The non-linguistic status of the Symmetry Condition in signed languages

Evidence from a comparison of signs and speech-accompanying representational gestures*

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Since Battison (1978), it has been noted in many signed languages that the Symmetry Condition constrains the form of two-handed signs in which two hands move independently. The Condition states that the form features (e.g., the handshapes and movements) of the two hands are 'symmetrical'. The Symmetry Condition has been regarded in the literature as a part of signed language phonology. In this study, we examine the linguistic status of the Symmetry Condition by comparing the degree of symmetry in signs from Sign Language of the Netherlands and speech-accompanying representational gestures produced by Dutch speakers. Like signed language, such gestures use hand movements to express concepts, but they do not constitute a linguistic system in their own right. We found that the Symmetry Condition holds equally well for signs and spontaneous gestures. This indicates that this condition is a general cognitive constraint, rather than a constraint specific to language. We suggest that the Symmetry Condition is a manifestation of the mind having one active 'mental articulator' when expressing a concept with hand movements.

1. The role of phonology in determining the shape of language

The physical shape of language results from the interplay between a variety of factors or forces. Language must be articulated, perceived, acquired, stored mentally, retrieved, etc. In addition, there are requirements that relate to the functions of

language as a means of communication, as well as to its role in signalling extra-linguistic characteristics of its users (mood, social class, etc.). Moreover, the nature of the linguistic, computational system imposes certain properties, which could be called linguistic principles. That is, the shape of language is determined by, among other things, the following factors (Anderson 1981): linguistic principles, articulation, perception, acquisition, storage/retrieval, extralinguistic signalling, communication demands.

For any particular 'element of language' it is not clear, off-hand, which aspects of its shape are determined by which factor(s), and this may easily lead to debates about the division of labour between fields such as phonology, phonetics, socio-linguistics, and so on, with respect to who is 'responsible' for explaining certain phenomena. Sometimes the debate is stated as that between 'formal' explanations (based on linguistic principles) and 'functional' explanations.

In the domain of phonetics (i.e. articulation and perception) and phonology (i.e. formal linguistic principles), one of the ways in which we could tease apart these factors is to compare linguistic and non-linguistic use of the articulators that generate signals. In spoken language, such a comparison is a difficult one because the repertoire of sounds that we can produce with our oral articulatory apparatus does not clearly function in any complex semiotic system other than the linguistic system. People make noises for other reasons than speaking, of course, but those noises are mostly involuntary and limited in complexity. Para-linguistic sounds (such as 'mmmm', 'pff', various kinds of 'clicks' used by speakers of many languages) display only a very limited aspect of the capacity of the articulatory apparatus and sometimes use the articulatory apparatus in a way that is not known in language (e.g., raspberry). Therefore, it is difficult to compare linguistic and non-linguistic sound production to ascertain whether an observed regularity in the sound system of language should be captured by principles of the formal linguistic computational system, i.e., phonology, or by more general principles of sound production that subsume both production of speech and non-linguistic sounds.

In the study of signed languages we encounter a different situation. Signed languages are visuo-motor languages, using the hands, the face and the torso as articulators. If we study the actions of these articulators purely within the boundaries of signed languages, it is not easy to definitively decide which properties are due to formal-linguistic principles and which are due to other factors. However, signed languages are unique in that they can be compared with a complex non-linguistic semiotic system that uses the same articulators, namely "representational gestures" that spontaneously accompany speech. Representational gestures include "iconic" and "deictic" gestures (McNeill 1992), in which iconicity and indexicality plays a crucial role in the form-meaning mapping. Furthermore, representational gestures have a very limited syntagmatic capacity: there are no abstract syntactic

rules that assign meaning to a string of representational gestures (McNeill 1992). A string of representational gestures can have meaningful relationships with one another only by virtue of iconicity and deixis (e.g., a string of gestures depicting a complex spatial layout). In summary, the semiotic principles governing the form-meaning mapping in co-speech representational gesture are distinct from the formal system of language, where iconicity is not the main organizing principle for form-meaning relationship though it plays a more important role in signed languages than in spoken languages.

This situation allows us to compare gesture and signed language in order to isolate form regularities that are due to factors that might lie outside the scope of the phonological component of signed language. More specifically, if regularities attested in signed languages are also found in gestures, we can infer that these regularities in signed languages are not necessarily phonological, i.e. not linguistic, but may be due to more general principles that encompass both signed language and gesture. It is, of course, possible that two separate principles in linguistic and gestural systems, by coincidence, generate the same regularities or that a general principle has been adopted by different cognitive systems in similar ways. We cannot exclude these possibilities. As a working strategy, however, we adopt Ockham's razor (i.e., the parsimony argument) and assume that regularities that generalize over multiple domains can be eliminated from those domains and assigned to a higher-level (presumably cognitive) faculty.

In this study, we focus on a form-regularity, called the Symmetry Condition, which has been attested in all signed languages that have been studied to date. Sign phonologists, implicitly or explicitly, regard this constraint to be a *phonological* constraint (originally proposed by Battison 1978). We will compare the degree of symmetry of signs in Sign Language of the Netherlands (*Nederlandse Gebarentaal*, henceforth NGT) and co-speech representational gestures produced by Dutch speakers. We will show that the gesture system is, in fact, subject to a very similar, or perhaps identical, constraint as the signed language. This finding leads us to remove the Symmetry Condition from the realm of signed language phonology.

The structure of this paper is as follows. In Section 2, we will first provide some general information about the shape of signs in signed languages and the Symmetry Condition. Then we proceed, in Section 3, with some brief remarks about gestures. In Section 4, we formulate our research goal in more detail. We describe an experiment in Section 5, the results of which are discussed in Section 6. In this same section, we present some additional results in support of our conclusions and we discuss the status of the Symmetry Condition. Finally, in Section 7, we offer our final conclusion and speculate on what part of the cognitive system the Symmetry Condition should be attributed to.

