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Manual *wh*-signs and English *wh*-mouthings differentiate BSL content and polar questions

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Abstract: How do deaf BSL signers signal polar and content questions? This study quantitatively investigates the manual and non-manual forms used to signal polar and content questions during dyadic conversations documented in the BSL Corpus. We found that non-manual movements such as eye, eyebrow and/or head movements do not differentiate content and polar questions in BSL. Instead, it is the presence or absence of conventionalised *wh*-forms that most strongly differentiates content questions in BSL, and these *wh*-forms can be signed in BSL and/or mouthed in English. These findings challenge the traditional manual versus non-manual paradigm for analysing polar and content questions in signed languages, while demonstrating how corpus methods can further our understanding of signed language variation and use.

Keywords: conversation; corpus; interrogatives; questions; sign language

Highlights

- Analysis of 416 polar questions and 140 content questions from dyadic conversations in the British Sign Language Corpus.
- Mouthed English question words and manual *wh*-signs are the strongest indicators of content questions in BSL.
- Non-manual eye, eyebrow and/or head movements do not differentiate content and polar questions in BSL.

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– Content questions are more likely to be signalled with two or more manual and/or non-manual strategies, while polar questions are more likely to be signalled with just one strategy.

1 Introduction

Many factors constrain the conventionalisation of manual and non-manual forms of question signalling in deaf community signed languages. Researchers interested in language structure and linguistic typology have previously compared how interrogative constructions are produced within and across signed languages (e.g., Cechetto 2012; Morgan 2006; Quer et al. 2017; Šarac Kuhn and Wilbur 2006; Zeshan 2004). The primary comparison has been between polar questions (i.e., yes/no questions) and content questions (i.e., open questions). However, most claims rely on intuitions or data elicited from very small numbers of signers, with little or no reference to conversational text types that more accurately represent deaf signers' interactions. Recent corpus-based investigations of polar and content questions in NGT (Dutch Sign Language), CSL (Chinese Sign Language), FinSL (Finnish Sign Language) and tactile STS (Swedish Sign Language) suggest that if larger numbers of signers engaging in conversation are considered, the picture may be quite different (Kimmelman and Vink 2017; Lajolinna 2021; Lin 2019; Manrique 2016; Mesch 2001).

Here we present a quantitative analysis of polar and content questions produced during dyadic conversations between 40 deaf BSL signers from four regions documented in the BSL Corpus (Schembri et al. 2013). These signers learned BSL from birth or early childhood before age seven. This study has two aims: (1) describe how this cohort of BSL signers signal polar and content questions using manual and/or non-manual forms of question signalling; and (2) identify key semantic, syntactic, pragmatic and/or sociolinguistic factors influencing signers' use of manual and/or non-manual strategies for signalling polar and content questions. In the following sections, we situate this study in context of the broader literature. We then outline the methods used for annotating and analysing questions identified in the BSL Corpus, and present the results of our corpus-based analysis. We end by discussing the implications for language description and linguistic typology.

2 Background

The literature on question signalling in signed languages is heavily shaped by the dichotomy of manual versus non-manual forms of expression in signed language linguistics. This has been referred to as the "manual bias" (see Puupponen 2019).

Researchers have been interested in identifying cross-linguistic patterns for the manual and/or non-manual forms used to signal questions in signed languages (see e.g., Cecchetto 2012; Zeshan 2006). Particular attention has been given to the presence or absence of conventionalised manual *wh*-forms within content questions, as well as the role of non-manual eye, brow, head and/or body movements for "marking" question structures grammatically (see Zeshan and Palfreyman 2017 for an overview). As non-manual question signalling is often argued to be syntactic in signed languages, a key point of interest is the extent to which specific syntactic and prosodic aspects are the sole indicator of polar and content questions (e.g., Sandler 2010). Non-manual signed language forms of expression function similarly to intonation in spoken languages, yet the pattern for intonation-only question signalling is less common across spoken languages (Dryer 2013).

Zeshan's (2006) typological survey of interrogatives across 35 (mostly Western) signed languages suggests that both manual and non-manual strategies are used to signal question structures cross-linguistically. Using survey elicitation methodology, Zeshan's study identified more variation with manual forms for question signalling, such as the position of *wh*-signs in content questions, compared to non-manual forms. For example, signers from most signed languages in the dataset used question particles mainly in polar questions, but for some signed languages, signers also used question particles in content questions. However, there was no signed language in Zeshan's study where manual question forms were obligatory for polar questions. Conversely, non-manual forms of question signalling, such as head movements and facial expressions, were more consistently used across the signed languages surveyed. In other words, it seems that non-manual movements such as head and eyebrow movements were reported as doing a lot of heavy lifting for question signalling in Zeshan's (2006) sample.

A range of linguistic factors have been claimed to influence how questions with manual *wh*-signs are structured and signalled, including verb type, topic marking, verbal morphology such as aspect and person marking, and the presence of other strategies for depicting, such as constructed action (Liddell 1980). However, very few studies have acknowledged that the distribution of non-manual signalling may vary according to factors other than the semantic function of questions, such as polar and content questions, especially when produced in more conversational settings. Two exceptions are Deuchar (1984) and Sutton-Spence and Woll (1999), who claimed that BSL signers generally furrow their eyebrows for content questions. Crucially, both also acknowledged that variation in signer's eyebrow movements may be due to other factors such as emotional affect (see de Vos et al. 2009). For example, Sutton-Spence and Woll remarked that, "If a person is puzzled, or angry, the brows may be down, even though the question is a Yes-No question" (1999: 67).

In addition, Deuchar (1984: 93) noted that, "We may wish to conclude that questions in BSL are grammatically marked by movement of the eyebrows from the neutral position, and semantically marked as to the degree of information required by their actual position, whether raised or lowered". Thus, Deuchar argued that it is not the particular direction of eyebrow movement that is important for signalling questions, but rather some change in brow position from what occurred before. More recently, experimental approaches have been used to determine the effect of emotion and question type on eyebrow position for deaf signers. Kimmelman et al. (2020) found that eyebrow position is affected by emotions in Kazakh-Russian Sign Language, with implications for the utility of computer vision solutions for the linguistic analysis of non-manuals in sign languages (Kuznetsova et al. 2021).

Many studies have focused on polar and content questions targeted in highly constrained elicitation tasks that are isolated from naturally occurring everyday interactions. This includes grammaticality judgements that are elicited from very small numbers of signers. For example, the position of *wh*-signs in content questions has received particular attention from linguists working within generative approaches, who are concerned with whether *wh*-movement in ASL is "leftward" or "rightward" (Neidle et al. 2000; Petronio and Lillo-Martin 1997). The crucial evidence needed to determine which generative analysis is more appropriate is the (un)grammaticality of sentences where the manual *wh*-sign functioning as object occurs only clause-initially, e.g., sentences such as (1).[1]

(1) A BSL signer demonstrates a BSL utterance with clause-initial *wh*-object.

Head	no head movement		
Eye & brow	down		
Hand	WHAT	BOY	BUY
Mouth	*what*	*boy*	*buy*
Translation	*what did the boy buy?*		

Drawing on elicited data, Neidle et al. (2000) claimed that structures like (1), with downward brows, squinted eyes and slight side-to-side headshake, are ungrammatical in ASL, while Petronio and Lillo-Martin (1997) claimed that some of their informants accept these structures while others reject them. Yet neither study

1 Small caps are used to represent English glosses of the manual BSL signs in each signed sentence.

specified how many deaf signers were consulted for these judgements, and no demographic information about individual informants was provided. The stalemate that has occurred in relation to the *wh*-movement debate for ASL demonstrates that it is not sufficient to make such claims based on judgements from a small number of deaf informants of unspecified background. Another problem is the overreliance on glossed examples when reporting in the literature. As noted by Neidle et al. (2000), the sentences that the two groups are judging may actually differ in important ways, and it is impossible to determine this without seeing video of the judged examples.

Recent corpus-based studies have demonstrated that the range of question types observed in everyday conversations within naturally occurring settings is significantly broader than previously suggested in the literature. Additionally, numerous factors may influence how polar and content questions are signalled in signed languages (Kimmelman and Vink 2017; Lajolinna 2021; Lin 2019; Manrique 2016; see also Deuchar 1984; Sutton-Spence and Woll 1999). Applying a Conversation Analysis approach, Manrique (2016, 2017) analysed how problems of signing, seeing and understanding are resolved within dyadic and multiparty naturally occurring interactions in LSA (Lengua de Señas Argentina) compared to problems of speaking, hearing and understanding (Schegloff et al. 1977). She focused on the type of questions that signers use when they do not understand what another signer has just signed, i.e., other-initiated repair. Manrique found that LSA signers use both polar and content questions to initiate these types of repairs (cf. *Do you mean John, my brother?* versus *What?*) among other types of question-like practices in these interactions.

