SHORT REPORT

Limitations on simultaneity in sign language

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Sign languages have two primary articulation tracts: the two hands. They also have secondary articulation tracts that can be partitioned: the nonmanuals. Thus multiple propositions can be conveyed simultaneously. We have attested at most four simultaneously articulated independent propositions in sign languages, and suggest that this limit follows at least partly from limitations on visual short-term memory to cope with the information received. It appears further that the simultaneous propositions must be connected, often sharing arguments or verbs, an account of which concerns matters of production and of cognitive load. A brief look at simultaneity in spoken language suggests that similar if not identical limitations apply.*

Keywords: sign language, simultaneity, gestures, visual short-term memory, cognition, syntax

1. INTRODUCTION. When we converse, information is often conveyed in multiple ways. For those using spoken language, we have, besides the vocal tract, nonverbal articulators as well, including eye gaze (Hanna & Brennan 2007), gesture (Kendon 2004), facial expression (Busso & Narayanan 2007), lip pointing (Sherzer 1983), and puffed cheeks (Sherzer 1993). Likewise, for those using a sign language, we have, besides the hands, nonmanual articulators as well, including facial expressions, eye gaze, mouth, and body posture (Baker & Padden 1978). In this short report we investigate how much information can be simultaneously expressed in sign language (by counting 'propositions') and conclude that there are limitations. We then consider the nature of these limitations, and finish by briefly comparing the situation in spoken language to the situation in sign languages.

2. SUBJECTS. We first demonstrate the variety of ways that individuals and other entities may be referred to in sign languages (we call these entities 'subjects' for the moment, as we intend for them to be subjects of predication, thereby forming propositions). We draw our examples from American Sign Language (ASL) and British Sign Language (BSL).

As a basic option, one can sign a lexical item indicating a subject (e.g. sign 'BOY'), perhaps then pointing to a location in space that then serves as a pronominal referent for that lexical item (and this spatial index can be used as a location for agreeing verbs, pointing verbs, and so on). Beyond that, signers have two main choices for representing subjects. One way is to depict them manually. Usually this is via an entity classifier. In Figure 1 (from Novak 2000) the left hand acts as a classifier for a person. Here the per-

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son is walking along. (The other hand signifies nothing, but, instead, is waiting to be used in the next utterance.)

FIGURE 1. The 1 classifier, showing a person walking along.[1]

Another option is where a signer may embody the subject. That is, the subject is mapped onto the signer's body, so that the signer's mouth becomes the subject's mouth, the signer's eyes become the subject's eyes, and so on. In Figure 2, from Paul Scott's (2003) BSL retelling of Aesop's fable of *The hare and the tortoise*, the hare has a disdainful, overconfident facial expression, and the tortoise has a patient, determined one. The signer's hands in these examples articulate running and walking (i.e. the predicate), and not the subject.

FIGURE 2. Human facial expressions for a disdainful hare and a patient tortoise.

The nonmanuals can also embody the subject while the hands/arms show a classifier indicating some property of that same subject (rather than the analogous part of that subject's body). In Figure 3 we have a scene from Paul Scott's poem 'Too busy to hug, too blind to see'. A mountain is talking roughly to the sea, which has been annoying it. The hands/arms are classifiers showing the mountain's shape. The rest of the signer has embodied the subject; for instance, the mouth of the signer is understood to represent the mouth of the (anthropomorphized) mountain (so the mountain has a mouth), and the poet's mouth has become the mountain's mouth, as the mountain mouths, 'What?!'. (The sea is indicated by the signer's eye gaze.)

[1] Figure 1 is found at http://www.yale.edu/asl12night/classifier1.html.

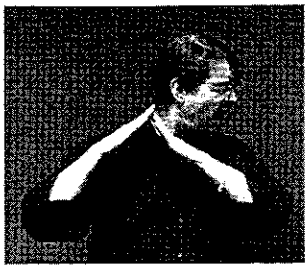


FIGURE 3. 'Mountain says, "What?!" to the sea below', from Paul Scott's poem 'Too busy to hug, too blind to see' (note the hands showing the mountain's shape).

