7. Do mouths sign? Do hands speak?: Echo phonology as a window on language genesis

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Abstract

Although the sign languages in use today are full human languages, certain of the features they share with gestures have been suggested to provide information about possible origins of human language. These features include sharing common articulators with gestures, and exhibiting substantial iconicity in comparison to spoken languages. If human protolanguage was gestural, the question remains of how a highly iconic manual communication system might have led to the creation of a vocal communication system in which the links between symbol and referent are for the most part arbitrary. Posing the question in this way, and regarding sign languages as 'manual' ignores the rich and complex role played by other articulators: body, face, and, in particular, the mouth.

As well as manual actions, sign languages include several types of mouth actions. The research reported here focuses on one subgroup: 'echo phonology', a repertoire of mouth actions which are characterised by 'echoing' on the mouth certain of the articulatory actions of the hands.

Three different types of data (narratives in 3 European sign languages, code mixing in hearing British Sign Language/English bilinguals, and functional imaging studies) provide examples of a possible mechanism in the evolution of language by which the units of an iconic manual communication system could convert into a largely arbitrary vocal communication system.

7.1 Introduction

Since gesture systems (home sign) can appear in the absence of linguistic input (Goldin-Meadow, 2003), the sign languages of Deaf[1] communities have sometimes been regarded as primitive communication systems and, the reasoning follows, as a precursor to spoken languages. Linguistic research over the past 40 years has shown that sign languages are not primitive and are in fact

[1] 'Deaf' with an upper-case 'D' is used to refer to membership of a sign language-using community and includes both hearing and (audiologically) deaf individuals.

full natural languages with complex grammars (Stokoe, 1960; Klima and Bellugi, 1979; Sutton-Spence and Woll, 1999). Nevertheless it is possible that sign languages, being in a visual-gestural modality, have features in common with evolutionary precursors of spoken language.

Although the sign languages in use today are full human languages, and are used by modern humans with 'language-ready' brains, certain of the features they share with gestures have been suggested to provide information about possible origins of human language. These features include sharing common articulators with gestures, and exhibiting substantial iconicity in comparison to spoken languages. This iconicity is present both in signs that represent concrete objects and actions, and those which represent abstract concepts. For example, signs in British Sign Language (BSL) referring to cognitive activities (THINK, UNDERSTAND, KNOW, LEARN, etc.) are generally located at the forehead, while signs relating to emotional activities (FEEL, INTERESTED, EXCITED, ANGRY) are located on the chest and abdomen.

If human proto-language was gestural, the question remains of how a highly iconic manual communication system might have led to the creation of a vocal communication system in which the links between symbol and referent are for the most part arbitrary. Posing the question in this way, and regarding sign languages as 'manual' ignores the rich and complex role played by other articulators: body, face, and, in particular, the mouth.

As well as manual actions, sign languages include several types of mouth actions. The research reported here focuses on one subgroup of these mouth actions: 'echo phonology', a repertoire of mouth actions which are not derived from spoken language, which form an obligatory accompaniment to some manual signs in a range of sign languages, and which are characterised by 'echoing' on the mouth certain of the articulatory actions of the hands.

Three very different types of data (narratives in 3 different European sign languages, anecdotal observations of hearing individuals bilingual in BSL and English, and functional imaging studies with deaf signers) will be presented. These provide examples of a possible mechanism in the evolution of language by which the units of an iconic manual communication system could convert into a largely arbitrary vocal communication system.

7.2 Historical perspectives

Many writers have suggested that human vocal language may have evolved from manual gestures. What is required to sustain such a claim is a plausible mechanism by which primarily manual actions could have transformed themselves into vocal actions. One mechanism (not even requiring

communicative gesturing as an intermediate stage) was suggested by Darwin in his study *The Expression of Emotions in Man and Animals* (1872):

> 'there are other actions [of the mouth] which are commonly performed under certain circumstances … and which seem to be due to imitation or some sort of sympathy. Thus, persons cutting anything may be seen to move their jaws simultaneously with the blades of the scissors. Children learning to write often twist about their tongues as their fingers move, in a ridiculous fashion' (p. 34).

Henry Sweet (1888) extended this notion to encompass a transition from manual gesture to 'lingual gesture':

> 'Gesture ... helped to develop the power of forming sounds while at the same time helping to lay the foundation of language proper. When men first expressed the idea of 'teeth', 'eat', 'bite', it was by pointing to their teeth. If the interlocutor's back was turned, a cry for attention was necessary which would naturally assume the form of the clearest and most open vowel. A sympathetic lingual gesture would then accompany the hand gesture which later would be dropped as superfluous so that ADA or more emphatically ATA would mean 'teeth' or 'tooth' and 'bite' or 'eat', these different meanings being only gradually differentiated' (pp. 50-52).