2.   Two-handed signs and signed language phonology[1]

In signed languages, a distinction can be made between signs made with one hand and signs made with two hands. The use of one or two hands is a distinctive feature of signs because they are able to form minimal pairs. Examples from NGT are 'to choose' versus 'sheet' in (2).

(2)

'to choose'   'sheet'
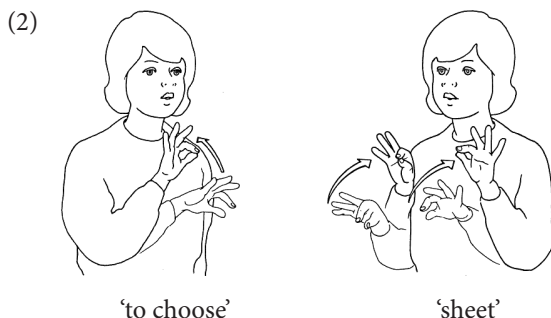
Within one-handed signs, the use of the right hand or the left hand in performing a sign is not phonologically distinctive, not in NGT, or in any other signed language, as far as we know. A possible explanation for the non-distinctiveness of the right/left hand distinction will be discussed in Section 7.

Within the category of two-handed signs, a further distinction can be made between signs in which two hands are 'copies' of each other (in a sense to be made precise below), the so-called *balanced* signs (van der Hulst 1996), and signs in which only one hand moves. The latter are called *unbalanced* signs (van der Hulst 1996). Examples of balanced signs from NGT are 'bicycle' and 'morning' in (3a) (as well as 'sheet' in 2), examples of unbalanced signs are 'green' and 'orange' (3b).

(3)   a.

'bicycle'   'morning'

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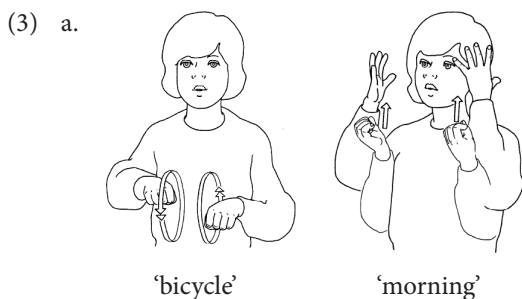
1.   For an overview of sign language phonology, see van der Hulst (1993).

b.

'green'   'orange'
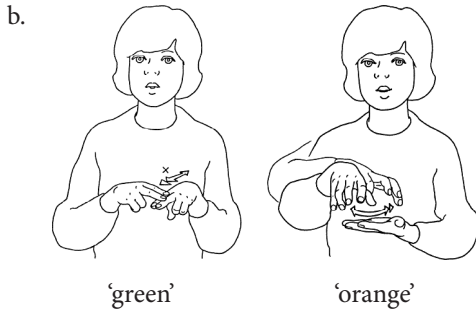
Balanced signs come in two major types, depending on whether their dynamics (for example, in terms of movement of the hand) are *identical* or *opposite* (in a sense to be made specific below). In signs like 'bicycle' (which both show movement of the hands) both hands move in an 'opposite fashion' (in this case, when one hand is up, the other is down), while in 'morning' both hands are in the same 'location' at the same time. Typically, such opposite movements are repeated (as in the sign 'bicycle'), which is why balanced signs like this are called *alternating signs*. However, in the NGT sign 'to die' (4) the hands have an opposite movement which is carried out only once: both hands are extended in front of the trunk, one palm up, the other palm down and then they both make a single 180 degree rotation.

(4)

'to die'
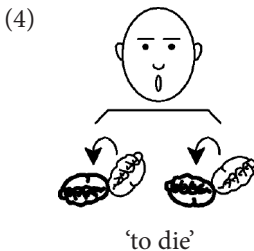
The distinction between balanced and unbalanced signs can be phrased in terms of their place properties. In general, signs can be made in the space in front of the body (called neutral space) or with reference to the body (i.e. a spatial area on the face, shoulders, trunk, arm, or hand). The latter case is of particular interest since if the hand is the location this means that the sign is of the unbalanced two-handed type, i.e. 'green' or 'orange'. Unbalanced two-handed signs, then, are effectively one-handed signs in which the location property happens to be the other hand (cf. Sandler 1989, 1993). The 'articulator hand' in such signs (as in almost all signs) will show some kind of dynamics, while the location hand will not.[2] Since signs of

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2. There is a special class of unbalanced signs in which both hands move. In this case, the articulator hand makes contact with the location hand and 'drags' the latter along in its movement.

this type have the non-articulator hand as a location specification, there can be no other location specification which implies that the whole sign is executed in neutral space (which we regard as the physical realization of 'no place'). In contrast, balanced signs (in which both hands are articulator hands) are free to choose a location specification (which can be any value except, of course, 'hand'). As an option, they can also have no place specification, which implies that they will be executed in neutral space (as, for example, 'bicycle' and 'morning'). An example of a balanced sign that has a location specification high on the trunk is the ASL sign for 'boss' (5) in which both hands pull out imaginary suspenders.

(5)

'boss'
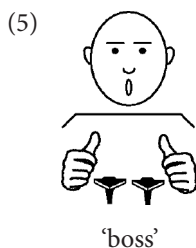
Above we remarked in passing that 'almost all' signs have some kind of dynamic property for their articulator. Below we discuss various types of dynamic properties in detail. In fact, it has been claimed that 'all' signs have a dynamic property. If this is indeed the case, we have another criterion that distinguishes balanced from unbalanced signs: if both hands have a dynamic property the sign must be balanced because both must be articulators; locations do not have dynamic properties.

