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# Lexical comprehension within and across sign languages of Belgium, China and the Netherlands

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There are hundreds of known sign languages around the world today, distinct languages each with its own historical and cultural context. Nevertheless, it is well known among signers who move through international spaces and across signing communities that a certain degree of mutual intelligibility is achievable during so-called *cross-signing*, even between historically unrelated sign languages. This has been explained by shared experiences, translanguaging competence and a higher degree of iconicity in the lexicons of sign languages. In this paper, I investigate one aspect of mutual intelligibility between four different sign languages: Sign Language of the Netherlands (NGT), Flemish Sign Language (VGT), French-Belgian Sign Language (LSFB) and Chinese Sign Language (CSL). Through a comprehension task with NGT signs, I analyze how accurately signers of the four sign languages identify NGT signs in an experimental sign-to-picture matching task, matching one target sign to one of four meaning choices: one target meaning and three distractors based on either form-similarity or plausible iconicity-mapping to the target sign. The results show that signers of VGT and LSFB perform better than CSL signers on this task, which may be attributed to lexical overlap, shared iconic mappings and experiences, as well as language contact due to geographic proximity. It is found that misidentification of target meanings is mostly caused by distractors with iconically plausible mappings between form and meaning. Across the four languages, signers' self-evaluations of their performance on the lexical comprehension task correlate with test scores, demonstrating that they generally judge their level of comprehension accurately.

# 1 Introduction

In the world today, there are over 200 known sign languages (Hammarström et al. 2022). Sign languages are distinct languages each with its own social and cultural contexts and history (Hou & Kusters 2019), although some sign languages can be traced back to (partly) shared origins that may still be observable through lexical similarities today. However, despite the fact that sign languages are distinct languages with their own signs and structural properties, it is well known among signers who move through international spaces and across signing communities that a certain degree of mutual intelligibility is achievable during so-called *cross-signing* – that is, signed interactions across different languages through accommodation and linguistic flexibility – even in cases where the languages involved are historically unrelated (Battison & Jordan 1976; Zeshan 2015; Moriarty & Kusters 2021). While this may seem counter-intuitive based on definitions traditionally applied to spoken languages – such as using mutual *un*intelligibility as a criterion for labeling languages as "distinct" – this has been explained by, among other things, shared experiences and translanguaging competence (Hiddinga & Crasborn 2011; Kusters et al. 2017; Byun 2019; De Meulder et al. 2019; Kusters 2021b) and a higher degree of iconicity in the lexicons of sign languages. That is, meanings of signs can sometimes be guessed correctly based on the form of a sign and its iconic mapping, even if the form and motivation behind the iconic mapping are different from those found in one's own language (Parkhurst & Parkhurst 2003; Occhino et al. 2017; Ortega 2017).

In this paper, I present the results from an experimental lexical comprehension task involving four different sign languages: Sign Language of the Netherlands (NGT, *Nederlandse gebarentaal*), Flemish Sign Language (VGT, *Vlaamse gebarentaal*), French-Belgian Sign Language (LSFB, *Langue des signes de Belgique francophone*) and Chinese Sign Language (CSL). The comprehension task is unidirectional in that it only involves a single target language (NGT) and measures how many signs NGT, VGT, LSFB and CSL signers can understand in isolation, without conversational context and without *mouthings*, the simultaneous silent articulation of a spoken word that may accompany the manual articulation of a sign (see Boyes Braem & Sutton-Spence 2001; Bisnath In press). This means that the focus is on the manual form of the sign, avoiding any spoken/written overlap particularly benefiting VGT signers via shared Dutch. As such, the experiment in itself is different from the communicative setting found in real-world interactions among signers, but is intended to serve as a comparative baseline for further research that goes deeper into cross-signing practices between these languages. That is, without contextualization and semiotic resources available in face-to-face interactions, to what extent are individual NGT signs understood by VGT, LSFB and CSL signers, and – for comparison – NGT signers? Additionally, the experimental design is set up in such a way that each target sign is to be matched with one of four meanings, each displayed as a pictogram to avoid written language interference: a correct target meaning; one distractor meaning based on *form*-similarity between the target sign and a

CSL sign based on phonological overlap in a lexical database; and two distractor meanings based on plausible *iconic* mappings between the target sign form and distractor meanings. Thus, an additional goal of this study is to see if either of these types of distractors poses a greater obstacle in identifying signs: the form-based distractors specifically targeting the CSL group; the iconicity-based distractors targeting all participants – see Section 3 for details about participants and the experimental design.

The paper is structured as follows: Section 2 provides a background of mutual intelligibility research (2.1), sign language lexical similarity (2.2) and contact signing (2.3), all motivating the research questions (2.4). Section 3 introduces the methodology in terms of the languages (3.1), participants (3.2) and experimental design (3.3). Section 4 provides the results in terms of comprehensison (4.1), response patterns (4.2) and correlations between performance self-evaluations and scores (4.3). The results are discussed in Section 5 and the paper concludes with Section 6.

# 2 Background

## 2.1 Mutual intelligibility

The question of defining (and distinguishing) languages is something linguists know to be complicated. Clearly, language-ness is not defined by linguistic features or historical relationships alone, but is deeply rooted in political and cultural ideas and power. To avoid certain elusive criteria, one operationalization of language-ness is *mutual intelligibility* – that is, if two people can understand each other's language, they are using (varieties of) the *same* language; if they cannot understand each other, their languages can be assumed to be *different* (see Gooskens & van Heuven 2021). One complicating factor is the concept of a *dialect continuum* (Gooskens 2020), where a series of dialects – let us call them A, B and C – can relate to one another in such a way that A is mutually intelligible with B, and B with C, but A and C are not mutually intelligible. However, there are also many regions with languages that for historical, cultural and political reasons are categorized as distinct, but nonetheless exhibit some degree of mutual intelligibility, e.g. Danish, Norwegian and Swedish in Scandinavia (Schüppert et al. 2015a). Mutual intelligibility has been studied systematically in a number of languages and linguistic areas to date, such as languages of the Nordic countries (Börestam 2015; Schüppert et al. 2015b), the wider Germanic language area (Gooskens et al. 2015; Möller & Zeevaert 2015; Gooskens & Swarte 2017; Gooskens 2020), Slavic languages (Golubović & Gooskens 2015; Jágrová et al. 2019), large-scale studies across multiple European language families (Heeringa et al. 2013), Kurdish varieties (Özek et al. 2021), Ethiosemitic languages (Feleke et al. 2020) and languages of China (Tang & van Heuven 2015) and Vanuatu (Gooskens & Schneider 2016). Besides linguistic (dis)similarities, there are additional factors influencing mutual intelligibility, such as language attitudes – that is, sentiments about different languages – and, perhaps more importantly,

previous exposure to the language (Schüppert et al. 2015b; Gooskens & van Heuven 2021). It is also common to see *asymmetries* in the intelligibility, such that one language group understands the other better than the reverse, which can often be related to language attitudes and differences in prior exposure through education, media and travel (Nábělková 2007; Börestam 2015; Gooskens & Swarte 2017). There are various ways of testing mutual intelligibility, ranging from lexical comprehension tasks (listening or reading) and cloze tests to face-to-face communication (Gooskens 2013; Möller & Zeevaert 2015; Gooskens & van Heuven 2021). The scores from such tests can be compared to linguistic measures that attempt to quantify linguistic distances in terms of lexical or grammatical (dis)similarity, in order to see whether the two are correlated (Tang & van Heuven 2015; Gooskens & Swarte 2017).

Turning to signed languages, there has been little research published on mutual intelligibility. There are over 200 known sign languages (Hammarström et al. 2022), but the issue of classifying these into genealogical "families" is often more challenging than for spoken languages, and classifications tend to be based on overlapping historical origins (if these are known) or linguistic similarities (see e.g. McBurney 2012; Power 2022) – Section 2.2 will delve deeper into lexical comparisons. However, it is well known by those who sign and spend time around deaf communities that some degree of intelligibility can be achieved even across unrelated sign languages. The findings from an early study on mutual intelligibility in a communication task between signers of American Sign Language on the one hand and signers of Danish Sign Language, French Sign Language, Hong Kong Sign Language, Italian Sign Language and Portuguese Sign Language on the other, illustrated that communication across different sign languages can be challenging (Jordan & Battison 1976). The authors noted a correlation between actual and reported comprehension, such that signers were able to correctly judge the accuracy of understanding, but also that signers reported a sense of "being on the verge of understanding" when watching a foreign sign language (Jordan & Battison 1976: 78), suggesting that a foreign sign language may feel as though it should be more comprehensible than it is. Rather than relying on transparency of, or familiarity with, other sign languages, some cross-linguistic interactions make use of the contact *lingua franca* known as International Sign, which has emerged out of international deaf interactions and is sometimes used as an official conference language, although not natively by anyone (Supalla & Webb 1995; Mesch 2010; Hiddinga & Crasborn 2011; Kusters 2021a).[1] A few studies have looked at comprehension among deaf people watching signing in International Sign and found that comprehension is lower than when viewing their own sign language (Rosenstock 2016; Whynot 2016).

[1] Other sign languages may also be used as a lingua franca in various contexts, notably American Sign Language (ASL) which has obtained a strong position internationally through e.g. education, media and travel (see Parks 2014; Kusters 2020; 2021a; Moriarty & Kusters 2021).

Especially relevant for this study is the research by Sáfár et al. (2015) on mutual intelligibility between Flemish Sign Language (VGT; *Vlaamse gebarentaal*), French Belgian Sign Language (LSFB; *Langue des signes de Belgique francophone*) and Sign Language of the Netherlands (NGT; *Nederlandse gebarentaal*). More specifically, the study was one-directional in the intelligibility testing, looking at how well signers of LSFB and NGT could understand VGT. The authors note that the two sign languages of Belgium – VGT and LSFB – have a high degree of lexical overlap in the manual part of the sign (estimations of up to 70% of the lexicon), but differ in the use of mouthings (by virtue of using Dutch or French as the basis for mouthings) and each exhibits regional variation. Based on historical sources, VGT and LSFB may both be descendants of Old French Sign Language, something they share with NGT, but there is an interesting interaction with mouthing here since NGT shares the Dutch spoken/written language context with VGT, although it is much less similar in terms of (manual) sign similarity (Sáfár et al. 2015: 357–359). In their empirical study, Sáfár et al. (2015) asked signers of LSFB and NGT to watch videos of VGT signing in the form of fables and informative texts – with and without mouthing – and found that whereas LSFB signers understood the texts better than the NGT signers, the difference was less pronounced in the mouthing condition, suggesting that the Dutch-based mouthing in VGT is a greater facilitator for NGT signers than for LSFB signers. They also found that both LSFB and NGT signers perform better on narrative texts (fables) than on informative texts, which suggests that the higher proportion of iconic/depicting constructions – signs that show visual forms and movement through embodiment and iconic configurations between body and hands – found frequently in narrative texts (see e.g. Börstell et al. 2016) may be beneficial when trying to comprehend a foreign sign language. Furthermore, Sáfár et al. (2015) discuss the lexical overlap between VGT, LSFB and NGT, but also language-internal lexical variation, and hypothesize that there might be "a geographical dialect continuum among regional variants within Belgium, but also across three countries, extending from France through Belgium to the Netherlands, comprising four sign languages: LSF [French Sign Language], LSFB, VGT, and NGT." (2015: 372). The findings by Sáfár et al. (2015) can be summarized as:

- VGT and LSFB have a high degree of lexical overlap (in the manual part of signs).
- VGT and NGT have a lower degree of lexical overlap, but share a Dutch basis for mouthings which facilitates intelligibility.
- The overlap in lexical signs across the sign languages of Belgium and the Netherlands (and also France) can point to a continuum of varieties across the countries, and there is lexical variation also *within* each of these languages.