To Sweet, therefore, should go the credit for hypothesising as a key link between gesture and spoken language, the 'sympathetic lingual gesture accompanying a natural hand gesture'. Richard Paget (1930) attempted to find evidence for such a theory. Like Sweet, Paget claimed that the earliest human language was a language of gestures, in which actions originally made by hand were unconsciously copied by movements or positions of the mouth, tongue or lips.

> 'Originally man expressed his ideas by gesture, but as he gesticulated with his hands, his tongue, lips and jaw unconsciously followed suit … The consequence was that when, owing to pressure of other business, the principal actors (the hands) retired from the stage … their understudies – the tongue, lips and jaw – were already proficient in the pantomimic art' (p. 133).

He supplies a number of examples of this process:

> 'Another … example may be given, namely, in connection with the beckoning gesture – commonly made by extending the hand, palm up, drawing it inwards towards the face and at the same time bending the fingers inwards towards the palm. This gesture may be imitated with the tongue, by protruding, withdrawing, and bending up its tip as it re-enters the mouth.
>
> If this 'gesture' be blown or voiced, we get a resultant whispered or phonated *word*, like **edə**, **eđə**, or **eđra** … suggestive of … our English word 'hither' (p. 138).

Paget's theory (known as the 'ta-ta' theory from the example above) was developed further by Swadesh (1971). He quotes another example of its application:

> '… a word like the Latin *capio*, I take, or English *capture*, whose root begins with a *k* sound and ends in the sound *p*, made by closing the lips. It has been suggested that the formation of the *k* sound at the back of the mouth, while the lips are open, is comparable to the open hand. The closing of the lips, then, is analogous to the fingers closing with the thumb as one takes hold of an object. Thus the pronunciation of the root *capio* is like the action of taking. Of course not all words are to be explained in this way; in fact, only a few. And yet the possibility that some words developed in this way is not denied by other qualities also evident in language' (p. 4).

Paget's theory can only be validated if there is evidence for a historical process by which overt gestures were reflected, reproduced in miniature, in gestures, particularly of the tongue and lips, which were then associated with the production of speech-sounds.

In the absence of any plausible mechanism for the shift from hand to mouth, or any historical evidence, the notion of a hand-mouth link remains as speculative as any other theory of language origins. One weakness of the approach of Paget and the others is that they all suggest that the mouth actions themselves share underlying imagery with the iconic manual gesture, leaving open the question of how a hypothesised highly iconic manual communication system could have led to the creation of a vocal communication system in which the links between symbol and referent are for the most part arbitrary.

7.3 Contemporary evidence

7.3.1 Neurobiological perspectives

Studies of neurons in the monkey brain by Rizzolatti and colleagues since 1996 (Rizzolatti, Fadiga, Gallese and Fogassi, 1996; Rizzolatti and Craighero, 2004) have identified 'mirror neurons', which fire when the animal observes another individual making specific movements (primarily for reaching and grasping). The mirror system, in temporal, parietal and frontal regions, is part of a system specialised for perceiving and understanding biological motion. Although research has not shown a mapping of vocalisation production onto perception of vocalisations, this mapping is implicit in Liberman and Mattingly's (1985) motor theory of speech perception, which proposes that speech is understood in terms of its articulation, rather than its perception. It should also be noted that the anatomical closeness of hand and mouth related neurons in the premotor cortex may relate evolutionarily to the involvement of both in common goals. The relationship between mouth actions related to eating, and those found in spoken language, have been discussed in detail by MacNeilage (1998).

Gentilucci (2003) has shown in a series of studies that when humans were asked to open their mouths while grasping objects, the size of the mouth opening increased with the size of the grasped object. Grasping larger objects and bringing them to the mouth induces increases in the size of mouth opening and voice spectra of syllables pronounced simultaneously. Observing another individual grasping or bringing different sizes of objects to the mouth also affects the articulation of syllables.

7.3.2 Gesture and speech

A number of theorists have postulated that gesture (on its own) is the origin of language. McNeill (2008) provides a strong set of arguments against this position.

His basic claim is that a primitive phase in which communication was by gesture or sign alone, could not have evolved into the kind of speech-gesture combinations that can be observed in modern human communication, suggesting that if such a phrase existed, it was not a proto-language, but a precursor of mimicry and pantomime. He argues that a 'gesture-first' theory:

> 'incorrectly predicts that speech would have supplanted gesture, and fails to predict that speech and gesture became a single system. It is thus a hypothesis about the origin of language that almost uniquely meets Popper's requirement of falsifiability – and *is* falsified, doubly so in fact' (McNeill, 2008:12).