Alternatively, the nonmanuals might embody the subject while the hands/arms present entity classifiers representing other arguments and what they are doing. In Figure 4 (from Novak 2000), the hands represent the characters of Orsino and Olivia, while the torso and head show the clown Feste, all from Shakespeare's *Twelfth night*. Here Feste says that sometimes he performs at Orsino's house, and sometimes at Olivia's house.

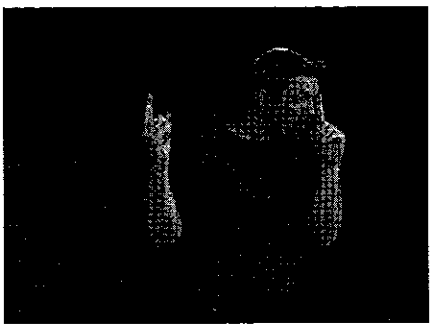


FIGURE 4. Each hand articulates a character and the rest of the body embodies a third character.

Less commonly, a signer may embody a subject through use of smaller portions of the body. Dudis (2004) points out that the body may be partitioned into zones that the signer can use to convey meaning. The head and face, for example, can be partitioned off from the rest of the torso (and see Wulf & Dudis 2005). Following Dudis 2004, we offer an example from ASL (although this example would work in many sign languages): in Figure 5, the hand indicates that someone is looking at the signer or at whomever the signer embodies; at the same time the signer's face looks puzzled. An immediate reading is that the puzzled face is that of the signer or of whomever the signer embodies—in which case the nonmanuals are all part of a single character. So someone (indicated by the hand) is looking at someone else (indicated by the nonmanuals), who is looking back in puzzlement. Alternatively, the puzzled face could be that of the person looking at the signer or at whomever the torso of the signer embodies. In this second possible interpretation, the head and face have been partitioned from the rest of the nonmanuals; the face embodies the same person that the manually articulated lexical sign represents (the looker), but the torso embodies the person looked at. Engberg-Pedersen (1993:103) calls this second reading SHIFTED ATTRIBUTION OF EXPRESSIVE ELEMENTS.

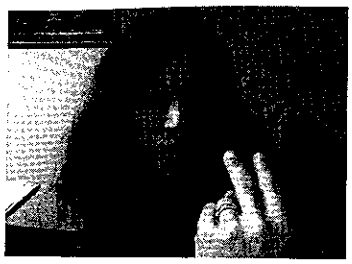


FIGURE 5. Hand shows someone looking at the person embodied by the signer; puzzled look on signer's face could belong to either the person looking or the person being looked at.

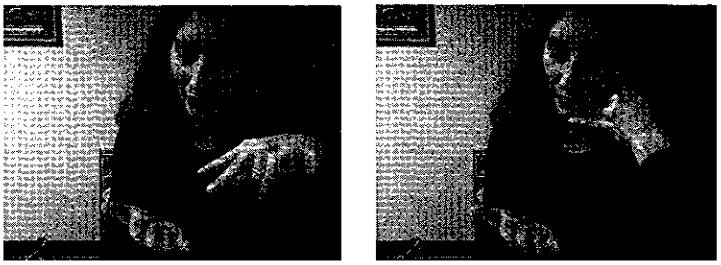
In the examples that follow, subjects are indicated through entity classifiers (or, sometimes, pointing signs, such as LOOK-AT in Fig. 5), embodiment via all the nonmanuals working together (perhaps with the hands/arms, as well), and embodiment via a partition of the nonmanuals.