Lexical (and grammatical) variation within the sign languages of Belgium and the Netherlands is well documented (Vanhecke & De Weerdt 2004; Vermeerbergen et al. 2013; Sáfár et al. 2015) and recent work in China suggests the same for Chinese Sign Language (Chen & Gong

2020) – see also Section 3.1. In fact, many sign languages exhibit a large degree of lexical variation *within* the language community (see e.g. Stamp et al. 2014; 2015; Lutzenberger et al. 2021; Horton 2022). Whereas lexical variation *within a signing community* can be extensive, this is something that generally does not hinder communication in interaction, as any miscommunication in face-to-face conversation can be repaired, and shared mouthing can aid understanding. For example, it has been shown for British Sign Language that (regional) signs presented in isolation and without mouthing as part of a lexical recognition task can be difficult to understand across regional varieties of the language, but this appears to be resolved if mouthing is present (Stamp 2016).

## 2.2 Lexical similarity across sign languages

As mentioned in the previous section, historical records on the origins and genealogy of sign languages are few, as are linguistic descriptions in the form of grammars that could be used for comparative research. Because of this, many researchers who have sought to investigate (un)relatedness between sign languages have adopted the lexicostatistical approach and compared signs across languages based on lists of meanings, e.g. Swadesh lists (see Power 2022). However, lexicostatistics is based on identifying shared *cognates* across languages, which is notoriously difficult for sign languages since we often cannot know which signs are similar because of borrowing and contact (see Quinto-Pozos 2008) rather than the languages sharing the same historical roots. Language contact is an issue for spoken language lexicostatistics too, but there is another, arguably more complicating factor here. Due to a high(er) degree of iconicity in the lexicons of signed languages, many identical/similar forms are likely to emerge independently without any cross-linguistic interaction or shared origins (e.g. Occhino et al. 2017; Ortega 2017; Östling et al. 2018; Dingemanse et al. 2020). This can be seen in examples such as signs for ‘bird’, which often contain either a depiction of the beak or the wings – both salient features of birds – and we tend to depict these features with our bodies in similar ways across languages. Thus, lexicostatistics on sign languages have to account for some degree of lexical similarity across languages even in cases where the languages are known to be unrelated (see Ebling et al. 2015), and it is usually impossible to know if this overlap is due to iconicity (independently creating such mappings), contact (borrowing forms or iconic mappings) or a combination of the two. Nonetheless, the lexicostatistical method has been applied to the study of many sign languages across the world, and the method is generally based on counting the number of shared phonological parameters across two signs with the same meaning and establishing whether the forms are similar enough to be counted as “cognates”. For example, this method has been used to compare sign languages in South and East Asia (Woodward 1993; Chen & Gong 2020), the Middle East (Al-Fityani & Padden 2010; Kastner et al. 2014), Europe (Parkhurst & Parkhurst 2003; Bickford 2005; Mesch 2006; Aldersson & McEntee-Atalianis 2008; Ebling et al. 2015;

Sáfár et al. 2015) and also sign languages sampled from different continents (Guerra Currie et al. 2002). Parkhurst & Parkhurst (2003: 12) suggest that with similarity measures alone, two sign languages that share more than 70% of their lexical items could likely be categorized as the same language, but 40% or lower would mean different languages. Even for sign languages known to be unrelated and not in contact, a base overlap of around 20–30% is expected due to shared iconic motivations, with the lowest scores found at just under 20% overlap (Guerra Currie et al. 2002; Al-Fityani & Padden 2010). Whereas some of these lexicostatistical studies have aimed to investigate sign language relationships for which no connections are known in order to establish how they historically relate to each other, others have compared languages that are known to be related, in order to see *how* similar they are, today. Sáfár et al. (2015), discussed in the previous section, observed a lexical overlap of around 78% between VGT and LSFB in their small dataset, but only 36% between VGT and NGT, which relative to the baseline of other studies would group LSFB and VGT together but categorize VGT and NGT as different.[2] Similarly, Johnston (2003) compared Auslan,[3] British Sign Language and New Zealand Sign Language and found a high degree of lexical overlap to the extent that they can be considered dialects of the same language, with the lexical variation *within* British Sign Language sometimes greater than that between British Sign Language and Auslan (cf. Stamp 2016). Crucially, any comparison of sign languages – and communication across them – needs to acknowledge the impact of iconicity (Occhino 2017; Occhino et al. 2017; Omardeen 2018) and cross-cultural similarities in gestures (Nyst et al. 2022) and metaphors (Östling et al. 2018; Börstell & Lepic 2020), as well as sociopolitical context (Palfreyman & Schembri 2022).

## 2.3 Sign languages in contact and interaction

Many deaf signers are in regular contact with other languages, both spoken/written languages as well as other signed languages. Besides being exposed to other national sign languages or e.g. International Sign as a lingua franca (Kusters 2020; 2021a), it is well documented that many signers live in or encounter environments with a multitude of languages, ranging from variation and lects within language communities (Hou & Kusters 2019; Sandler et al. 2020; Van Mensel & De Meulder 2021) to contact with other sign languages through geographic proximity or travel and migration (Quinto-Pozos 2008; Hiddinga & Crasborn 2011; Zeshan & Webster 2019; Friedner & Kusters 2015; Moriarty & Kusters 2021; Duggan & Holmström 2022), which leads to awareness of linguistic variation as well as potential code-switching situations. Much of this research has adopted the idea of *translanguaging* (e.g. García & Wei 2018), acknowledging that a flexible use of language(s) in an interactive setting has the potential to employ a wide range of meaning-making resources in a semiotic repertoire, which includes gesturing, pointing and

[2] Percentages calculated on the basis of the numbers reported in Table 3 in Sáfár et al. (2015: 359).

[3] Auslan is the name of the most widespread sign language of Australia.

reference to the immediate context and shared experience, and the possibility to incorporate multimodal elements of different signed and written languages and symbols (Kusters et al. 2017; Holmström & Schönström 2018; De Meulder et al. 2019; Kusters 2019; 2021b; Safar 2019). The contact signing between two (or more) sign languages has been called *cross-signing*, referring to the accommodating and flexible signing that takes place when signers without a shared sign language meet (Zeshan 2015). Research into this practice has looked at both natural contexts of sign language contact and accommodations and adaptations of lexicon and communicative strategies over time (Bradford et al. 2019; Byun 2019; Kusters 2020), as well as more experimental settings in which signers of different sign languages are brought together and asked to interact or complete communicative tasks to see which strategies they use to make meaning and to repair instances of miscommunication (Jordan & Battison 1976; Zeshan 2015; Byun et al. 2018; 2019; 2022; Webster et al. 2019). Undoubtedly, deaf signers possess many semiotic resources for meaning making, and often have extensive experience communicating across language and modality borders. Turning to the sign languages of Belgium and the Netherlands, we have seen from Sáfár et al. (2015) that there is some lexical overlap between the languages and also some degree of mutual intelligibility, but one question is to what extent individual lexical items can be recognized or comprehended across the languages when context and mouthings are not available to facilitate understanding. Assuming that there is a level of lexical overlap between these languages – possibly due to history, contact or similar cultural and geographic contexts giving rise to similar iconic mappings – would signers of these languages be better at comprehending individual signs than signers of a culturally and geographically more distant sign language (e.g. CSL)? These are questions that will be addressed in this study, and the research questions guiding the study are detailed in the following section (Section 2.4).

## 2.4 Research questions

Based on the previous research described, it is clear that deaf signers are experienced and skilled at communicating successfully in situations that require flexible and adaptive languaging. However, whereas work on spoken languages has compared linguistic measures and experimental methods to investigate mutual intelligibility, few studies have combined these approaches when looking at signed languages. In this study, the goal is to bridge this gap by measuring the level of lexical comprehension of individual signs, taking into account lexical variation within sign languages (by having signers identify sign variants from their own sign language) and differences across sign languages (by having signers identify signs of a foreign sign language). The study is part of a larger project that looks at cross-signing between signers of four different sign languages, and includes both experimentally controlled comprehension tasks and face-to-face interactions. The four languages of this project – NGT, VGT, LSFB and CSL – were chosen on the basis of their different linguistic, cultural and contextual relationship

to each other. With NGT as the language of comparison, how much mutual intelligibility and successful cross-signing can we expect between languages that share some linguistic (e.g. Dutch mouthings with VGT; some lexical overlap with VGT and LSFB) and cultural/contextual (the Belgian sign languages being culturally/geographically close to NGT) properties, compared to languages that do not (e.g. CSL). In this context, the current study is a first step towards establishing a baseline for lexical comprehension between the languages involved in the greater project, which opens doors to investigating the impact of lexical overlap, similarities in iconic mappings and shared culture and experiences with regard to cross-linguistic intelligibility. Thus, the findings from this study can help to evaluate and situate the results of the other more interactional tasks within the project, which involves signers of three "foreign" languages – VGT, LSFB and CSL – meeting and communicating with signers of NGT in person during an organized visit to the Netherlands (see Sections 3.1 and 3.2 for details about the languages and participants sampled).

The current study explores lexical comprehension through an experimental sign-to-picture matching task, in which signers are asked to match lexical signs – presented as videos in isolation, without any linguistic context or accompanying mouthings – to correct meanings (see Section 3.3 for details about the experimental design). The explicit research questions to be addressed are as follows:

i. Do signers of VGT, LSFB and CSL differ in comprehension of lexical NGT signs?
ii. Do signers improve on their lexical comprehension after cross-signing exposure?
iii. Are form-based distractors chosen more often than iconicity-based distractors?
iv. How accurate are signers in evaluating their own lexical comprehension?

Question (i) aims to compare the three non-NGT languages to NGT (as a baseline, since NGT signers are tested on their own language) and to each other, to see whether these languages can be mapped as closer or more distant to NGT based on lexical comprehension. The hypothesis here, based on the socio-historical and geographic contexts of the languages, and the previous work by Sáfár et al. (2015), is that VGT and LSFB signers will understand NGT signs better than CSL signers. Question (ii) looks at whether or not signers improve over time, comparing their comprehension scores on day 1 (before meeting signers from the other sign languages) and day 3 (after which they had interacted with other signers) of the data collection visit. The hypothesis here is that they will improve on the comprehension task since they over the course of the three days will have had more exposure to NGT and other sign languages than they had on the very first day. Question (iii) specifically targets the CSL signers and aims to explore whether there are patterns in the distribution of incorrect sign–meaning matches of the participants with regard to the two distractor types: form-based vs. iconicity-based. The distractor types (described in

detail in Section 3.3) differ in that the form-based distractors can be represented by a CSL sign that shares a form-similarity with the target sign in form only (i.e. with a different meaning), whereas the iconicity-based distractors are meanings that could plausibly be iconically mapped onto the target sign form. Here, the expectation is that the form-based distractors would be more distracting to CSL signers than signers of the other languages, as they have a similar sign form with that meaning in their lexicon. Lastly, question (iv) addresses whether the signers' self-evaluations of their own performance on the lexical comprehension task correlate with their actual scores – that is, whether they accurately assess the degree to which they identify the meanings of the NGT signs.

# 3 Methodology

## 3.1 Languages

This study is situated within a larger project aiming to study cross-signing and international sign interpreting. For the purposes of this project, signers from four sign languages were invited to a data collection visit to Nijmegen, the Netherlands over the course of three days in April–May 2019. The four languages included in the project were selected as follows: first, Sign Language of the Netherlands (NGT, *Nederlandse gebarentaal*) was selected as the central sign language to which the others would be compared, since the research took place in Nijmegen, the Netherlands; second, Flemish Sign Language (VGT, *Vlaamse gebarentaal*) and French Belgian Sign Language (LSFB, *Langue des signes de Belgique francophone*) were selected as two other sign languages that themselves have an interesting relationship in terms of history and mutual intelligibility (see Section 2.1) and are also geographically close to NGT, but only one of which shares a spoken language connection for e.g. mouthings and writing (VGT and NGT in relation to Dutch); lastly, Chinese Sign Language (CSL) was selected as a sign language at a larger geographic and cultural distance to NGT – as well as to VGT and LSFB – and to which there is no known historical connection or language contact with NGT, VGT or LSFB. A main hypothesis of the project is that mutual intelligibility should be higher for languages that are linguistically, geographically and culturally closer, and these four languages would serve as an interesting point of comparison with regard to interactions between language contact, culture, linguistic distances and shared contexts with regard to surroundings and spoken languages, while signers from all languages can be assumed to share some unique experiences as deaf signers. **Figure 1** illustrates some of the main ways in which the four languages relate to each other on different levels, although many other factors undoubtedly also influence the communicative success across languages and individuals.