As with the earlier writers on the subjects, Rizzolatti and Arbib (1998) also see gesture as fading once speech has emerged:

> 'Manual gestures progressively lost their importance, whereas, by contrast, vocalization acquired autonomy, until the relation between gestural and vocal communication inverted and gesture became purely an accessory factor to sound communication' (p. 193).

In such models, gesture is seen as unintegrated with speech – both in modern human communication and in human evolution.

Another thread in the 'supplantation of gesture by speech' argument relates to the advantages of speech over gesture (Corballis, 2003). McNeill, Duncan, Cole, Gallagher and Bertenthal (in press) have argued that speech is the default form of human communication because it has fewer dimensions, is more linear, is non-imagistic (and hence more arbitrary (with the potential for a larger lexicon), etc. Given this asymmetry, McNeill argues that even though speech and gesture were selected jointly, it would still work out that speech is the medium of linguistic segmentation:

> 'Sign languages – their existence as full linguistic systems – impresses many as a reason for gesture-first, but in fact, historically and over the world, manual languages are found only when speech is unavailable; the discrete semiotic then transferring to the hands. As we shall see later, this transfer takes place automatically. So it is not that gesture is incapable of carrying a linguistic semiotic, it is that speech (to visually disposed creatures) does not carry the imagery semiotic' (p. 13).

7.4 Hands and mouth in sign language

7.4.1 Mouth actions and other non-manual articulators

As mentioned above, sign languages of the deaf offer a unique perspective on language, since they embody the structural and communicative properties of spoken language, while existing entirely within a wholly visual-gestural medium. Among other insights, they enable investigators to clarify the core components of language in distinction to those that reflect input or action characteristics of the language system. This difference is reflected in the articulators on which languages in the two modes rely. Sign languages make use of non-manual articulators, including actions of the head, face and trunk (e.g., Liddell, 1978; Sutton-Spence and Woll, 1999). Within the face, eye actions such as eye narrowing, changes in direction of gaze and eyebrow

actions (raise/lower) play important roles in sign language communication (Crasborn, 2006). In addition, although sign languages are unrelated to the spoken languages used in the surrounding hearing community, sign languages do borrow elements from spoken language (Sutton-Spence and Woll, 1999). Other mouth actions (*mouth gestures*) are unrelated to spoken languages (see figure 7.1 below).

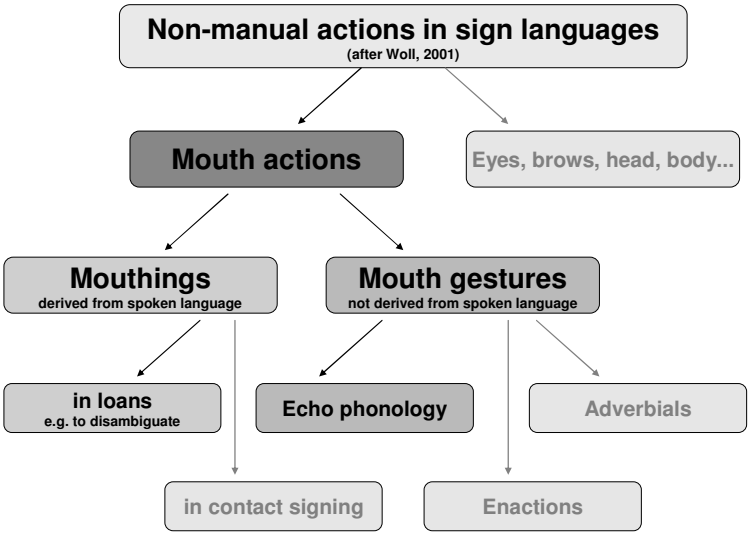

Figure 7.1: Mouth actions in sign language

7.4.1.1 Mouthings. Sign languages can borrow mouth actions from spoken words – speech-like actions accompanying manual signs than can disambiguate manually homonymous forms. These are considered to be borrowings, rather than contact forms reflecting bilingualism in a spoken and signed language, since there is evidence that signers can learn these without knowing the source spoken language. These can disambiguate signs with similar or identical manual forms. For example, the BSL signs, ASIAN and BLUE, are manually identical (see figure 5.7c). To distinguish which meaning is meant, mouthings are incorporated, derived from the mouth actions used when speaking the words 'Asian' or 'blue'.

7.4.1.2 Adverbials are arrangements of the mouth which are used to signal manner and degree (e.g. to indicate that an action is performed with difficulty or with ease; to indicate if an object is very small or very large, etc.).
7.4.1.3 In Enaction (sometimes called mouth-for-mouth), the action performed by the mouth represents that action directly (e.g. in CHEW, the mouth performs a 'chewing' action, while the sign is articulated on the hands).