3. SIMULTANEITY IN SIGN LANGUAGE: UP TO FOUR PROPOSITIONS. The subjects that we have been discussing have properties attributed to them (e.g. above, the hare is running, or the mountain is saying something), forming propositions. We are not going to attempt much more here than an intuitive understanding of the term; identifying propositions and their syntactic analog, clauses, with respect to sign language is difficult (Padden 1988, Crasborn 2007). For the examples here, however, a simple characterization suffices: a proposition is a predicate and its constellation of arguments (Johnston et al. 2007) and is free of internal conjunction. With this characterization, classifier constructions, for instance, constitute propositions, where the handshape indicates an argument and where orientation, location, and movement indicate a predicate (Padden 1988, Morford & MacFarlane 2003:219, Pizzuto et al. 2008 and the references cited there). This is true even for stationary classifier constructions. For example, if we sign a person walking toward a bicycle and use a classifier for the bicycle, the orientation of the classifier handshape can show whether the front or side or rear of the bicycle faces the person, or whether the bicycle is lying on its side or leaning against a wall, and so on. Thus, the orientation and location are predicative. So classifiers used in a locative way—so-called *transferts situationnels* 'transfers of situations' (Cuxac 1985, 2000, Vermeerbergen 2006, and many others)—are used to form propositions. In propositions with multiple arguments of a single predicate, the argument that the signer embodies is taken to be the subject (Meir et al. 2007).

While there are many different sorts of simultaneity in sign language (Friedman 1975, Miller 1994, Vermeerbergen et al. 2007), we focus on the number of propositions that may be simultaneously expressed. The simultaneous production of two propositions is fairly common in everyday signing in many sign languages (Milkovic et al. 2007). The manual articulators may express one proposition while the nonmanuals express another (as we saw in one reading of Fig. 5 in which someone is looking at the signer and the signer is puzzled). Simultaneity may be purely manually expressed, as well, as each hand expresses a proposition. For instance, with LOOK-AT, the two hands could be pointed toward each other, asserting that two entities are looking at each other. Likewise, we can have simultaneous classifier constructions; in talking about an accident between a motorcycle and a car, each hand could be a classifier and they could move toward each other and hit.

Another common type of example is seen in Figure 6. In Fig. 6a a signer signs that someone is reading a book. Then the signer holds the nondominant hand and the eye

gaze steady, while the dominant hand signs being on the telephone, in Fig. 6b. The non-dominant hand and eye gaze in Fig. 6b indicate not merely the existence and location of the book, but the fact that the subject is still reading while talking on the phone.



a. b.

FIGURE 6. We can gloss (a) as 'She is reading'. We can gloss (b) as 'She is reading and she is talking on the phone'.

Simultaneous production of more than two propositions, however, is usually seen only in poetic or other highly creative sign language, where language production can be pushed to its limits. We draw our more complex examples, then, from signed poems.

A signer can express three propositions using both hands plus the nonmanuals. First, in Dorothy Miles's BSL poem 'Trio' (published 1998, but recorded 1985), the final sign of the second stanza is (loosely) translated into English as 'Dog dozes; I doze; bird dozes' (Figure 7). One hand portrays a dog's head and the other hand portrays a bird's head. The signer's nonmanuals embody a human character. To sign 'Dog dozes; I doze; bird dozes', the hands rock backwards slightly so that the heads portrayed by the fingers point upwards, and the fingers open and close to represent the opening and closing of the snoring mouths of the dog and bird. Simultaneously, the signer puts her own head back and opens and closes her mouth to present a snoring human. Here, then, three subjects all perform the same action, using analogous movements of the articulators.

FIGURE 7. 'Dog dozes; I doze; bird dozes' from Dorothy Miles's poem 'Trio'.

Paul Scott, in his BSL poem 'Three queens' (2006), shows three subjects simultaneously performing the same action. Two are indicated by pointing signs (LOOK-UP, from queen to flag), and one is embodied. A single moment (shown in Figure 8) captures the three queens of the poem (Elizabeth I, Victoria, and Elizabeth II) ranged across history, looking up at the same flag.

FIGURE 8. 'Three queens in three times looking up at the same flag' from Paul Scott's poem 'Three queens'.