Specifically, Manrique (2016, 2017) looked at how signers request a seeing or understanding problem to be solved by analysing the entire sequence that unfolded. This included what happens before and after a repair was initiated, identifying the type of problem indicated by the questioner, and the type of solution provided by the responder. It also included looking at the information uptake that closed the sequence, or whether it was upgraded into another (often more specific) type of repair until the problem was solved. Results indicated that the specific manual and non-manual strategies used to signal these questions are most likely driven by signers' need to solve problems of signing, seeing and understanding through repair, such as by requesting confirmation or checking understanding, rather than any presumed structural differences between polar and content questions, or a need to seek information more generally.

Kimmelman and Vink (2017) investigated question-answer pairs in NGT primarily to compare manual and non-manual aspects of so-called rhetorical *wh*-structures (i.e., *wh*-clefts, which are similar in structure but not function to regular questions), with regular non-rhetorical questions. They concluded that the

variable distribution of manual and non-manual question signalling in NGT may represent different stages of grammaticalisation from "regular information-seeking question structure" to more rhetorical structures used to topicalise information. Kimmelman and Vink proposed that future studies also consider how factors such as ambient spoken language contact may explain variation in signers' use of polar and content questions. Lin (2019) came to a similar conclusion after investigating questions in the Shanghai dialect of CSL. Lin proposed that CSL is a "particle rich" signed language with respect to question signalling, similar to the ambient majority spoken languages that also rely heavily on question particles such as Mandarin.

Finally, Lajolinna (2021) analysed the eyebrow movements that FinSL signers used for content questions in conversation data, to determine what kind of eyebrow movements are used in this question type and if these brow movements have additional functions. Brow lowering was the most common eyebrow movement observed in FinSL content questions. However, Lajolinna also observed that a "considerable amount" of content questions were signalled with brow raises, or with no visible brow movement at all. These findings align with studies of other non-manual movements, providing corpus-based evidence for the "semiotic versatility" and plurifunctionality of head movements in FinSL (Puupponen 2019).

Investigations of signed language corpora have identified much more variation in non-manual signalling of polar and content questions than has previously been assumed or identified through other methods, calling into question the efficacy of the "manual versus non-manual" and "polar versus content" paradigms for investigating questions in signed languages. In general, there is little evidence for conventionalisation of specific eye, brow or head movements for marking polar or content questions specifically. Indeed, it has been found that there is no difference between how deaf BSL signers and hearing non-signers perceive the non-manual aspects of polar and content questions, which suggests these intonational aspects are not conventionalised for signed languages (Campbell et al. 1999). Instead, they may be related to visible aspects of face-to-face communication in general.

Furthermore, as observed in Meir (2004), the role of mouthings (i.e., mouth patterns based on spoken words) in question signalling may be of particular import for at least some signers of some signed languages. English mouthings are extremely common in BSL, including mouthings that co-occur with manual signs and mouthings that are not aligned with any manual sign at all (see Proctor and Cormier 2023). It is therefore important to factor in the possibility that English mouthings may contribute to non-manual question signalling in BSL. Corpus-based investigations on how question structures are formed and used in signed conversations are necessary to tease apart various factors before debates about how questions are structured can

be resolved. In this paper, we focus on BSL specifically, in light of claims made about BSL and the broader signed language literature.

3 Research questions

In this paper we investigate and describe BSL using pre-arranged free conversation data archived in the BSL Corpus (Schembri et al. 2013). BSL is closely related to Auslan, New Zealand Sign Language and perhaps more distantly to other signed languages used in some former British colonies and thus shaped by British colonialism (see Johnston and Schembri 2007). Our main research question is: how do deaf BSL signers signal questions using manual and non-manual forms? Manual question forms include conventionalised manual BSL signs such as WHO, WHAT, WHERE, and WHEN. Non-manual forms include head movements such as nods, as well as eye and eyebrow movements, mouthings of English forms such as *who*, *what*, *where*, *when*, and mouth gestures such as 'downward mouth'.

We take the position that multiple bodily strategies are often coordinated into multimodal composite utterances that signal various acts of meaning (Clark 1996; Enfield 2009). Signals are "the acts by which one person means something for another" (Clark 1996: 155). This terminology is useful because it avoids making assumptions about which acts of meaning are 'linguistic' or not, which is an ongoing debate in the signed language linguistics literature (see e.g., Lillo-Martin and Meier 2011; Schembri et al. 2018). Instead, any and all meaningful actions can be analysed in terms of their composite signalling properties, such as whether the actions describe, depict and/or indicate (see Ferrara and Hodge 2018).

While signers' and speakers' choices of signalling methods are motivated by their broader decisions about "what they are doing and why", they are also constrained by the signalling methods and semiotic resources available within specific interactions, e.g., whether two sighted hearing people are speaking face-to-face and visible to each other, or speaking over the telephone and therefore not visible to each other (Clark 1996: 186). Various strategies for question marking may therefore be specific to signed languages and/or shared by sighted speakers engaging in co-present, multimodal interaction (see e.g., Andrén 2014; Harrison 2014). It is an empirical question whether various patterns of question signalling are the same or different across co-present signed and spoken language contexts, as is determining the broader explanations for this variation and what these might say about human language and communication overall.

4 Methods

4.1 BSL corpus data and study participants

Our analysis is based on approximately 5.5 h of dyadic pre-arranged free conversation between 40 deaf signers documented in the BSL Corpus (Schembri et al. 2013).[2] Participants were balanced for gender (20 women, 20 men) and four regions in England (10 for each of the four cities Birmingham, Bristol, London, Manchester). Participants were on average 47.8 years old at the time of recording (SD = 17.8 years, 17–77 years). Most participants are right-hand-dominant signers (n = 37). Only 3 signers are left-hand-dominant. There are 24 participants (60 %) who come from hearing families, while 16 come from families with at least one deaf parent (40 %). Those from deaf families learned BSL from birth, while most of those from hearing families reported learning BSL before age seven. Two signers reported learning BSL between ages eight and twelve (LN25 and BL22). The majority of participants identified as White (n = 36, 90 %), with 3 participants identifying as Black and 1 participant identifying as South Asian. We also considered if participants had experience teaching BSL at the time of filming: 10 out of the 40 signers had experience teaching BSL (25 %), as opposed to 12 who had no experience teaching BSL (30 %). We have no information about whether any of the remaining 18 signers did or did not teach BSL (45 %). A total of 726 tokens of questions were annotated in this dataset. As we are using conversational data, tokens of questions are unequally distributed across participants, ranging from a minimum of 5 tokens per participant to a maximum of 44 tokens per participant (M = 18.2).

4.2 Representation in the BSL corpus and current study

Before proceeding further, we want to acknowledge some issues with the representation of deaf signers in the BSL Corpus as a whole, and the current study in particular. It is important to note that a corpus can rarely, if ever, claim to be entirely balanced and representative: it can only be described in terms of *how* it is balanced and representative (Gries 2009). The BSL Corpus was initially designed to document eight major regional urban varieties of BSL as used by deaf people who learned the language from their parents and/or peers as young children growing up in the UK, i.e., cohorts of deaf signers traditionally described as "native and near-native"

2 Conversation topics were spontaneous and not pre-planned but the filming sessions were pre-arranged, which means that the interactions documented in the BSL Corpus were not as fully spontaneous as they might be in everyday life.

signers (Schembri et al. 2013). Thus regional representation was limited in each country, and data from only four regions in England form the focus of this study. The 10 % figure mentioned above representing Black, South Asian, and other minoritised ethnic deaf people within this cohort was based on 2001 Census of England and Wales data used to plan participant demographics for the BSL Corpus in 2008 (Office for National Statistics 2006). The main focus was varieties of BSL used by deaf signers who experienced relatively uninterrupted signed language acquisition during early childhood, and who therefore represent language conventions transmitted across multiple generations of signing peoples (see Johnston 2006). In addition, the categories provided for participants to choose on the background questionnaire for gender were only male and female.

This obviously does not capture the full range of signing peoples who use BSL in the UK, including regions outside the eight urban cities studied, those who are non-binary, hearing people who acquired BSL from birth or in early childhood, deafblind signers who use tactile BSL, or deaf or hearing people who learned BSL during or after transition to adulthood (the latter sometimes referred to as "new signers"; De Meulder 2019). Minority ethnic representation among signers in the BSL Corpus is also lower than intended, mainly because deaf signers from Black or South Asian backgrounds could not be recruited in some locations. This at least partly reflects the fact that no deaf fieldworkers from minoritised ethnic backgrounds were employed during the data collection phase of the BSL Corpus project. It is clear that the 10 % figure itself was too low in 2008 and should have been closer to the 20 % identified in the 2011 Census (Oxford Policy Management 2015). Of course, it is also misguided to rely on percentage representation figures in the context of corpus data sampling. It is not possible, for example, that data from one deaf Black signer can be representative of all deaf people from Afro-Caribbean or African backgrounds who grew up using BSL in the UK.

4.3 Annotation of BSL corpus data

Data consist of one ELAN file for each signer in the dyadic conversation. The ELAN software enables precise time alignment of annotations with the corresponding video sources on multiple user-specifiable tiers (Crasborn and Sloetjes 2008). Approximately 500 manual signs in each file had previously been tokenised and assigned ID-glosses, along with free translations into English (Fenlon et al. 2015; see Johnston 2010 for more information about ID-glossing). The same files (n = 40) were enriched with annotations for the current study. In the first instance, we created clause and other relevant annotations for approximately 500 manual signs in each file. Each file therefore contains whatever number of clause annotations are necessary to parse the initial 500 tokens of manual signs.