7.4.2 Echo Phonology

The term **Echo Phonology** (Woll and Sieratzki, 1998) is used for a class of mouth actions that are obligatory in the citation forms of lexical signs. In the BSL sign TRUE (see figure 7.5d below), the upper hand moves downwards to contact the lower hand, and this action is accompanied by mouth closure, synchronised with the hand contact. This type of non-speech-like mouth gesture has been termed 'echo phonology' (EP), since the mouth action is considered secondary to that of the hands (Woll and Sieratzki, 1996; Woll, 2001). That is, the mouth gesture 'follows' the hand actions in terms of onset and offset, dynamic characteristics (speed and acceleration) and direction and type of movement (opening, closing, or internal movement). Thus, these gestures illustrate a condition where 'the hands are the head of the mouth' (Boyes-Braem and Sutton-Spence, 2001). EP mouth gestures are not derived from or influenced by the forms of spoken words borrowed into sign; rather, they are an obligatory, intrinsic component of this subgroup of signs, their patterning presumably constrained by common motor control mechanisms for hands and mouth (Woll, 2001). The signs in which they are found require the presence of the mouth gesture to be well-formed, and mouth action includes some movement: either the exhalation or inhalation of breath, or a change in mouth configuration during the articulation of the sign: for example, EXIST (wiggling of fingers, no path movement, accompanied by [ʃʃ]); TRUE (active hand makes abrupt contact with palm of passive hand, accompanied by [am] – see figure 7.5d below); DISAPPEAR (spread hands close to 'flat O' shape, accompanied by [θp]).

The essential dependence of the mouthing on the articulatory features of the manual movement can be seen in three BSL signs all meaning 'succeed' or 'win'. Three different oral patterns of mouthing co-occur with these signs, and one cannot be substituted for the other.

In SUCCEED, the thumbs are initially in contact, but move apart abruptly as the mouth articulates [pa]. In WIN, the hand rotates at the wrist repeatedly as the mouth articulates [hy]; and in WON, the hand closes to a flat O, while the mouth articulates [ʌp]. Most importantly, the action of the mouth in signs with echo phonology, while echoing that of the hands, is not in itself

iconic. Sweet, Paget and the other early writers cited above postulated that iconicity in the mouth gesture itself was the source of spoken words. However, it is difficult to see how a mouth gesture on its own could iconically express the semantic notion of 'succeed' or 'true'. Echo phonology illustrates a mechanism by which abstract concepts, which can be represented by iconic manual gestures, can be attached to abstract mouth gestures.

7.5 Echo Phonology in different sign languages

In a study comparing narratives in three sign languages (http://www.let.ru.nl/sign-lang/echo/index.html), the occurrence of echo phonology was compared with other types of mouth action. The chart below shows the percentage of signs accompanied by mouth actions other than mouthings, in narratives of Aesop's fables. Although there is variability across the data for two signers of each of the three sign languages (Swedish, British, Netherlands) echo phonology is found in all three (figure 7.2) (van der Kooij, Crasborn, Waters, Woll, Mesch, in press).

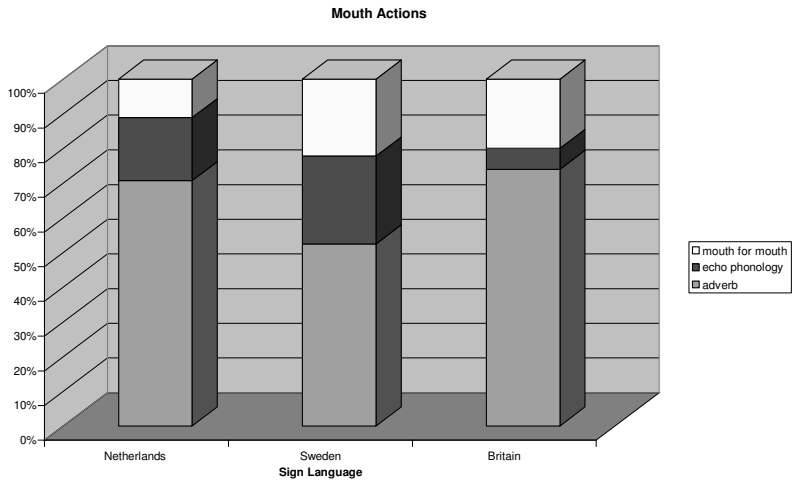

Figure 7.2: Echo phonology in 3 sign languages

7.6 Evidence from bilinguals

Sign and speech are frequently mixed in bilingual signers (both deaf and hearing. Because these languages occur in different modalities (bimodal bilingualism), a unique type of mixing can take place: code blending, where elements from a spoken language appear simultaneously with elements of a

sign language. Either language can serve as the base language, and the elements can either be overlapping or identical. Van den Bogaerde provides many examples in the language of deaf mothers to their children. In the first example below, Dutch is the base language, and one of the spoken words is accompanied by a sign with the same meaning. In the second example, Dutch Sign Language is the base language, and one of the signs is accompanied by a word with the same meaning:

