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FUNCTION VARIABLES IN METAPHORIC INTERPRETATION: EVIDENCE FROM ICONICITY IN SIGN LANGUAGES

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1 The interpretation of metaphor

Ever since Aristotle, the nature of metaphor has been a hotly debated topic. What does Romeo mean when he utters (1)?

(1) Juliet is the sun.

Clearly, Romeo does not mean that Juliet is an extremely massive object composed mostly of hydrogen. He appears to mean that Juliet has some relevant property that is shared by the sun: perhaps that she is beautiful, or necessary for his life, etc. But how does this actually work? How is (1) interpreted in such a way? Two major theories have been proposed to account for the interpretation of metaphor. According to the predication view (Ortony 1979; Fogelin 1988), there is some property P associated with the sun, and (1) predicates P of Juliet. The logical form of (1), then, would be something like (1').

(1') P($\mathbf{i}$)

According to the categorization view (Glucksberg 1990; Glucksberg and Keysar 1993), sentence (1) expresses a category membership statement, similarly to (1''), which expresses the statement that Juliet is a member of the category **woman.**

(1'') Juliet is a woman.

What category does Juliet belong to according to (1)? Under the categorization view, there is a superordinate concept, **sun***, which includes the sun, but also other individuals that are relevantly similar. Then (1) means that Juliet is an instance of **sun***, as formalized in (1'''').

(1''') **j** ≤ **sun***(1'')

How can we decide between the two theories?

In this paper we provide a novel answer to this question. Specifically, we will consider sign languages, which provide unique insights into this problem. As we will see, metaphors in sign languages interact significantly with iconicity; iconicity, in turn, interacts interestingly with assignment functions; and this will allow us to conclude that metaphoric interpretation relies crucially on function variables, which will provide evidence for a version of the predication view.

2 Metaphors and assignment functions

We will follow a version of the predication view proposed by Stern (2000). He argues that in a metaphor like (1), there is a set of properties associated with the sun; and then a function picks out one of these properties, and predicates it of Juliet.

Let us assume that the set of properties is something like

(2) P = {be beautiful, be necessary for life, be the center of the universe, …}

Sterns's proposal amounts to the application of a choice function f to P, and the predication of the resulting property of Juliet. So, the logical form of (1) is:

(3) (f(P))(**j**)

Stern assumes that the set P is a singleton, so that f is a constant function picking the single property in P, but he allows that P may have a greater cardinality, as in (2). The question is, then, how is f determined?

We propose that the choice function is actually a function variable X. The logical form of (1) is therefore actually:

(4) (X(P))(**j**)

In the standard way, the interpretation of formulas like (4) is relative to a model and an assignment function. Like all variables, the value of X is determined by the assignment function. This will be the key to the interaction of metaphor with iconicity, as observed in sign languages.

3 Assignment functions and iconicity

Although modern linguistics since at least Saussure highlighted the arbitrary nature of the linguistic sign, research in the several last decades showed that natural languages are replete with

iconicity (e.g. Heiman 1980, 1985; Givón 1985; Raffaele 1995 and references there). Research on the linguistic structure of sign languages enhanced the importance of iconicity in natural languages, and opened the door for investigating how iconicity interacts with and even influences linguistic structures in both sign and spoken languages (see inter alia Frishberg 1975; Fischer 1999; Taub 2001; Meier, Cormier, and Quinto-Pozos 2002; Meir 2003, 2010; Sandler and Lillo-Martin, 2006; Pizzuto, Pietrandrea, and Raffaele 2007; Perniss 2007; Perniss, Thompson and Vigliocco 2010). In particular, a fact that will turn out to be crucial to our investigation of the meaning of metaphors is that iconicity can affect the range of assignment functions.

Evidence for this fact comes from the interpretation of pronouns in sign languages. Pronouns are usually represented as variables, which receive their value from assignment functions. These functions are subject to well known constraints. One example of these constraints is the Complement Set Restriction: when a set is introduced by a quantifier, a pronoun may refer to that set, to the superset that it is derived from but not to its complement set. Thus, both (6a) and (6b) are fine as continuations of (5), but (6c) is bad.