In the remainder of this article, we will focus on balanced signs. The form of either type of balanced signs (alternating or non-alternating) is subject to a constraint, which concerns the four major distinctive elements of signs, namely *movement*, *handshape*, *orientation*, and *location*. The constraint is known as the *Symmetry Condition* (6), and it seems to be common across signed languages (among others ASL, Battison 1978; NGT, van der Hulst 1996; Sign languages of

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An example is the ASL sign 'to help' (i) in which the articulator hand shaped as a fist rests in the palm up location hand and then moves outward (see van der Hulst (1996) for more information on the classification of two-handed signs).

(i)
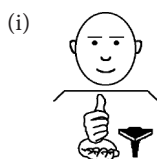
Aboriginal Australia, Kendon 1988a; British Sign Language, Sutton-Spence & Woll 1999). The essential idea of the Symmetry Condition is that in two-handed signs in which both hands are active articulators (i.e. in which one is not the location for the other), both hands have the same or opposite values for the parameters that are necessary to specify the form properties of signs:

(6)   Symmetry Condition
      If a sign involves both hands as active articulators, both hands:
      a.   make an identical or an opposite movement;
      b.   have an identical handshape;
      c.   have an identical or an opposite orientation;
      d.   have an identical location.[3]

In signed language linguistics, the Symmetry Condition has often been assumed to be a constraint at the level of phonology.

3.   Gestures

Co-speech gestures come in many varieties. One important factor that differentiates them is whether the form-meaning relationship is fully determined by convention (Kendon 1988b; McNeill 1992). So-called emblematic gestures ("emblems" in short) such as the "OK-gesture" with a ring formed by the thumb and the index finger have a fully conventionalized mapping between the form and meaning, not unlike signs in signed language. In contrast, in co-speech representational gestures ("iconic" and "deictic" gestures), the form-meaning mapping is relatively unconventionalized (McNeill 1992). The form and meaning are related by iconicity (similarity) in iconic gestures and by indexicality (spatio-temporal contiguity) in deictic (pointing) gestures (McNeill 1992). The minimal role that convention plays in determining the form of representational gestures is in sharp contrast with the critical role it plays for signs in signed languages. Therefore, in this study, we compare signs with the least conventionalized co-speech gestures, i.e. representational gesture (henceforth simply "gestures").

  Although it has been claimed that the cognitive processes underlying the production of gesture and speech are interrelated (McNeill 1985, 1992; Kita 1993; Krauss, Chen & Chawala 1996; de Ruiter 1998), gesture as a semiotic system is not a part of the grammar of language. Gesture, however, is similar to signed language in two respects. First, both gesture and signed language use the visuo-motor

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3. Since it is still a debate which locations count as phonological features in signed languages, we will not discuss 'location' any further.

modality: the movements are produced by all kinds of body parts (our analysis, however, focuses on hand movements) and the information conveyed by the movements is picked up visually. Second, the form of signs and gestures can be phonetically described by the same formational elements, i.e. types of movement, location, handshape, and orientation of the hand (see van Gijn (1997), for studies of gestures with such an approach).

4. The logic of the study

Because signs and gestures make use of the same visuo-motor modality and their forms are built up from the same elements, it might be the case that they are subject to similar formational constraints such as the Symmetry Condition. The goal of this article is to compare the degree to which signs and gestures obey the Symmetry Condition.

The comparison must be based on signs and gestures produced in discourse since gestures (of the type in question) cannot be elicited in isolation. Though the form-meaning relation in gestures is largely unconventionalized, unlike that in signs, we still assume that gestures have an underlying target representation or 'articulatory plan' for their forms. The form-target is an abstract representation, which is primarily determined by the meaning to be conveyed because form and meaning are related by similarity and spatio-temporal contiguity. This abstract form-target is sent to the motor system, which generates the actual hand movements for gestures. As gestures are semiotic entities, in which a form stands for a meaning (McNeill 1985, 1992), we assume that the form specifications of gestures must be planned in conjunction to their meaning at some abstract level in the mind.

Being interested in a comparison of balanced signs and two-handed gestures, both used in a discourse situation, we might expect a performance effect such that the intended symmetry is not realized perfectly. *Weak-hand freeze* (one hand is held still instead of making the movement) and *weak-hand drop* (one hand is completely inactive in the execution of the sign) are extreme instances of non-perfect realizations of balanced signs, and furthermore, we expect milder imperfections as well. In other words, the execution of a sign or gesture can be somewhat 'sloppy'. Bearing this in mind, we formulate our basic logic of the study as follows: if signs and gestures produced in discourse obey the Symmetry Condition to the same degree, it is inferred that the target representation of both balanced signs and two-handed gestures are subject to the same condition. This inference can be depicted as in (7).

(7)

	sign		gesture
physical realization	symmetrical to a certain degree	=	symmetrical to a certain degree
		our inference ↓↓	
underlying target representation	symmetrical	=	symmetrical

If we indeed find that the physical realization of signs and gestures in our data set is equally symmetrical, it is necessary to rule out the possibility that our data set is too small or not representative enough. In order to do so, we focus on two differences between signs and gestures that are due to the fact that signs constitute a phonological system, while gestures do not. First, in signed languages, we find distinctive locations in that signs can be articulated in neutral space or with reference to a body location. Gestures are largely executed in neutral space (McNeill 1992), and do not appear to use distinctive body locations, except where body parts are a part of what the gesturer wishes to express. If our corpus reflects this difference it *is* large and representative enough to reflect, at least, some differences due to sign language phonology. Second, in signed languages, parameters such as handshape and orientation take several discrete (as opposed to continuous) values. This guarantees a set of contrastive forms that can be used as building blocks for morphemes for the signed languages. However, a given form parameter for gestures does not take a fixed number of discrete values. Gestural representations crucially depend on iconicity and indexicality, and they are essentially analogue representations and use a full range of form parameters. The goal of this study was to capture this fundamental difference between signs and gestures in the domain of handshapes. We expect that signs are produced in such a way that differences among contrastive handshapes are maximized. More specifically, handshapes in sign tokens found in discourse will cluster around handshapes that are distinct in the sign language, and in-between handshapes are relatively rare. In contrast, gestural representations are analogue and do not have discrete form targets. Thus, we expect that gesture tokens produced in discourse are more likely to have in-between handshapes than sign tokens. We focused on handshapes to test these predictions. Finger selection is one of the crucial factors that contrasts distinctive handshapes in sign language. We coded signs and gestures for (degree of) 'sloppiness' of handshape, in other words, how clearly fingers are selected or unselected. The sloppiness coding captures how often signs and gestures take in-between handshapes. Again, if our corpus reflects this difference it *is* large and representative enough to reflect, at least, some differences due to sign language phonology.

