Talk is cheap

Speech comes naturally to humans. We are tuned to speech in utero, we swiftly learn to voice our thoughts and wants, and we do so seamlessly, by recruiting specialized oral and brain mechanisms that have likely evolved in our species alone.

Speech and language are so tightly linked that we tend to think about them as one and the same. So while Noam Chomsky famously attributed our linguistic competence to abstract universal rules[1, 2], a growing literature in brain and cognitive sciences has sought to anchor language in the speech system. For example, Friedemann Pulvermüller and colleagues have shown that when we hear syllables like *ba* (sounds produced by the lip), we engage the lip motor area in the brain; when we listen to *ta*, it is the tongue motor area that becomes active[3]. In light of these observations, it is tempting to equate language with speech.

Speech, in this view, holds the key for the human capacity for language, its internal structure and evolutionary origins. Expressing such sentiments, the psychologist Peter MacNeilage noted that "'The possession of speech,' T. H. Huxley once remarked, 'is the grand distinctive character of man' (1871)." ([4], p.3) Speech can likewise account for the internal structure of language. According to the linguist John J. Ohala,"The ultimate task of phonology is to discover the causes of the behavior of speech sounds" [by unveiling] "the way speech is created and used by humans". ([5], p. 189)And it is the control of speech that has further sparked the evolution of language. In the words of the psychologist Phillip Lieberman "The neural substrate that regulated motor control in the common ancestor of apes and humans most likely was modified to enhance cognitive and linguistic ability. Speech communication played a central role in this process. "([6], p. 36)

The "language as speech" view implies that your command of English is primarily a sensory and motor feat. So in uttering sentences like *dogs bark* (not *bark dogs*), you display not abstract syntactic principles that are specific to language. Rather, your linguistic abilities reflect exquisite control over the sequencing of your lips and tongue, akin to your ability to tap your finger to rhythm, chew or dance. The uniquely capacity of our species for language, then, concerns not language itself but aural acuity and oral acts. And the translational implications of this view affect our understanding of language disorders and the acquisition of reading—the ability to decode language in a visual format.

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But nearly seventy million Deaf signers across the world use a manual language. Sign languages demonstrably differ from nonlinguistic gestures, and these languages are not mutually intelligible (just as French is not immediately comprehensible to English speakers), nor are they patent to non-signers. Yet manual languages come to humans naturally and spontaneously.

The psychologist Susan Goldin-Meadow has shown that Deaf children raised in hearing families (with no sign language exposure) generate home signs of their own accord, complete with rudimentary rules to which their mothers are not privy[7, 8]. And when home-signers gather together, a new language is born. The spontaneous birth of sign languages has been meticulously documented in Nicaragua (e.g., by Judy Shepard-Kegl, Ann Senghas, Marie Coppola, Diane Brentari; [9, 10]) and Israel (by Wendy Sandler and colleagues; [11]), but many other cases are well known.

Not only can human brains support language in two different formats; these systems recruit shared brain mechanisms that are synergistically linked([12-14]). These links are patently evident in the effect of early experience with sign language on subsequent linguistic competence.

It is well known that children who are deprived of language in early development do not fully catch up when they encounter language later in life. Consequently, Deaf children raised in hearing families are at risk of lacking early access to language. But while early linguistic experience is critical, its format (speech or sign) matters far less.

Research by Rachel Mayberry has shown that early linguistic experience with sign language facilitates the later acquisition of English; in fact, the benefit from early exposure to signs was comparable to the benefit associated with another spoken language (e.g., Urdu, French) [15].

This striking result is open to multiple explanations. One possibility is that early access to language provides the child with social, emotional and cognitive advantages that are not specific to language itself, and it is those non-linguistic skills that facilitate later language learning. But an intriguing, as yet uncertain alternative is that linguistic principles themselves transfer across modalities. An early exposure to sign language helps because some of its rules are relevant to the later acquisition of English. In other words, language is neither speech nor sign. Rather, language is an abstract algebraic system that can emerge in either the oral or manual modalities.

Results from my lab ([16]) support this possibility. My colleagues and I found that people apply the rules of their spoken language to signs, and they do so spontaneously—despite no previous experience with a sign language.