(5) Most students came to class.
(6) a.　They asked good questions (*they*=the students who came to class)
　　 b.　They are a serious group. (*they*=the students)
　　 c.　*They stayed home instead (*they*=the students who did not come to class)

The Complement Set Restriction is satisfied universally, in spoken as well as signed languages. However, in sign languages, iconicity can override this constraint (Schlenker *et al*. 2013).

In sign languages signers can realize anaphora by different means. The most wide-spread anaphoric device is by making use of loci in the signing space, which are associated with discourse referents. This association is established by signing an NP and then pointing to, or directing the gaze towards a specific point in the signing space. Such a point, often called an R(eferential)-locus (Lillo-Martin and Klima 1990), serves as an overt referential representation of the NP, and subsequent pointing to or directing a verb towards this R-locus has anaphoric functions, such as pronominal or verb agreement functions.

According to Schlenker *et al*., when translating sentence (5) above to American Sign Language (ASL), the signer signs the sign COME in location (a) in space. Pointing to that sign in the following sentences yielded interpretations similar to the English ones. The pronoun THEY, realized as an arc at the (a) locus,[1] can be interpreted only as referring to the maximal set, the set of students who came to class.

However, in ASL there is another anaphoric strategy to convey sentences (5-6). This strategy involves creating a special diagrammatic representation of the set of all students and the sub-set of most of the students. The diagram is created by tracing a circle in space that represents all students (which Schlenker *et al*. refer to as area *ab*), and then tracing a smaller circular area within the large area (area *a*), representing the maximal set (the students who came to class). This iconic representation automatically makes available an area in space that is included in *ab*, but lies outside of area *a*, representing the complement set *b* (the students who did not come to class). These diagrammatic relationships are represented in Figure 1. Subsequent pointing to areas *a*, *b* or *ab*, yield grammatical sentences which indicate reference to all three sets (students who stayed at home (7a), students who came to class (7b) and all students (7c)):

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[1] The arc movement of the sign encodes the plurality of this pronominal sign (THEY as opposed to S/HE).

(7) POSS-1 STUDENT IX-arc-ab MOST IX-arc-a a-CAME CLASS.

'Most of my students came to class.' (8, 196; 8, 197; 8, 206; 8, 224)
a. 7 IX-arc-**b** b-STAY HOME
'They stayed home.'
b. 7 IX-arc-**a** a-ASK-1 GOOD QUESTION
'They asked me good questions.'
c. 7 IX-arc-**ab** SERIOUS CLASS.
'They are a serious class.'
(Schlenker *et al*. p. 98, example 8).

Complement set anaphora is made possible by using this strategy because the iconic representation of the diagram in Figure 1, by tracing the larger circle and a circle embedded in it, creates another area in space (as is created by the printed diagram) which can be associated with the complement set. Thus, the iconic representation of sets as areas in space enables an assignment function to assign a value that is normally unavailable.
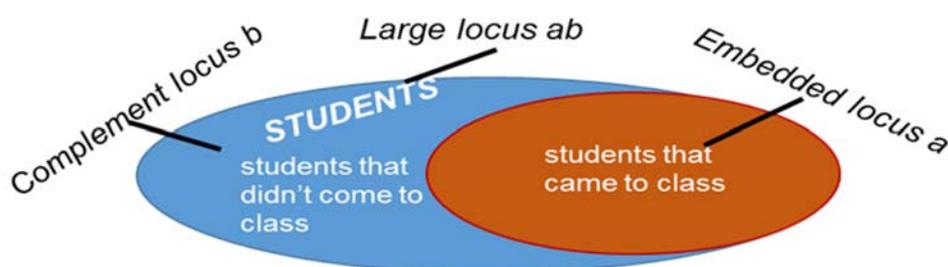

Figure 1: Iconic diagram representing the three sets (based on Schlenker et al. 2013:99)

It follows, then, that iconicity can affect the range of assignment functions: while assignment functions usually cannot assign the complement set to an anaphoric variable, iconicity can allow them to do so.

We propose that metaphor provides another case in which iconicity interacts with the range of assignment functions. Specifically, metaphor is anaphoric, and gets its interpretation using assignment functions. This predicts that iconicity can affect the interpretation of metaphor in specific ways. As we will show, this prediction is borne out.