In terms of historical connections between the languages, it is often assumed that NGT, VGT and LSFB have some shared historical connection to Old French Sign Language, and this is

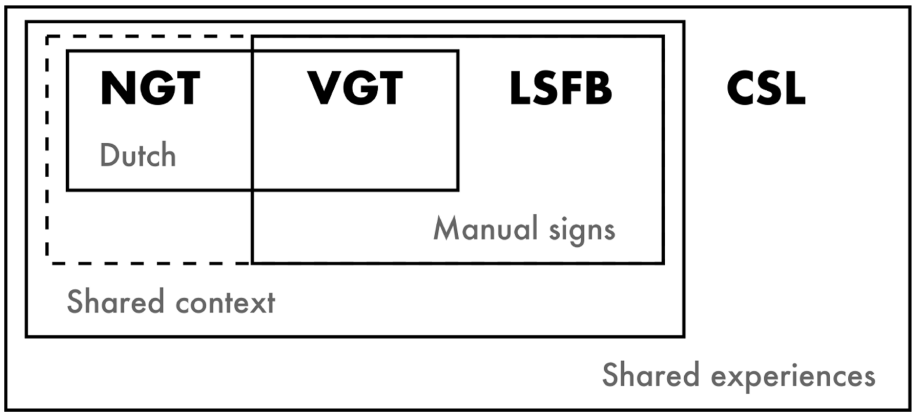



**Figure 1:** The languages of the study in terms of shared features and contexts.

mentioned in work attempting to categorize the languages (e.g. Sáfár et al. 2015; Hammarström et al. 2022). However, the exact nature of these types of historical connections between sign languages is rarely documented, and the connections may have been limited to contact between educational institutions (cf. McBurney 2012; Power 2022). Based on some of the empirical research on the three languages of Belgium and the Netherlands, we know that the lexical overlap between VGT and LSFB is substantial (albeit with different mouthings), whereas NGT shares some but much fewer lexical signs with VGT and LSFB (Sáfár et al. 2015). CSL, on the other hand, has no known historical connection to any of the other three sign languages of the sample, and the lexical overlap between NGT and CSL is small (Börstell et al. 2020), in line with what is expected for unrelated sign languages in terms of a baseline amount of similar iconic mappings (e.g. Parkhurst & Parkhurst 2003; Al-Fityani & Padden 2010; Ebling et al. 2015). CSL in itself has been shown to exhibit regional lexical variation, and it is possible to categorize CSL into a general Northern and Southern variety (Chen & Gong 2020). The categorization of the four languages based on historical records and linguistic comparisons forms the basis of the classification made in Hammarström et al. (2022), illustrated in **Figure 2**. The classification tree in **Figure 2** is part of the much larger non-genealogical tree labeled *Sign Language* in Glottolog 4.7, under which all sign languages are organized, but whereas NGT, LSFB and VGT fall under the same higher branch (under which LSFB and VGT are closer together), CSL is on a completely different branch.[4] It should be noted that while I simply refer to the language as CSL in this paper, the participants represent the variety from Shanghai, which would correspond to the southern variety (cf. Chen & Gong 2020; Hammarström et al. 2022).

[4] In lieu of established "family" groupings that are often lacking for sign languages, Glottolog uses labels ending with *–ic* as a placeholder for groups of languages assumed to be more closely associated (see also https://glottolog.org/glottolog/glottologinformation).

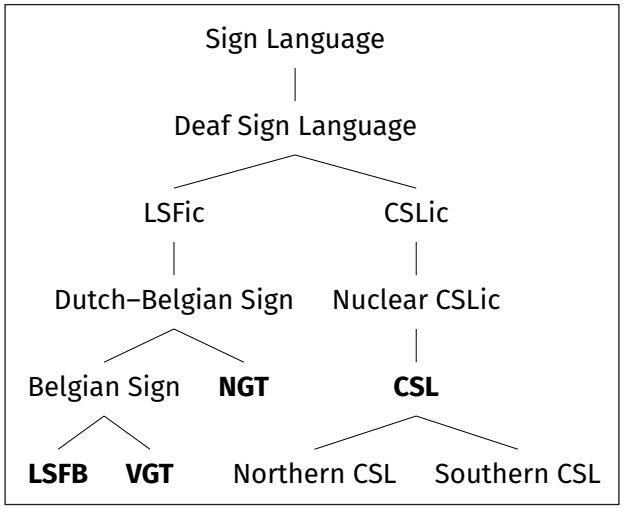



**Figure 2:** Language classification based on *Glottolog 4.7* (Hammarström et al. 2022). Languages in this study are shown in **bold**.

## 3.2 Participants

The current study involves 27 participants (ages 20–48; mean age 32.3; SD 10.1) from four different sign languages, who were all present in Nijmegen, the Netherlands during three days from April 30th to May 2nd 2019, when different types of data were collected for the larger project on cross-signing and intelligibility. The signers represented the four languages described in Section 3.1: NGT (n = 15), VGT (n = 2), LSFB (n = 5) and CSL (n = 5). The Chinese group arrived four days before the first day of data collection in order for them to adjust to the time zone difference having traveled from Shanghai by plane. The NGT, VGT and LSFB signers traveled to Nijmegen the day before the data collection started, by car or train. The participants were recruited with the help of contact persons in each of the three countries involved: The Netherlands, Belgium and China. For each language, the project team first recruited a special liaison, a deaf individual from the community who had international experience with traveling and cross-signing communication. These liaisons were crucial in the recruitment of participants, as experts within their respective communities who could find deaf signers willing to participate, but also as a point of contact between researchers and participants. For NGT, we recruited 15 signers from across the country. For each of the other three sign languages, we aimed to recruit 5 signers, which would allow for the 15 NGT signers to each be paired with one signer from another sign language for the interactive communication tasks. All participants had to fulfil a few basic requirements to be eligible for the overall project: 1) they had to be primary signers of their own sign language;[5] 2) they should have minimal experience with international signed

[5] All participants list their own respective signed language as their primary language. Two LSFB signers have acquired another (non-sample) signed language before LSFB, but now use LSFB as their primary language. Five NGT signers list sign-supported Dutch (NMG; *Nederlands met gebaren* 'Dutch with signs') alongside NGT.

interaction and not be proficient in the other sign languages of the study;[6] and 3) they should have at least a secondary degree (e.g. high school), such that the educational background was more or less uniform across the participants of all language groups. Travel, accommodation and food were financed by the project, and participants and liaisons were remunerated for their contribution. In the end, we successfully recruited signers meeting these requirements for NGT (n = 15; ages 20–48; mean age 36.2; SD 11.6), LSFB (n = 5; ages 23–29; mean age 24.2; SD 2.68) and CSL (n = 5; ages 28–37; mean age 32; SD 3.32), but due to a couple of late cancellations and ineligibility in meeting some of the participation criteria, we ended up with two signers for VGT (n = 2; ages 22–27; mean age 24.5; SD 3.54). The number of participants is small, but they were each selected based on our pre-established criteria for eligibility and availability to participate in a series of in-person activities. However, the results for VGT in this study should be taken with extra caution, as there were only two participants analyzed from an already restricted sample of participants. Participants were accompanied to and during the data collection visit by their respective language liaison, who helped organize practicalities around travel as well as translate information about tasks and participation. Participants were informed about the goals and expectations of the data collection and signed consent forms in their respective written language (Dutch, French and Mandarin Chinese). Besides having little to no proficiency in other sign languages prior to the data collection visit, we intentionally kept the language groups apart until their first meeting with the signer they had been paired with from another sign language group. Thus, the first round of experimental tasks – such as the first trials (i.e. day 1) of the current study – was conducted before they had encountered the other participants from other language groups. In addition to the experimental and communicative tasks during day 1, participants attended two lectures in spoken English interpreted into International Sign and NGT, and attended two dinners with the entire group of participants, liaisons and a small number of deaf and hearing signing project researchers and assistants from different countries before the final day (day 3), when the participants repeated the experimental task of this study and took part in additional tasks.

## 3.3 Experimental design

The lexical comprehension task for this study was organized as a Qualtrics (2019) survey split into two sets: test set A and B. Each test set consisted of 40 unique questions but otherwise identical structure. Questions were split into two sets to make each trial shorter for the convenience of the participants, allowing for a break in between to avoid fatigue. Before the test sessions, the group liaisons instructed participants about the general aim of the task at hand, and any additional clarifications would always go through the liaison to the participants. The foreign participants had been informed that they would be meeting *other* sign languages, and from which countries.

[6] Most participants mention being exposed to some foreign sign languages through social media and brief interactions while traveling, but they all have self-reported comprehension levels from none to minimal for any of the other sign languages of the study.

For this specific task, signers were told to match each sign video to a meaning, but not told explicitly which sign language was in the video, although at least NGT signers quickly identified the signers in the videos. Each test set trial started with a prompt that asked the participant to fill out their participant number they were given during the data collection visit, and the prompt was displayed in four written languages: English, Dutch, French and Mandarin Chinese. After this prompt, the participant would be presented with the 40 questions of the test set, one at a time, in a randomized order for each trial and participant. Each question was a self-paced sign-to-picture matching task, consisting of a target sign video showing a single NGT sign from the NGT dataset (Crasborn et al. 2020b) in Global Signbank (Crasborn et al. 2020a). All NGT sign videos each contain a single sign, articulated in isolation without any mouthing. This differs from more natural NGT signing, in which mouthing is frequent (Bank et al. 2016). However, avoiding mouthing in dictionary entries is preferred by some lexicographers for various reasons – e.g. as a form of lemmatization – and is crucial to this experiment since it means that VGT signers do not have the advantage of seeing Dutch mouthings. Below the video, there was a 2 × 2 grid of four meaning choices represented by Sclera pictograms (Sclera NPO 2019) with radio buttons next to each to show the selection, although the entire pictogram and frame functioned as a clickable button – see **Figure 3**. The meanings were represented by pictograms to make the test

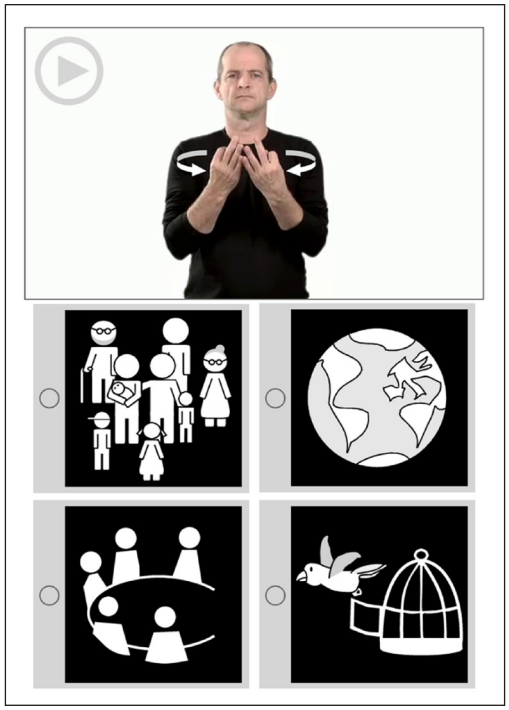


**Figure 3:** Design of the question presentation in the survey, with a target sign video – here: the NGT sign FAMILY-A 'family' (Crasborn et al. 2020b: sign ID 830) – above a 2 × 2 grid of meaning choices represented by Sclera NPO (2019) pictogram symbols.

uniform across languages and to avoid any spoken language interference in the selection. For each question, the meaning choices in the 2 × 2 grid were presented in a randomized location, resulting in a randomization of both question order across each trial and meaning choice grid configuration within each question presentation.