The shortest clip is 03:03 min long; the longest clip is 20:31 min long. The mean duration across video clips is 08:09 min. These durations vary due to the conversational nature of the discourse. Signers were encouraged to discuss whatever topic they wanted to discuss, for however long they wanted, up to around 30 min. Signers covered a broad range of topics in their conversations, including their experiences growing up deaf, their relationships with parents and teachers, their working life, deaf clubs and other organisations, deaf sports, childhood and travel memories, and other events that were current during 2008–2010, when the BSL Corpus was documented. Examples include attending the 2005 Melbourne Deaflympics (a major event in modern deaf history), the social effects of the 2007–2008 global financial crisis (referred to as "credit crunch" in the UK), and the 2008 BBC drama *House of Saddam* (then available with closed captions on BBC iPlayer).

BSL questions were first identified and annotated following the fundamental unit of conversation structure: the *adjacency pair*. The first part of an adjacency pair is typically an initiated action, such as a question, and the response is the second part, a related action that in this case is an answer following the initial turn (Sacks et al. 1974). For example, an answer to a question could be displayed as a simple nod responding to a polar question. Adjacency pairs such as question-answer, greeting-greeting, or offer-acceptance have certain characteristics: they present two ordered turns (e.g., a question followed by an answer), displayed by different participants, and are adjacently placed (i.e., one after the other), belonging to a pair-type relationship (Schegloff 2007: 13). In this study, we also identified whether a question was directed to the other participant, or whether it featured in enactments where the same participant enacts a question and provides the answer as part of a narrative. This distinction helps to differentiate between two different types of conversational units (see Section 5.1 below for more on this subset of enacted questions).

Annotation of the BSL Corpus data analysed here was based on guidelines developed for the Auslan Corpus (Johnston 2010) and documented in the Auslan Corpus Annotation Guidelines (Johnston 2019). Questions were coded and analysed in terms of their semantic function: whether the question is a polar question or a content question. We then coded how each question was signalled: whether manual signs and/or non-manual forms were used, and if there was one form of signalling or multiple forms. We also coded aspects of syntactic structure, such as whether the polar or content question contained manual question signs, where these question signs were located within the question utterances, the scope of any non-manual forms used to signal the question, and some pragmatic functions. For example, we coded whether the question was initiated at the start of a turn or during the continuation of a turn, and whether the question occurred within enacted discourse (cf. reported speech, constructed action, role shift, personal transfer). We did this to check whether the fundamental pragmatics of turn-taking might have an effect on

question signalling. Finally, we considered whether any socio-demographic factors influence individual signers' expression of these question types in BSL, such as their age, gender, region, family background (e.g., parents deaf or hearing), reported age of BSL acquisition, and BSL teaching experience.

Each ELAN file was viewed multiple times by three annotators, including Hodge and Manrique, and the research assistant Maxwell Barber (a deaf lifelong signer of BSL). All instances of questions were identified and details about each token were annotated further on additional tiers. Table 1 describes the function of the ELAN tiers

Table 1: Tiers used to identify and annotate questions in BSL.

Tier name	Tier function
Question	Identifies a stretch of signing as signalling a question which requests a response, and whether the question was signalled as a continuation of the signer's turn ("continuing") or if the signer initiated a turn to ask the question ("initiating"). Also identifies whether the question successfully elicited a response (unmarked) or did not elicit a response (i.e., no response, suffixed as "NR"). Uncertainly identified tokens are suffixed with a question mark.
Q-manual	Identifies the presence or absence of manual question forms, i.e., single, multiple, absent. Manual question forms include WHO, WHAT, WHEN, WHERE, HOW, as well as some tokens of PALM-UP and some pointing.
Q-non-manual	Identifies a question as signalled with or without non-manual expression, i.e., present, absent. This may include English mouthings, gestural mouth actions, eye and brow movements, and/or head movements. This tier codes non-manual signalling as occurring, even though different combinations of manual and non-manual expressions are possible.
Q-position	Identifies the position of manual question forms within a clause, i.e., pre-predicate, post-predicate (non-reprise and clause-final), post-predicate (non-reprise), reprise (clause-final), reprise (non-clause-final), other (e.g., single manual question forms in clauses without a predicate, multiple question forms that are not a reprise), and null (no manual question form).
Q-semantic	Identifies the semantic function of the question, according to traditional typological analyses, e.g., polar question, content question.
Q-social action	Identifies the social action of the token question, according to interactional analyses, e.g., request information, request confirmation, request repair.
Head	Identifies meaningful head movements related to question signalling, i.e., up, down, nod, headshake, forward, backward, sideward, null.
Eye and brow	Identifies meaningful eye and brow movements related to question signalling, i.e., up, down, squint, null, not visible.
Constructed action	Identifies questions during constructed action or dialogue, and also the character role being enacted (cf. Role shift, quotatives, reported speech).
Mouth gesture	Identifies any BSL mouth gestures related to question signalling, e.g., downward corners of the mouth.
Mouthing	Identifies any English mouthings related to question signalling, e.g., *who*, *what*, *when*, *where*, *how*.

used to enrich the BSL question data with information relating to our research questions. The main unit of analysis is the Question tier, which was used to identify and annotate tokens of questions in the first instance, while additional information about each token was annotated on other tiers.

Tokens where the annotator was not confident about the identification of the question were tagged with a question mark. This annotation process ensured that all instances of questions evidenced within the conversations in the study dataset were identified and included, and none were cherry-picked or arbitrarily excluded, in keeping with the variationist principle of accountability (e.g., Tagliamonte 2006). It also means that in our statistical analysis, we could focus on those tokens that are confidently identified, all of which have been revised by more than one annotator, and some of which have also been checked by two other annotators (see Section 4.4 below). As all tokens of questions were produced spontaneously during these pre-arranged free conversations, the total number of tokens identified provides a fairly accurate indication of the proportion of questions within the conversations documented in the BSL Corpus.

4.4 Assessing stability of annotations in the BSL corpus

It is important to check if other annotators agree or disagree with the annotations created to investigate questions in BSL. This is done as an assessment of how annotations stabilise over time to represent a broad consensus, more so than a form of 'validation' (see Hodge and Crasborn 2022; Johnston 2019). A detailed coding schema to annotate and quantify the frequency of use of multiple manual and non-manual components of questions was developed as per Table 1. Questions were initially identified by Hodge, Barber, and Manrique. All question tokens were then reviewed, revised and coded by the three annotators. Any tokens where annotators disagreed or were uncertain about the analysis were annotated as uncertain with a question mark in the Question tier. The final dataset was then analysed by the third author, Winter, and Hodge using the statistical methods described in Section 4.5.

One outcome of the annotation and revision process was greater confidence in our overall analysis of polar and content questions, and fewer uncertain cases in the final results presented here. Henceforth, when counts of uncertain cases are very low for particular categories in the sections below, they are omitted from the data visualisations for ease of presentation. Another outcome was greater attention to other-initiated repair-type questions, some of which have not typically been

discussed in the signed language literature and were overlooked during earlier revisions (see Manrique 2016, 2017). This revision process highlights the benefits of uniting researchers with expertise in different yet complementary cognitive-functional frameworks within a single corpus study.

4.5 Statistical analysis

All analyses were conducted with R version 3.6.1 (R Core Team 2019). The 'tidyverse' package version 1.3.0 (Wickham et al. 2019) was used for data carpentry and plotting. The 'ranger' package version 0.12.1 (Wright and Ziegler 2017) was used for random forest analysis. The 'tuneRanger' package version 0.5 was used to tune random forest parameters (Probst et al. 2019). The 'FactoMineR' package version 2.4 was used to perform Multiple Correspondence Analysis (Lê et al. 2008). The 'factoextra' package version 1.0.7 (Kassambara and Mundt 2017) was used for interpreting and visualising the results of the Multiple Correspondence Analysis. Scripts, data, tables and figures are available in the following Open Science Framework repository: https://osf.io/mjwug/. The basic annotations for each file (ID-glosses and translations) are available to registered researchers via the CAVA repository for the BSL Corpus: https://bslcorpusproject.org/cava/. Other annotations can be made available on request.

4.6 Examples from the BSL corpus dataset

(2) MC21 asks MC22 if she is taking a towel on their beach holiday (polar question with non-manual forms only, i.e., eyebrows raised and head nod movement).

Head	nod———		
Eye & brow	up———		
Hand	TAKE	TOWEL	PT:PRO2SG
Mouth	*take*	*towel*	*you*
Translation	*Are you taking a towel?*		

MC21F67WHNC: 04:55.683-04:57.763

(3) LN06 checks with LN05 where he flew to on his holiday (content question with non-manual forms only, i.e., eyebrows down, pressed lips, and no *wh*-sign, showing an exception to the tendency for content questions to have *wh*-signs and English mouthing).