4 Metaphor and iconicity: the double meaning constraint

Meir (2010) notes that some expressions that receive a metaphorical interpretation in spoken languages cannot be so interpreted in sign languages. For example, (8-10) normally do not mean that the house/acid/car literally ate all my savings/the metal/gas, but rather that these substances were consumed by the event that took place.

(8) The house ate up all my savings.
(9) The acid ate through the metal.
(10) My car eats gas.

However, this metaphorical interpretation of the verb *to eat* is unavailable when these sentences are translated to sign languages, such as American or Israeli Sign Languages (ISL). Meir attributes the unavailability of metaphorical interpretation to the iconicity of the sign EAT in these languages, whose form represents putting something into the agent's mouth (Figure 2a). She suggests that the iconicity of this sign clashes with the shifts in meaning that take place in these metaphorical extensions. This explanation is based on Taub's (2001) model that both iconicity and metaphors are built on mappings of two domains: form and meaning in iconicity, source domain and target domain in metaphors. Iconic signs that undergo metaphoric extension are therefore subject to both mappings.

However, this double mapping is not always available. When the two mappings do not preserve the same structural correspondence, Meir (2010) argues that the metaphorical extension is blocked. This line of explanation accounts for the impossibility of using the ISL sign EAT in the above expressions. The meaning of 'eat' is 'to put (food) in the mouth, chew if necessary, and swallow'. That is, the food is consumed as a result of the eating event. But the consumption of the food is not represented iconically in the form of the sign. The form of the sign iconically represents holding a small object (by the 🖐 handshape), and putting it into the agent's mouth (represented by the movement of the hand towards the signer's mouth). Each of the formational components of the sign (its handshape, location and movement) corresponds to a specific meaning component of the event of eating, as is shown in the left and middle columns of Table 1.

Yet the metaphorical use of 'eat' in the above sentence profiles the consumption: 'The house ate up my savings' means that the house consumed my savings as the agent consumes the food in an eating event. The metaphorical mapping between the two domains is presented by the middle and right columns of Table 1. The two mappings, the iconic mapping and the metaphoric mapping, do not match, as can be seen from Table 1.

Iconic mapping		Metaphorical mapping
Articulators	Source	Target
🖐 handshape	Holding an object (food)	X
Mouth	Mouth of eater	X
Inward movement	Putting food into mouth	X
X	Consumption of food	Consumption of object

Table 1: Double mapping for EAT and 'consuming is eating'

The meaning component that is active in the metaphorical mapping, the consumption, is not encoded by the iconic form of the sign. And the meaning components of the iconic mapping – the mouth, manipulating an object, putting into mouth – are bleached in the metaphor. The mismatch in the double mappings of the verb EAT and its intended metaphorical interpretation suggests that there is some kind of interaction between the iconic form of a sign and the kinds of metaphorical extensions it can undergo. Specifically, the iconic form of a concept and its metaphorical extension cannot profile different aspects of that concept. This is captured in the following constraint (Meir, 2010):

The Double-Mapping Constraint (DMC): A metaphorical mapping of an iconic form should preserve the structural correspondences of the iconic mapping. Double-mapping should be structure-preserving.
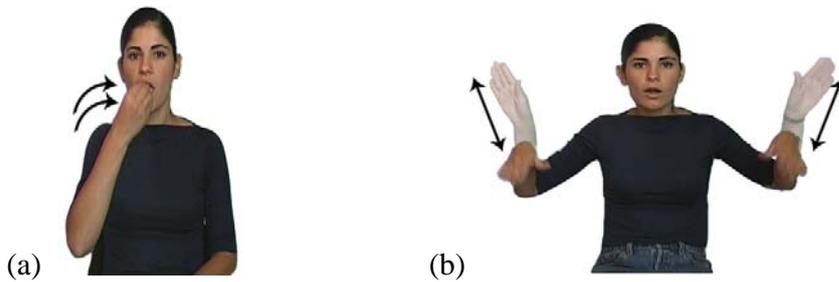
Figure 2: The iconic ISL signs (a) EAT and (b) FLY

The DMC can account for other metaphors that are possible in many spoken languages but not in sign languages, such as *Time flies; He climbed the ladder of success; The project took off*. In each of these expressions, the concept undergoing metaphorical extension is represented in ISL and ASL by an iconic sign, whose form highlights aspects of the meaning that should be bleached in the metaphor. In FLY (Figure 2b), the hands represent the flapping of the wings, a meaning component irrelevant for the metaphor. The metaphor profiles the speed of motion, which is not represented by the form of the sign. Similarly, the form of the ISL sign CLIMB highlights the manner of motion (moving by grasping the wrings of the ladder in an alternating fashion) rather than the upward movement intended as the basis for the metaphoric interpretation; and the form of the ISL sign TAKE-OFF highlights (by its handshape) the instrument performing the action (an airplane), which is irrelevant for the metaphor.