The 80 target sign videos were selected from the NGT dataset in Global Signbank (Crasborn et al. 2020b; a) based on two criteria: first, the sign should be a basic lexical sign with a meaning that could be represented with a Sclera NPO (2019) pictogram;[7] second, the sign *meaning* should be present also in the CSL dataset in Global Signbank (Crasborn et al. 2019). Each sign was also discussed with an NGT signer to ensure that it was a known sign in use, although there are lexical variants for many meanings in NGT with different distributions and frequency of occurrence. For each target sign, a pictogram was selected to represent its meaning in a visual, non-written form. Then, three *distractor* meanings were selected for each target sign. First, a form-based distractor was chosen on the basis of CSL sign forms. For each target sign in NGT, its form-description in Global Signbank (Crasborn et al. 2020a) was compared to all signs in the CSL dataset using the form-based cross-linguistic search method described in Börstell et al. (2020) – and also used in Omardeen (2018) – which involves quantifying the matching of form-features in arbitrary pairs of signs. The form-based distractor is thus the *meaning* of a CSL sign whose: 1) form is sufficiently similar to the NGT target sign (>70% form-similarity); 2) meaning is different than that of the target sign; 3) meaning could be represented by a Sclera pictogram. The motivation behind the form-based distractor is thus to see whether CSL signers – more so than the signers from the other groups – incorrectly chose this meaning due to them having a similar sign form with that meaning in their language. I label this distractor *form-based* due to its selection on the basis of form-overlap with the target NGT sign, but the form–meaning mapping in the CSL sign may potentially be considered iconically motivated, particularly by CSL signers (cf. Occhino et al. 2017). The other two distractors were selected on the basis of plausible iconic mappings alone, such that the author – who is a hearing, European signer – analyzed the target sign form and selected alternative meanings that could plausibly be mapped iconically onto the target sign form and could additionally be represented by a Sclera pictogram. For example, in **Figure 3**, the target meaning ‘family’ in the target sign video is shown with a target meaning pictogram on the top left, a form-based distractor on the top right with the meaning ‘Earth’, since the CSL sign for this meaning was sufficiently similar to the target sign form, and two iconicity-based distractors on the bottom row: ‘group’ and ‘birdcage’, respectively. The iconicity-based distractor meanings here were selected because they could plausibly be mapped onto the target sign form, with the hands articulating in a circle, which could iconically depict a congregation of people or a round/spherical shape, with the extended fingers potentially representing individuals or

[7] There are over 5000 Sclera pictograms as of December 17, 2022.

bars of a fence/cage. Whereas the circular/arc movement is found also in NGT signs for ‘group’ and ‘cage’, the handshape is a distinguishing feature for the correct target meaning ‘family’. The two iconicity-based distractors were selected in order of plausibility/imageability to the author: the first plausible iconic mapping for the target sign form that came to mind was selected first, followed by the second plausible iconic mapping that came to mind. The configuration of the four meaning options always uses the same 2 × 2 presentation grid as illustrated in **Figure 3**, but the real experimental setting always randomized the presentation grid configuration – that is, the location of each option within the 2 × 2 grid was randomized for each participant, trial and question. The experiment was piloted with deaf and hearing (signing and non-signing) participants prior to data collection. This piloting was conducted to ensure the functionality of the survey and the interpretability/usability of the test from the point of the participants – that is, to see that participants could understand the task and respond to the survey. However, each individual pictogram (or, pictogram-to-video combination) was not evaluated in terms of iconicity or transparency. The full list of combinations of sign videos and pictograms can be found in Appendix A (Tables A1–A2).

Prior to testing, participants were not informed about the nature of the distractors (e.g. that one was matched a CSL sign in form), but simply asked to match the sign in the video to the correct meaning among the pictograms. During testing, the sign video for each question was displayed in a video player, allowing the participant to replay the video as many times as they wanted. Each test set trial ended with a text prompt – again in English, Dutch, French and Mandarin Chinese – that asked the participant to evaluate their performance on a scale from 1 to 7, phrased as “*How well do you think you did? (1 is the worst; 7 is the best)*”. Participants each did two trials per test set (A and B): one trial per test set on day 1 of the data collection visit, and one trial per test set on day 3. The trials were always completed in the same order with test set A first, followed by test set B. Participants were not explicitly asked to complete any trial within a certain time frame; the median test time for each test set trial across participants was approximately 30 minutes.

The survey responses were analyzed with R 4.3.0 (R Core Team 2023) in the RStudio interface. Data tidying and visualization were done with the `tidyverse` (Wickham et al. 2019), `scales` (Wickham & Seidel 2022), `ggbeeswarm` (Clarke et al. 2023), `patchwork` (Pedersen 2022) and `stargazer` (Hlavac 2022) packages, and statistical analyses were performed with the `lme4` (Bates et al. 2015) and `emmeans` (Lenth 2023) packages.

## 4 Results

The following sections will be guided by the research questions (see Section 2.4): Section 4.1 focuses on comprehension scores and changes across test days, relating to research questions (i) and (ii); Section 4.2 concerns patterns among incorrect response relating to research

question (iii) about distractors; Section 4.3 compares comprehension scores to participants' self-evaluations, relating to research question (iv).[8]

## 4.1 Lexical comprehension

We can calculate a *comprehension score* based on the number of correct sign-to-picture matches in the lexical comprehension task. A paired t-test shows no difference between scores on test set A vs. test set B ($t(26) = -1.8758$; $p = 0.07195$), so test sets are not separated in the following. **Figure 4** shows the comprehension scores of each participant, grouped by language. Here, the comprehension score is calculated in terms of the percentage of correct responses overall. We can see from **Figure 4** that there is a decline in comprehension score moving from NGT as the baseline group (being tested on their own language), through VGT, LSFB and CSL, in accordance with the hypothesized result. It is noticeable that the NGT signers do not perform at 100%, but overall achieve closer to 80% correct responses (median accuracy: NGT 78.7%) – see **Table 1**. This is clearly higher than the accuracy of the other language groups (median accuracy: VGT 62.8%, LSFB 60.6%, CSL 53.7%), but point to the task itself posing some challenges for NGT signers too, similar to what Stamp (2016) observed with British Sign Language signers on a British Sign Language (regional) sign recognition task. To compare the scores against NGT as a baseline, we could simply calculate the median comprehension scores by language, and adjust the accuracy by dividing by the NGT score. This adjusted accuracy and difference to NGT can be seen in the two right-most columns in **Table 1**.

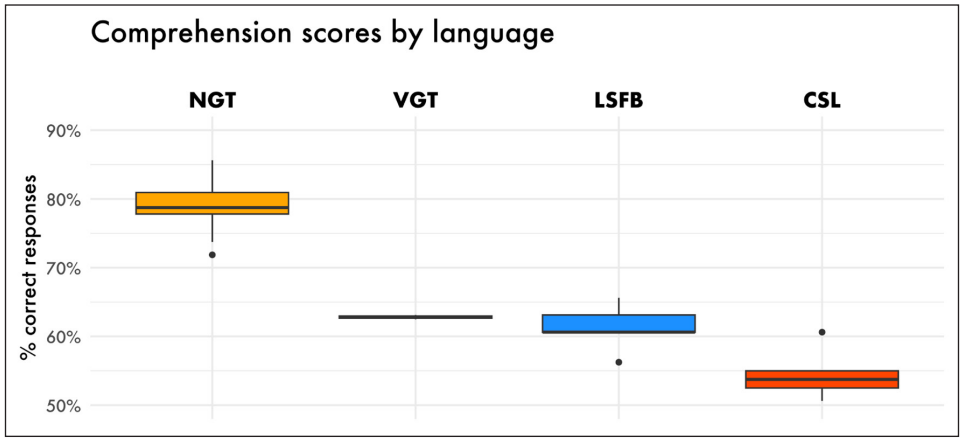



**Figure 4:** Comprehension scores by language.

To test whether the difference between language groups is statistically reliable, I fitted a mixed effects logistic regression model with answer (correct vs. incorrect) and language as fixed effects,

[8] Link to data, scripts and appendices: https://doi.org/10.17605/OSF.IO/2JS7Q.

| Language | Median accuracy (%) | Accuracy (to baseline) | Difference |
|---|---|---|---|
| NGT | 78.7% | 100% | |
| VGT | 62.8% | 79.8% | –20.2% |
| LSFB | 60.6% | 77.0% | –23.0% |
| CSL | 53.7% | 68.2% | –31.8% |

**Table 1:** Comprehension scores by language (medians across participants and trials).

and participant and test item as random effects with random intercepts. Comparing this against a null model, there was a statistically reliable effect of language ($\chi^2(3) = 60.548$; $p < 0.0001^{***}$), showing that the four language groups have a significantly different performance on the lexical comprehension task. This model tests the languages against NGT as the intercept, but it is also interesting to look at differences between the other languages individually. Thus, I calculated estimated marginal means of the pairwise combinations of all languages – see **Table 2**. Here we see that there is a statistically significant difference between NGT and the other three languages, but also between CSL and each of the two Belgian sign languages VGT and LSFB. However, there is no difference between VGT and LSFB. This result supports the hypothesis that both VGT and LSFB would perform better than CSL, and the absence of a difference between VGT and LSFB aligns with previous research noting a substantial degree of similarity between VGT and LSFB (see Sáfár et al. 2015). Simultaneously, the results for VGT should be interpreted with extra caution, seeing as it is the smallest language group by far in terms of signers participating in this study (n = 2).

| Language pair | Estimate | SE | *z* ratio | *p* value | |
|---|---|---|---|---|---|
| NGT – VGT | 1.213 | 0.183 | 6.639 | < 0.0001 | *** |
| NGT – LSFB | 1.317 | 0.128 | 10.277 | < 0.0001 | *** |
| NGT – CSL | 1.761 | 0.129 | 13.614 | < 0.0001 | *** |
| VGT – LSFB | 0.104 | 0.199 | 0.524 | 1.0000 | |
| VGT – CSL | 0.548 | 0.199 | 2.759 | 0.0348 | * |
| LSFB – CSL | 0.444 | 0.150 | 2.966 | 0.0181 | * |

**Table 2:** Estimated Marginal Means for each language pair with Bonferroni correction.
*Note:* $*p < 0.05$; $**p < 0.01$; $***p < 0.001$.

Turning to differences in test scores between test days, **Figure 5** suggests minor increases from day 1 to day 3. However, using a paired t-test to investigate the differences across days for each participant, there is no significant difference in the scores from day 1 to day 3 ($t(26) = –1.3982$; $p = 0.1739$). Thus, we can conclude that there was no statistically significant improvement in the performance on the lexical comprehension task on the last day of data collection by which

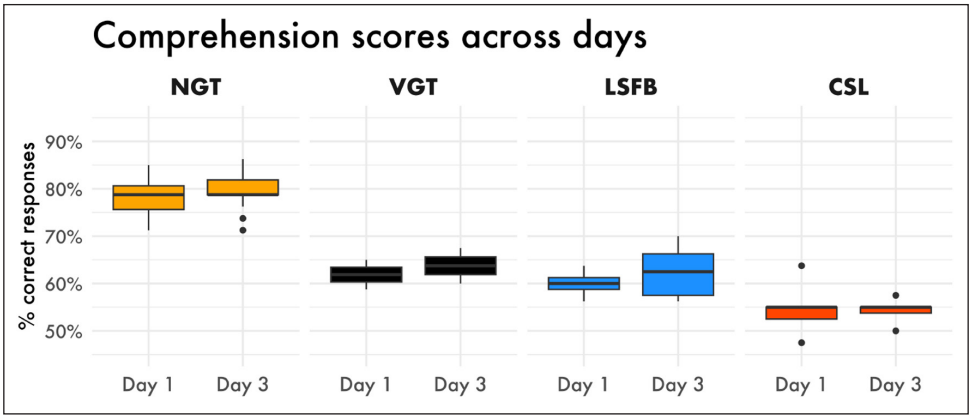



**Figure 5:** Comprehension scores across days by language.

time the participants had interacted with signers from the other language groups over two days, compared to the first day before they had met the signers from the other language groups. Thus, the hypothesis that participants would improve on this task over the course of the data collection visit is not supported.