In these experiments, we gauged the responses of speakers to signs in American Sign Language. Our participants were sign language naïve—none commanded a sign language. If language were solely a sensory and motor affair, then one would expect these naïve participants to treat these visual displays in a nonlinguistic fashion, akin to pantomime or dance. Knowledge of language should be utterly irrelevant here.

What we found, instead, was that speakers' responses to signs depended on linguistic structure. First, people shifted their responses to the same sign depending on the implied level of linguistic analysis (phonology vs. morphology). And even more remarkably, the responses of these naïve speakers to signs further depended on the structure of their spoken language. Thus, English speakers showed one pattern of response; the responses of Hebrew speakers were diametrically opposite. And critically, these differences were lawfully predicted by the distinct morphological structure of English and Hebrew (for details, see Figure 1). Subsequent research has extended this research to Mandarin Chinese and Malayalam, and the conclusions upheld: the responses of these speakers to signs were predictable by the characteristics of their *spoken* language morphology.

These results demonstrate that naïve speakers spontaneously treat signs as linguistic entities and project to them grammatical principles of their native spoken language. If knowledge of language can project from one stimulus modality to another, then the relevant principles cannot possibly be either aural/oral or visual/manual. Knowledge of language thus includes rules that are algebraic and abstract.

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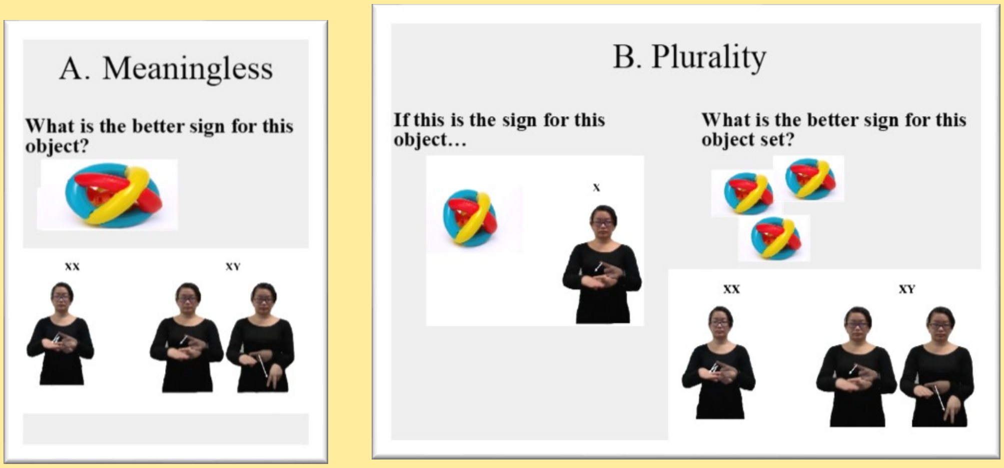
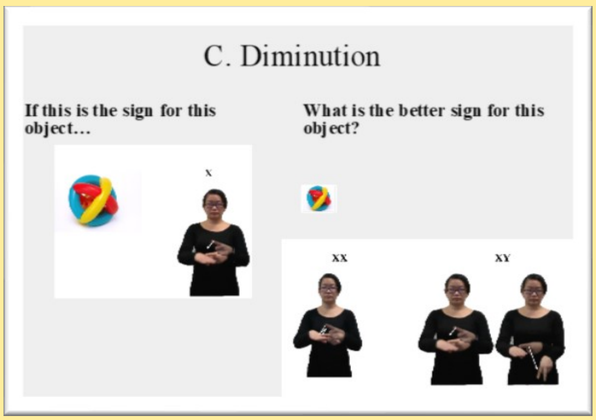
These discoveries shed light on human nature and solve a number of linguistic mysteries. They explain why human communities can spontaneously generate language in either format, why signed and spoken languages share some of their structure and engage common brain mechanisms ([12-14]), and why early experience with sign language facilitates the subsequent acquisition of spoken language ([15]).

The amodal nature of language also underscores the significance of sign languages, their complexity, expressive power, and the many advantages they confer on their users, on par with spoken languages.

