ≈ air movement
3	-airflow	+motion	movement of articulators to obstruct airflow ≈ movement depiction
4	+airflow	+friction	airflow sibilance ≈ sibilance of friction and/or ≈ rubbing of two surfaces
5	+labial	+motion	movement of lips ≈ motion depiction
6	-vocal folds	+telic	lack of vocal fold vibration ≈ cessation of an event
7	-tongue resting	+telic	active tongue movement to create [-airflow] articulation ≈ cessation of an event

be significant ($p < 0.05$) in 5 languages on an individual basis (Chaoyang, Akan, Kam, Maai, and Manyika Shona). Though not as robust as other findings, taken together with the other [+telic] associations, this [+velum] to [+telic] pattern would suggest that unvoiced stops are likely associated with telicity, nasal consonants are an exception. This implies that the occlusion created by nasal consonants (air blocked from entering the oral cavity) is just as important as the occlusion of air from escaping the oral cavity for [+telic] ideophones. We can propose that it is the articulatory gesture of blocking of air, an articulatory property common to [+velum] and [-airflow] consonants, that affords the perceptuo-motor analogy of [+telic]. Vocal fold vibration is inherent to nasals. However, as our results show, [-vocal folds] is significantly associated to [+telic] ideophones. This implies that the [-airflow] consonants are those that are unvoiced. Based on the articulatory similarities between [-airflow] and [+velum] consonants, we might also propose that the voicing inherent to nasals is not as important for perceptuo-motor analogy of [+telic] as the occlusion of air. Overall, our results also show for some languages certain articulatory properties pattern with semantic features while others do not. Therefore some perceptuo-motor analogies could be language specific. These language-specific results may have come about for a number of reasons. Firstly, phoneme inventories differ across languages so it is inevitable that some languages make use of certain articulatory features less than others, e.g., voicing. Crucially, we did not take predictable phonotactic processes into account when entering the ideophones into our database. Phonotactic processes could result in the addition or deletion of certain segments in order to satisfy language-specific phonological rules and thus potentially obscuring and/or skewing the articulatory features present for imitative purposes only. Controlling for said phonotactic processes requires in-depth analysis per language (Thompson & Do, in press). We would like to emphasize, however, that our main goal here was to see if there were any cross-linguistic articulatory-semantic patterns despite the presence of language-specific phonotactic patterns. The significance of eight articulatory-semantic feature mappings show that this is possible.

Future directions of research could look into how syllable structure affects the patterning of articulatory features with semantic features. For example, stop consonants, characterized as [-airflow] in our study, might be more attested in codas

of ideophones depicting telic events, since the coda is the final segment of a syllable and is thus considered imitative of an events endpoint (Hinton et al., 1994; Strickland et al., 2017). Articulatory properties of vowels are also an obvious direction for future studies, especially given what has been gleaned from the rich literature on *kiki-bouba* studies (Lockwood & Dingemanse, 2015), as well as recent acoustic work on vocal imitations (Perlman & Lupyan, 2018). Given that we only report correlations between individual articulatory features and individual semantic features, future tests could look at how features cluster together, e.g., [+labial] [-airflow] or [+telic] [+motion]. Experimental research could test the results of our study by seeing whether (1) articulatory feature and semantic feature patterns are easily learnable for novel words or ideophones, (2) speakers refer to these articulatory features or perhaps exaggerate them when explaining the meaning of ideophones, as with Dingemanse (2015)'s study on folk definitions of Siwu ideophones. Finally, our study unifies iconicity in the spoken and visual modalities, since both rely on movement to make imitative meanings.

Acknowledgments

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