## 4.2 Response patterns

Moving on to research question (iii) and the distribution of the distractor types, we need to look specifically at the *incorrect* responses in more detail. The distribution of distractor types among the incorrect responses for each language is shown in **Figure 6**, in which the three distractors are shown along the x-axis, grouped into form and iconic, respectively, as distractor types. What is immediately clear from this picture is that there is a high degree of similarity across languages in the distribution of distractors chosen: first, iconicity-based distractors are more frequent than the form-based distractor; second, the first iconicity-based distractor is more frequent than the second one. The second point is not related to any intended aim of the research design itself, but nonetheless noteworthy from this distribution. With regard to the form-based distractors, the design specifically targeted meanings based on form-similarity with existing CSL signs. Thus, the expected pattern would be that CSL signers should be more prone to selecting the form-based distractor, if this indeed is a potentially distracting option. However, we see no difference in the distribution of distractors chosen when comparing the CSL responses to any or all of the others combined. On the other hand, we do see that the distribution between form-based and iconicity-based distractors is clearly skewed across all language groups. If the distribution were completely even across the three distractors, we would expect one third of the incorrect responses being a form-based distractor (i.e. 33%), and two thirds an iconicity-based distractor (67%). Instead, we find that the distribution across languages is 22% to 78%, which is a statistically significant difference with an exact binomial test (expected probability = ⅔; actual probability = 0.782; $p < 0.0001$***).

**Figure 7** illustrates that participants across the four languages have more iconicity-based than form-based distractors among their incorrect responses, with the upper plot showing the absolute distribution and the lower plot the relative distribution of responses. In the lower plot, the dashed lines mark the hypothetical even distribution among the three distractors, and only two participants – the two right-most NGT signers – have form-based distractors exceeding the

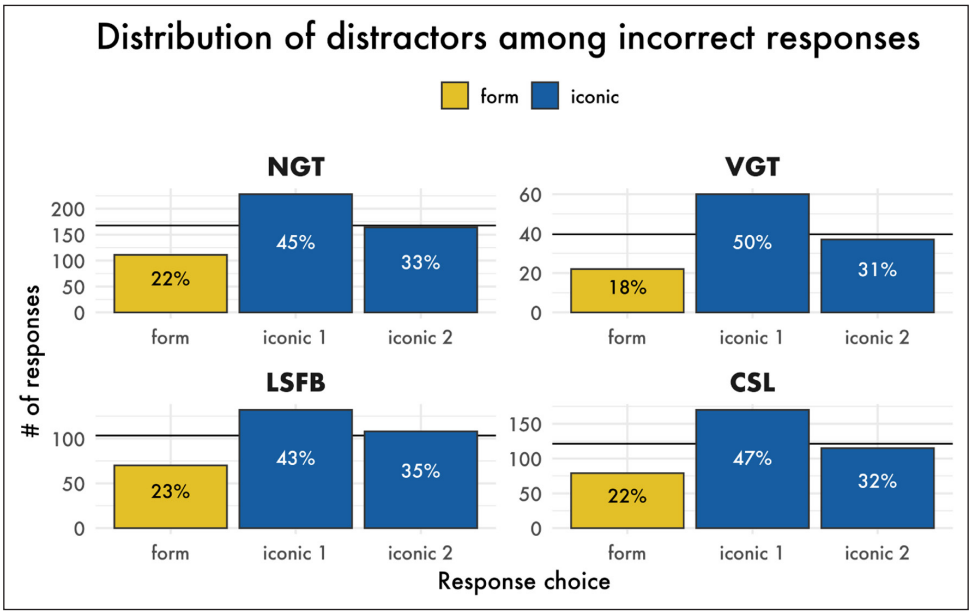



**Figure 6:** Distribution of distractors among incorrect responses across languages. Absolute responses on the y-axis and relative distribution by language group as percentages in each column. The horizontal line represents a balanced distribution.

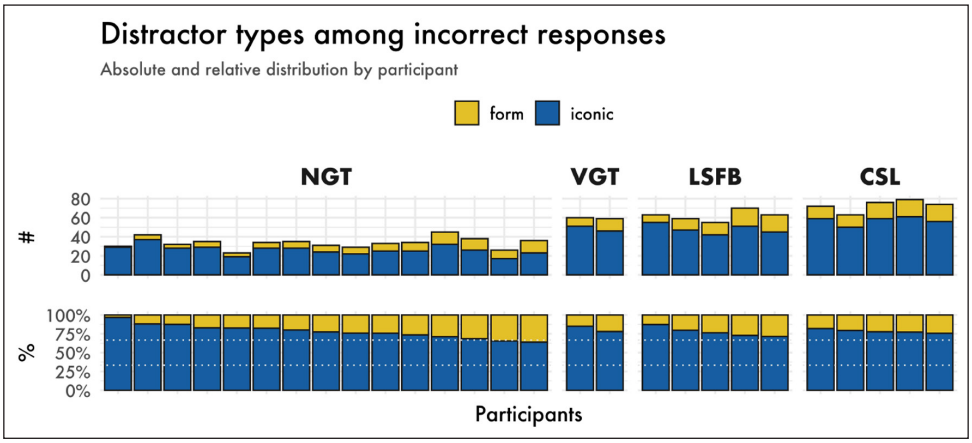



**Figure 7:** Distribution of distractors among incorrect responses across languages and participants. Absolute numbers in the upper plot and relative distributions in the lower plot. The dashed, horizontal lines represents a balanced distribution.

line. However, even for these two participants, the form-based distractors never exceed the iconicity-based distractors as the most frequent response, seeing as *one* of the iconic distractors is more or equally frequent in those cases. Overall, participants strongly prefer the iconicity-based distractors over the form-based ones, even the CSL signers who were specifically targeted by the form-based distractor type. Thus, research question (iii) can be answered in the negative: participants – and more importantly the targeted CSL signers – show a strong pattern in the direction of favoring iconically plausible meanings as the most likely (incorrect) response. Despite potentially being (more) distracted by the form-based distractors, the CSL signers exhibit the same distribution and preference pattern as the other three language groups.

The distribution of responses is varied across test items, and the summarized distribution per test item across all participants can be found in Figure B1.

## 4.3 Self-evaluations of comprehension

The final research question (iv) concerned signers' self-evaluations of their performance on the lexical comprehension task. Here, we can look at the self-evaluation scores from the final question prompt in the survey, where participants were asked to rate their own performance on the lexical comprehension task they just completed on a scale from 1 (worst) to 7 (best). **Figure 8** shows the distribution of self-evaluations across the languages, where we can see that NGT signers rate their own performance the highest overall, followed by VGT signers, and lastly similar ratings by LSFB and CSL signers. Correlating this with the comprehension scores of the corresponding test trials that were evaluated, there is a statistically significant positive correlation between comprehension scores and self-evaluations, using a Pearson's product-moment correlation

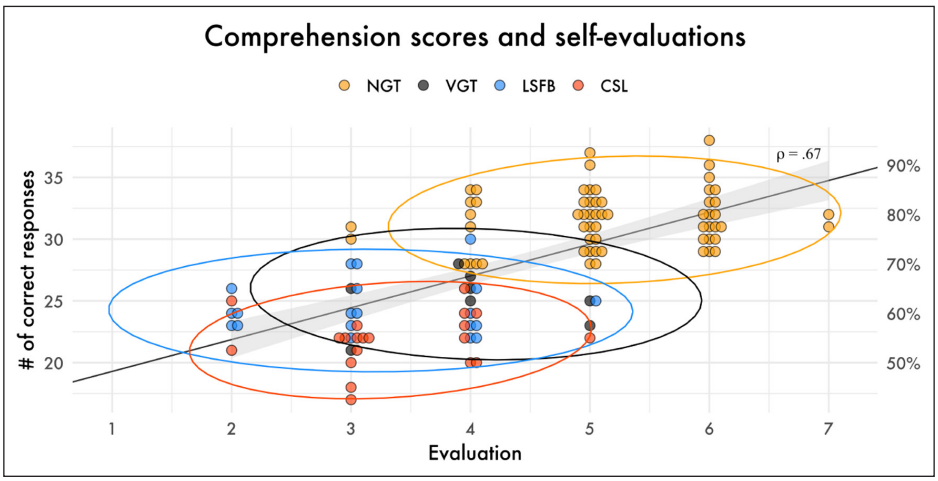



**Figure 8:** Correlation between comprehension scores and self-evaluations across participants and languages with a fitted linear regression. Ellipses group languages based on a multivariate t-distribution.

($\rho = 0.67$; $t(106) = 9.2362$; $p < 0.0001$***), illustrated by the regression line in **Figure 8**. With regard to research question (iv), the general pattern thus suggests that signers are able to estimate their own performance on this lexical comprehension task quite accurately, but we also see great variation within each language group. This shows that while there is a general positive correlation between self-evaluations and comprehension scores on this task, there is also substantial individual variation across participants within each group, visible from the variance in **Figure 8**.

## 5 Discussion

This study was guided by four separate research questions, laid out in Section 2.4. The first one related to whether signers of VGT, LSFB and CSL differ in comprehension of lexical NGT signs. This question could be answered in the positive, and in line with the hypothesized pattern. Signers of VGT, LSFB and CSL did differ in their accuracy in the sign-to-picture matching task with NGT signs, specifically in that VGT and LSFB signers perform significantly better than CSL signers on this task, while there was no difference between VGT and LSFB. However, since the number of participants is quite low – and especially so for VGT with only two participants – the results here should be interpreted with some caution and preferably be corroborated by additional approaches (e.g. other comprehension tasks) and potentially larger studies with more participants. While this result reflects the hypothesis based on the cultural, geographic and linguistic distances between the languages, we should also be somewhat careful about this comparison including CSL, since the experimental design targeted this group with a dedicated distractor (the form-based one) and could potentially have struggled more with the task because of this. I return to the discussion of distractor distributions later in this section.

The difference in comprehension between NGT, VGT and LSFB mirrors previous work on mutual intelligibility between VGT on the one hand and LSFB and NGT on the other, confirming that there is some mutual intelligibility across these three languages, but that VGT and LSFB are likely closer to each other than to NGT (Sáfár et al. 2015). In Sáfár et al.'s (2015) study, they showed that the presence of mouthing in VGT signing makes the language more intelligible to NGT signers, since both languages make use of mouthings based on spoken Dutch. In the study presented in this paper, no mouthing was present since sign videos in the NGT Signbank (Crasborn et al. 2020b) do not include any mouthings. If mouthings had been present, it is likely that the VGT signers would have performed better, and perhaps significantly better than their LSFB peers, as they would benefit from recognizable visually articulated spoken words. Mouthing in NGT exhibits variation, but is generally frequent (Bank et al. 2016) and would be one of several multimodal properties of natural and interactive signing that at least VGT signers could utilize in order to comprehend NGT signing, despite (manual) sign forms potentially differing. However, in the conditions of this lexical comprehension task with isolated signs without mouthings, VGT

and LSFB signers perform equally well. The natural follow-up to this study is to see how the same signers manage cross-signing communication in the interactive tasks, paired with a signer from another sign language. In those tasks, it is likely that the pairs of NGT and VGT signers would make use of Dutch mouthings as part of their *semiotic repertoire* (see Kusters 2021b) for making meaning. However, in the pairs without a common spoken/written language, it is possible that mouthings sometimes complicate rather than facilitate cross-signing comprehension. This is because a mismatched mouthing-to-manual form leads to processing multiple conflicting signals, either because the mouthing does not correspond to any expected form (i.e. the mouthing is interpreted as a non-word or is not interpretable in the context) or because the mouthing is interpreted as pertaining to a completely different meaning (i.e. the mouthing is interpretable, but activates an incorrect meaning that does not match the manual form). Thus, while it is well known that English is often used as a mouthing language in international signing contexts, it is only helpful when all parties understand it as it otherwise may be a complicating factor for comprehension, and is only to be used in combination with other meaning-making strategies such as iconic depiction (see e.g. Zeshan 2019; Kusters 2020; Bierbaumer 2021).

