Speakers' gestures predict the meaning and perception of iconicity in signs

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Abstract

Sign languages stand out in that there is high prevalence of conventionalised linguistic forms that map directly to their referent (i.e., iconic). Hearing adults show low performance when asked to guess the meaning of iconic signs suggesting that their iconic features are largely inaccessible to them. However, it has not been investigated whether speakers' gestures, which also share the property of iconicity, may assist non-signers in guessing the meaning of signs. Results from a pantomime generation task (Study 1) show that speakers' gestures exhibit a high degree of systematicity, and share different degrees of form overlap with signs (full, partial, and no overlap). Study 2 shows that signs with full and partial overlap are more accurately guessed and are assigned higher iconicity ratings than signs with no overlap. Deaf and hearing adults converge in their iconic depictions for some concepts due to the shared conceptual knowledge and manual-visual modality.

Keywords: iconicity; gesture; sign language; embodied cognition

Introduction

A question that has puzzled psychologists and linguists for decades is to what extent sign iconicity is accessible to individuals with no knowledge of a sign language. Iconicity, defined as the direct relationship between a linguistic form and its referent, is a ubiquitous property of sign languages observable at many of their linguistic levels of organisation (Cuxac, 1999; Perniss, Thompson, & Vigliocco, 2010; Pietrandrea, 2002). Sign-naïve adults can accurately guess the meaning of only a small proportion of signs (Griffith, Robinson, & Panagos, 1981; Grosso, 1993; Klima & Bellugi, 1979; Pizzuto & Volterra, 2000), but it has been hard to establish what factors allow them to map certain features of a sign to its correct referent. In an attempt to shed light on this question, we look at the iconic gestures produced by hearing non-signers. Given that iconic gestures are expressed through the same (manual-visual) modality, and importantly, they also share the property of iconicity (Kendon, 2004; McNeill, 1992), we entertain the hypothesis that non-signers may rely on their own gestural repertoire to make form-meaning judgements about signs.

Iconicity in gesture and sign

Gestures are a fundamental aspect of human communication and are present in all ages and cultures (Kendon, 2004; McNeill, 1992). Gestures are holistic units highly integrated with speech that together convey unified semantic information of a multimodal utterance (Kelly, Creigh, & Bartolotti, 2010; McNeill, 1992). Sign languages, in contrast, occur independently from speech, and critically, they have the same levels of linguistic organisation as those reported in spoken languages (Sandler & Lillo-Martin, 2006).

One point of intersection between sign and gesture is iconicity. Speakers can depict through iconic gestures the visual form of a concept and integrate them with speech as part of a multimodal message. For instance, when a speaker says '*I'll be outside'* while producing the gesture of *smoking* it is clear to the interlocutor that she is going for a cigarette. On the other hand, a large proportion of a signed lexicon has iconic motivation (Pietrandrea, 2002), and crucially, signs may have overlapping structures as gestures (e.g., the sign TO-SMOKE depicts a person smoking a cigarette).

The similarities between sign and gesture were overlooked for many decades, but in recent years scholars have begun systematically comparing both modes of manual communication to shed light on their differences and similarities (e.g., Cormier, Schembri, & Woll, 2013; Goldin-Meadow & Brentari, 2015; Perniss, Özyürek, & Morgan, 2015; Quinto-Pozos & Parrill, 2015). Given the growing body of evidence showing that gestures and signs share more forms and functions than previously assumed (arguably due to the shared manual-visual modality) (Perniss et al., 2015), we investigate whether non-signing adults fall back on their own gestural repertoire to make judgements about conventionalised signs. The aim of the present study is therefore to investigate whether the overlap in form between signs (i.e., linguistic structure) and gestures (i.e., iconic depictions) predicts non-signers' ability to guess the meaning of signs and assign iconicity ratings.