1.	**Signed**			VALLEN
	Spoken	die	gaat	vallen
	English gloss	that	goes	fall
	Translation	*That [doll] is going to fall*		
2.	**Signed**	$INDEX_{hij}$	JAS	BLAUW
	Spoken			blauw
	English gloss	$INDEX_{he}$	COAT	BLUE
	Translation	*He has a blue coat*		

However, in mixed code blending, each language contributes complementary information in simultaneous constructions. In Example 3, the signed and spoken elements (POP + geel) combine to form a single phrase:

3.	**Signed**	POP SPELEN	
	Spoken		geel
	English gloss	DOLL PLAY	
			yellow
	Translation	*(I want) to play with the yellow doll*	

Strikingly, there are no examples in van den Bogaerde's corpus study of any sequential code switching or mixing, although this is the norm for unimodal bilinguals. However, anecdotal observations from conversations between hearing people with deaf parents (bilinguals native in both BSL and English) indicate that some of the mouth gestures found in signs with echo phonology can appear (with voicing) as code mixing with English in the absence of production of any manual signs.
Examples include:

1. A: 'Have you done that poster?'
   B: '[ʃʃʃ] (NOT-YET), I'll do it tomorrow'
2. A: 'It was terrible. It was like '[ʌmp]' ' (END/absolutely over)

3. 'I couldn't get a straight answer from anyone. It was completely [pɪpɪpɪp]' (VARIED/inconsistent)

These examples are suggestive of a possible leap from mouth gestures accompanying signs to a situation where mouth gestures appear to have independent existence as lexical items. Further research is necessary to explore whether these forms are more similar to vocal gestures or to words. In either case they demonstrate that echo phonological elements can occur within speech.

7.7 Functional imaging study

Despite the differences in the modality of the perceived signal, the neural organisation of language processing is remarkably similar for sign and for speech. Studies of patients with brain lesions reliably show that sign language processing is supported by perisylvian regions of the left hemisphere (e.g., Atkinson, Marshall, Woll and Thacker, 2005). Neuroimaging studies show similar patterns of activation for processing sign language and spoken language when acquired as native languages by deaf people and hearing people, respectively. In particular, sign language processing elicits activation in the superior temporal plane and posterior portions of the superior temporal gyrus and left inferior frontal cortex including Broca's area (BA 44/45) (MacSweeney et al., 2002; Neville et al., 1998; Petitto et al., 2000), just as for spoken language (Capek, Bavelier, Corina, Newman, Jezzard et al., 2004; MacSweeney et al., 2002)

Speech and sign, however, do not appear to rely on identical brain networks. In a study directly contrasting BSL (deaf native signers) and audio-visual English (hearing monolingual speakers), MacSweeney and colleagues (2002) did not find any laterality differences between the languages. However, MacSweeney and colleagues (2002) did find differences between sign language and audio-visual speech, which they attributed to the modality of the input rather than to linguistic processes. Regions which showed more activation for sign than audiovisual speech included the middle occipital gyri, bilaterally, and the left inferior parietal lobule (BA 40). In contrast, audio-visual English sentences elicited greater activation in superior temporal regions than signed sentences.

With these considerations in mind, a study (Capek et al., 2008) explored the following conditions in which lists of single items were presented to deaf native signers in the fMRI scanner: (1) silent speechreading of English (SS); (2) BSL signs with no mouth action (hands only – HO); (3) BSL signs with

mouthings (disambiguating mouth – DM) and (4) BSL signs with mouth gestures (echo phonology – EP).

The stimuli were designed to vary on the dimensions of presence or absence of mouth opening/closing; presence or absence of hand and arm movements; and presence or absence of English-based mouth actions (figure 7.3).

	mouth opening and closing	hand- arm movements (BSL)	English-derived mouth
No mouth (HO)	-	+	-
Phonology (EP)	+	+	-
Disambiguating mouth (DM)	+	+	+
Silent speech (SS)	+	-	+

Figure 7.3: Characteristics of stimuli

Stimuli consisted of single words/signs, examples of which are given in figure 7.4. The list of silently spoken words was based on English translations of the signs below (figure 7.4).

