A preliminary study on the production of signs in Brazilian Sign Language when one of the manual articulators is unavailable

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Abstract
This paper aims at discussing the realization of some Brazilian Sign Language signs, articulated with both hands, when one of them is unavailable. As will be discussed, this unavailability is caused by extra-linguistic factors, as well as by a linguistic one. The data considered here were collected through the observation of spontaneous signing and discussed with three subjects. Their analysis revealed that the production of two-handed signs when one of the hands is not available does not simply consist of realizing them with only one hand, but alternatively employing other strategies, such as using a one-handed sign equivalent in meaning.

Index terms: sign language, manual articulators, dynamical system

1. Introduction
One of the striking differences between sign languages and spoken languages concerns the fact that the former are mainly articulated by the hands and perceived by the eyes, while the latter are articulated by the vocal tract and mainly perceived by the ears.

Even though sign languages can use both hands to produce their lexical items, the articulation of signs differs in terms of the number of hands required. There are signs which are one-handed and others which are two-handed. The same holds true for the lexical items in Brazilian sign language (henceforth Libras), as reported by [1].

The author also pointed out that there is no major difference between one-handed and two-handed signs in Libras, in terms of absolute frequency estimated from the Libras dictionary [2]. Out of the 2,269 simplex signs in the dictionary, 44% are one-handed, whereas 56% are two-handed.

In spite of the fact that signs can be articulatorily described as being one or two-handed, the observation of spontaneous signing has revealed that some signs vary in terms of the number of hands with which they are produced. More precisely, sometimes some one-handed signs are articulated with two hands, while some two-handed signs are realized with only one hand.

Recently, [3] showed that the variation regarding the number of hands in some Libras signs can be governed by factors of different nature. According to the author, these factors can be related to (i) the expression of emphasis, (ii) the occurrence of lexical and grammatical processes, and (iii) the influence of the phonological context within which the sign is realized (what can be treated as co-articulation).

It is noteworthy that the first two factors seem to affect solely one-handed signs, whereas the third one seems to affect both one and two-handed signs. This seems to be the case because, as reported by [3], the expression of emphasis, as well as the occurrence of some lexical and grammatical processes, consists of articulating, with two hands, some signs usually produced with only one hand. Unlike them, the influence of the phonological context, in turn, can result not only in one-handed signs being articulated with two hands, but also in two-handed signs being produced with only one hand.

Besides that, a perturbational factor governs the articulation, with one hand, of two-handed signs. That refers to the unavailability of one of the hands during signing. One of the hands may be unavailable because it may be performing another activity, such as carrying or holding something.

As it will be discussed in section 3.1, the striking thing about it is that, in some cases and for some signs, the unavailability of one of the hands does not result simply in the articulation, with one hand, of a two-handed sign, but in the use of another sign similar in meaning and usually produced with only one hand, instead.

In addition, observations of signing have also shown that the unavailability of one of the hands can be motivated not only by its performing an extra-linguistic activity, but also by linguistic context.

Sometimes, as it will be discussed in section 3.2, during signing, the non-dominant hand is not available, because it is articulating what has been called a buoy by [4]. Buoys consist of signs produced by the non-dominant hand held stationary in the signing space. They are used in sign languages for different reasons. One of them relates to listing and referring back to referents. This type of buoy, called list buoy, has been, sometimes, observed co-occurring with two-handed signs and, as a result, causing them to be produced with only one hand. Nevertheless, there seems to be different factors governing the maintenance or the non-maintenance of the buoy during the production of two-handed signs.

This paper aims at discussing the data related to two-handed signs produced when one of the hands is unavailable, which have been collected through the observation of spontaneous signing. This collection and the patterns identified up to now seem to be an important step toward the designing of experiments which will allow for a better understanding of the factors behind the occurrence of such patterns, and the extent to which they occur in the language, as well.

2. Data collection
The data discussed here comes from three main sources: (i) observation of spontaneous signing; (ii) observation of videos available on the internet in which Libras is used; and (iii) discussions with the subjects of this study.

The data analyzed comprises 30 signs and the subjects consulted are three females, two deaf and one bilingual hearing, aged between 32 and 43 years old.

It is noteworthy saying about the data collected from spontaneous signing observations that special attention was given to some situations in which one of the hands could be unavailable to sign. Thus, most of those observations come from car driving situations in which signers usually hold the steering wheel with one hand and sign only with the other.
3. Data analysis

3.1 The articulation of two-handed signs when one of the hands is unavailable

The articulation of two-handed signs in situations when one of the hands (usually the non-dominant) is performing another activity could simply be thought of as consisting of producing such signs with one hand.

However the analysis of the data collected up to now has revealed that this is not the only possibility. For some two-handed signs, in addition to its articulation with only one hand, it is possible that a one-handed sign equivalent in meaning be used, instead. On the other hand, for some others, in spite of the possibility of using a one-handed sign equivalent in meaning, it is not possible to articulate them with only one hand. As it will be shown in the next two subsections, other patterns are still possible, which indicates that the production of two-handed signs when one of the hands is not available is even more complex.