Perception of sign iconicity

Iconicity and the extent to which sign-naïve adults can understand the meaning of iconic signs has been a central focus of attention in sign research. The first investigations on the topic demonstrated that iconicity is not easily accessible to non-signers and that the meaning of signs is very difficult to access. In their seminal study, Klima and Bellugi (1979) asked hearing adults without any knowledge of a sign language to guess the meaning of a set of signs. When signs were presented in isolation and when they had to select the correct meaning out of five plausible candidates, participants showed a very low success rate (less than 10%). They showed significant improvement, however, when they were presented the sign along with its English translation, and were asked to explain the iconic relationship between the sign and its meaning. Participants showed overall agreement in that they were able to accurately describe the iconic motivation of more than 50% of the signs (e.g., most participants agreed that the sign VOTE depicted a person putting a ballot in a box). This study set a benchmark in sign language research and convincingly argued that iconicity is difficult to access by hearing non-signers and that the notion of iconicity is better understood as a property that lies in a continuum with the meaning of some signs being more transparent than others.

Another study highlights the possibility that similarities between signs and the gestures used by the hearing community may assist sign-naïve participants in guessing the meaning of signs. Grosso (1993) showed a set of iconic and arbitrary signs in Italian Sign Language (LIS) to hearing non-signing adults and asked them to guess their meaning. Participants could not provide a correct response for a large proportion of signs (76%) but they were very accurate for a considerable number of items on the list (24%). A detailed analysis of the correctly guessed items revealed that these signs resemble the emblems commonly used by Italian speakers (e.g., the sign GOOD has the same form and meaning as the emblem used by hearing Italians). Emblems have a conventionalised, culture-specific form and meaning (Kendon, 1995, 2004) so when non-signing adults are confronted by signs that overlap in structures, they rightly assume that they also share the same meaning. This study is one of the first to suggest that non-signers' ability to guess the meaning of signs is based on the structural similarities between conventionalised (linguistic) signs and the gestures produced by the surrounding speaking community.

A limitation of this study is that it presupposes that only emblems facilitate the accurate guessing of the meaning of signs but does not say how other types of gestures may also be recruited. Emblems have highly conventionalised hand configurations, are used for specific pragmatic purposes (Kendon, 1995, 2004), and have mental representations akin to those of abstract words (Gunter & Bach, 2004), so they are retrievable gestural entities that can be compared with convetionsalised signs. However, other types of iconic gestures may also be used as a basis to make judgments about the meaning of signs. In this study, we turn to the systematic iconic gestures shared in a community of speakers to investigate how overlap in form with conventionalised signs influences meaning-based judgements about signs.

Systematicity in iconic gestures

The form of iconic gestures has been assumed to be variable, with their structure depending on the context in which they are used, the interlocutor, and the communicative intent of the speaker. It has been assumed that individuals tailor their gestures to the main focus of a conversation and as a result they vary in form and meaning from one conversation to the next (Müller, 2013). However, recent studies have found that contrary to this received knowledge, the iconic gestures produced by hearing adults exhibit a high degree of systematicity, and tend to represent very similar forms across individuals.

For instance, it has been found that the iconic co-speech gestures used in object descriptions are highly systematic and their form depends on the physical properties of the referent (Masson-Carro, Goudbeek, & Krahmer, 2015). Objects that can be manipulated with the hands (e.g., a pen) are represented with gestures mimicking how the object is held; while objects with low manipulability affordances (e.g., a sink) are represented through gestures outlining their shape. A striking degree of systematicity has also been reported in elicited silent gestures (i.e., pantomimes). When asked to express concepts in pantomime, participants tend to systematically differentiate actions from tools through distinct gestural forms (i.e., re-enactment of bodily movements for verbs and handshapes representing the form of objects for nouns) (Padden et al., 2013; Padden, Hwang, Lepic, & Seegers, 2015). More recently, high degree of systematicity in the structure of pantomimes has also been found across different semantic domains and for geographically unrelated cultures. Ortega and Özyürek (2016) elicited pantomimes from Dutch and Mexican adults and found that both groups employ remarkably similar strategies to depict referents. Through the implementation of specific types of iconic representations and their combinations, participants systematically represent concepts across different semantic domains. These pantomimes bare strong resemblance with the structures of recently discovered sign languages (Safar & Petatillo, in preparation), so it has been argued that pantomimes reveal some of the cognitive dispositions that give rise to a signed lexicon in emerging sign languages.