Head	no head movement
Eye & brow	down———————
Hand	TAKE-OFF
Mouth	*pressed lips*
Translation	*Where did you fly?*
	LN06F44WHC: 00:29.711-00:30.231

(4) BM08 checks with BM07 who he was texting (content question with manual and non-manual forms, i.e., eyebrows down, head forward, manual *wh*-question form and English *wh*-mouthing, showing a typical content question).

Head	forward———————			
Eye & brow	down———————			
Hand	WHO	TEXT-TO	WHO	TEXT-TO
Mouth	*who*		*who*	
Translation	*Who were you texting?*			
	BM08M18AHC: 00:09.698-00:11.018			

(5) LN24 checks that LN23 is not driving home from the party (polar question with non-manual forms only, i.e., eyebrows raised at the end, and note that headshake and brows down at the start is likely related to overall negation).

Head	headshake———	
Eye & brow	down———	up———
Hand	DRIVE	NO
Mouth	*drive*	
Translation	*You're not driving, are you?*	

LN24M31BHC: 06:26.440-06:27.645

(6) LN04 asks LN03 if she went to a deaf school (polar question with manual and non-manual forms, in this case the manual forms are double pointing).

Head	nod———			
Eye & brow	down———			
Hand	PT:PRO2SG	DEAF	SCHOOL	PT:PRO2SG
Mouth	*you*	*deaf*	*school*	
Translation	*You went to a deaf school, didn't you?*			

LN04F41WHC: 06:41.829-06:43.229

5 Results

In Section 5.1, we report on the syntactic context of questions in this dataset in terms of the clause structures they occurred in. In Section 5.2, we report on the semantic type of questions that occurred. In Section 5.3, the manual and non-manual strategies used to signal polar and content questions in this dataset are described. Section 5.4

provides more detail about signers' use of English mouthings and mouth gestures, and Section 5.5 covers signers' use of eyebrow and head movements to signal questions. In Section 5.6, we analyse signers' use of multiple strategies for signalling polar and content questions. In Section 5.7, we report on the position of manual *wh*-question signs within question utterances, and the scope of any non-manual forms used to signal the question. In Section 5.8, we analyse some pragmatic functions of these questions, such as whether the question was initiated at the start of a turn or during the continuation of a turn. In Section 5.9 we address whether any socio-demographic factors influence individual signers' expression of these question types in BSL. Finally, in Section 5.10 and Section 5.11 we conduct a Multiple Correspondence Analysis and a random forest analysis of all strategies for signalling polar and content questions, to determine which strategies are most prominent in question signalling during the signed conversations analysed here.

5.1 Syntactic context of questions in this dataset

We first provide an overview of the syntactic context in which these questions occurred. Most questions were produced as single clauses (546 tokens, 75 %). The remaining question tokens occurred within complex clause utterances (82 tokens, 11 %), within utterances shared between two signers (38 tokens, 5 %), or as interactional fragments (31 tokens, 4 %). Some question tokens (29 tokens, 4 %) occurred within clause utterances that could not be confidently identified and analysed. In the following analyses, we exclude questions occurring within enacted utterances or constructed actions (n = 103; 14 % of total question tokens) because these questions do not request a response from the other participant. Instead, both question and answer are enacted by the same participant as part of a narrative, i.e., they involve the same signer re-enacting two or more interlocutors asking and answering questions within a period of enactment. The dataset analysed subsequently therefore comprises a total of 623 question tokens (86 % of the total tokens annotated).

5.2 Semantic type of questions

Figure 1 shows that most questions in the revised dataset of 623 question tokens were polar questions (416 tokens, 67 %), and fewer tokens were content questions (n = 140, 22 %). There were only 45 tokens that were of type 'other' (7 %), and 22 that were disjunctive 'alternative' questions (4 %), which are questions such as *Are you coming today or tomorrow?* that often present two options (see Bolinger 1978; Koshik 2005). The 'other' type is a catch-all category for anything that does not fit the types polar,

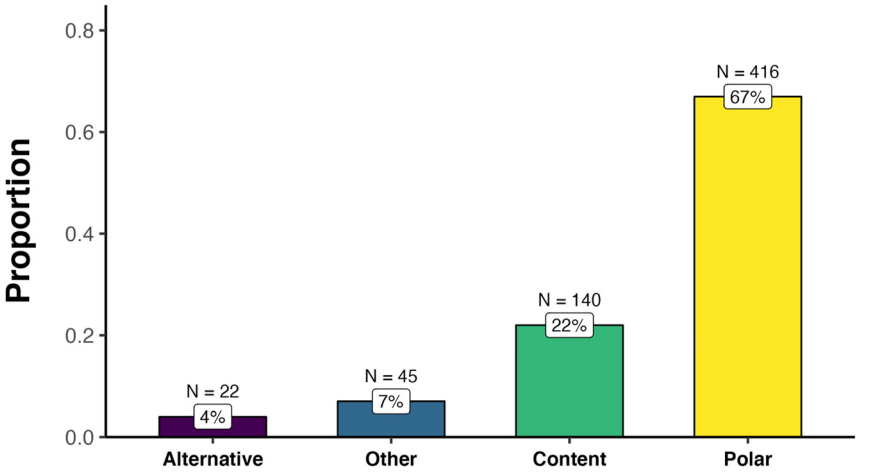


Figure 1: Proportion of questions according to semantic type (n = 623).

content, or alternative, such as rhetorical questions or outlouds, where signers express thoughts such as *Where did I put my key?* that are not meant to be responded to by another person. As there were far fewer tokens of 'other' and 'alternative' question types observed in the corpus data, our analysis focuses on polar and content questions only (556 tokens, i.e., 89 % of the revised dataset of 623 question tokens). In other words, there are 556 tokens of polar and content questions in the final dataset analysed below. This is in line with our research questions, which are focused on the difference between polar and content questions.

5.3 Manual and non-manual signalling of polar and content questions

Figure 2(a) shows that the overwhelming majority of both polar questions (n = 409, 98 %) and content questions (n = 135, 96 %) were produced with some form of non-

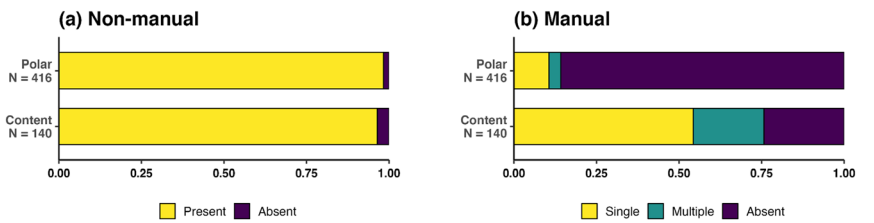


Figure 2: Semantic types broken up by (a) manual and (b) non-manual signalling of questions according to semantic type.

manual question signalling coded in this study. This includes English mouthing (e.g., *who*, *what*, *when*), mouth gestures (e.g., downturned mouth), eyebrow movements and head movements. Only very few polar questions (n = 7, 2 %) or content questions (n = 5, 4 %) were produced without any of these non-manual signals. Figure 2(b) reveals that there were more differences between polar and content questions with respect to manual signalling. For polar questions, manual signalling was absent in the majority of cases (n = 357, 86 %). A few polar questions were signalled using one manual question sign (n = 44, 11 %); even fewer were signalled using multiple question signs (n = 15, 4 %; see Example [5]). Content questions differed from polar questions in having more tokens produced with a single manual question sign (n = 76, 54 %) or multiple signs (n = 30, 21 %). Only 34 content questions had no manual question sign (24 %). What Figure 2(b) does not show is that there were also differences in the types of question signs. While the manual question signs for content questions included signs such as WHO, WHAT, WHERE, WHEN and HOW, this was not the case with polar questions, which included PALM-UP and some kinds of pointing.

5.4 Use of English question mouthings and mouth gestures

Figure 3(a) shows that signers frequently incorporated English question mouthings like *who*, *what*, *where* and *when* into their content questions, yet it was rare for signers to use English question mouthings in polar questions. For polar questions, question mouthings were absent for the overwhelming majority of cases (n = 403, 97 %); a single question mouthing was present in only 13 cases (3 %),[3] and there was not a single question that included multiple question mouthings. For content

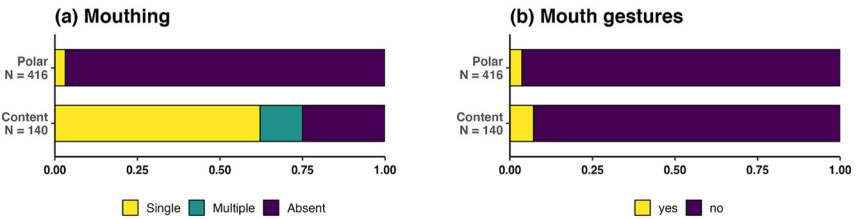


Figure 3: Distribution of (a) English mouthings and (b) mouth gestures used to signal questions.