The comprehension scores showed that signers comprehend foreign signs much better than chance levels. In this task with four meaning options, the chance level would be 25%, whereas the observed accuracy ranges from about 50% to 65% across signers (see **Figure 4**). Furthermore, comprehension scores are higher than the percentage of lexical overlap between the involved sign languages found in previous research – a lexical overlap of around 30% between VGT and NGT according to Sáfár et al. (2015) and $<$10% between NGT and CSL based on estimations in Börstell et al. (2020). This illustrates that one must be careful when comparing different methods to estimate similarity between languages. Signers from VGT, LSFB and CSL comprehend NGT signs at a much higher rate than the calculated lexical overlap between the same language pairs, which means that the two metrics are not interchangeable. While we can use both lexicostatistical methods and mutual intelligibility tasks to measure types of linguistic distances, we must account for intelligibility measures arriving at higher comprehension (i.e. shorter linguistic distance), at least for signed languages. It seems as though even in this type of de-contextualized experimental setting with isolated signs, there is a receptive comprehension of other sign languages that goes beyond lexical similarity. Iconicity undoubtedly plays a role here, in that iconic construals can be interpreted even when the construals are mapped onto specific signs and meanings differently from your own language (cf. Occhino 2017). That is, signers may have a receptive understanding of other sign languages by comprehending forms they have not directly encountered before, but which can be understood based on a correct analysis of the iconic form–meaning mapping. At the same time, it is possible that certain iconic mappings are misinterpreted, as these are not universally transparent and in fact culturally (and linguistically) dependent to some extent (Occhino et al. 2017; Kusters 2020). However, interactive face-to-face communication could

overcome many of the comprehension obstacles, not only in terms of contextualizing the signing, but also by allowing for repair to happen during communication (Byun et al. 2018; 2019), in order to resolve e.g. false friends (Börstell et al. 2020) or misinterpreted iconic mappings, and result in greater communicative success still. In summarizing research on cross-signing through a wide range of methods, Zeshan (2019) emphasizes that the factors behind communicative success are cumulative, ranging from linguistic distances between the languages involved to quantity of exposure and additional resources such as shared knowledge of a written language. In the lexical comprehension task presented in this paper, few of those facilitating factors were available to the participants, and some are unavailable simply due to the absence of an interactive communication setting. Thus, the experimental paradigm used here abstracts away from many of the tools and practices available to us during contextualized face-to-face interactions, but helps us quantify to what extent iconicity can aid intelligibility in cross-linguistic interaction. Instead of iconic augmentation that can be achieved in interactive signing – e.g. through added depictive descriptions – this experiment relies on lexical overlap and (iconic) transparency. Iconicity is subjective and gradient (e.g. Occhino et al. 2017; Ortega 2017), naturally leading to some signs being more easily guessed than others. The success rate for any item in this experiment is thus a combination of the transparency of the target sign in relation to the target and distractor meanings, as well as the overlap of lexical items and iconic construals across languages.

Having established that signers across languages in our sample performed well in comprehending foreign signs, and importantly much better than chance levels, it was initially also hypothesized that signers would *improve* on their lexical comprehension scores across test days. Specifically, it was assumed that after exposure to NGT and other foreign sign languages through interaction in both experimental and social settings, participants would be able to utilize newly acquired knowledge of specific (NGT) signs as well as a wider range of (new) iconic mappings. However, this hypothesis could be rejected in that there was no statistically significant improvement over the course of the visit (day 1 to day 3), across participants and languages, showing that signers performed at similar levels before and after two days of cross-signing exposure. One potential shortcoming of the experimental design of this study is its use of identical test sets across days, since it could introduce priming effects. To avoid priming, the design would ideally have items from subsets of tests rotated between days, to ensure participants have not been exposed to a sign (in a video in the survey) previously in any trial. However, despite this potential shortcoming, no significant learning effects (i.e. improvements) are seen across days, suggesting that neither priming nor *learning* of "foreign" signs through exposure in the formal and informal meetings with other signers had any visible effect. Although Zeshan (2019) found that exposure to signers of other sign languages and cross-signing was one of the key factors facilitating communicative success in a series of communication tasks, the experiment described in this paper is quite different, possibly making any exposure and interaction between

the sign language groups of little use for the task. First of all, as already acknowledged earlier, the lexical comprehension task in itself is de-contextualized and not very representative of interactive communication. Second of all, the task posed problems even for NGT signers, who like their peers from the other groups did not achieve perfect scores, despite the signs "representing NGT". Many sign languages exhibit lexical variation (see e.g. Stamp et al. 2014; 2015; Börstell & Östling 2016; Lutzenberger et al. 2021; Horton 2022), and it has been shown in experiments with British Sign Language that when presented with isolated, de-contextualized signs (without mouthings), it can be a difficult task recognizing e.g. regional signs from other regions than your own (Stamp 2016). If the NGT signers would have been presented with the same signs but contextualized and/or with accompanying mouthings, it is expected that they would perform even better. Nonetheless, the signs in the two test sets only amount to 80 signs in total, and are not necessarily signs that one would expect to encounter on a daily basis. Thus, even if the signs' meanings are basic and more or less universally understood, the chances of those signs being encountered during the test days are slim based on lexical frequency distribution alone. Furthermore, when signers would interact across language groups, they would most likely engage in cross-signing and negotiating meaning in a flexible fashion, adopting each other's or possibly creating new sign forms for various concepts, as has been noted in different types of language contact situations between signers in various contexts (see e.g. Zeshan 2015; Bradford et al. 2019; Kusters 2020; 2021a), rather than simply adopting NGT signs specifically. And due to lexical variation in NGT (individual, regional, etc.), the chances of the specific sign forms from the task being used and acquired over the course of the test days are statistically small. Part of the hypothesized improvement was based on the idea of participants getting exposed to a wider range of sign forms and iconic mappings, and thereby would be better at interpreting or analogizing meanings based on other signing constructions encountered (cf. Lepic & Occhino 2018). However, since it was not possible to observe any improvement in the lexical comprehension task across test days in this study, it would be useful to investigate whether participants improve in other interactive communication tasks face-to-face, for which certain tasks and contexts call for the (repeated) use of specific signs. However, the exposure may prove to be too small for any measurable changes after only a couple of days of exposure through interaction.

Looking at the other side of the data, when participants got the sign-to-picture matching wrong, we observed some clear patterns in the responses. Following the objectives of third research question, the goal was to see whether there was a preference for either of the two types of distractors: form-based vs. iconicity-based distractors. The experimental design specifically targeted the CSL signers with the form-based distractors, which were selected based on the basis of existing CSL signs similar in form. As such, it was expected that this distractor type would be a bigger obstacle for CSL signers than for the other language groups. However, there were no differences between the language groups in terms of the distribution of distractor choices: among

the incorrect responses, all language groups strongly preferred the iconicity-based distractors over the form-based ones compared to a balanced, random distribution, and the CSL group was no different in this respect. Instead, there is a remarkable similarity in the distribution across all language groups (see **Figures 6–7**), with an almost identical distribution across NGT, LSFB and CSL, which are the languages with the most participants and thus more reliable in this case. VGT with its two signers in this study – meaning it should be interpreted with extra caution – nonetheless patterns in much the same way as the other language groups. Ultimately, the high degree of uniformity in response patterns across language groups points to interesting similarities in how signers interpret sign forms and deduce their meanings.

An additional finding with regard to the patterns among incorrect responses was that the two iconicity-based distractors show an internal distribution consistent with the design and construction of the experiment. As described in Section 3.3, the iconic distractors were selected in order from the first most plausible mapping that came to mind, followed by the second most plausible one, and the distribution of responses points in the direction of this being a shared preference ordering across the four languages. That is, the signers participating in this lexical comprehension task chose the first iconicity-distractor more often than the second one, and are thus aligned with the motivations underlying the experimental design – albeit not designed with the intention of investigating any such pattern – as well as with each other, in what constitutes a *more* plausible iconic mapping. A possible follow-up study would be to look in more detail which specific items are confused, whether they are the same across language groups and if confusable items align with existing sign forms in the other languages. Additionally, one could compare the results with responses from hearing non-signers, to see whether or not the same items show a similar confusability for non-signers as they did for the signers in this study. Figure B1 shows the complete distribution of responses across all participants and items, illustrating that whereas most target meanings are the most frequent choices across groups (including NGT), a few individual items are matched incorrectly by the majority of participants across trials. For example, the sign for ‘computer’ (item A21) depicts turning dials/knobs, and meanings such as ‘TV’ and ‘radio’ are found among the distractors, both plausible iconic mappings and even likely ones, and there is even a similar sign variant for ‘TV’ in NGT, confusing the NGT signers. Naturally, the pictograms themselves could potentially be a source of confusion, since whatever features are prominent and salient in the pictogram could influence the interpretation of the sign–meaning mapping (cf. Thompson et al. 2009). That is, if the pictogram promotes dials on a radio set, that could lead more signers to match it to the sign video with this depiction, even though its “true” meaning is ‘computer’. However, in this specific case, none of the three electronic devices have very prominent dials in their respective pictograms, and since the experimental design used here does not force participants to answer quickly, it is reasonable to suspect that such effects would be smaller since there is more time for participants to analyze and evaluate both form and meaning

options before responding, as opposed to a timed processing experiment. A future improvement of the experimental design would be to select stimulus pictograms through a more fine-grained process, balancing concepts and pictograms based on factors such as abstractness and iconicity/transparency, and piloting test items individually.

Lastly, the final research question posed was whether signers would evaluate their own lexical comprehension accurately. There was indeed a general positive correlation between participants' self-evaluations after each test trial and their actual comprehension scores in those trials, although variation between participants is clear. The general trend would point to an awareness of the level of comprehension in this specific task, which by extension suggests that they reflect over each sign whether they are certain about the meaning – and to what degree – or if they are guessing from two or more of the meaning choices, and can estimate their overall level of certainty. Jordan & Battison (1976: 78) noted that when signers were exposed to a foreign sign language, they could feel like they were "on the verge of understanding", although not fully comprehending everything. Whether or not this was experienced by the participants in this study is not known, and the task itself is also quite different with multiple meaning choices simultaneously facilitating through priming (target) and interfering through competition (distractors). However, over the course of 40 test items per trial, the participants must have sensed their level of confidence and to what extent they were unsure or simply guessing for certain items, since their self-evaluations generally align with their comprehension scores – despite obvious variation between individual participants. Interestingly, CSL and LSFB signers have similar self-evaluations (see **Figure 8**) but different comprehension scores (cf. **Figure 4**). Perhaps this is a consequence of expectations, in that CSL signers *expect* to do poorly in this foreign context far from home, and thus evaluate any successful comprehension higher, whereas LSFB signers might expect to do better in a "next door" context, but experienced a challenging task. Overall, there is a positive correlation between comprehension scores and self-evaluations in this experimental task, albeit with a small sample of signers (particularly for VGT) and individual variation in the evaluations. Perhaps self-evaluations would generally be higher if it were an interactive communication task, since miscommunications can then be negotiated and resolved through conversation, which is quite different from a one-directional, experimental task such as the one described in this paper, in which they also did not get any feedback on their performance. Undoubtedly, signers have more tools and resources at their disposal when interacting face-to-face, and can negotiate and figure out specific meanings through repair, rephrasing and accommodation, when needed.

## 6 Conclusion

In this paper, I have presented the results from a lexical comprehension task across four sign languages. It was found – in line with expectations – that VGT and LSFB signers comprehend lexical signs from NGT better than do signers of CSL. This finding was expected based on previous

research suggesting a higher degree of lexical overlap, but it may also be rooted in other factors that concern shared historical and cultural contexts and contact, which may give rise to additional similarities across languages, such as gestural practices and types of iconic mappings. NGT signers performed significantly better than the other groups, although they did not comprehend 100% of the signs in the task, which is to be expected when posed with an experimental task in which signs are presented in isolation, without contextual and interactional cues and without mouthings, when the language itself has internal regional variation in its lexicon. The results from this experiment should, however, be taken with some caution, due to the smaller samples of participants (particularly VGT) and differences in the task itself with regard to the motivation behind distractors (i.e. form-based distractors targeting CSL).

Looking at the effect of cross-signing experience during the test days, there was no significant difference in the performance between day 1 and day 3 across participants and languages. Although the participants did experience intense cross-signing interactions both in test sessions and outside in more informal contexts, this appears to have had no effect on the performance on the lexical comprehension task in this study.

In terms of incorrect sign–meaning matches (i.e. when participants chose a distractor instead of the target meaning), it was shown that the distribution is not balanced or random. Across all four languages, including targeted CSL, participants strongly favored the iconically plausible options. In short, if there is a possibility to plausibly map a sign form to a meaning, this choice is preferred.