It seems, then, that iconicity interacts with metaphor in an interesting way: it restricts the possibility of an iconic sign to be used or interpreted metaphorically, if the property which is iconically represented in the form of the sign is not the property which the metaphor is based on. But what is the source for this restriction? Why does iconicity interfere with metaphorical extension of a sign? We attribute this interference to another property of iconic expressions, the fact that they cannot be inhibited. Yet metaphorical interpretation requires the inhibition of certain properties of the word. It is the tension between these two factors that will feature prominently in our explanation of the DMC. Inhibition, then, is crucial to our suggestion, to which we turn in the next sections. We first look at the role of inhibition in metaphoric interpretation, and then at its interaction with iconicity.

5 Metaphor and inhibition

Intuitively, in order to interpret a metaphoric statement such as (1), we need to inhibit the literal properties of the sun, such as being very massive or very hot or 150 million kilometers from Earth; we keep only the properties that are relevant to the interpretation of the metaphor. The notion that metaphor interpretation requires inhibition has received some experimental confirmation.

Glucksberg *et al.* (2001) show that properties that are not relevant to the metaphorical interpretation are negatively primed, i.e. inhibited. Subjects were asked to judge the acceptability of target sentences following either metaphors or literal statements. For example, a sentence like (12) was judged following either the literal (11a) or the metaphorical (11b).

(11)   a. The hammerhead is a shark.
         b. My lawyer is a shark.
(12)   Geese can swim.

Glucksberg *et al.* found that (12) took longer to judge when preceded by (11b) than when preceded by (11a). Their explanation is that the word *shark* normally primes the property *swim*, facilitating the interpretation of a sentence containing it. However, if *shark* is interpreted metaphorically, this property is not primed. This is why (12), which contains the word *swim*, takes longer to judge when following the metaphorical (11b) than when following the literal (11a).

Fernandez (2007) extended these findings, by showing that the irrelevant property is not simply not primed, but actually inhibited. Using a lexical decision task, Fernandez showed that words that are related to the literal meaning of the metaphor actually took longer to judge than words that were not related at all.

For example, consider (13) and (14): in both of them, a target word follows a sentence. The target word in (13b), *skin*, is not related to any of the words if (13), hence it is not primed. In contrast, the target word in (14b), *animal*, is related to the word *zoo* appearing in (14a). But note that *zoo* is used metaphorically in (14a), and the interesting result is that the judgment of (14b) is actually *slower* than the judgment of (13b)! This result demonstrates that the literal meaning of *zoo* is actually actively inhibited, not merely not primed.

(13) a. Wisdom teeth are troublemakers.
     b. skin
(14) a. State schools are zoos.
     b. animal

Interestingly, the effect occurs only after 1500 msec, which is consistent with the fact that inhibition takes time.

Langdon *et al.* (2002) provide evidence for the inhibition hypothesis from a different direction: the behavior of schizophrenic patients. In particular, they studied both the ability of these patients to inhibit irrelevant information and their interpretation of metaphors, and found the following correlation: "the better the patients were at suppressing prepotent inappropriate information… the more likely they were to recognize appropriate uses of metaphorical speech." (Langdon *et al*. 2002: 95)

6 Iconicity and inhibition

Thompson *et al.* (2010) found that iconic signs are much harder to inhibit than non-iconic ones, even in tasks that require no access to meaning. They asked deaf signers of British Sign Language (BSL) to make a phonological decision: to decide whether BSL signs, presented in video clips, were produced with a handshape with straight or curved fingers (see Figure 3). The signs were both iconic and non-iconic, but importantly, the iconicity of the signs was irrelevant for the task, as the task did not involve access to the meaning or meaning components of the signs.