3 The English question mouthings identified in these tokens are all mouthings of *wh*-signs used within polar questions, e.g., mouthing *what* in "know what I mean?".

questions, question mouthings were absent for only 35 tokens (25 %); all other tokens either had single question mouthings (n = 87, 62 %), or multiple mouthings (n = 18, 13 %). Figure 3(b) shows that mouth gestures were rarely involved in signalling questions in this dataset: the majority of polar questions (n = 401, 96 %) and content questions (n = 130, 93 %) were characterised by an absence of mouth gestures relating to question signalling.

5.5 Use of eye, eyebrow and head movements

For eye and eyebrow movements, our annotation system allowed for multiple eye or eyebrow movements to be annotated within a given question token. For example, we annotated if a question was signalled with an upward eyebrow movement followed by a downward movement, and/or whether the signer was squinting. There were a total of 410 question tokens (74 %) that occurred with a single eye and eyebrow movement. A much smaller number (n = 49, 9 %) involved multiple eyebrow movements. Ninety question tokens (16 %) were not accompanied by any discernible eyebrow movements. Seven tokens (1 %) were excluded from further analysis because the eyes were not visible enough to determine if an eyebrow movement occurred. As can be seen in Figure 4a, whether there were single, multiple, or no eyebrow movements was largely the same for polar questions and content questions. The majority of polar questions (n = 303, 74 %) and content questions (n = 107, 78 %) involved single eyebrow movements; very few polar questions (n = 66; 16 %) and content questions (n = 24, 18 %) had no eyebrow movements; and there was a slightly higher proportion of multiple eyebrow movements for polar questions (n = 43, 10 %) than content questions (n = 6, 4 %).

In considering what type of eyebrow movements were involved, we focus on the question tokens with only one eye or eyebrow movement, and only on the three most

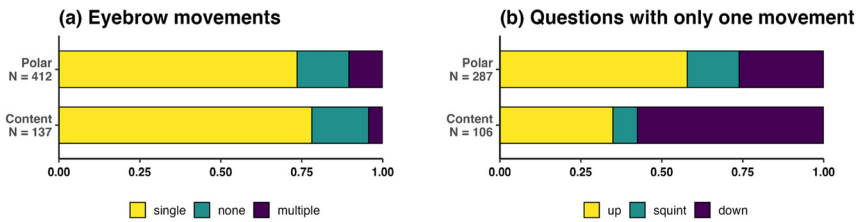


Figure 4: Distribution of (a) eyebrow movements and (b) type of eye and eyebrow movements for question tokens with only one eyebrow movement.

dominant types “up”, “down” and “squint” (see Figure 4b, n = 393). Content questions have proportionally more downward eyebrow movements (n = 61, 58 %) compared to polar questions (n = 75, 26 %). In contrast, polar questions showed proportionally more upward eyebrow movements (n = 166, 58 %) compared to content questions (n = 37, 35 %). There was overall a low number of eye squints, but these occurred proportionally slightly more often with polar questions (n = 46, 16 %) than content questions (n = 8, 8 %).

We used the same approach for considering head movements. Most question tokens involved single head movements, with similar proportions for polar questions (n = 241, 58 %) and content questions (n = 77, 55 %). There was a slightly higher proportion of polar questions with multiple head movements (n = 50, 12 %) compared to content questions (n = 4, 3 %). There were proportionally slightly more content questions (n = 58, 42 %) than polar questions (n = 125, 30 %) with no discernible head movement whatsoever.

In considering what type of head movements were involved, we focus on those questions with a single head movement. Since there were overall extremely low total counts of ‘up’ (n = 10) and ‘backward’ head movements (n = 8), we will not discuss these two types of movements with respect to their distribution in polar and content questions, and the totals in Figure 5b reflect this. Figure 5 shows the relative proportions for all other types of head movements in polar and content questions (n = 300). There were proportionally slightly more ‘sideward’ head movements for content questions (n = 13, 17 %) than polar questions (n = 21, 9 %). Polar questions in turn had proportionally many more nods (n = 122, 51 %) than content questions (n = 22, 29 %). The number of head shakes was similar for polar questions (n = 32, 13 %) and content questions (n = 11, 14 %). There were proportionally slightly fewer ‘forward’ head movements for polar questions (n = 36, 15 %) than content questions (n = 18, 23 %). Finally, the proportion of ‘down’ head movements was relatively similar for polar questions (n = 17, 7 %) and content questions (n = 8, 11 %). Taken

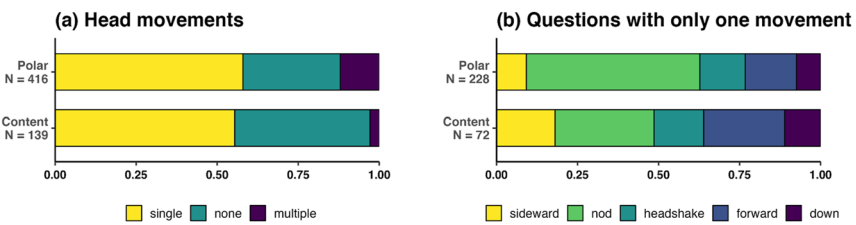


Figure 5: Distribution of (a) number of head movements and (b) type of head movements for question tokens with only one head movement (‘up’ and ‘backward’ not shown due to few cases).

together, this analysis of eyebrow movements and head movements suggests that polar and content questions do not differ that much from each other in terms of whether they occur with head or eyebrow movements. Rather, the type of movement differs much more strongly.

5.6 Use of multiple strategies for signalling polar and content questions

So far we have analysed various strategies for signalling polar and content questions in isolation. Now we consider signalling with multiple strategies in combination, such as whether an eyebrow movement was used together with a manual *wh*-sign to signal a content question. Figure 6 shows how many question tokens had zero, one, two or more distinct signalling strategies. The maximum that can be obtained was five strategies, i.e., a question token signalled using at least one manual question sign and any head movement, any eyebrow movement, any question-related English mouthing, and/or any question-related mouth gesture. As can be seen, most question tokens involved at least two strategies (404 tokens, 73 %). Comparably fewer question tokens relied on one encoding strategy (124 tokens, 22 %). Even fewer question tokens relied on none of the strategies quantified here (28 tokens, 5 %). These were tokens that may have been signalled using strategies that were not coded in this study, such as the use of sign repetitions to seek clarification; manual or non-manual sign holds at the end of a question; and freeze looks (see Floyd et al. 2016; Manrique and Enfield 2015).

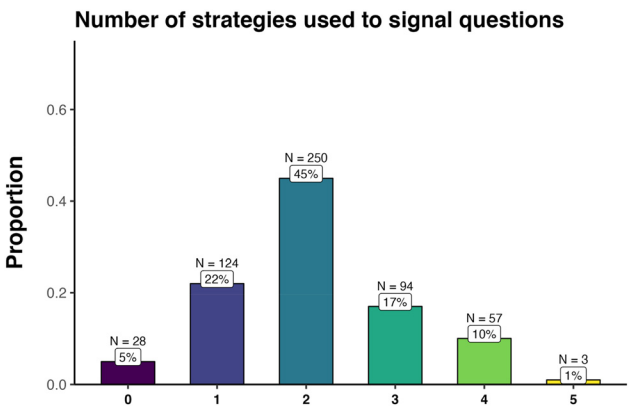


Figure 6: Number of strategies used to signal polar and content questions.

There was a clear difference between polar and content questions with respect to the number of strategies involved in question signalling. Nearly all content questions were signalled with two or more strategies (n = 130, 93 %), and only very few with just one strategy (n = 8, 6 %). Conversely, polar questions had a lower proportion of questions with multiple strategies (n = 274, 66 %), and correspondingly more questions signalled with just one strategy (n = 116, 28 %). The proportion of cases with zero strategies was low for both polar questions (n = 26, 6 %) and content questions (n = 2, 1 %). More detail about the combinations of strategies used to signal polar and content questions is described in Section 5.10.

5.7 Position of manual question signs in polar and content questions

Figure 7 shows the distribution of manual question signs in terms of their position within the polar or content question. It focusses only on those question tokens that include one or more manual question signs (n = 163, 106 content questions, 59 polar questions). For both types of questions, the most frequent distribution for the position of manual forms was the category 'other'. This includes, for example, tokens of single-sign utterances, where the only sign is a manual question sign, as well as utterances with multiple question signs that are not a reprise, i.e., two

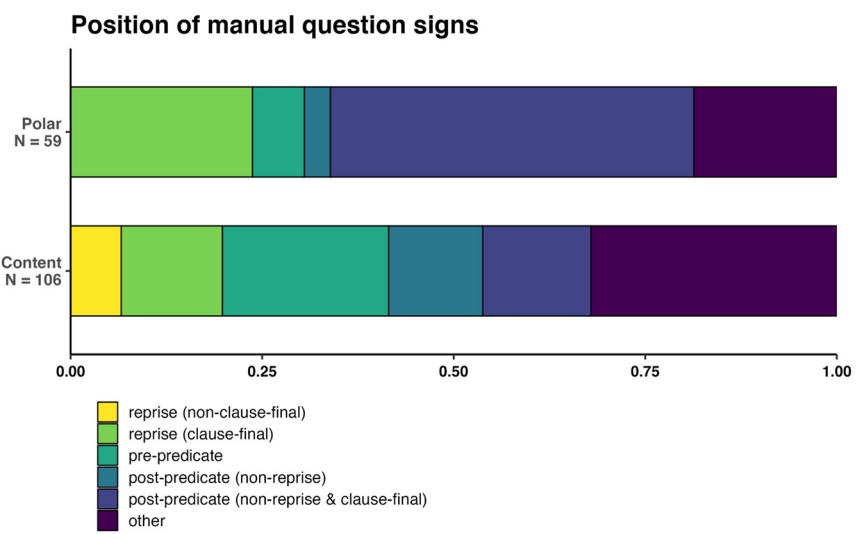


Figure 7: Position of manual question signs within polar and content questions.