Finally, language is at the core of reading—a cultural technology that recycles the core cognitive and brain mechanisms of language. Reading acquisition presents particular challenges to the Deaf, as reading requires that learners become aware of the link between spelling and the sound structure of language (e.g., *seed* and *cent* share their initial phoneme), and this skill is exceedingly difficult for Deaf individuals to attain ([17-21]). Finding that some of the rules governing linguistic patterns are amodal is encouraging because it could offer a bridge for the acquisition of reading skills by Deaf readers.

Speaking is a human instinct. As Steven Pinker put it, *people know how to talk in more or less the sense that spiders know how to spin webs[22].* But unlike spiders, we spin our linguistic webs from multiple raw materials. Speech is the default linguistic channel in hearing communities, but language and its channel are not one and the same.





D. Choice

	A. Meaningless	B. Plurality	C. Diminution
English speakers	XY	XX	-
Hebrew speakers	XY	-	XX

Figure 1. The double identity of doubling.

In a series of experiments[16], people with no command of a sign language were presented with two types of novel signs in American Sign Language (ASL). One sign exhibited *doubling* (two repeated syllables, XX); another sign had two different syllables (XY). Responses to these two types of signs (XX and XY) were evaluated under two conditions.

In one condition (Panel A), the signs were presented as names for a single object, so doubling had no special significance; the signs were bare *phonological* forms. In other conditions, the doubling in form (the change from X to XX) indicated a systematic change in meaning, either plurality (Panel B) or diminution (Panel C). So here, doubling implicitly signaled as a *morphological* operation. The task, in the two conditions (phonological and morphological) was the same. Participants were simply asked to choose which sign makes a better name for the object/object set: XX or XY. We administered these experiments to speakers of two languages—English and Hebrew.

In so doing, we sought to address two questions. First, do responses to signs *vary* across conditions (*phonological* vs. *morphological*)? Second, do the responses of naïve speakers to *signs* depend on the structure of their *spoken* language (English vs. Hebrew)?

We reasoned that, if speakers treat signs strictly as visual displays of a motor activity, then responses to signs should depend only on the demands they exact on the visual and motor systems; linguistic factors should be irrelevant. And since the stimulus (an XX sign) was always unchanged, responses should be ***invariant*** across the two linguistic levels (phonology and morphology) and speakers' linguistic experience (English and Hebrew).

Our results, however, showed these our two linguistic factors strongly affected the responses of naïve speakers to signs. When doubling had no meaning (in the *phonological* condition, Panel A), speakers of both languages exhibited a doubling *aversion*, as they reliably dispreferred XX to XY signs. But when doubling indicated a systematic change in meaning (in the morphological conditions, Panels B &C), speakers now showed a reliable *preference* for the XX signs.

So far, we have seen that responses to the stimulus shift (from aversion to preference) depending on the ***linguistic level*** of analysis (phonology vs. morphology). Panel D illustrates the findings, and you can trace it for each of the two participant groups (speakers of English and Hebrew). This shift shows that responses to the stimulus reflect not the stimulus itself (or its sensorimotor demands) but rather the distinct representations projected to it by the mind. Linguistic research presents a simple explanation for this shift. Doubling exhibits structural ambiguity, as it is amenable to two distinct parses, much like ambiguous figures in vision. The phonological parse is ill-formed, as it violates a putatively universal grammatical constraint on adjacent identical element (The Obligatory Contour Principle, [23, 24]), so XX<XY. In contrast, the morphological parse of doubling is better-formed than XY controls [25]), so XX>XY. Clearly, then, the linguistic level of analysis (phonology vs. morphology) matters even when the stimulus modality is unfamiliar.

Remarkably, responses to signs also depended on the morphology of participants' spoken ***language***. English speakers only preferred the XX signs when doubling indicated plurality; Hebrew speakers only preferred XX signs when doubling indicated diminution (see D).These distinct preferences for signs are in line with the different morphologies of the two languages, as English morphology marks plurality, whereas Hebrew uses doubling to indicated diminution (e.g., *klavlav*, a puppy, from *kelev* dog). The preferences for signs are also in line with the responses of English and Hebrew speakers to novel spoken words.

Taken as a whole, these results show the responses of naïve speakers to signs depend on linguistic factors, including the linguistic level of analysis and their linguistic experience. These studies are the first to show that speakers spontaneously project grammatical rules from their native spoken language to signs.

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