EP	DM	HO
EXIST [ɯ]	FINLAND/METAL	TABLE
WIN [hy]	BATTERY/AUNT	CHERRY
NONE [pu]	WOOD/PROBLEM	BUTTER
SUCCESS [pa]	RUSSIA/BOY	KNOW
END [pəm]	ITALY/WIN	FAX

Figure 7.4: Examples of stimuli

Figure 7.5 shows examples of each of the stimuli types:

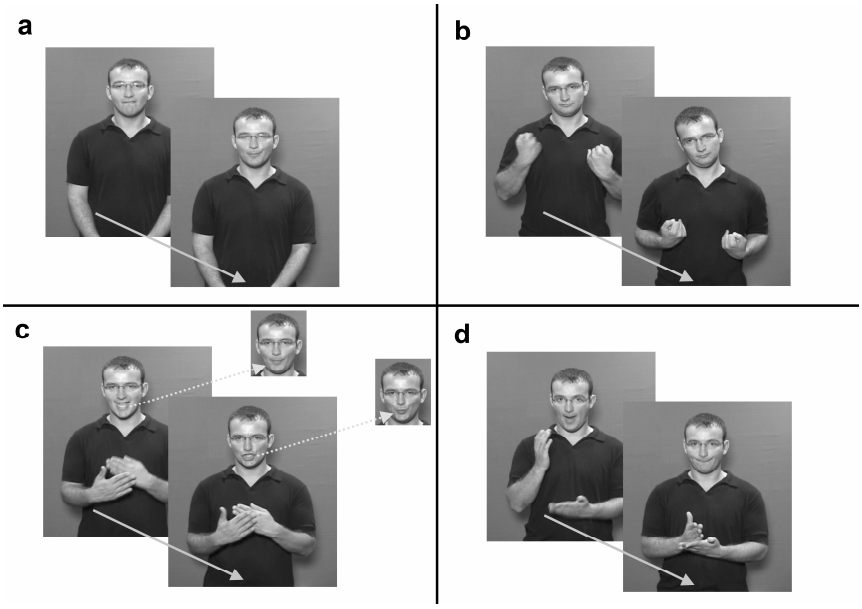

Figure 7.5: Illustrations of stimuli

7.5a. SS. Silent articulation of the English word "football". The fricative (/f/)('foot..'), and the semi-open vowel /ɔ:/ ('..ball') are clearly visible

7.5b. HO. The BSL sign ILL

7.5c. DM. The BSL sign ASIAN shows the mouthing of /eɪ/ and /|/. The face insets show the corresponding parts of the mouthings for the manual homonym BLUE, where /b/ and /u:/ can be seen

7.5d. EP. The manual sequence for [TRUE] requires abrupt movement from an open to a closed contact gesture. As this occurs, the mouth closes abruptly.

This experiment was designed to address a number of specific questions: to what extent does the pattern of activation between speech perception and sign language perception differ?; does the processing of mouthings (DM) differ compared to signs without mouth action (HO)?; does echo phonology (EP) generate distinctive activation compared with mouthings (DM)?; How do non-signers differ from signers?

Thirteen (6 female; mean age 27.4; age range: 18-49) right handed participants were tested. Volunteers were congenitally, severely or profoundly deaf native signers, having acquired BSL from their deaf parents. Stimuli were presented in alternating blocks of each of the experimental and a baseline condition. Participants were instructed to understand the signs and words and they performed a target-detection task in all conditions, to encourage lexical processing. During the experimental conditions, participants were directed to make a push-button response whenever the stimulus item contained the meaning 'yes'. This 'yes' target was presented in an appropriate form across all 4 conditions, specifically: as an English word with no manual component in the SS condition, as a BSL sign with no mouth action (but BSL-appropriate facial affect) in the HO condition, as a BSL sign with an English mouth pattern in the DM condition and as a BSL sign with a motoric mouth echo in the EP condition. Full details of the experimental protocol and analysis may be found in Capek et al. (2008).

7.7.1 To what extent does the pattern of activation for speech perception and sign language perception differ?

7.7.1.1 Speechreading (SS)

The major area of activation was perisylvian (superior temporal and inferior frontal), with somewhat more extensive activation on the left than the right. These findings conform with other recent studies. They confirm that silent speech can activate regions in deaf people's brains that have been identified as auditory speech processing regions in hearing people.