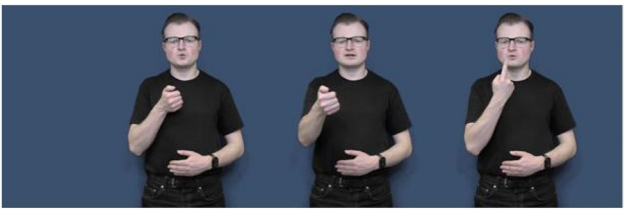
unique question signs. These tend to be questions with pointing signs at the start and end of the question, and questions that include manual question signs and PALM-UP – in other words, questions with manual forms that do not fit any of the other categories discussed in the literature and also annotated for this study. Beyond the category 'other', the most common pattern for both content and polar questions is for a manual question sign to occur post-predicate (non-reprise and clause-final), then pre-predicate. Finally, the least common positions for manual signs are reprise (non-clause-final), reprise (clause-final) and post-predicate (non-reprise).

In order to determine if BSL Corpus data can shed light on the *wh*-movement debate described in Section 2, we looked at the 27 tokens of pre-predicate question signs in more detail. Most of these question signs were adjuncts (signs such as WHERE, WHEN, WHY and HOW) rather than arguments. We did find four tokens of question signs WHO or WHAT in object position, such as Example (4).[4] These four tokens do suggest that question signs in object-initial position are not ungrammatical as claimed by Neidle et al. (2000). However, none of these four tokens had a clear overtly expressed subject and thus none were in the order of OSV. It may be that BSL Corpus data does not directly address the issue of object-initial orders involving question signs because these orders are not observed in the BSL Corpus dataset described here.

It is more important to interpret results about the position of manual question signs in light of how signers also use English mouthing to signal content and polar questions. For example, consider a question that contains an utterance-initial mouthed English *wh*-question form and a post-predicate manual question sign, as in Example (7). This is different to a question that contains a sole post-predicate manual question sign without English mouthing, as in Example (8). The former contains more conventionalised encoding regardless of syntactic position of the manual sign. These kinds of possibilities are frequent in BSL conversations. However, they were not recognised in earlier investigations of question signalling in signed languages. As the BSL Corpus data shows, both manual signs and English mouthing are important for investigations of questions in BSL. Thus, studies on the position of manual question signs need to also concurrently consider data on the occurrence and positions of English mouthing forms that signal questions.

4 Four tokens of pre-predicate *wh*-signs function as object are: LN23M33WDC_CLU#002, LN03F47WDC_CLU#012–14, BM08M18AHC_CLU#001 (Example [4]), MC24F64WHC_CLU#037.

(7) A BSL signer demonstrates a BSL content question with *wh*-mouthing.



Head	no head movement	
Eye & brow	down———	
Hand	TEXT	WHO
Mouth	*who text*	*who*
Translation	*who are you texting?*	

(8) A BSL signer demonstrates a BSL content question without *wh*-mouthing.

Head	no head movement	
Eye & brow	down———	
Hand	TEXT	WHO
Mouth	*text*	
Translation	*who are you texting?*	

5.8 Pragmatic context of polar and content questions

Several pragmatic factors may influence how BSL signers signal questions, including what was signed before it was produced and whether the question was requested by another person. In terms of the non-manual strategies used to signal questions, following Deuchar (1984) and noted in Section 2, we wanted to check if it may just be necessary for the polar or content question to look different from whatever the signer was doing with their face and body before asking the question. In other words, whether visible perceptual contrasts are important to question signalling, in addition to or instead of specific manual and/or non-manual forms for signalling questions. We were also curious if there was any effect on whether the question requested a response during a conversation from the other signer, e.g., if questions that did not

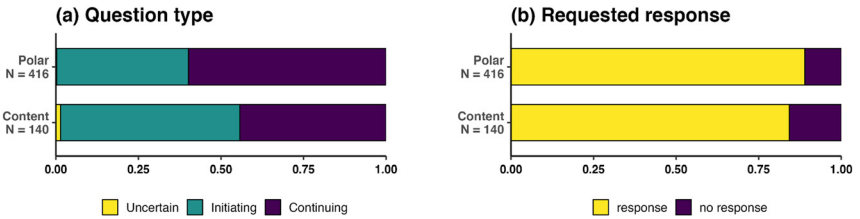


Figure 8: (a) Proportion of questions that were initiating or continuing, (b) proportion of questions that requested a response (yes/no).

elicit a response have something noteworthy about them. Therefore we annotated the Question tier to investigate whether signers' choices of manual and non-manual signalling may be influenced by what they were doing before and during their question utterance.

The Question tier included codes for whether a question was asked within a continuation of the signer's discourse, i.e., the signer was already signing and then asked a question, or if it occurred as a self-initiated turn, i.e., the signer was not signing, but instead interrupted the other signer or otherwise initiated their own turn by asking a question. Figure 8a shows that the majority of polar and content questions were asked by the signer who was already holding the floor at the time of asking a question (311 tokens, 56 %). Slightly fewer questions were asked by a signer interrupting or otherwise initiating a turn (242 tokens, 44 %). A small proportion of questions were not certainly identified as either continuing or initiating, or as questions at all (3 tokens, 1 %). Content questions were proportionally slightly more likely to be initiating (n = 76, 54 %) than polar questions (n = 166, 40 %). Polar questions were slightly more likely to be continuing (n = 249, 60 %) than content questions (n = 62, 44 %).

We also coded whether questions function as adjacency pairs requesting a response from the other signer, in order to filter out those questions that did not demand a response from the recipient during a conversation. Figure 8b shows that most questions did request a response (488 tokens, 88 %), while a few questions did not request any response (68 tokens, 12 %). Most of the latter were rhetorical questions, outlouds or enacted questions that did not seek a response. The majority of polar questions (n = 370, 89 %) and content questions (n = 118, 84 %) requested a response.

5.9 Question signalling as a function of sociolinguistic factors

We also explored the extent to which strategies for signalling both polar and content questions differ as a function of five sociolinguistic variables: whether the signer

grew up in a deaf or hearing family; whether the signer teaches BSL or not; and their age, gender, and region (Birmingham, Manchester, London, Bristol). We separated signers into a 'younger' and 'older' category based on a median split. For each of the sociolinguistic variables, we first established that each of the groups used a similar proportion of polar and content questions. This tells us that any differences in strategies between these groups may be due to different preferences, rather than resulting from using more or less content or polar questions within the corpus. The analyses of sociolinguistic factors reported in this section combine polar and content questions as otherwise numbers are too low when broken up by question type and the sociolinguistic factors. In other words, the following analysis looks at how question signalling in general differs as a function of sociolinguistic factors, regardless of the polar/content distinction.

We explored the data with Pearson standardised residuals to check if particular form features are over- or under-represented for any of the groups mentioned above, focusing on those results for which residuals are larger than |2| as a heuristic threshold to gain insight into this data. There were no such 'significant' over-or under-representations as a function of BSL teaching, deafness in the family, age, or gender. However, there was noteworthy regional variation, with signers from Birmingham and Manchester being more likely to not use manual question signs (83 % and 77 %) in comparison to Bristol (54 %) and London (62 %) signers. Conversely, Bristol and London signers were more likely to use either single or multiple manual question signs. Table 2 shows the total counts of manual question signalling, collapsed across the polar/content distinction, with standardised residuals in brackets.

Another aspect of question signalling that showed noteworthy regional variation relates to head movements. Table 3 shows the proportion of single, multiple and no head movements during question signalling (regardless of polar/content distinction), with standardised residuals in brackets highlighting

Table 2: Manual question signalling as a function of region (percentages are computed row-wise, within region); these figures collapse across content/polar type questions.

	Absent	Single	Multiple
Birmingham	83 % (+4.0)	14 % (−2.7)	3 % (−2.5)
Bristol	54 % (−4.4)	35 % (+4.0)	11 % (+1.3)
London	62 % (−2.4)	24 % (+0.8)	14 % (+2.8)
Manchester	77 % (+2.3)	17 % (−1.7)	6 % (−1.3)

Table 3: Head movement types as a function of region (percentages are computed row-wise, within region); these figures collapse across content/polar type questions.