Thompson *et al.* found that iconic signs led to slower reaction times and more errors in the participants' responses. They suggest that meaning is activated automatically for highly iconic signs, because of the closer form-meaning mapping in these signs. This automatic activation of meaning interfered with the task because it provided information that could not be inhibited yet was irrelevant to the task at hand. It seems, then, that iconicity cannot be ignored, even when it is irrelevant.

a.   b.

Figure 3: Examples of handshapes with (a) straight fingers and (b) with curved fingers.

Another possible inhibitory effect of iconicity was found by Baus *et al.* (2013). The tasks in this study did involve meaning, as bilingual (ASL-English) signers were asked to translate signs (iconic and non-iconic) from ASL to English and from English to ASL, or to determine whether a given ASL sign and a given English word match in meaning. The findings show that iconicity interfered with the performance of fluent ASL-English bilinguals: their responses to the ASL-into-English translation task and the matching task were significantly slower for iconic signs than for non-iconic ones. These results are surprising. In the Thomson *et al.*'s (2010) study described above, iconicity seemed to interfere with the task because it caused automatic access to meaning, which was irrelevant to the phonological task in that study. Yet in the translation task, faster access to meaning is expected to speed translation for iconic signs. The authors suggest that the iconicity of the signs "forced" the participants to use a specific translation strategy that slowed down performance. In order to translate a word, an association must be formed between the lexical systems of the source and target languages (*word-word association*), or the associations can be formed through the conceptual systems (*conceptually mediated translation*). Baus *et al.* tentatively suggest that "the imagistic or sensory-motor properties of the iconic signs induced these signs to be translated via conceptual mediation, which slowed translation times" (2012: 269). An explanation along these lines supports the hypothesis that iconic properties of signs cannot be inhibited.

7 Putting it all together

We can now put it all together. By showing how metaphor, assignment functions and inhibition interact, we provide an explanation for the DMC. This explanation relies on our hypothesis that metaphoric interpretation involves function variables, and therefore provides support for the predication view of metaphor

Recall that we argue that metaphoric interpretation involves a contextually determined set of properties *P*, and a function variable *X*. This function variable, like all variables, is assigned a value by an assignment function: the value is a choice function out of *P*. Once a value is assigned, one property, *X(P)* is selected, and is taken to be the predicated property under the metaphoric interpretation. All other properties in *P* are inhibited, and do not take part in the resulting interpretation.

But suppose some property $p \in P$ is expressed by iconic means in a sign language. We have seen that iconic signs cannot be inhibitedand we deduce that the properties that are iconically represented in such signs, cannot be inhibited. Hence, property p, the property that is expressed iconically, cannot be inhibited. It therefore follows that the choice function assigned to X is a function that *must* pick p, and cannot pick the intended property for the metaphoric interpretation. The end result is that the metaphoric interpretation is blocked, precisely as described by the DMC. Consider example (13).

(13) The house ate all my savings

The set of properties associated with the property *eat* is, plausibly, something like (14).

(14) $P = \{$*put entity in mouth, consume entity, chew, swallow, …*$\}$

The intended metaphoric interpretation, is, of course, that my savings are consumed by the house. It is generated by assigning to the function variable X the choice function that picks the property of consuming the entity:

(15) $X(P) =$ *consume entity*.

This is how the metaphor is interpreted in a language like English. However, the story is different in a sign language in which the sign for EAT is an iconic representation of a different property of the eating event, namely *put entity in mouth*. In this case, obligatorily, X is assigned a choice function that picks the iconically presented property, i.e.

(16) $X(P) =$ *put entity in mouth*

The intended metaphoric interpretation is thereby blocked, and we can only get the odd interpretation that my savings were put into the house's mouth.

8 Conclusion

The nature of metaphor has been a hotly debated topic since Aristotle. We proposed here a version of the predication view that can adequately capture the nature of metaphors. Specifically, we argue that the interpretation of metaphor involves a function variable, and the value of this variable is provided by an assignment function. Crucially, there is no obvious role for function variables in the categorization view.

As evidence for our proposal, we have shown that in sign languages, iconic properties, which cannot be inhibited, must be picked by this function, even if this blocks the intended metaphoric interpretation.   Hence, an investigation of iconicity in sign language provides evidence relevant to the debate on the nature of metaphor in general.

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