Can we get four simultaneous propositions? It appears so. Cases may be found in which the mouth operates as a partition, separate from the rest of the nonmanuals. Dudis (2004:232) notes that 'oral articulators can be partitioned to produce an onomatopoeic item' (and see Boyes Braem & Sutton-Spence 2001, Woll 2001). In 'Tree', another BSL poem by Paul Scott,[2] we find a complex and elegant use of simultaneity in the description of a person who is looking for a cat stuck up a tree. One hand represents the ground that the tree is located on (we meet the tree earlier in the poem, so the ground evokes it here). The other hand represents a person moving back and forth near the tree. The signer mouths 'meow' repeatedly, showing that a cat is meowing (and Paul Scott has confirmed to us that it does not mean the person meows). Eye gaze shifts as the head turns from side to side, showing that the person is looking around for the cat while walking up and down. We have four articulators here producing four propositions (the ground gives the location of the tree; the person moves around the tree; the cat meows; and the person scans the area for the source of the meowing).

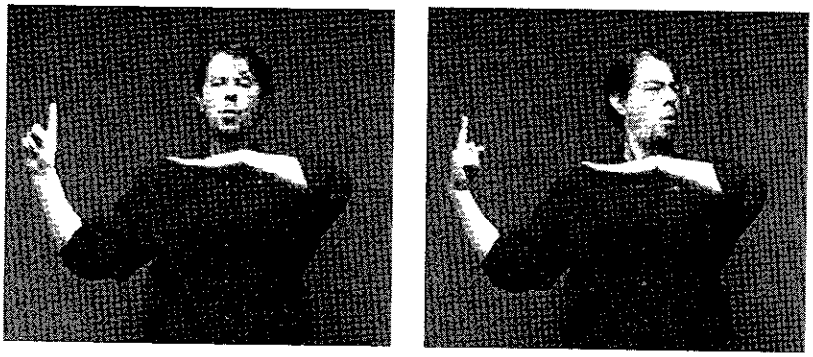


FIGURE 9. Man looking for the meowing cat in Paul Scott's 'Tree'. Right hand refers to the man walking around; left hand refers to the ground where the tree is located; eyes show the man looking and mouth shows the cat meowing.

Some may argue that the classifier evoking the ground is merely a pronoun or a buoy (a stationary hand that helps keep track of referents in the discourse), and not a separate predication (Liddell 1998, 2000, 2003). We believe this is not a valid objection (see our

[2] Performed at the Centre for Deaf Studies, University of Bristol, January 2009; online: www.bristol.ac.uk/blspoetryanthology.

earlier note about locative classifier constructions). As a check, however, we asked native signers whether it would be grammatical to have the nondominant hand sign the proposition TREE FALLS as everything else goes on. They concur that it would be. One agreed to demonstrate in Figure 10.

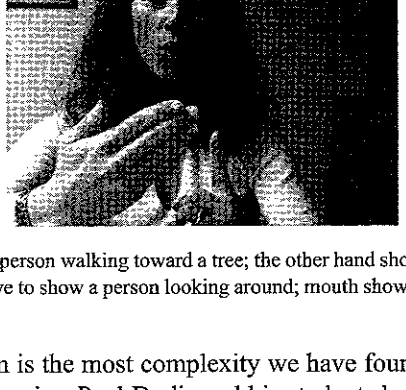


FIGURE 10. A hand shows a person walking toward a tree; the other hand shows a tree falling toward the person; eyes move to show a person looking around; mouth shows a cat meowing.

Four propositions then is the most complexity we have found in our examination of simultaneity in sign. Likewise, Paul Dudis and his students have found a maximum of 'four distinct visible blended elements' (p.c., June 2009). Further, looking over the data in this section, we note that in these simultaneous language events the total number of referentially distinct arguments is never greater than four (seen in Fig. 8, where we have three queens and one flag) and the total number of distinct subjects is never greater than three (so in Fig. 9, with four propositions, two propositions have the same subject—the man). This observation holds for all examples we have collected.