The relevance of these studies is two-fold: first, they demonstrate that iconic gestural depictions are not as variable as previously assumed, but rather are deployed systematically to represent concrete concepts within specific semantic domains. Second, such systematicity results in shared knowledge about some manual forms across a community of speakers. As a consequence, individuals are likely to have expectations of how a concept should be represented in the manual-visual modality – at least for a set of referents. This has important implications for the perception of sign iconicity by non-signers. Non-signing adults confronted by conventionalised signs for the first time will not make judgements about their meaning in a vacuum. Rather, they are likely to fall back on their gestural knowledge to make judgments about the meaning of iconic signs.

The Present Study

Based on evidence that many iconic gestures are highly systematic across individuals (Masson-Carro et al., 2015; Ortega & Özyürek, 2016; Padden et al., 2013, 2015; van Nispen, van de Sandt-Koenderman, Mol, & Krahmer, 2014) it is possible to assume that non-signing adults have at their disposal a cohort of shared gestures with specific forms and meanings on which they may base their judgment about signs. In order to test this hypothesis, we carried out two studies. In Study 1 we elicited pantomimes from non-signing adults to determine which gestures were the most systematic across participants. Once these pantomimes were selected, we compared them to signs from Sign Language of the Netherlands (NGT) and looked for signs that overlapped in form to different degrees (full, partial, or no overlap). These signs served as stimulus materials for Study 2. In this study, a different group of participants were presented with the signs and were asked, first, to guess their meaning. After they gave their response, they were given the correct translation, and then were asked to give iconicity ratings. The prediction is that when signs map directly to their gesture non-signing adults will be more accurate at guessing their meaning and will assign higher iconicity ratings (e.g., the gesture and the NGT sign TO-SMOKE represent a person smoking a cigarette so participants are likely to be very accurate and give high iconicity ratings). The expected results will lend credence to the hypothesis that sign-naïve adults base their responses not only on their emblems (Grosso, 1993), but also on other types of (iconic) gestures that are systematic within a community.

Methodology

Study 1: Pantomime generation task

Participants

Twenty native speakers of Dutch (10 females, age range: 21-46, mean: 27 years) living in the area of Nijmegen, the Netherlands, took part in the study.

Procedure

Participants were seated in front of a computer and were asked to produce a gesture that conveyed exactly the same meaning as the word on the screen. They were explicitly told that it was not allowed to speak or to point to any object in the room and that they could say 'pass' if they were unable to generate a pantomime. Two cameras were positioned on each side of the participant to record their gestural productions. Trials started with a fixation cross (500 ms) followed by the target word (4000 ms) time during which they had to produce their gesture. After the 4000 ms ended, the next trial began. The motivation behind this strict timing was to elicit participants' most intuitive response. Participants were presented a total of 273 words.

Pantomimes were coded according to the description parameters proposed by Bressem (2013), which are based on the phonological parameters *handshape*, *location*, and *movement* of sign languages. Based on these features, we looked at the gestures that exhibited the same structure across a large number of participants. If the same gesture was produced by at least 12 out of 20 participants, it was considered the *default* gesture for that concept. These resulted in a total of 119 pantomimes that were consistent across a large proportion of the pool of participants (mean number of participants producing the same pantomime: 15.14).

These *default* gestures were compared to their NGT translation on each phonological parameter (i.e., handshape, location and movement) to select items with different degrees of form overlap. This comparison resulted in three categories of signs. 1) Full overlap (N=36): gesture-sign pairs did not differ in any parameter (Figure 1A). 2) Partial overlap (N=56): this category includes signs in which only one parameter differed from the gesture (Figure 1B). 3) No overlap (N=54): signs in which two or more parameters differed. This category consisted of 27 signs that did not overlap at all with the elicited gesture, plus an additional 27 signs for which no default gesture could be established (Figure 1C). These three groups of NGT signs (N=146) were the stimuli for Study 2.