We conclude this section with an important delimitation of the class of two-handed signs that are relevant for our study. We have already excluded unbalanced signs, arguing that these are essentially one-handed, since the 'other hand' functions as the place of articulation. There are, in addition, systematic exceptions in signed languages to the Symmetry Condition. These are the so-called two-handed *classifier constructions* in which both hands represent a separate referent, e.g. one hand represents a car and the other hand a bicycle and the two bump into each other. Another example from our database is a two-handed classifier sign in which one hand moves horizontally, representing an animal walking away, while the other hand falls from above and hits the moving hand, representing an object that falls and hits the animal. In these two-handed movements, the Symmetry Condition is violated: the handshapes of both hands can be totally different. In addition, the shape and the direction of the movements of both hands can be completely different, and likewise for the orientation property.

There is, of course, an important difference between 'regular' balanced two-handed signs and classifier constructions. In the former case, both hands represent 'one entity', whereas in the classifier constructions both hands represent different entities. We can also put this differently: balanced signs are monomorphemic, whereas classifier constrictions are poly-morphemic. Battison (1978) who was the first to propose the Symmetry Condition for signs from ASL based the condition on signs that refer to one entity only and did not consider two-handed classifier constructions. Therefore, we assume that the Symmetry Condition does not apply to two-handed two-referent classifier constructions and exclude these constructions and equivalent type of gestures from our study.

To summarize, in this study, we compare the degree of symmetry of balanced signs and co-speech representational gestures with one referent that are produced in discourse. If the signs and gestures are equally symmetrical, then we conclude that the Symmetry Condition is operative for both signs and gestures and that the Condition is a general (non-linguistic) constraint.

5.   Methods

5.1 Data collection

The signs were collected from four native signers of NGT and the gestures from six native speakers of Dutch. The subjects watched short animated cartoon stories and narrated these stories to a listener. The subjects were told that this study was about story telling. Since the narrations in both languages were elicited by the same stimuli, the content that the speakers and signers tried to convey are considered to be comparable.

5.2 Coding

Narratives for two scenes in the animated cartoon were selected for the analysis (the two scenes are described in the appendix of McNeill (1992) under the line numbers from 1 to 36, and from 197 to 232). The flow of signs and gestures were segmented into *movement phases*, such as preparation, stroke, hold, and retraction, under principled procedures (Kita et al. 1998).[4] In the preparation phase, the hand moves from the resting position to the starting position of the meaningful part of the gesture or sign. In the meaningful part of the hand movement, the stroke phase, the hand moves with effort and attention in comparison to neighbouring movement phases. After the stroke phase, the hand may get into another preparation phase for the next gesture or sign or will move into the retraction phase, by bringing the hand back to the resting position. Between preparation, stroke and retraction, the hand may stay still, which is called the hold phase. Among types of movement phases, we have isolated the crucial parts from transitional movements that necessarily occur in between different signs and different gestures. The hold and stroke phases are crucial in that they constitute the lexical part of sign production and the meaning bearing part of gesture production.

Furthermore, we restricted our analyses to the following types of signs and gestures. We looked at balanced signs, i.e. signs in which the two hands move without touching each other and having only one referent, like the NGT signs for 'sheet' (2), 'bicycle', and 'morning' (3a). So we left out unbalanced signs as well as the two-handed classifier constructions. As for gestures, we focused on iconic, metaphoric, and beat gestures as defined in McNeill (1992) (iconic gestures depict physical events, metaphoric gestures depict abstract concepts, beat gestures emphasize certain segment of speech with small up and down hand movements). We excluded one gesture token from the analysis since it was an emblem whose arbitrary relation between form and meaning is determined by convention, similarly to signs. Among 87 gestures of this type, 76% were iconic gestures, 11% were metaphoric gestures, and 13 % were beat gestures. Some examples of iconic gestures from our corpus are given in (8). In (8a) the gesture iconically refers to a board while the informant says: "…he puts down a piece of wood with a board on top of it…" (the position in the sentence where the gesture is made is between square brackets). In (8b) the gesture depicts the act of throwing something as the informant says "…and he throws the weight on the other side… ".
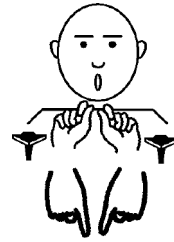
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4. The concept for movement phases for gesture was originally discussed in Kendon (1972), and expanded by McNeill (1992).

(8)   a.   b.

"…he puts down a piece of wood   "…and [he throws the we]ight
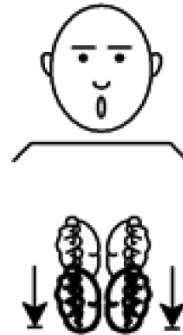[with a board on top of it]…"   on the other side… "

Metaphoric gestures do not represent concrete objects and actions, but have an abstract content. (9a) is an example of a metaphoric gesture in our corpus. In this gesture, two hands open up to form a "cup", which does not seem to iconically represent "the cat", but rather a container that holds a message, in accordance with the "conduit metaphor" for communication (Reddy 1979). (This interpretation follows McNeill's (1992) interpretation of a similar gesture on his page 148.) The cup arguably represents an idea of the "event" in which the cat sees the bird, and this idea is presented to the listener in the gesturally expressed container. (9b) is an example of a beat gesture, which consists of a small rhythmical movement (typically up and down) with a neutral handshape and which seems to highlight information important in the discourse context (McNeill 1992).