4. EXPLANATION FOR THE OBSERVED RESTRICTIONS ON SIMULTANEITY? We are going to assume that we have identified the upper limit on the number of propositions that may be simultaneously conveyed. The restriction of at most four simultaneous propositions cannot follow simply from the number of articulators the human body has. We already noted that the face and head can be partitioned off from the body (Fig. 5). And we noted that the mouth can be partitioned off from the rest of the nonmanuals (Figs. 9 and 10). So the nonmanuals can potentially be partitioned into three areas: mouth, eyes (and rest of the head), and torso. Given the two hands, we have the physiological potential to express five propositions. In fact, in one playful piece of language by Paul Scott, his right foot is employed to express that someone is pressing the accelerator on a car; and if a person were sitting, both feet would be available as articulators. So we have the physiological potential to express even more than five propositions simultaneously (although we should note that the use of the feet is highly marked in sign languages and would only be accepted in language play or other exceptional situations). But no simultaneous events with more than four propositions were attested, nor could we imagine plausible examples.

One might, alternatively, seek an explanation based on motor coordination. Experiments on bimanual tasks show the brain appoints one hand as prime actor while the other is assistant even in tasks where both hands work together exerting force on a held object (Johansson et al. 2006). Additionally, asymmetrical simultaneous movement is difficult (demonstration: pat your head and rub circles on your belly at the same time); there is a general preference for the limbs to move with reflexive symmetry (e.g. Sem-

jen et al. 1995) and any other simultaneous movement is performed with lower degrees of accuracy and stability. If asymmetric or nonreflexive symmetric movement is speeded up, it typically reverts to symmetric reflexive movement quickly (Kelso 1984).

Unsurprisingly, the vast majority of frozen two-handed signs in any sign language we have seen discussed either use one hand as an immobile base while the other acts on it or move the two hands symmetrically (Battison 1978, Napoli & Wu 2003). In our corpus asymmetric movement of the hands is rare, even with classifier constructions. Such movements are difficult to perform. For example, Mary Beth Miller, an ASL storyteller, simultaneously fingerspells C-A-T on one hand and C-O-W on the other in her 'Cat-cow' skit (Miller 1992), something we can do only with concerted practice, and even then it is challenging and cannot be maintained for long. The movements in Fig. 10 are just as hard, largely because the most proximal joint of movement for one manual articulator is the shoulder, while that for the other is the elbow. Native signers told us that while they understand Fig. 10 and this was the first thing they thought of when asked to sign all four propositions at once, on second thought, as nonpoets, they would probably do something easier to produce, such as sign the tree falling, then sign the man walking, and finally sign that the two events happened at the same time. Or they would move the tree classifier a little bit, then the man classifier a little bit, then the tree classifier a bit more, and so on, until the tree hit the man, so that at no point would both hands move.

We also know that the timing and movement of nonmanual articulations are related to those of simultaneously occurring manual articulations. In the phenomenon known as echo phonology (Woll 2001), sharp movements on the hands correspond to sharp movements on the mouth; smooth manual movements drive smooth mouth movements; opening hands cooccur with opening mouth; and so on. Our observations have been that these hand movements also correlate with changes in eye aperture, so that hands opening frequently cooccur with the mouth and eyes opening. And we note with interest something different from echo phonology but supportive of the idea that the articulations of eyes and hands exhibit connections: our model for Fig. 10, a native signer of ASL, most naturally focused her eyes on the hands as they moved toward each other and had to concentrate in order to free her eyes to look around.

In sum, it is reasonable to ask whether motor-coordination constraints could account for the limitations in our attested data. We see no evidence supporting this. Eye gaze can have an independent subject from other articulators, so one might guess that the 'Tree' example by Paul Scott would, out of context, be open to an interpretation in which a person is moving back and forth near a tree and a cat is meowing and some third party is looking around: four propositions with four distinct subjects. But no native signer we have asked finds this interpretation possible. Rather, the fact that the person moves about in a seeking way and that the eyes and head move in a seeking way heavily favors the interpretation of shared subjects. The only alternative interpretation we have been offered is that the meowing cat is also looking around; again, two propositions share a subject.

When we have suggested different scenarios that might call for four propositions with distinct subjects, no signer has produced such a simultaneous linguistic event. For example, when we have suggested a scenario in which all of the articulators other than the eyes-head remain as in Paul Scott's poem, but the eyes-head, instead, direct the gaze at the hand representing the person walking, we get interpretations in which the eye gaze is that of the cat, not of some external observer. When we have suggested a scenario in which the eye gaze is toward the tree, we get interpretations in which the eye gaze belongs to the person or to the cat (presumably in the tree), not to some external observer. When we have pushed for an interpretation in which there is an external ob-

server, signers have not used eye gaze to express this, but, rather, sequential conjunction. We conclude that the observed restrictions on number of subjects and arguments are not due to limitations on production, but to some other factor.