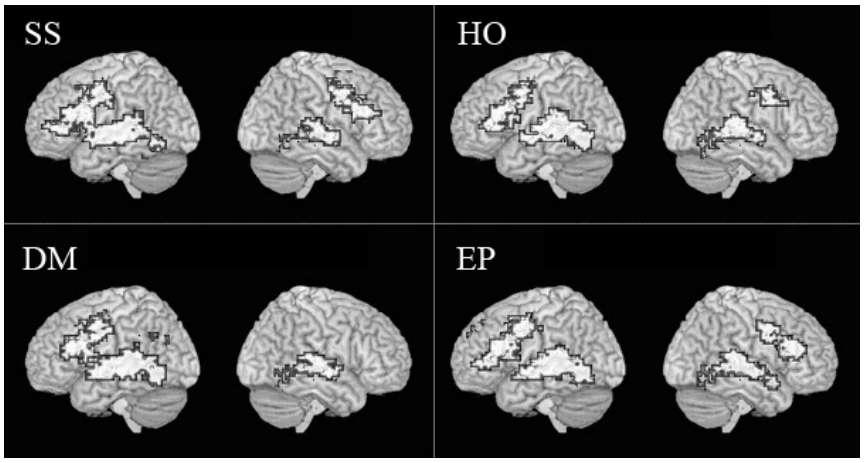

Figure 7.6: Brain activation
7.6a (top left) activation during silent speechreading (SS)
7.6b (top right) activation during processing of signs without any mouth actions (HO)
7.6c (bottom left) activation during processing of signs with disambiguating mouth actions (DM)
7.6d (bottom right) activation during processing of signs with echo phonology (EP)

7.7.1.2 Sign language (HO, DM, EP)

In all three sign language conditions, there is also activation in perisylvian regions. It affirms that sign language in Deaf native signers activates core language regions that are typically found when hearing people listen to speech. Although both sign language and speech involve perisylvian regions, sign language perception activated more posterior and inferior regions. For this analysis, silent speechreading is compared with the 3 sign conditions (figure 7.7)

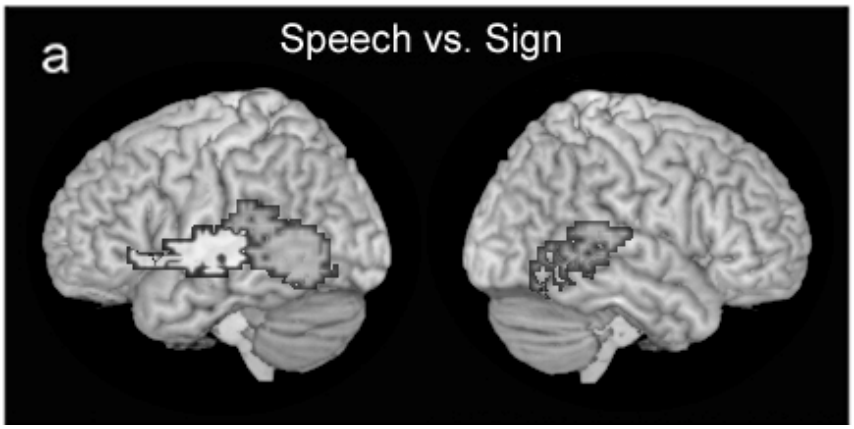

Figure 7.7: Silent speech (light grey) vs. Signs (EP, DM & HO) (dark grey)

7.7.2 Does the perception of signs with mouthings (DM) differ from signs with no mouth (HO)?

If language (speech vs. sign) is the crucial reason for the more posterior activation found in BSL perception, then signs with disambiguating mouth and signs without mouth should be processed identically. On the other hand, if the articulators used determine the areas of activation, then DM and HO signs should differ, with more posterior activation for the NM signs. The data support the first alternative: anterior activation characterised DM and posterior activation HO (figure 7.8). There was greater activation for signs with mouth actions in superior temporal sulci of both hemispheres; additional activation in the left inferior frontal gyrus; and HO signs activated more right posterior temporo-occipital regions. These may be particularly important for the perception of hand actions. These findings are very similar to those exploring distinctive patterns of activation consequent on observation of hand and mouth gestures that are unrelated to sign language.

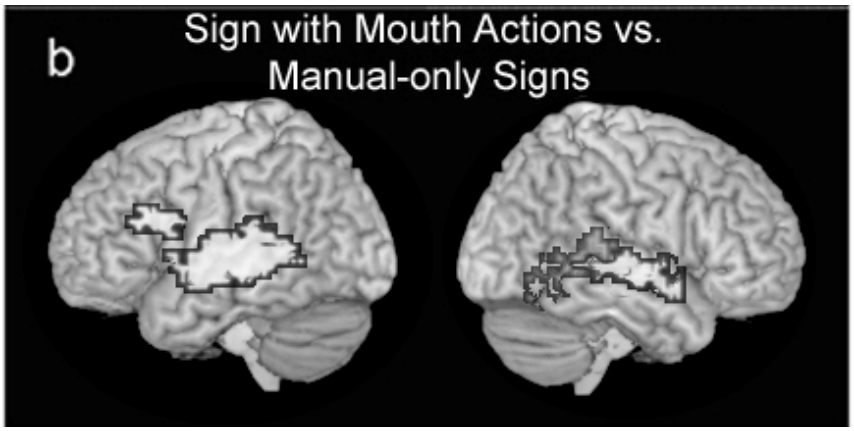

Figure 7.8: Signs with mouth actions (DM & EP) (light grey) vs. HO signs (dark grey)

7.7.3 Does echo phonology (EP) generate distinctive activation compared with other mouthings (DM)?

The contrast between the condition that used DM and the one that used EP provides further insight into the cortical correlates associated with observing specific articulators within sign language. Here the pattern differed. DM generated relatively greater activation in a circumscribed region of the left middle and posterior portions of the superior temporal gyrus, while EP produced relatively greater posterior activation. This can be considered to reflect the fact that DM is more 'speech-like' than EP. Thus EP appears to occupy an intermediate position between signs without mouth and signs with mouth actions derived from spoken language (figure 7.9).