(9)   a.   metaphoric gesture   b.   beat gesture
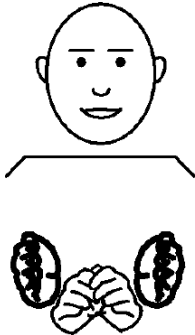
"…that [cat] sees the bird…"   "…no, it was […a bl]ue
                                         something…"

The different form elements of signs and gestures were transcribed according to the features defined in GesturePhone (van Gijn 1997). GesturePhone is a phonetic coding system which is based on possible phonetic properties (not necessarily distinctive) that were used to code signs in SignPhon, a database tool for

the phonological analysis of signed languages (Blees et al. 1996). In the Appendix, we list the features used in our study. The difference between SignPhon and GesturePhone is that in SignPhon the citation form of signs, i.e. the target form of the signs is transcribed, whereas in GesturePhone the actual form of signs and gestures that is found in the discourse is transcribed. We can expect that this "discourse" form may deviate from the target form and that "the same" sign or gesture performed several times may look slightly different every time.

In the following subsections, we will briefly explain the details of the coding system, as well as our operational definition of violations to the Symmetry Condition. A complete list of coding values is given in the Appendix. The coding is detailed enough to detect most of the violations to the Symmetry Condition, and we measure the degree of symmetry in signs and gestures with the same "yard stick".

5.3 Distinction and coding

5.3.1 *Handshape*

For the coding of handshapes, we made use of the HamNoSys handshape chart (Prillwitz et al. 1989) in which a handshape code consists of a letter and a number that refer to the columns and rows of this chart, respectively.[5] Roughly speaking, the letters stand for the number of selected fingers and the numbers for the degree of aperture of these selected fingers. For example, the handshapes B1 and C1 in (10) only differ in the number of selected fingers, 'all' and 'one' respectively, but their aperture is the same, namely 'extended', and the handshapes B1 and B4 in (10) have all fingers selected but in the former the fingers are 'extended' and in the latter they are 'hinging'. We coded the handshapes at the beginning and at the end of a sign and gesture, because these two values can differ if a change occurs during a sign or gesture.[6]

(10)

      B1   C1   B4

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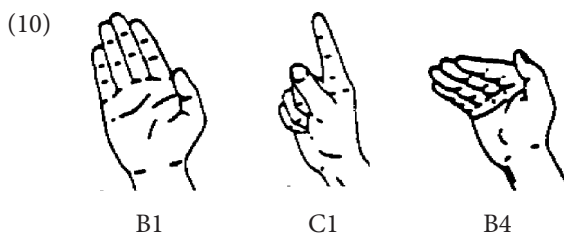
5. The letters and numbers are an addition by Blees et al. (1996). They are not mentioned in Prillwitz et al. (1989).

6. Such changes of the hand do not involve finger selection, which is another universal constraint that all sign languages seem to follow, as first established for ASL in Mandel (1979).

For the purpose of this study, we grouped a number of different handshapes into broader categories, according to which fingers are selected and the position of these selected fingers with respect to 'abduction' (finger spreading), 'hinging' (i.e. the fingers flex in the base joints or knuckles), and 'clawing' (i.e. the fingers flex in the upper two joints). The handshapes that only differ by the thumb position were classified into the same category because some of the variations in thumb position are allophonic in NGT. If the codes of the two hands come from the same category of handshapes, this was not considered to be a violation of the Symmetry Condition. Thus, the handshapes B1, B4 and C1 in (10) are in three different categories, since either the selected fingers or the position of these fingers are not the same. But the handshapes B2 and B3 in (11) are in the same category as B1.

(11)

     B1   B2   B3
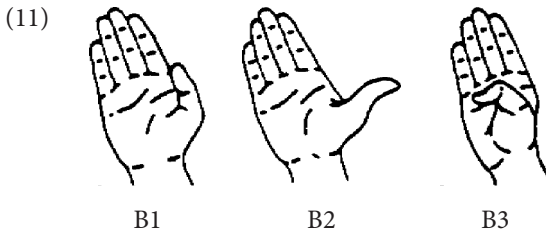
5.3.2 *Orientation*

Within orientation, a distinction is made between palm and finger orientation. Finger orientation is the direction in which the base joints or knuckles are pointing. For both we distinguished the values for the three spatial dimensions up-down, front-back, ipsilateral-contralateral. (The ipsilateral side is that side of the body the hand is connected to, the contralateral side is the opposite side of the body the hand is connected to.) The palm and finger orientation can change within one sign or gesture as a result of rotation of the forearm and the wrist. Therefore, we coded the palm and finger orientations at the beginning and at the end of a movement. If the codes for both hands are the same or counterparts of a symmetric pair, the Symmetry Condition is obeyed. If, for example, the palm of one hand is facing the front-ipsilateral direction and the palm of the other hand the front-contralateral direction, it is not a violation of the Symmetry Condition. However, if the palm of the latter hand is facing a side-way direction, it is a violation.

5.3.3 *Movements*

There are two major types of movement. First, there is the so-called global or path movement in which the hand travels from one location in absolute space to another. An example is the NGT sign 'sheet' in (2a). In the second kind of movement, the hand stays at one location in space and makes a local movement. A hand-internal

or local movement consists of a change in orientation of the hand, a change in the shape of the hand, or both. Global and local movements can be produced at the same time as can be seen in the sign for 'morning' in (3a): the hands are making an upwards path movement and an opening handshape change at the same time.