In fact, we believe that the numerical restrictions on subjects and arguments observed in our attested data are only apparent, and do not hold in general. In particular, we can imagine examples with four distinct subjects and five arguments in total. Consider Fig. 8 again. Here we have three queens looking at a flag. But what if the signer (one of the queens) turned his head side to side in a searching way while his mouth mouthed 'meow', comparable to what happens in Figs. 9 and 10? (The new poem, then, might be about how one queen was easily distracted, while the other two were dutiful.) We still have only four propositions, but now we have four distinct subjects and a total of five arguments (three queens, a cat, and a flag).

The numerical restriction we feel confident of, then, is a maximum of four propositions, from which a maximum of four distinct subjects follows. As for the fact that so few total arguments are observed and that so often those arguments are shared by different propositions, our findings are suggestive of a requirement that the propositions be connected somehow. In Fig. 6, with two simultaneous propositions, the subject of the two propositions is the same. In Figs. 7 and 8, with three simultaneous propositions, the predicates are the same (and in Fig. 8 the predicates are dyadic, sharing an object). In Figs. 9 and 10, with four simultaneous propositions, the subject of two of the propositions is the same. There are, however, instances of two simultaneous propositions in which no arguments or verbs are the same (see Milkovic et al. 2007 for many such examples), and we return to this issue later. For now, let us proceed with the idea that simultaneity of propositions requires some as yet unspecified kind of connectedness among the propositions.

What could account for a limit of four propositions and some connectedness among them? We suspect further explanation lies in areas of cognition other than language proper. Two areas to explore are basic abilities to discriminate and remember numbers of objects, and visual perception. The two areas come together nicely.

Under many conditions, adults can pay visual attention to three or four objects simultaneously (Pylyshyn & Storm 1988, Pylyshyn 1989, 1994, 2000, 2007, Kahneman et al. 1992, Scholl & Pylyshyn 1999, Sears & Pylyshyn 2000, VanRullen & Koch 2003). (In experiments in which visual cues move, Alvarez and Franconieri (2005) show that attention capacity increases significantly above four items if the items move very slowly. Sign language articulators, however, move quickly.) With respect to subitizing (Kaufman et al. 1949), human infants and vertebrate animals distinguish between groupings of up to four, but for numbers greater than four our innate core knowledge of number discrimination needs to be aided by a symbolic counting system (Carey 2001, Cowan 2001, Spelke 2003, Campbell 2004, Laurence & Margolis 2007). Researchers have tied this maximum number to issues of vision and memory.

It seems our attention is limited to a three-to-four-item capacity (where each item could be a chunk of information, as in Miller 1956, Chase & Simon 1973) prior to the storage of any items in short-term memory, so the limit arises from a visual-spatial attention bottleneck (Trick & Pylyshyn 1994, Carey 2004, Feigenson et al. 2004). The upper limit of four may well be a limit on visual short-term memory (VSTM) (Cowan 2001, for example).

The subitizing and vision research together might predict that a maximum of four simultaneous propositions is allowed in sign language. In fact, Hurford (2007) argues that four objects of attention is the limit due to constraints on short-term memory (not

just visual memory), and this limit is reflected in the fact that four arguments are generally the most a proposition can contain. He sees 'evolutionary processes leading from limitations on visual attention to syntactic limitations on the clause structure of public language' (2007:95). While Hurford is concerned with the chunking of language information with respect to the internal structure of sentences, we are concerned with chunking of the number of whole propositions expressed simultaneously in a sign event, so, unlike Hurford, our concern is directly related to studies on vision as well as language.