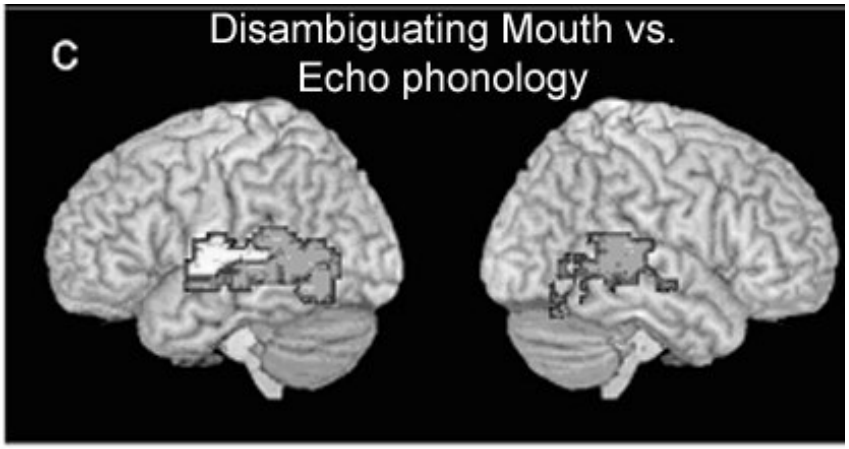

Figure 7.9: DM (light grey) vs. EP signs (dark grey)

These findings suggest a strong conclusion concerning brain organisation for the perception of sign language. The task required participants to process material linguistically. In order to achieve lexical processing, BSL users must integrate perceptual processing hands and of face/head, and this needs to be achieved fluently and automatically. If the cortical circuitry for sign language processing were driven by a mechanism that is 'articulation-blind', we would expect there to be no systematic differential activation between, for example, signs with mouthings (where the mouth information is non-redundant), signs without mouthing (where there is no mouth information or signs with echo phonology, where the information on the mouth is redundant. Yet the contrasts analysed here suggest this is not the case. It appears that mouth actions, when they are a required component of the sign, differentially activate a circumscribed region within the middle and posterior portions of the superior temporal gyrus. More generally, there is a strong similarity between the patterns of distinctive activation for mouth actions and for hand actions. This suggests that when the language processor is engaged, it requires ongoing access to visual information about the articulators that deliver information to it, and that this information can be distinguished in terms of relative cortical location. The core language processes themselves, appear to be similarly constituted for sign language and for speechreading in Deaf native signers.

7.8 Conclusion

One issue for those concerned with suggesting a link between gesture and word has always been how the largely visually-motivated gestures could have been transformed into the largely arbitrary words of spoken language. Echo phonology provides evidence for a possible mechanism. Firstly, the phenomenon appears to be fairly common across different sign languages (although the occurrence of echo phonology needs to be researched in non-European sign languages). Secondly, the oral activities in echo phonology are themselves non-visually motivated. It is impossible to reconstruct from a syllable such as [ʃ] the meaning 'exist', although the manual activities can be interpreted as visually representing the marking of an area in space. Thirdly, the actual inventory of elements in echo phonology looks very much like a system of maximal contrasts in a spoken language phonology (although there are some limitations because of the absence of sound contrasts). Fourthly, functional imaging research on the representation of signs and words in the brain suggests that echo phonology occupies an interesting intermediate position.

This paper represents only a very preliminary exploration of echo phonology. However, the data lead us to a number of conclusions. They support the arguments of those who argue against the notion that a unimodal manual protolanguage preceded the evolution of spoken language, since they demonstrate the extent to which signs are combined with mouth actions. The data also provide a window onto a mechanism by which the arbitrary pairing of a referent with a symbol (Saussure's defining feature of spoken language) could have occurred. Further research is needed to explore the presence of echo phonology in other sign languages (including those with a more recent point of creation than BSL) and whether echo phonology is subject to change (for example, added or transformed in a process of sign conventionalization). These studies may provide more insights into the origins of phonological/lexical structure in spoken language, and from that to the evolution of human language.

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