5.3.3.1   *Global movement.*   For the global or path movement, we coded the shape of the movement, e.g. whether it was a straight or an arc movement, and the direction of the path movement. We defined a violation of the shape of the path movement to the Symmetry Condition in the following way: if the hands have different codes, it is a violation. An example of a violation to the Symmetry Condition is a sign or gesture where one hand moves straight and the other moves in an arc.

The direction of a movement is coded according to the three dimensions in absolute space: up-down, front-back, or ipsilateral-contralateral. These three pairs are symmetric pairs. If the codes for the two hands are the same or opposite counterparts, the movement is considered to obey the Symmetry Condition. That is, when one hand is moving upwards and the other hand is moving downwards, this is considered symmetrical because both hands are moving along the same spatial axe. However, if the direction of one hand has a component along one of the axes (e.g. an upward movement) and that of the other hand does not (e.g. it is moving forward), there is a violation.

5.3.3.2   *Local movement.*   A local movement can consist of a change in orientation of the hand or a change in the shape of the hand. Here we first discuss orientation changes and then handshape changes.

An orientation change involves either a rotation of the forearm or a movement of the wrist so that the direction the palm of the hand points to changes.

When the forearms are extended horizontally with the palms facing each other, the forearm can rotate in such a way that the palm of the hand can face the floor or that the back of the hand can face the floor. These two options are called 'pronation' and 'supination', respectively. A repetition of 'pronation' or 'supination' was coded as 'rotation'.

In addition to orientation changes involving rotation of the forearm, two other types of orientation changes are possible. Both involve movements that are made at the wrist. The hand can either bend towards the palm or the back side of the forearm, which are called 'flexion' and 'extension'. Or the hand can move sideways in the direction of the pinky or in the direction of the thumb. These are called 'ulnar and radial flexion', respectively.

If the codes for orientation change in the two hands are the same or counterparts of a symmetric pair, the orientation change is considered to obey the Symmetry Condition. E.g. if one hand is performing 'flexion' and the other hand

'extension', this is not a violation to the Symmetry Condition, whereas if one hand is performing a 'flexion' and the other hand a 'pronation', this is a violation.

The second type of local movement is handshape change, which involves changes in the position of the selected fingers. The position of the fingers at the beginning and the end of the signs and gestures has been coded as part of the handshape codes discussed in Section 5.3.1. If these codes differ for beginning and end, a handshape change can be inferred. In addition, separate codes were used that directly represent handshape changes. Among the symmetric pairs for handshape change are closing vs. opening of the hands and abduction vs. adduction (i.e. spreading and the opposite of spreading of the fingers, respectively).

Finally, there are other handshape changes that have no symmetrical counterpart such as rubbing or wiggling of the fingers.

If the codes for handshape change in the two hands are the same or counterparts of a symmetric pair, the handshape change is considered to obey the Symmetry Condition. For example, if one hand is making an opening movement and the other hand a closing one, we did not regard this as a violation, while we did for cases in which one hand is closing, while the other shows rubbing of the fingers. If one hand is making a path movement and the other one only a hand internal movement, this is also counted as a violation to the Symmetry Condition.

5.4 Formational features not related to the Symmetry Condition: Hand sloppiness and body contact

The gestures and signs are also coded for two formational features that are not part of the Symmetry Condition but that are relevant for signed language phonology. These are sloppiness of the handshape and contact with the body.

A handshape was coded as 'sloppy' if the unselected fingers are in an 'in-between' position, i.e. not fully extended or not fully curled or not fully hinging. For example, in a sloppy C1 handshape (see (10) for a picture of a non-sloppy C1 handshape), the non-selected fingers are not fully curled into the palm as in the non-sloppy example, but in a position between fully curled and hinging, or between hinging and fully extended. A handshape was also coded as 'sloppy' if multiple fingers are selected but the selected fingers are not in the same position. For example, in a sloppy B4 handshape (see (10) for a picture of a non-sloppy B4 handshape), the index, middle, and ring fingers are angled as illustrated in (10), but the small finger is more upright than the other three selected fingers. Furthermore, it was coded for gestures and signs whether the hand makes contact with the body (i.e., touching the torso or the face).

6.   Results and discussion

6.1 Results

The four signers of NGT produced on average 50.3 two-handed balanced one-referent signs (the range: 36–65). The six Dutch speakers produced on average 14.5 two-handed, balanced (non-emblem) gestures with a single referent (the range: 4–31). The following analyses are based on these sets of signs and gestures.

The mean proportions of tokens that violated different aspects of the Symmetry Condition were calculated. For each aspect of the Symmetry Condition, the two-tailed independent sample t-test (df (degrees of freedom) = 8) compared the mean proportions for the sign tokens and the gesture tokens. The results are summarized in Table 1.

The mean number of gesture and sign tokens that contributed to the calculation of the proportions varied across the rows in Table 1 because not all signs and gestures were relevant for any given aspect of the Symmetry Condition (e.g. some gestures did not involve any handshape change).