Still, we see no obvious way in which limits on dealing with multiple items, or on VSTM, or on short-term memory in general can account for our further finding that the propositions must be connected somehow. Nevertheless, other vision research might be helpful here. When viewers are presented with two perceptually distinct stimulus components simultaneously and asked to monitor them for changes in a common property (such as contrast), their discrimination accuracy decreases as compared to when they are presented with only one stimulus (Magnussen & Greenlee 1997, Olzak & Wickens 1997). Thomas et al. 2000, however, shows that the problem is not in the simultaneity per se, but rather in the process of making dual decisions about a single property. If, instead, viewers simultaneously monitor one component for a change in contrast and another component for a change in spatial frequency, discrimination accuracy is not affected. Simultaneity of visual stimuli that does not call for interrelating the stimuli does not affect discrimination tasks, but simultaneity of visual stimuli that does makes the discrimination tasks more difficult.

This finding might suggest that a simultaneous sign event with propositions having distinct arguments and verbs would be more easily interpreted than one in which propositions shared an argument or verb—since random propositions do not demand that the viewer interrelate them, but propositions with shared arguments or verbs do. One does not sign random separate propositions simultaneously, however. Rather, the visual stimuli in these sign events must be related. The viewer must realize that, in a case like Paul Scott's 'Tree', the person is looking around because he hears a cat meowing, and is moving back and forth near the tree because the meowing is loudest near the tree. The four propositions are not just simultaneous in time, but connected by the pragmatics of what we know about cats (they climb trees and meow) and about people (they know that noise gets louder as you move toward the source and that cats meow and climb trees).

In all of our examples of sign simultaneity the propositions are related semantically or pragmatically (a point made frequently in the literature; see for example Miller 1994), and this holds even of the instances of two simultaneous propositions that do not share an argument or verb, as mentioned earlier. This is not an accident of our examined corpus; coherency is a valued factor in stories and poems. Thus simultaneity in sign language calls for relating the visual stimuli—and the semantic and pragmatic connections between the propositions contribute to comprehensibility. In this way, visual language data differ from other visual data. In fact, this kind of pragmatic linking aids in comprehensibility of syntactically complex structures in spoken language, as well (with regard to self-embedding, see Sampson 1996, Vasishth & Lewis 2006 and the references cited there).

The more semantic, pragmatic, and grammatical connections there are between the various articulators in a simultaneous sign event, the less the cognitive burden on the audience, regardless of visual complexity. From Kaneko's (2008) study of sign poetry, we see that once the observer has determined that the eyes, head, and body are working in tandem to convey information, for example, there is no additional cognitive load in watching these discreet articulators. Viewers' attention is drawn to all three with little trouble, so the difficulty of interpreting a simultaneous sign event is not a matter of vi-

sual density (in Kaneko's terms) but of cognitive load. It is, thus, our hypothesis that connectedness among simultaneous propositions reduces the cognitive load.

While our account deals more with issues of perception than production, we find it promising. After all, what is the point of producing incomprehensible language? We exercise a certain freedom of choice in language production, allowing us to take into account likelihood of perception (Grodner & Gibson 2005, Ferreira & Engelhardt 2006, Arnold 2008). Deaf poets, storytellers, and comedians are sensitive to audience perception; they aim to be accessible and welcoming (Sutton-Spence & Napoli 2009).

5. SIMULTANEITY IN SPOKEN LANGUAGE. Speech is often accompanied by gestures (around 90% of the utterances in Nobe 2000 were accompanied by gestures), many of which are coexpressive, giving information that overlaps with the information of the utterance but packaging it differently (McNeill 2000, Kendon 2004). In other instances, however, gestures give nonoverlapping propositional information; thus simultaneity occurs in spoken language, as well as in sign.

Both sign and spoken language use emblems (conventionalized gestures, like the thumbs-up gesture), but both also use what we might call productive emblems, that is, gestures that out of context may mean nothing, but within a given context take on a specific meaning. Productive emblems occur frequently as propositions in communication between deaf children who have no access to sign language (Volterra & Erting 1994, Emmorey 2002, Goldin-Meadow 2003, 2007).