	No head movement	Single	Multiple
Birmingham	38 % (+1.7)	53 % (−1.3)	9 % (−0.5)
Bristol	18 % (−3.9)	69 % (+2.9)	13 % (+1.3)
London	27 % (−1.5)	62 % (+1.2)	11 % (+0.5)
Manchester	43 % (+3.3)	49 % (−2.5)	8 % (−1.1)

patterns that deviate strongly from expectation (>|2|). A noteworthy pattern in this table is that Manchester signers showed a higher proportion of questions with no head movement (43 %) than Bristol (18 %) and London (27 %) signers. Proportionally speaking, Manchester signers performed fewer single head movements for questions (49 %) than signers from Birmingham (53 %), London (62 %) and Bristol (69 %).

Next, we zoom into what specific head movements the single head movements represent, looking at the same five most common categories – down, forward, sideward movements, or headshakes and nods – that we also analysed in Section 5.5. This revealed that Birmingham signers were somewhat more likely to perform sidewards head movements (standardised residual = +2.6), and correspondingly less likely to perform forward movements (–2.0). In terms of descriptive percentages, 20 % of single head movements for Birmingham signers were sidewards, as opposed to only 12 % for Bristol, 8 % for Manchester, and 6 % for London. Regarding forward head movements, Bristol (21 %), Manchester (21 %) and London (19 %) signers showed very similar proportions, compared to signers from Birmingham (10 %). Signers from Manchester showed fewer downwards movements (–2.1 standardised residual, 3 % of single head movements), compared to signers from Bristol (7 %), London (13 %) and Birmingham (7 %). Thus, there were regional differences both with respect to whether head movements were used (Manchester signers show fewer head movements), as well as with respect to which specific head movements featured in question signalling (Birmingham more sideward, fewer forward head movements; Manchester fewer downward movements).

In terms of whether questions occurred together with eye movements, signers from Manchester had the most questions without any eye movements (23 %), followed by signers from Bristol (17 %), London (16 %) and Birmingham (10 %) (see Table 4). In contrast, Birmingham signers showed the largest proportion of single eye movements (83 %), followed by signers from London (73 %),

Table 4: Eye movement as a function of region (percentages are computed row-wise, within region); these figures collapse across content/polar type questions.

	No eye movement	Single	Multiple
Birmingham	10 % (−2.6)	83 % (+2.7)	7 % (−0.9)
Bristol	17 % (+0.3)	72 % (−0.8)	11 % (+0.8)
London	16 % (−0.3)	73 % (−0.4)	11 % (+0.9)
Manchester	23 % (+2.5)	70 % (−1.7)	8 % (−0.7)

Bristol (72 %) and Manchester (70 %). There were no stark differences in the use of multiple eye movements, which showed similarly low proportions for all four groups.

Focusing on singular eye movements that were either "up", "down" or "squint" (the three most common categories, see Section 5.5), Table 5 shows that Birmingham signers used squints proportionally more often (54 %) than up (21 %) or down (25 %) eye movements. Manchester showed a similar pattern, with a higher proportion of squints (56 %) and correspondingly fewer up (16 %) or down (28 %) movements. London signers also used squints frequently in question signalling (55 %), but they showed a much stronger preference for downwards eye movements (43 %) compared to the other regions, and correspondingly very few up movements (3 %). Bristol patterned similar to London, but with even more down movements (56 %) and even fewer squints (41 %), and similarly low numbers of up movements (4 %). Overall, these results suggest that Birmingham and Manchester signers pattern more closely together with respect to manual signs (Table 2), as well as with respect to eyebrow movements. This mirrors similar sociolinguistic patterns for clause negation in BSL, suggesting a possible difference between northern and southern regions in the UK (Hodge et al. under review).

Table 5: Eye movement types (three most common types of single eye movements) as a function of region (percentages are computed row-wise, within region); these figures collapse across content/polar type questions.

	Down	Up	Squint
Birmingham	25 % (−2.6)	21 % (+0.3)	54 % (+3.2)
Bristol	56 % (+3.5)	4 % (−1.9)	41 % (−2.2)
London	43 % (+1.7)	3 % (+0.4)	55 % (−3.1)
Manchester	28 % (−1.7)	16 % (+0.8)	56 % (+1.3)

5.10 Multiple correspondence analysis of all strategies for signalling polar and content questions

So far, the only analysis that has considered multiple strategies for signalling questions has lumped all encoding strategies together into a simple count variable (see Section 5.6). This revealed the dominant pattern is for signers to use multiple strategies with 73 % of cases, with the remaining questions relying on a single strategy for signalling a question, or a strategy that was not quantified in this study. In this section, we consider if and how specific strategies co-occur within polar and content questions.

We used Multiple Correspondence Analysis (MCA) to assess these co-occurrences. This method can be used to investigate the structure of associations between all the categorical variables together. MCA is a dimension reduction technique similar to Principal Component Analysis (PCA), but for categorical data. It allows us to reduce a large number of categorical variables to a smaller number of dimensions based on whether those categorical variables are associated with each other. In order to do this, all strategies relating to how questions were signalled (e.g., head movements, manual question signs) were split into a binary (yes/no) predictor variable. This meant that some of the more complex variables were broken up into their individual components. For example, the head movement variable was broken up into a variable 'Head-Forward' coding for whether the head moved forward or not, another variable 'HeadNod' whether there was a nod or not, and so on. Consequently, the form features annotated in the BSL Corpus dataset were broken up into 16 different binary variables. All 16 variables were input into the Multiple Correspondence Analysis (see Figure 9).

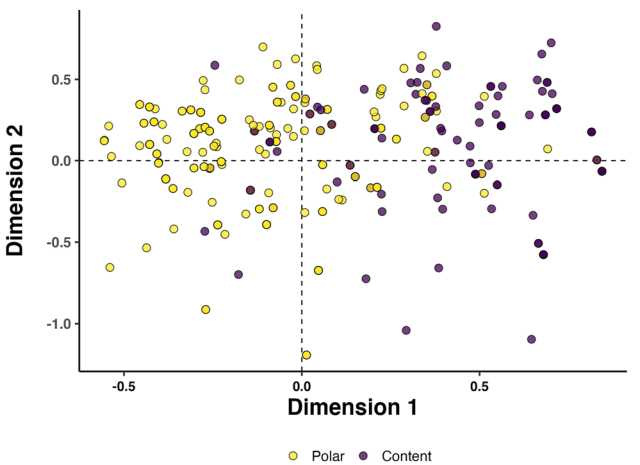


Figure 9: Multiple correspondence analysis of all categorical variables.

Figure 9 shows how particular question tokens are situated in the two-dimensional space spanned by the first two dimensions resulting from the Multiple Correspondence Analysis (dimension 1 captures 11 % of the variation in strategies; dimension 2 captures 10 %).[5] Each dimension will be explained in turn. Looking at the contributions to the first dimension showed that the presence of a single mouthing and the presence of a single manual sign latched strongly onto this dimension; they contribute 20 % and 15 % of the definition of this variable, respectively. Moving from left to right along the *x*-axis of Figure 9, we can see that dimension 1 separates polar questions (fewer single mouthings and fewer single manual signs) from content questions (more single mouthings and more single manual signs), although there is also overlap. It should be emphasised that the MCA does not "know" about the polar/content type distinction, and only investigates which strategies are statistically associated with which other strategies. Dimension 1 shows that mouthings and manual signs strongly go together, and our visualisation with separate colours for polar and content questions shows that this happens to also strongly differentiate the two question types.

The second dimension is most strongly defined by the absence of eye or eyebrow movements (23 % of the definition of the dimension), as well as by the absence of head movements (14 %). This shows that questions that have no eye or eyebrow movements also tend to have no head movements (high values on dimension 2). However, when we colour each data point separately for question type, we can see that dimension 2 does not allow us to distinguish easily between polar and content questions. Altogether, this analysis suggests that of all the form features that distinguish polar and content questions, the presence or absence of mouthings and manual signs (dimension 1) is most important, and these two variables are associated with each other. Head and eye or eyebrow movements are also associated with each other, but in comparison less distinctive with respect to the polar/content question distinction.

5.11 Random forest analysis of all strategies for signalling polar and content questions

We then used all variables as predictors to assess whether specific strategies allow predicting whether a question is a polar question or content question. This analysis also allows us to do two things: first, we can assess how successful question type can be predicted from form features alone; second, we can assess which strategies are

5 The fact that the first two dimensions only capture 21 % of the variation in strategies for signalling questions together suggests that there is overall much variation in the data that cannot be explained by the MCA.

Table 6: Random forest analysis of content and polar questions in the BSL dataset.

	Predicted class	
	Content question	**Polar question**
Content question	105	35
Polar question	13	403

most predictive of question type. For this analysis we used random forests, a machine learning algorithm that performs well in situations when there are many potential predictors to consider and these are potentially collinear, such as when question tokens with manual signs are more likely to have English mouthings. The random forest is trained on predicting the polar vs. content question distinction from all 16 different binary form feature variables. Table 6 cross-tabulates whether the token question was a polar or content question (rows) against the predicted class (columns). Overall, accuracy was very high with 91.4 % accuracy in predicting the polar/content distinction from presence of strategies alone. The out-of-bag prediction error is 8.6 %, suggesting that this analysis would generalise well to unseen data.[6]

Figure 10 shows the variable importances for the top ten most predictive strategies. The absolute values of this variable importance measure are not interpretable, i.e., this statistic only yields insights into the relative importance of different strategies with respect to each other. There was a clear pattern where the presence/absence of mouthing and the presence/absence of manual signalling were vastly more predictive of the polar/content question distinction than any other variables. This suggests that these two form features are most important for the difference between polar and content questions. In fact, if one uses mouthing as sole criterion for whether a question is polar or content, one would be correct 91.4 % of the time in classifying a question as one of these two types. Using manual question signs as a sole criterion would lead to a correct classification 83.3 % of the time for this dataset.