Study 2: Open-cloze and iconicity rating

Participants

The participants of this study were a different group of 20 hearing native speakers of Dutch (14 female, mean age = 21.8 years) with no knowledge of NGT or any other sign language. None of them took part in the pantomime generation task.

Stimuli

The stimuli consisted of videos of the 146 NGT selected from Study 1 (i.e., signs with full, partial, and no overlap with gesture). Videos were produced by a deaf signer with neutral face and without mouthings to avoid giving away cues about the meanings of the signs.

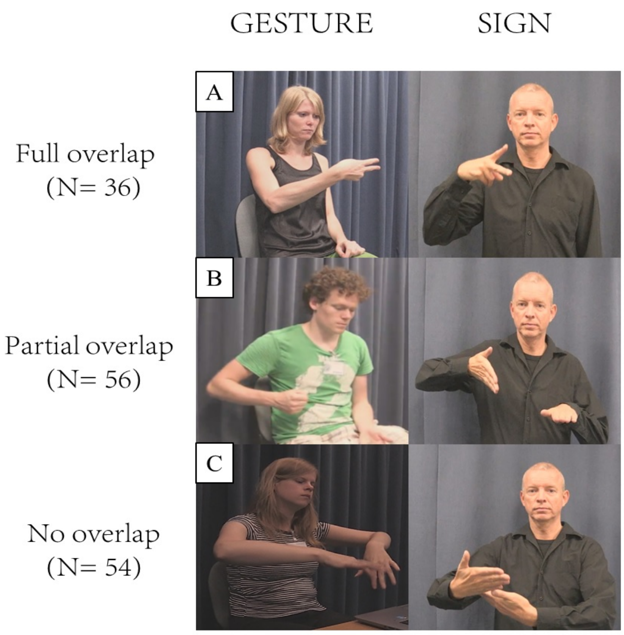

Figure 1: Examples of sign-gesture pairs with different degrees of overlap. A) TO-CUT shares all the components (handshape, location, movement) between sign and gesture. B) TO-SAW differs in only one parameter (handshape). C) In LAPTOP, sign and gesture have no overlap.

Procedure

At the beginning of each trial, an NGT sign in citation form was presented. After the video had played in full and disappeared from the screen, a new screen was presented instructing participants to guess the meaning of the sign and write its meaning in one word (typed). Participants were required to type in an answer for every item but they were also allowed to skip items if they could not come up with a meaning. After participants had entered an answer, a new screen of instructions came up. Here participants were given the actual meaning of the sign and were asked to judge how well the sign represented its meaning. The sentence read: 'The meaning of the sign is [translation equivalent]. How much does the sign look like its meaning?' The screen displayed a 7-point Likert and participants were required to type in their rating (1 representing the lowest similarity and 7 the highest).

Analysis

Participants gave a response for a large proportion of the signs with passes representing only 6.5% of responses. Despite being instructed to write only one word, many responses were phrases, but they were still included in the analysis. Based on the Dutch version of the Boston Naming Task (Roomer, Hoogerwerf, & Linn, 2011), answers were coded as correct and incorrect. Answers were coded as correct if they matched exactly the expected answer (e.g., sign: TO-PULL; response: to pull) or if they were synonyms of each other (e.g., sign: TO-PHONE; response: to ring). This category also included answers that were not the same part of speech as the target sign, but where the answer was specific to the target concept (e.g., sign: TO-PHONE; response: telephone)[1]. We also included phrases containing a verb and the correct argument depicted in the sign (e.g., sign: BANANA; response: to peel a banana). Responses that did not fit into any of these categories were classed as incorrect answers.

Incorrect answers were subdivided into responses that were semantically related and unrelated to the sign. Semantically related answers included responses that belonged to the same semantic domain (e.g., sign: DUCK; response: penguin); as well as answers that were lacking the appropriate abstraction to the target concept (e.g., the sign MONKEY, which re-enacts how a primate scratches the sides of its torso, was often labelled as *scratching*).