Lastly, it was found that participants overall evaluated their own performance on the lexical comprehension task accurately, although there was individual variation. This suggests that signers generally judge their own comprehension in this type of task accurately, despite the lack of context or communicative interaction to relate it to, or any feedback in terms of being shown the correct answer after each question. Thus, even though this type of task is unusual and lacks the interactive feedback of a real-life conversation, there is still some self-awareness of one's level of comprehension of signs in a (possibly foreign) sign language.

All in all, the findings from this study provide empirical data for understanding cross-signing and mutual intelligibility across sign languages. Even across unrelated sign languages, signers in this experiment could comprehend foreign signs to a quite high degree, which is part of the puzzle of how cross-signing communication functions – and more specifically how it can be successful – and a crucial part of the ability to correctly interpret a sign's meaning lies in the flexible use and understanding of iconic mappings.

# Appendix A

| Item | NGT sign | Sclera: target | Sclera: distractor (form) | Sclera: distractor (iconic 1) | Sclera: distractor (iconic 2) |
|---|---|---|---|---|---|
| A01 | SPRING | lente 2 (‘spring’) | handschoenen (‘gloves’) | champagne (‘champagne’) | vuurwerk kijken (‘watch fireworks’) |
| A02 | CHOOSE | kiezen (‘choose’) | vuilnisbak vol (‘full trash can’) | luis (‘louse’) | naald en draad (‘needle and thread’) |
| A03 | STAR | ster (‘star’) | medicatie pillen ovaal (‘oval pill’) | spugen grond (‘spit ground’) | groeien (‘grow’) |
| A04 | READ | lezen (‘read’) | springen (‘jump’) | duiken (‘dive’) | schilderen 4 (‘paint’) |
| A05 | UNDER-STAND | begrijpen (‘understand’) | spijt (‘sorry’) | gedachten leeg (‘thoughts’) | blinden en slechtzienden 3 (‘blind and low vision’) |
| A06 | HUN-GER-A | honger (‘hunger’) | verdrietig (‘sadness’) | koe melken (‘milk cow’) | eten (‘eat’) |
| A07 | TO-VIS-IT-A | bezoek van (‘visit from’) | straat 2 (‘street’) | trein 2 (‘train’) | verhuizen (‘move’) |
| A08 | BLOOD | bloed 4 (‘blood’) | hoeveel (‘how much’) | brand (‘fire’) | sneeuw (‘snow’) |
| A09 | FATHER-A | vader (‘father’) | hoofd 2 (‘head’) | masker (‘mask’) | neus (‘nose’) |
| A10 | BEAR-D | beer (‘bear’) | stress bevende handen (‘stress trembling hands’) | jas (‘coat’) | rugzak dragen 2 (‘wear backpack’) |
| A11 | EGG-A | ei breken (‘crack egg’) | dun 2 (‘thin’) | ballen (‘ball’) | ballon (‘balloon’) |
| A12 | LOVE | lief (‘love’) | gezonde voeding 2 (‘healthy food’) | overgeven (‘vomit’) | gevoelens 6 (‘feelings’) |
| A13 | TOR-TOISE-B | schildpad (‘tortoise’) | mandarijntjes (‘mandarins’) | slak huisje (‘snail’) | grot (‘cave’) |
| A14 | FAMILY-A | familie 2 (‘family’) | aarde (‘Earth’) | groep 4 (‘group’) | vogelkooi open (‘birdcage’) |
| A15 | NAME-H | naam (‘name’) | regenboog (‘rainbow’) | schrift (‘writing’) | vlag (‘flag’) |

(Contd.)

| Item | NGT sign | Sclera: target | Sclera: distractor (form) | Sclera: distractor (iconic 1) | Sclera: distractor (iconic 2) |
|---|---|---|---|---|---|
| A16 | NOW-B | nu (‘now’) | slecht (‘bad’) | scheplepel 2 (‘spoon’) | elektriciteit (‘elecricity’) |
| A17 | TIRED-B | moe (‘tired’) | moeilijk (‘difficult’) | varken (‘pig’) | hemd (‘shirt’) |
| A18 | YEAR-C | het jaar rond (‘year around’) | koffie 2 (‘coffee’) | hamer (‘hammer’) | pleister (‘band aid’) |
| A19 | DOG-C | hond 3 (‘dog’) | klok 1u (‘clock’) | broek lang (‘pants’) | lopen (‘walk’) |
| A20 | THINK-OVER-C | nadenken (‘think over’) | alleen op weg (‘alone (on road)’) | oog (‘eye’) | dromen (‘dream’) |
| A21 | COM-PUTER-B | computer (‘computer’) | tv kijken (‘watch TV’) | radio (‘radio’) | fornuis (‘stove’) |
| A22 | HEAR-B | horen (‘hear’) | afspraak maken 2 (‘make appoint-ment’) | rechts (‘right’) | tweeling (‘twin’) |
| A23 | SHY-B | verlegen (‘shy’) | oma (‘grand-mother’) | suiker zak 2 (‘sugar (bag)’) | snoepje (‘candy’) |
| A24 | TREE-C | boom (‘tree’) | hotel (‘hotel’) | raket 2 (‘rocket’) | toren (‘tower’) |
| A25 | LAUGH-G | lachen samen (‘laugh together’) | schrikken (‘startle’) | spel mijn beurt (‘my turn (game)’) | hart (‘heart’) |
| A26 | FAT | dik 2 (‘fat’) | verschillend (‘dif-ferent’) | zwanger 2 (‘pregnant’) | rok (‘skirt’) |
| A27 | HOW-C | hoe 3 (‘how’) | bakken (‘bake’) | gewichten (‘weights’) | vandaag 5 (‘today’) |
| A28 | FUTURE-A | toekomst (‘future’) | bakken 2 (‘fry’) | bijl (‘axe’) | kameel (‘camel’) |
| A29 | MOUSE-B | muis (‘mouse’) | kaas (‘cheese’) | geld (‘money’) | boter 2 (‘butter’) |
| A30 | WHEN | wanneer 4 (‘when’) | alles (‘all’) | cijfers (‘numbers’) | grasveld (‘lawn’) |
| A31 | RIVER | rivier (‘river’) | wandelen bergen (‘mountain hike’) | krab (‘crab’) | computer muis 2 (‘computer mouse’) |
| A32 | WARM-B | warm (‘warm’) | operatie (‘operation’) | koorts (‘fever’) | leeftijd volgorde (‘age order’) |
| A33 | LIE | liegen (‘lie’) | ouders 2 (‘par-ents’) | kauwgom bel blazen (‘bubble gum’) | meisje (‘girl’) |

(Contd.)

| Item | NGT sign | Sclera: target | Sclera: distractor (form) | Sclera: distractor (iconic 1) | Sclera: distractor (iconic 2) |
|---|---|---|---|---|---|
| A34 | HOUSE-B | huis (‘house’) | kerk 2 (‘church’) | bergen (‘mountains’) | camping (‘camping’) |
| A35 | AWAKE | wakker worden (‘wake up’) | pinda nootjes (‘peanuts’) | ochtend 3 (‘morning’) | bril (‘glasses’) |
| A36 | STAND-C | armen over elkaar staan (‘stand arms crossed’) | stempelen figuur (‘stamp’) | vork (‘fork’) | stekker (‘electric plug’) |
| A37 | WRITE-D | schrift schrijven (‘write writing’) | school (‘school’) | krant 2 (‘newspaper’) | zaadjes 2 (‘seeds’) |
| A38 | BOOK | boek 2 (‘book’) | doosje openen (‘open box’) | mosselen (‘mussels’) | kaart en kompas eng (‘map (and compass)’) |
| A39 | COLD-A | koud (‘cold’) | druk doen (‘busy’) | bang (‘scared’) | wind (‘wind’) |
| A40 | RAIN-C | regen (‘rain’) | groenteboer (‘greengrocer’) | groep 3 (‘group’) | piano vleugel (‘piano’) |

**Table A1:** Stimuli for Test A, showing the item label, the gloss for the NGT sign video and Sclera image names for target and distractor meanings and translations.

| Item | NGT sign | Sclera: target | Sclera: distractor (form) | Sclera: distractor (iconic 1) | Sclera: distractor (iconic 2) |
|---|---|---|---|---|---|
| B01 | CHAIR | stoel (‘chair’) | sterk 2 (‘strong’) | weegschaal balans zwaarder 2 (‘scales’) | voeten 2 (‘feet’) |
| B02 | SEA | zee (‘sea’) | wandelen heuvels (‘hiking hills’) | dolfijn (‘dolphin’) | auto kever (‘car’) |
| B03 | GET-UP | bed opstaan (‘get out of bed’) | kom 2 (‘bowl’) | slee (‘sled’) | ogen sluiten (‘close eyes’) |
| B04 | WOLF-B | wolf (‘wolf’) | islam symbool (‘Islam (crescent)’) | springen achteruit (‘jump back’) | garage reparatie (‘garage repair’) |
| B05 | APPLE | appel (‘apple’) | toren (‘tower’) | giraffe (‘giraffe’) | tomaat 2 (‘tomato’) |
| B06 | PAY | betalen (‘pay’) | maand (‘month’) | plakband (‘tape’) | brief verzenden (‘send letter’) |
| B07 | WINTER | winter (‘winter’) | tafel groep (‘table group’) | vrienden 2 (‘friends’) | huwelijk (‘marriage’) |

(Contd.)