The proportions of violating tokens ranged from 0 to .38 for signs and from 0 to .53 for gestures. The absolute degrees of violation are not very informative as these values change according to the level of details in the coding and the amount of 'noise' introduced by articulation. What is important is that there is

Table 1. The mean proportions of gesture and sign tokens that violated different aspects of the Symmetry Condition.

	sign			gesture			t-test	
	M	SE	n	M	SE	n	t	p
path movement shape	0	0	43.0	0	0	10.0	–	–
path movement direction	.093	.025	43.0	.072	.034	10.0	0.443	.67
initial palm orientation	.29	.034	50.3	.29	.080	14.5	0.032	.98
final palm orientation	.31	.053	50.3	.34	.072	14.5	−0.278	.79
initial finger orientation	.26	.019	50.3	.25	.049	14.5	0.119	.91
final finger orientation	.27	.024	50.3	.35	.072	14.5	−0.903	.39
initial handshape	.21	.0087	50.3	.27	.051	14.5	−1.020	.34
final handshape	.23	.0071	50.3	.18	.072	14.5	0.53	.61
orientation change	.33	.051	33.0	.36	.103	11.5	−0.222	.83
handshape change	.38	.057	19.3	.53	.066	6.8	−1.581	.15

Note: "M" refers to the mean, "SE" to the standard error, and "n" to the mean number of gesture or sign tokens that contributed to the calculation of the proportion. "t" refers to the t-statistic, "p" to the p-value based on independent sample t-test.

Table 2. The mean proportions of gesture and sign tokens in which the handshape was sloppy and in which the hand made a contact with the body.

	sign			gesture			t-test	
	M	*SE*	*n*	*M*	*SE*	*n*	*t*	*p*
sloppy handshape	.20	.077	50.3	.49	.062	14.5	−2.704	.027
contact with body	.11	.062	50.3	0	0	14.5	–	–

Note: "M" refers to the mean, "SE" to the standard error, and "n" to the mean number of gesture or sign tokens that contributed to the calculation of the proportion. "t" refers to the *t*-statistic, "p" to the *p*-value based on independent sample *t*-test.

no statistically significant difference in the degree of violation between sign and gesture in all aspects of the Symmetry Condition.

Our data, however, pointed to some differences between signs and gestures that can be motivated by signed language phonology. The mean proportions of sign and gesture tokens in which the handshape was sloppy were calculated. In addition, the mean proportions of sign and gesture tokens in which the hand made a contact with the body were calculated. The means for signs and gestures were compared by the two-tailed independent sample *t*-test ($df = 8$). The results are summarized in Table 2.

The gestures were significantly more likely to have a sloppy handshape than the signs. In addition, while the gestures never made contact with the body, 11 percent of sign tokens made a contact with the body.

6.2 Discussion

We examined the forms of NGT signs and gestures accompanying spontaneous speech and investigated whether signs followed Battison's (1978) Symmetry Condition better than gestures. We found no evidence that signs and gestures differ in the degree of violation of the Symmetry Condition. Thus, we conclude that the Symmetry Condition is not necessarily a part of the phonology of NGT. We suggest that the Symmetry Condition is a general constraint that encompasses both linguistic and non-linguistic ways of using body movement for representational purposes.

In support of our conclusion, we mention here that if the Symmetry Condition were a phonological constraint, we would expect some languages to violate it. But there is no report of such signed languages. Our conclusion immediately explains why no sign language to date has been found to violate the Symmetry Condition.

The lack of statistically significant differences between signs and gestures may simply mean that our sample was not large enough or representative enough to capture any linguistically relevant differences. However, we have discussed two

indications that our samples were in fact large and representative enough to capture differences that were motivated by sign phonology. First, we found that handshapes were more likely to be sloppy in gestures than in signs. We argued in Section 4 that the difference between signs and gestures in handshape sloppiness is due to the phonological status of contrast among different handshapes in NGT. In a given signed language, a finite set of handshapes is distinctive. In order to facilitate the identification of distinctive handshapes, it is conceivable that signs are produced with a categorical target handshape. In contrast, in spontaneous gestures accompanying speech, there are no categorical targets for handshape. The target handshape can vary in an analogue fashion, using a more gradient range of form parameters; thus, when described with categories (by GesturePhone in our study), many gesture tokens showed an in-between handshape. This difference in the status of handshapes in signs and gestures leads to the difference in handshape sloppiness. We suggest that discrete and categorical nature of the production of handshapes, which we found in this study, may be related to categorical perception of distinctive handshapes.

The second indication that our sample was large and representative enough comes from the analysis of body contact. We found that signs were more likely to make a contact with the body than gestures. Whereas contact with body locations is a distinctive property in signed languages, this is not so in the gesture system. Since in the phonology of NGT (and other signed languages), different locations on the body are distinctive, it is important to maintain clear differences between the locations. In contrast, in spontaneous gestures accompanying speech, the hands do not touch the body unless there is an iconic motivation to do so. This difference in the status of locations on the body in signs and gestures leads to the difference in likelihood of contact with the body.

Given that our samples attest to these two differences between signed languages and gesture, we feel confident that our corpus was large enough to also reveal genuine resemblances.

7.   Concluding remarks: The one-handed mind

If the Symmetry Condition is not a phonological constraint, then what kind of constraint is it? Where should this constraint be located if it is not in the language faculty? Given the fact that the motor control system prefers symmetrical hand movement (e.g., it is easier for the two hands to each draw a circle in the air than to draw two different shapes), one might hypothesize that the Symmetry Condition is a general property of the motor control process. If that is so, it should be the case that all two-handed movements *must* have a symmetrical target. However,

this is clearly not the case. When two hands represent two separate classifiers in NGT, the use of the two hands is typically asymmetrical. For example, imagine a NGT sentence referring to movements of a vehicle and a person with respect to each other, in which the left hand represents a vehicle moving (a flat hand with the palm facing down) and the right hand represents a person moving (a handshape in which the extended index finger is pointing up). In this sentence, the handshape and the orientation of the palm and the fingers are linguistically specified to be asymmetrical between the two hands. If the movements of the vehicle and the person have different trajectory shapes and directions, then the path movement direction and shapes are linguistically specified as asymmetric. Note, however, that Engberg-Pedersen (1993: 227–229) discusses a Danish Sign Language example that suggests that signers prefer not to simultaneously represent different trajectory shapes in the two hands. Though the motor control system has a preference for symmetry of hand movement, and signing might reflect this preference to some extent, as in Engberg-Pedersen's example, this tendency cannot fully account for the Symmetry Condition. Since signers can produce the vehicle-person example above, and since the Symmetry Condition is conditioned by kinds of representation (e.g., one-referent signs vs. bi-classifier constructions), it is likely to be a constraint in a higher cognitive system.