This complexity seems to be a result of at least three different factors: (i) lexical, (ii) individual and (iii) articulatory.

The lexical factor relates to the fact that some two-handed signs have a one-handed sign equivalent in meaning. As a consequence, when one of the hands is busy, the signer can use the latter instead of a version of the former produced with only one hand.

The individual factor, in turn, concerns basically the different lexical repertoire that each signer seems to use. More precisely, not all signers seem to use both a two-handed and a one-handed sign for the same concept. As a result, not all signers will be able to use a one-handed sign to express the same or similar meaning conveyed by a two-handed sign, when one of the hands is unavailable. In that case, the signer will have to employ other strategies.

Finally, the articulatory factor refers to the role that certain articulatory features can play in determining which two-handed signs can be produced with only one hand and which cannot. Despite that, however, it is noteworthy saying that signers vary in their acceptability judgment for the articulation, with only one hand, of some two-handed signs.

The class of two-handed signs includes two major types of signs, which differ from each other regarding the role of the non-dominant hand during their articulation. More precisely, this class contains signs in which the non-dominant hand performs the same activity as the dominant hand and some others in which the former functions as a point of articulation for the latter.

As this difference seems to account, to some extent, for the occurrence of some distinct patterns, the data collected up to now were divided into two groups.

3.1.1 Two-handed signs with both hands moving

In this category, we grouped together the Libras signs which are produced with two moving hands. After the discussion with our subjects, we identified two different patterns regarding the strategies signers can use to articulate them or to express their meaning when one of their hands is not available.

The first one can be illustrated by the sign NOTHING (Figure 1a). This sign, usually realized with two hands, can be produced with only one hand, if the other is performing another activity.

Figure 1: Sign NOTHING articulated with two hands (a) and with only one hand (b).

However, as there is a one-handed sign also meaning ‘nothing’ (Figure 2), it is possible that a signer, because of the unavailability of one of the hands, prefers using it instead of producing the sign NOTHING, as in Figure 1b above.

Figure 2: Alternative one-handed sign meaning ‘nothing’.

The same pattern can be observed in other Libras signs such as ASL, BIOLOGY and CAR. A different pattern, however, is displayed by the sign SIBLING, illustrated in Figure 3 below.

Figure 3: Two-handed sign SIBLING in (a) and alternative one-handed signs meaning ‘sibling’ in (b) and (c)

It seems that this sign, unlike NOTHING, cannot be articulated with only one hand. According to our subjects’ intuition, the one-hand version of SIBLING is rather odd. Still according to them, they would prefer, instead, using one of the one-handed signs, Figure 3b and 3c, which also mean ‘sibling’.

To sum up, there seems to be at least two different patterns for two-handed signs articulated with both hands moving. As Table 1 summarizes, some signs can be articulated with only one hand or substituted for a one-handed sign equivalent in meaning, whereas others do not have the first option, but only the second one.

Table 1. Summary of the behavior of two-hand moving signs

<table>
<thead>
<tr>
<th>Two-hand moving signs</th>
<th>Articulated only with one hand</th>
<th>Substituted for a one-handed sign equivalent in meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASL, BIOLOGY, CAR, NOTHING</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SIBLING</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

3.1.2 Two-handed signs with one of the hands functioning as a point of articulation

In this category, we grouped together two-handed signs that, unlike the ones in the previous class, are not produced with both hands moving. Instead, they are produced with one of the hands stationary, since it functions as the sign’s point of articulation.
Through the discussions with our informants about the signs of this category, we have identified five different patterns regarding the different strategies signers can employ to express the meaning of such signs when one of their hands is unavailable.

The first pattern identified occurs with the sign WHY (Figure 4a).

![Figure 4: Sign WHY articulated with both hands (a) and with only one hand (b). In (c), a one-handed sign also meaning 'why'.](image)

This sign, as the images in Figure 4b and 4c suggest, can be articulated with only one hand or substituted by a one-handed sign also meaning 'why', respectively. In addition, the sign WHY can also be realized only through its facial expression, as the image in Figure 5a shows.

![Figure 5: Sign WHY articulated only through non-manual activities (a) and a non-manual sign also meaning 'why' (b).](image)

According to one of our subjects, an alternative for 5a would be another sign also meaning 'why' and whose production also involves only non-manual activities. This sign, represented by the images in Figure 5b, consists of raising the head and mouthing something like [p] approximately three times.

Observations carried out up to now suggest that both signs seem to be used especially when both hands are unavailable or when, for some other reason such as tiredness, the signer does not want to sign using his or her hands. Nevertheless, expressing the meaning of 'why' only through non-manual activities when one of the hands is busy doing something else seems to be a possibility, at least for one of our subjects.

The second pattern is observed with the sign NERVOUS. As the illustration in Figure 6a shows, this sign, similarly to WHY, can be produced only with one hand. However, unlike that sign, it does not have a one-handed sign with similar meaning. Instead, it has a two-handed sign (Figure 6c), which can be used in its one-hand version.