The semantically unrelated category included responses that were plainly wrong, or answers derived from visual information of the sign, but that had no relationship with the concept (e.g., the sign MOUNTAIN describes the outline of two horizontal bumps, but it was often interpreted as a *camel*).

For the open cloze, the proportions of correct, semantically related, and semantically unrelated answers were calculated for every item, thereby collapsing across participants' answers. Missing answers were discarded for this analysis and did not contribute to the proportions. For the iconicity ratings, all values were averaged across participants to obtain the mean ratings for each of the 146 signs.

[1] In Dutch, verb/noun distinctions are differentiated through affixes to the root. For example, telef*oneren* (to phone) is a verb and telef*oon* (telephone) is a noun. The English translations do not reflect that participants responded with a single word.

Results

Performance on the open cloze was highly variable across participants and items. While only nine items (6.2%) were correctly identified by all participants, half of the signs (73 signs) were correctly identified by at least 25% of participants. For 26 items (17.8%), all answers were semantically related to the target meaning, suggesting that participants were able to correctly identify some aspect of the sign but did not make the full abstraction to the target meaning (e.g., sign: TO-FLY; response: bird). Regarding the iconicity ratings, participants were able to give a response for all items. In order to establish to what extent sign-gesture overlap contributes to guessing the meaning of a sign and assign iconicity ratings, we considered the following variables in the statistical analysis.
Independent variable: Degree of overlap (full, partial, and no overlap)

Dependent variables:

i. Proportion of correct answers (open cloze)
ii. Proportion of semantically related answers (open cloze)
iii. Proportion of semantically unrelated answers (open cloze)
iv. Mean iconicity rating

A multivariate ANOVA was run to determine the relationship between type of gestural overlap (full, partial and, no overlap) and the dependent variables of the open cloze and the iconicity ratings. Using Pillai's Trace we found a significant overall effect of the degree of overlap, $V = 0.541$, $F(6,230)=14.205$, $\eta^2= .27$, $p < .001$. The following sections will describe the between-subjects effects for each dependent variable.

i) Turning to the proportion of *correct answers* in the open cloze, tests of between-subjects revealed a significant effect of degree of overlap, $F(2,116)=24.168$, $\eta^2= .194$, $p < .001$. Planned contrasts revealed an increase of correct answers from no overlap items (M = 0.12, SE = .03) to partial overlap (M = 0.46, SE = .05, Δ = -0.31, SE_Δ = .06, p <.001, BCa 95% CI [-0.45, -0.18]), but no significant difference between partial and full overlap (M = 0.61, SE = .06, p = .209). The proportion of correctly identified items was thus higher for items with full and partial overlap than for those with no overlap (Figure 2).

ii) Regarding the proportion of incorrect answers that were *semantically related* to the sign, a test of between-subjects effects revealed no significant effect of the degree of overlap between gestures and signs, p = .305. That is, wrong answers in the open cloze were equally distributed across the three types of signs (full, partial, and no overlap).

iii) Turning to the proportion of incorrect answers that were *semantically unrelated* to the target concept, tests of between-subjects effects revealed a significant effect of the degree of overlap, $F(2,116)=26.909$, $\eta^2= .317$, $p < .001$. Signs with no overlap were significantly less likely to be guessed correctly (M =0.75, SE = .05) than those with partial overlap (M = 0.41, SE = .05, Δ = 0.34, BCa 95% CI [0.21, 0.47], p < .001). Signs with full overlap were significantly more likely to be guessed accurately than signs with partial overlap (*M* = 0.21, *SE* = .04, Δ = 0.192, BCa 95% CI [0.05, 0.33], *p* =.009). In other words, the less similar a sign is from a gesture, the more likely it is to be guessed inaccurately.

iv) When we look at iconicity ratings, we found an association with the degree of overlap between sign and gesture $F(2,111.836)=54.13$, $\eta^2=.483$, $p < .001$. Planned contrasts revealed a significant increase of mean iconicity ratings from no overlap (*M* = 3.18, *SE* = 0.22) to partial overlap (*M* = 5.34, *SE* = .17, Δ = -2.13, BCa 95% CI [-2.617, -1.642], $p < .001$) but not from partial to full overlap (*M* = 5.92, *SE* = .15, *p* = .07). These results suggest that when signs have greater overlap in form with their gestures they perceive signs as more iconic (see Figure 3).