The Symmetry Condition implies that there is a 'force of symmetry' embedded deeper in our cognitive system. We tentatively propose that when expressing one concept as a target (i.e. one referent signs and gestures), the mind does not regard the two hands as two different entities. In other words, the mind has only one active 'mental hand' for one concept. In Section 2, we briefly mentioned that the choice of the right or the left hand in one-handed signs in signed languages is not distinctive. If it is true that the mind has only one active 'mental hand', this non-distinctiveness of the hands in one-handed signs follows immediately. The Symmetry Condition is another manifestation of the mind having only one active 'mental articulator' for expressing one concept. Thus, when two hands are used to express a single concept, the movement, the orientation, and the shape of the two hands are necessarily the same or the symmetrical opposite, in other words, symmetrical. However this 'force of symmetry' is not applicable when two concepts are expressed by two hands, as in bi-classifier constructions.

In short, our conclusion is that the Symmetry Condition is not a phonological generalization of signed languages; thus, it is not part of our language faculty. Nor is it accounted for by a general tendency in motor control. Rather, it is a constraint on our cognitive system for using our hands for representational purposes.

Acknowledgments

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Appendix

Coding categories from GesturePhone (van Gijn 1997) used in this study (based on SignPhon (Blees et al. 1996)). Codes are in italics. The codes that constitute a symmetric pair are indicated by "<" and ">" (e.g. <*up*, *down*>).

1.   Path Movement Shape

The shape of the trajectory of how the wrist changed its location is coded (the hand internal movements such as flexion or extension at the wrist has to be ignored).
straight, circle, round, iconic, 7-form, ?-form, x-form, +-form, z-form
Note: The code "iconic" is given to a movement that has a complex movement trajectory to which other codes cannot be assigned.

2.   Path Movement Direction

A movement direction can involve more than one axis at the same time (e.g. up + front).

   <*up*, *down*>, < *front*, *back*>, <*ipsilateral*, *contralateral*>

Note: The ipsilateral side is that side of the body the hand is connected to, the contralateral side is the opposite side of the body the hand is connected to.

3.   Hand Orientation Change

An orientation change can involve more than one of the following types (e.g. pronation + flexion).

<supination, pronation>
Supination and pronation are forearm rotations from the elbow. Supination rotates the horizontally extended forearm so that the palm that is facing the floor turns away from the floor when the forearm is horizontal. Pronation rotates the forearm so that the palm that is facing away from the floor turns to the floor when the forearm is horizontal.

rotation
If the movement consists of a (repeated) supination and pronation, it is coded as rotation (the order of supination and pronation is not relevant).

<flexion, extension>
Flexion and extension are movements of the wrist joint. Flexion moves the hand to the direction of the palm, and extension moves the hand to the direction of the back of the hand.

nodding
If the movement consists of a (repeated) flexion and extension, it is coded as nodding (the order of flexion and extension is not relevant).

<ulnar flexion, radial flexion>
Ulnar and radial flexion are movements of the wrist joint. Radial flexion moves the hand to the direction of the thumb, and ulnar flexion moves the hand to the direction of the little finger.

lateral flexion
If the movement consists of a (repeated) ulnar flexion and radial flexion, it is coded as lateral flexion (the order of ulnar and radial flexion is not relevant).

4.   Handshape Change

A handshape change can involve more than one of the following types (e.g. opening + abduction).

<opening, closing>
Opening is the movement towards a flat hand with all the finger joints and knuckles extended. Closing is the movement towards a fist.

<abduction, adduction>[7]
Abduction is spreading of the fingers. The space between the fingers becomes bigger. Adduction is the opposite movement towards the position where all neighbouring fingers are touching each other.

<hinging, the opposite of hinging>
Hinging bends the fingers from the knuckles. The opposite of hinging extends the fingers from the knuckles.

<clawing, the opposite of clawing>
Clawing bends the fingers at the top two finger joints. The opposite of clawing extends the fingers at the top two finger joints.

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7. The features 'adduction' (the opposite of spreading), 'the opposite of hinging', and 'the opposite of clawing' are created by us for coding conveniences. They form symmetric pairs with 'spreading', 'hinging', and 'clawing', respectively.

<opening wave, closing wave>
Opening wave is a wave-like opening of the hand, where the fingers open one by one. Closing wave is a wave-like closing of the hand, where the fingers close one by one.

wiggling
Wiggling of the fingers.

rubbing
Rubbing of the finger tips.

cutting
Imitation of the movement of scissors with extended index and middle fingers.

5.   Orientation

The orientation of the palm and the fingers (i.e. the vector from the wrist to the knuckles) are coded at the beginning and the end of a sign or gesture. Orientation can involve more than one axes at the same time (e.g. up + front).

<up, down>, *<front, back>*, *<ipsilateral, contralateral>*

6.   Handshape

The handshape is coded at the beginning and the end of a sign or gesture. The codes in the HamNoSys handshape chart (Prillwitz et al. 1989) are used with the addition of letters and numbers of Blees et al. (1996).

      Some of the handshapes in the HamNoSys chart are defined as equivalent since the chart provides more detailed distinctions than is desirable. We grouped different handshapes according to which fingers are selected and the position of these selected fingers with respect to 'abduction', 'hinging' (i.e. the fingers flex in the base joints or knuckles), and 'clawing' (i.e. the fingers flex in the upper two joints). The thumb was ignored because some of the variations in thumb position are allophonic in NGT. If the codes of the two hands come from an equivalent handshape group, this was not considered to be a violation of the Symmetry Condition.