![Figure 6: Sign NERVOUS articulated with both hands in (a) and with only one in (b). In (c), another sign for 'nervous' which can be used in its one-handed version, instead.](image)

The third pattern occurs in signs like NIGHT (Figure 7a). This sign, unlike WHY and NERVOUS, looks very odd when produced with only one hand, as in Figure 5 (p), according to our three subjects. For them, if one of the hands is not available, they would probably use a two-handed sign, also meaning 'night' (Figure 7c), but in its one-hand version.

![Figure 7: Sign NIGHT articulated with both hands in (a) and with only one in (b). In (c), another sign also meaning 'night' which can be used in its one-handed version, instead. The asterisk in (b) stands for our subjects' unacceptability judgment for such articulation of the sign NIGHT.](image)

The fourth pattern identified is related to signs such as MAKE-ARRANGEMENTS (Figure 8a). This sign differs from the previous ones in that it seems to have no one-handed or two-handed sign equivalent in meaning, at least, according to our informants.

Another interesting fact about such signs concerns the way their articulation can vary. In situations where the non-dominant hand is not available, signers can produce the sign MAKE-ARRANGEMENTS in the air, as in Figure 8b. Signers can also use other parts of their body as a point of articulation. One of such articulations is illustrated in Figure 8c, where the sign is articulated on the forehead. Another possibility it to produced it on the ipsilateral thigh.

![Figure 8: Sing MAKE-ARRANGEMENTS articulated with both hands in (a), with one hand in (b) and (c).](image)

It is noteworthy that similar processes seem to happen with other signs. It is very common, for example, to see the sign TRUTH (Figure 9) being produced on the table or on another surface when the non-dominant hand is not available or simply when those surfaces are more immediately accessible.

![Figure 9: Sign TRUTH](image)

Finally, the fifth pattern observed consists of signs such as MATH (Figure 10a). As the images in Figure 10 show, this sign can be articulated with only one hand or be replaced by another one-handed sign equivalent in meaning.
It seems that this pattern occurs especially with two moving hand signs. As for two-handed signs in which one of the hands functions as a point of articulation, a different pattern seems to occur, at least for some of these signs.

As the images in Figure 12a show, the sign GRAPE has, as one of its point of contact, the non-dominant hand. When co-occurring with a list buoy, it is possible to use one of the fingers associated with that referent as a point of contact, as Figure 12b illustrates.

3.2 Two-handed signs and buoys

Sometimes, one of the manual articulators is unavailable to sign because it is performing an extra-linguistic activity such as carrying or holding something. However, it is also possible that one of the hands is not available to sign because it is already being used to sign. In other words, as sign languages allow for the possibility of signing two signs at once (one in each hand), sometimes both hands cannot be used to sign a two-handed sign because one of them is producing a different sign.

The signs that we have observed to be articulated simultaneously with others are basically those called buoys by [4]. Signs of this type, usually produced with the non-dominant hand held stationary in the signing space, play different roles in sign languages. One of them is to list and refer back to referents, situations in which they are called list buoys.

Our observations have revealed two different patterns regarding the maintenance of buoys during the production of two-handed signs.

One of them consists of articulating two-handed signs, such as CAR (Figure 11a) with only one hand, as the other is producing a buoy (Figure 10b).

Table 2. Summary of the behavior of two-handed signs with one of the hands functioning as a point of articulation

<table>
<thead>
<tr>
<th>Two-handed signs with one of the hands functioning as a point of articulation</th>
<th>Articulated only with one hand</th>
<th>Replaced by a two-moving hand sign equivalent in meaning</th>
<th>Replaced by a one-handed sign equivalent in meaning</th>
<th>Articulated only through facial expression</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHY</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>NERVOUS, PREGNANT</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>TALK, NIGHT</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>MAKE-ARRANGEMENTS</td>
<td>Yes</td>
<td>?</td>
<td>?</td>
<td>No</td>
</tr>
<tr>
<td>MATH, NEAR, SECRET</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Figure 10: Two signs for MATH, being the one in (a) two-handed and the one in (c) one-handed. In (b), it is shown a one-hand version of (a).

Unlike signs such as NERVOUS and NIGHT, MATH has no two moving hand sign equivalent in meaning which could be used in its one-hand version, instead. Table 2 summarizes the patterns that have been identified up to now.

Figure 11: Sign CAR in isolation in (a) and co-occurring with a list buoy (b).

4. Conclusions

Through observations of spontaneous signing as well as discussions with our subjects, a pattern seems to emerge: the realization of two-handed signs when one of the hands is unavailable is not as simple as realizing such signs with only one hand. There are different possibilities for producing this type of signs and all of them seem to depend on factors of different nature, such as lexical, individual and articulatory. The unavailability of one of the manual articulators can be a consequence not only of extra-linguistic factors, but also of linguistic ones.

Further research must check if there are other patterns besides the ones identified up to now and which other signs can co-occur with them. In addition, it will be necessary to check if the type of perturbation (extra-linguistic or linguistic) has any influence on the strategy employed to produce two-handed signs when one of the hands is not available.

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6. References