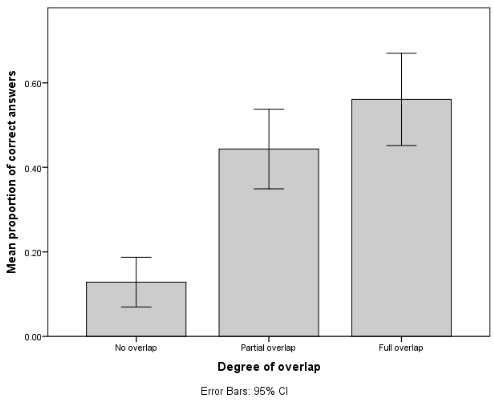

Figure 2: Mean proportion of correctly guessed answers as a function of gesture overlap with the target sign

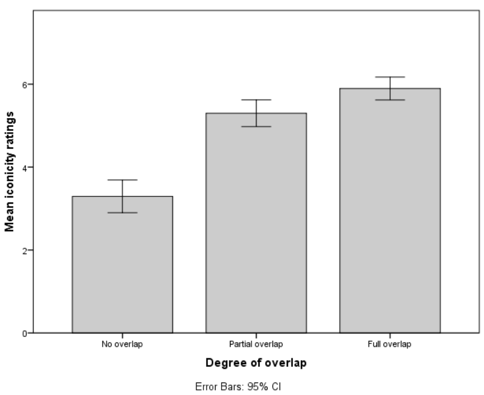

Figure 3: Mean iconicity ratings as a function of gesture overlap with the target sign

Discussion

These data expands on previous research by showing that the gestural repertoire of non-signing adults is recruited to make judgments about the meaning of lexical signs. We showed that signs that overlap in form with their gestures are guessed more accurately and are judged as more iconic. The proportion of correct answers and iconicity ratings were higher for signs that overlapped in form with gestures, but there was no additional improvement between full and partial overlap. This suggests that despite their slight structural differences, these two types of signs bear enough resemblance to participants' gestures to make an association between them.

Signs and gestures share the same physical constraints to express a concept in the manual modality, with the referent shaping to some extent the features than can be expressed with the hands (Masson-Carro et al., 2015). It is therefore not surprising that signs and gestures converge in the strategies to depict the visual characteristics of many concepts. If signs and gestures have similar structures for some concepts, it means that deaf and hearing adults share conceptual knowledge about these concepts (i.e., visual, semantic, perceptual, sensorimotor representations). When there is sufficient overlap between signs and gesture, non-signing adults may tap into these schemas to make judgements about the meaning of signs. These findings also relate to research showing that humans – as well as other primates – understand and evaluate the correctness of others' actions through the activation of brain regions engaged when they perform the same actions themselves (Koelewijn, van Schie, Bekkering, Oostenveld, & Jensen, 2008; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996).

The errors produced by participants, however, clearly show that if gesture and sign mismatch, or if the meaning of signs departs slightly from the features they depict, participants are unable to estimate accurately the meaning of a sign. As a result, they will also rate the sign as less iconic. Non-signers have a very limited scope to assign meanings to signs and seem to be inclined to describe only what is directly encoded in them. While they are capable of extracting some visual information from the signs they often fail to respond with the correct metonymic associate (e.g., they respond *scratch* instead of *monkey*). This goes to show that despite their similarities, sign languages have established linguistic conventions not shared with gestures and thus are inaccessible to non-signing adults.

This study adds to the body of research investigating how modality shapes linguistic/communicative structures (Perniss et al., 2015).

Acknowledgments

This work was supported by a Veni grant by the Netherlands Organisation for Scientific Research (NWO) awarded to the first author. We would like to thank the members of the Multimodal Language and Cognition lab at Radboud University for their helpful comments, in particular to Swen Schreiter, Linda Drijvers, and James Trujillo for their support.

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