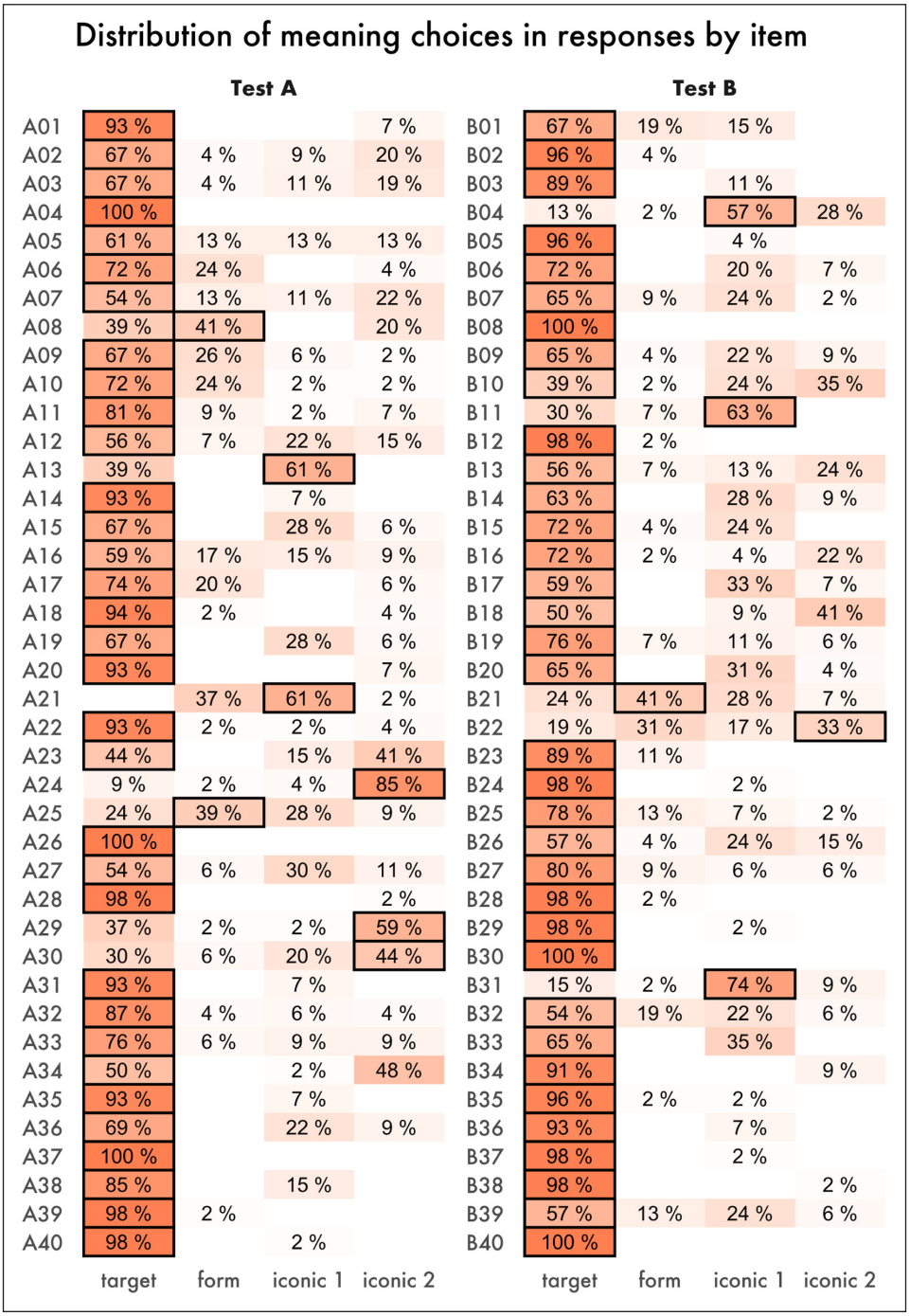
| Item | NGT sign | Sclera: target | Sclera: distractor (form) | Sclera: distractor (iconic 1) | Sclera: distractor (iconic 2) |
|---|---|---|---|---|---|
| B08 | CAR | auto 3 (‘car’) | dansen (‘dance’) | boot roer (‘boat’s wheel’) | weegschaal balans leeg (‘scales’) |
| B09 | NIGHT | nacht 2 (‘night’) | perzik (‘peach’) | pet (‘cap’) | wetenschap (‘science’) |
| B10 | DATE | datum (‘date’) | knikkeren (‘marbles’) | kip (‘chicken’) | spijkers (‘nails’) |
| B11 | EVENING-B | avond (‘evening’) | lekker (‘tasty’) | vertrouwelijk (‘secret’) | zoete snacks (‘sweets’) |
| B12 | MEAT-C | vlees (‘meat’) | gans (‘goose’) | hand schudden 2 (‘shake hands’) | klembord (‘clipboard’) |
| B13 | DAY | dag 2 (‘day’) | ruiken (‘smell’) | kleur blauw (‘blue’) | make up (‘make-up’) |
| B14 | FLOWER-B | bloemetje (‘flower’) | bus missen 2 (‘miss bus’) | verkouden (‘cold’) | neus snuiten (‘blow nose’) |
| B15 | SAY | praten (‘speak’) | idee (‘idea’) | vraag stellen 2 (‘ask question’) | morgen 5 (‘tomorrow’) |
| B16 | MOTHER-C | moeder (‘mother’) | kleur grijs (‘grey’) | gisteren 5 (‘yesterday’) | citroen (‘lemon’) |
| B17 | WATER-A | glas vullen water (‘fill glass with water’) | hoeveel 2 (‘how much’) | zand (‘sand’) | grasveld 2 (‘lawn’) |
| B18 | SIT-B | zitten (‘sit’) | urne (‘urn’) | kasteel (‘castle’) | gevangene 2 (‘prisoner’) |
| B19 | PLAY-A | spelen tuin (‘play yard’) | spreektaal gebaren (‘signing’) | bewolkt 2 (‘cloudy’) | weegschaal balans lichter 2 (‘scales’) |
| B20 | ANGRY-A | boos (‘angry’) | medaille (‘medal’) | tijger (‘tiger’) | zebra (‘zebra’) |
| B21 | GRAND-FATHER-E | opa (‘grandfather’) | zwijgen (‘silent’) | lekker 2 (‘tasty’) | tanden poetsen 2 (‘brush teeth’) |
| B22 | PERSON-B | man (‘man’) | tractor (‘tractor’) | kalender 2 (‘calendar’) | betaling verplicht (‘payment needed’) |
| B23 | STEAL | stelen (‘steal’) | deur open (‘open door’) | portemonnee (‘wallet’) | handtas dragen (‘wear handbag’) |
| B24 | MOON | maan (‘moon’) | olifant (‘elephant’) | croissant (‘croissant’) | papegaai (‘parrot’) |
| B25 | DANCE-C | dansen 2 (‘dance’) | balanceerschijf (‘balance board’) | vergelijken (‘compare’) | duwen (‘push’) |

(Contd.)

| Item | NGT sign | Sclera: target | Sclera: distractor (form) | Sclera: distractor (iconic 1) | Sclera: distractor (iconic 2) |
|---|---|---|---|---|---|
| B26 | LEARN-A | samen leren (‘learn together’) | sleutel rond (‘round key’) | haar kammen lang (‘comb hair’) | taal begrijpen niet (‘not understand (speaking)’) |
| B27 | WHO-A | wie (‘who’) | middagmaal (‘dinner’) | klein (‘small’) | tanden 3 (‘teeth’) |
| B28 | DRINK-A | drinken (‘drink’) | wijn 2 (‘wine’) | geeuwen (‘yawn’) | tandarts (‘dentist’) |
| B29 | MORNING-A | ochtend 3 (‘morning’) | groei en leven (‘grow and live’) | kamer verlaten (‘leave room’) | zonnecreme (‘sunscreen’) |
| B30 | SEE-B | zien (‘see’) | kerstboom 2 (‘Xmas tree’) | huilen (‘cry’) | bloemen ruiken (‘smell flowers’) |
| B31 | MANY-C | veel (‘many’) | hek (‘fence’) | buffet (‘buffet’) | glas leeg (‘empty glass’) |
| B32 | HARE-D | haas (‘hare’) | ezel (‘donkey’) | mier (‘ant’) | vlinder (‘butterfly’) |
| B33 | SICK-B | ziek (‘sick’) | stekker insteken (‘connect plug’) | mug (‘mosquito’) | spuit (‘syringe’) |
| B34 | LION-A | leeuw (‘lion’) | dronken (‘drunk’) | chirurg (‘surgeon’) | kat (‘cat’) |
| B35 | THIRST | dorst (‘thirst’) | scheren 3 (‘shave’) | gevoelens (‘feelings’) | ketting (‘chain’) |
| B36 | SUN-B | zon (‘sun’) | ballenbad ballen gooien (‘ball pit throw balls’) | douchen (‘shower’) | parfum 2 (‘perfume’) |
| B37 | EAT-B | eten handen (‘eat’) | kunstgebit indoen (‘insert dentures’) | kussen (‘kiss’) | nest vogel (‘bird’s nest’) |
| B38 | SLEEP-A | slapen (‘sleep’) | hoofdpijn (‘headache’) | kussens (‘pillows’) | hotel 2 (‘hotel’) |
| B39 | WHAT-A | wat (‘what’) | klok (‘clock’) | symbool wifi (‘wifi’) | regenworm (‘earthworm’) |
| B40 | PHONE-A | telefoon (‘telephone’) | doven en slechthorenden 2 (‘deaf and hard-of-hearing’) | gehoorbeschermingsdopjes bij lawaai (‘noise-canceling headphones’) | muziek (‘music’) |

**Table A2:** Stimuli for Test B, showing the item label, the gloss for the NGT sign video and Sclera image names for target and distractor meanings and translations.

# Appendix B




| | Test A | | | | | Test B | | | |
|---|---|---|---|---|---|---|---|---|---|
| | target | form | iconic 1 | iconic 2 | | target | form | iconic 1 | iconic 2 |
| A01 | 93 % | | | 7 % | B01 | 67 % | 19 % | 15 % | |
| A02 | 67 % | 4 % | 9 % | 20 % | B02 | 96 % | 4 % | | |
| A03 | 67 % | 4 % | 11 % | 19 % | B03 | 89 % | | 11 % | |
| A04 | 100 % | | | | B04 | 13 % | 2 % | 57 % | 28 % |
| A05 | 61 % | 13 % | 13 % | 13 % | B05 | 96 % | | 4 % | |
| A06 | 72 % | 24 % | | 4 % | B06 | 72 % | | 20 % | 7 % |
| A07 | 54 % | 13 % | 11 % | 22 % | B07 | 65 % | 9 % | 24 % | 2 % |
| A08 | 39 % | 41 % | | 20 % | B08 | 100 % | | | |
| A09 | 67 % | 26 % | 6 % | 2 % | B09 | 65 % | 4 % | 22 % | 9 % |
| A10 | 72 % | 24 % | 2 % | 2 % | B10 | 39 % | 2 % | 24 % | 35 % |
| A11 | 81 % | 9 % | 2 % | 7 % | B11 | 30 % | 7 % | 63 % | |
| A12 | 56 % | 7 % | 22 % | 15 % | B12 | 98 % | 2 % | | |
| A13 | 39 % | | 61 % | | B13 | 56 % | 7 % | 13 % | 24 % |
| A14 | 93 % | | 7 % | | B14 | 63 % | | 28 % | 9 % |
| A15 | 67 % | | 28 % | 6 % | B15 | 72 % | 4 % | 24 % | |
| A16 | 59 % | 17 % | 15 % | 9 % | B16 | 72 % | 2 % | 4 % | 22 % |
| A17 | 74 % | 20 % | | 6 % | B17 | 59 % | | 33 % | 7 % |
| A18 | 94 % | 2 % | | 4 % | B18 | 50 % | | 9 % | 41 % |
| A19 | 67 % | | 28 % | 6 % | B19 | 76 % | 7 % | 11 % | 6 % |
| A20 | 93 % | | | 7 % | B20 | 65 % | | 31 % | 4 % |
| A21 | | 37 % | 61 % | 2 % | B21 | 24 % | 41 % | 28 % | 7 % |
| A22 | 93 % | 2 % | 2 % | 4 % | B22 | 19 % | 31 % | 17 % | 33 % |
| A23 | 44 % | | 15 % | 41 % | B23 | 89 % | 11 % | | |
| A24 | 9 % | 2 % | 4 % | 85 % | B24 | 98 % | | 2 % | |
| A25 | 24 % | 39 % | 28 % | 9 % | B25 | 78 % | 13 % | 7 % | 2 % |
| A26 | 100 % | | | | B26 | 57 % | 4 % | 24 % | 15 % |
| A27 | 54 % | 6 % | 30 % | 11 % | B27 | 80 % | 9 % | 6 % | 6 % |
| A28 | 98 % | | | 2 % | B28 | 98 % | 2 % | | |
| A29 | 37 % | 2 % | 2 % | 59 % | B29 | 98 % | | 2 % | |
| A30 | 30 % | 6 % | 20 % | 44 % | B30 | 100 % | | | |
| A31 | 93 % | | 7 % | | B31 | 15 % | 2 % | 74 % | 9 % |
| A32 | 87 % | 4 % | 6 % | 4 % | B32 | 54 % | 19 % | 22 % | 6 % |
| A33 | 76 % | 6 % | 9 % | 9 % | B33 | 65 % | | 35 % | |
| A34 | 50 % | | 2 % | 48 % | B34 | 91 % | | | 9 % |
| A35 | 93 % | | 7 % | | B35 | 96 % | 2 % | 2 % | |
| A36 | 69 % | | 22 % | 9 % | B36 | 93 % | | 7 % | |
| A37 | 100 % | | | | B37 | 98 % | | 2 % | |
| A38 | 85 % | | 15 % | | B38 | 98 % | | | 2 % |
| A39 | 98 % | 2 % | | | B39 | 57 % | 13 % | 24 % | 6 % |
| A40 | 98 % | | 2 % | | B40 | 100 % | | | |

**Figure B1:** Distribution of meaning choices in responses by item and test set. Percentages show how often each option was selected. Tiles with border lines are the most frequently selected meaning options.

## Abbreviations

CSL = Chinese Sign Language, NGT = Sign Language of the Netherlands (*Nederlandse gebarentaal*), LSFB = French Belgian Sign Language (*Langue des signes de Belgique francophone*), VGT = Flemish Sign Language (*Vlaamse gebarentaal*).

## Supplementary files

Data, scripts and appendices: https://doi.org/10.17605/OSF.IO/2JS7Q

## Ethics and consent

The research within the project *Deaf communication without a shared language* (application 2018-4695) has been evaluated and approved by the *Ethics Assessment Committee Humanities* of the Faculty of Arts and the Faculty of Philosophy, Theology and Religious Studies (EACH) at Radboud University, Nijmegen (the Netherlands) on September 12th, 2018. Participants were informed that their participation was voluntary and gave their consent to the data being used for research within the project described. Participants received monetary compensation for their participation.

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## Competing interests

The author has no competing interests to declare.

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