Productive-emblem propositions in spoken language are often found in comedian performances. The comedian Jack Benny, for example, was famous for a sideways eye gaze, accompanying speech or occurring alone, conveying 'that was a joke'. The comedian Bill Cosby, in his 1965 performance of *Noah* (accessible on youtube.com), moves his eyes upward and from side to side as he says, 'Right', to indicate he doesn't believe the voice from above is God. Later this eye action still indicates 'who do you think you're kidding?', regardless of the simultaneous speech-tract proposition.

Three propositions are, likewise, possible. Consider the situation in which a hand gives the thumbs-up emblem as the eyes look toward the side, and the mouth says, 'I can't tell you your test results until tomorrow'. The thumbs-up tells the addressee that the test went fine. The eyes, by contrast, might be telling the addressee that there is someone relevant within hearing range (but, crucially, who cannot see the thumbs-up).

Can we get four? One way would have each hand deliver a separate proposition. In the scenario outlined above, the speaker could add an emblem on the other hand—perhaps the gesture of making a circle with the index finger at the side of the head to indicate that the eavesdropper is crazy. Our feeling is that even as a joke it does not work.

Another way would be to partition the body minus the hands. We have not studied simultaneity in spoken languages at length; we expect, however, that this type of partitioning does not occur, if we can judge from the fact that linguists we have talked with find examples of such partitioning in sign languages to be remarkable (as in the shifted-attribution interpretation of Fig. 5).

So we do not see a way to get four propositions by exploiting the nonverbals. Spoken language, however, allows modulations of the suprasegmentals to deliver information that is arguably propositional. For example, a sarcastic tone adds the information that the uttered proposition is untrue; an ironic tone, that the uttered proposition is ironic. (Sign language expresses sarcasm and irony via the nonmanuals, so inclusion of them in our discussion would not increase the maximal number of simultaneously expressed propositions.)

Can we take a language event that already has three simultaneous propositions and make the tone sarcastic or ironic, yielding a fourth proposition? We expect the more creative readers might be able to come up with examples.

So speakers can express simultaneously at least three propositions with three separate subjects by exploiting the nonverbal. And perhaps they can express four propositions by exploiting the suprasegmentals. The sarcastic or ironic tone, however, would convey a proposition that takes the sentence expressed verbally as its subject—so this fourth proposition would be connected tightly to the speech-tract sentence. And in the examples we have imagined (with the thumbs-up), there is semantic and pragmatic connection among the propositions. This looks very much like the limitations set on simultaneity in sign languages. And, importantly, the total number of arguments in a simultaneous language event involving speech can go well past four (since the spoken proposition alone could have four arguments), suggesting the connectedness restriction on simultaneity is, indeed, visual in nature, rather than strictly linguistic.

There may be other important differences relevant to simultaneity between the two modalities. For one, we suspect that the types of nonpropositional information conveyed by the secondary tracts (the nonverbals for spoken language and the nonmanuals for sign language) are similar in all languages regardless of modality (see Ekman & Friesen 1975, Campbell et al. 1999, Yau 2008). But it could well be that the types of propositional information conveyed by the secondary tracts differ between the modalities. The secondary tract in sign language consists of articulators that are highly constrained in terms of what they can do. The secondary articulators in spoken language, however, include the hands, capable of a wide range of precise movements. We expect, then, that the sorts of propositional information conveyed by the hands in spoken language might be much more varied than the sorts of propositional information conveyed by the nonmanuals in sign language. While spoken English does not seem to exploit the hands as secondary articulators in very creative ways (insofar as we have seen), perhaps other languages do (southern varieties of Italian come to mind).

In sum, there is more to say about simultaneity in both modalities.

6. CONCLUSION. Sign languages allow at most four simultaneous propositions, a limit that probably follows from constraints on visual short-term memory. Spoken languages, so far as we know, allow three by way of exploiting the nonverbals, but may possibly allow a fourth by exploiting suprasegmentals.

Further, simultaneous propositions in sign languages exhibit a connectedness that is always semantic and pragmatic, but often syntactic, as well. These connections help to render a simultaneous sign event coherent and comprehensible.

More research needs to be done on this entire area. We hope our readers are tantalized and spurred to further investigation.

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