The random forest analysis corroborates the picture painted by the MCA, even though both approaches are conceptually very different. The MCA looks at correlations between strategies; the random forest analysis tries to predict question type from strategies. Together however, both analyses show that content questions

6 A caveat with this analysis is that the random forest pools all data, not differentiating signers. This means that individual variation is unaccounted for, and the out-of-bag prediction error is likely underestimated.

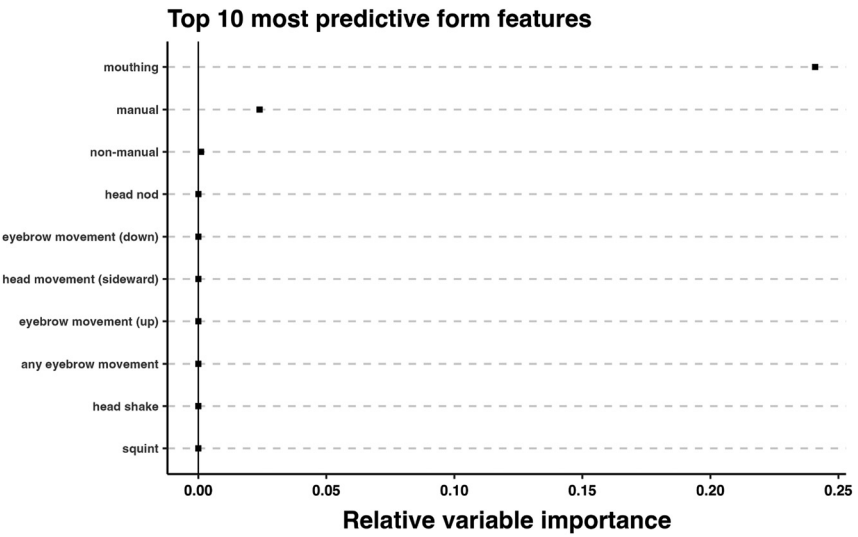


Figure 10: Relative variable importances for the top ten most predictive predictors in the random forest analysis.

are associated with English mouthings and manual signs, in contrast to polar questions. It also shows that *in comparison to the overwhelming importance of manual signs and mouthings*, non-manual eye, eyebrow and/or head movements are relatively much less important in distinguishing content and polar questions. This is not to say that there are not clear differences between content and polar questions for these other variables, as revealed by our descriptive analysis; however, when everything is taken together, highly conventionalised mouthings and manual signs dominate the polar/content question type distinction.

6 Discussion

6.1 Overview of findings

In this study, we used descriptive and exploratory statistical methods to investigate how BSL signers signal polar and content questions in conversation data in the BSL Corpus. Based on a subset of 623 tokens of polar and content questions analysed here, we found that polar questions are more frequent in dyadic conversations than content questions, and that almost all questions involve non-manual signalling, including eye and eyebrow movements, head movements, and English *wh*-

mouthings. A major finding is that multiple strategies are most often used to co-signal question types, which means that any theory or analysis where the differentiation of question types primarily relies on, or overly emphasises just one of these strategies – as is built into the manual versus non-manual marking paradigm – is missing a lot.

The main differences between polar and content questions relate to signers' use of manual *wh*-question forms and mouthing of English *wh*-question forms. Content questions were more likely to involve single or multiple manual *wh*-forms. The most common position of these *wh*-signs within content utterances can be described as 'other', which ranges from questions consisting of one manual *wh*-form (i.e., a single-sign utterance), to questions with both manual and mouthed English *wh*-question forms, to questions with multiple manual *wh*-forms in more than one syntactic position in a multi-sign utterance, either with or without mouthed English *wh*-forms. Next most common was for manual *wh*-question forms to occur in post-predicate positions, then pre-predicate. Other positions (e.g., reprise) were also observed. If polar questions did include manual question forms, these were not *wh*-forms, but instead other manual strategies not analysed here (see Section 5.6). Content questions were also more likely to include single or multiple English *wh*-mouthings, while these were largely absent for polar questions.

Taken together, the data on manual question and English mouthing *wh*-forms present a more complex picture of question signalling than has been previously reported for BSL or other signed languages, especially for the signalling of content questions. These data indicate that theoretical investigations of *wh*-sign positions, such as the debate about *wh*-movement under generative analyses, may be over-simplified by focusing solely on manual question signs and non-manual brow, eye and head movements. Instead, this data from the BSL Corpus demonstrates how claims regarding the position of manual question *wh*-forms should also take into account the presence or absence of mouthed English *wh*-forms for signed languages with English as the majority ambient language. Likely signed languages with other ambient spoken languages should consider this too. Most importantly, analysis of corpus data illustrates just how problematic it can be to base theoretical analyses on a few judgements of isolated, contrived examples.

Following typological investigations of questions in signed languages, we also investigated signers' use of non-manual signals such as eyebrow and head movements. We found it is most common for questions to be signalled using just one type of eyebrow and/or head movement, regardless of whether it is a polar or content question. With respect to the type of movements, content questions were more likely to have downward eyebrow movements, whereas polar questions more likely to have upward eyebrow movements. If there was no discernible head movement, these were most likely content questions. Nods were more likely to be used in polar questions, as were eye squints, which were infrequent overall. Questions with

multiple eyebrow and/or head movements tended to be polar questions. Yet all types of eyebrow and head movements were identified in both polar and content questions, and none of these strategies differentiated between polar and content questions as strongly as manual and mouthed English *wh*-forms did.

We also considered how these different manual and non-manual strategies are combined within question tokens. Most question tokens involved at least two strategies; fewer relied on only one strategy. Nearly all content questions were signalled with two or more strategies, and only a very few with just one strategy. Conversely, polar questions had a lower proportion of questions with multiple strategies, and correspondingly more questions signalled with just one strategy. It is interesting to observe that the less frequent question type (content questions) is signalled with more strategies than the more frequent type (polar questions), as discussed in Section 5.6. This is in line with what has been observed for spoken languages, where frequent forms generally tend to be shorter, or less marked (Piantadosi et al. 2011; Zipf 1949). The proportion of cases with zero strategies (i.e., strategies observed in the data but not coded for this study) was low for both polar and content questions.

Overall, analysis of manual and non-manual question signalling in BSL suggests that this traditional binary distinction is too simplistic. The data presented here instead suggest that it is the presence or absence of conventionalised *wh*-forms that most strongly differentiates content from polar questions in BSL, and that these can be signed and/or mouthed. While mouthing played a large role in the BSL Corpus with especially content questions, mouth gestures did not. It is possible that the mouth gestures coded in the data have other more primary functions beyond question signalling, perhaps relating to stance, expressions of uncertainty, and/or disapproval.

6.2 Other factors influencing question signalling in BSL

The majority of the questions analysed here were produced from one of the parties during dyadic conversations and requested some type of response from the other signer. We checked if the interactional context of questions might have an effect on how questions were signalled, such as whether the question was asked by someone holding or interrupting a turn. Most questions were asked by the signer who was holding the floor, and fewer were asked by the signer interrupting or otherwise initiating a turn. Content questions were slightly more likely to be used to initiate a turn than polar questions, whereas polar questions were more likely to be used in continuing a turn. This indicates something of the conversational nature of the

interaction and how different types of questions may be driven by the demands of solving problems of understanding within the interaction.

When one of the parties during an interaction does not understand or does not see what was signed before, they might initiate repair to fix the problem using a question-like form. These questions index a prior moment in a given conversation, and function as a way to confirm or check understanding (e.g., *Do you mean X?*, *Tonight?*). On the other hand, questions that initiate a new topic or ask for new information via standard content questions do not deal with problems of seeing or understanding when they are not related to what was signed before by the other signer. Note that *wh*-question signs are often used to initiate repairs during conversation, but in relation to what was said previously, such as asking *What? Who? When?* (see Manrique 2016, 2017 for more details).

Some of the manual question forms included in the current study, such as PALM-UP and some kinds of pointing signs, are different from the traditional *wh*-question forms typically considered in the signed language literature, i.e., manual signs meaning *who*, *what*, *when*, etc. These may have been identified as having a question function in the context of other signals that we did not code for in the current study such as manual holds or freeze looks (Floyd et al. 2016; Manrique and Enfield 2015). This would make sense given that PALM-UP and pointing signs are known to regulate interaction, in addition to holds and freeze looks (Cooperrider et al. 2018; Ferrara 2020). In future research, it would be useful to also code for holds and freeze looks to empirically determine their role in question signalling in BSL (see Manrique 2016, 2017 for LSA). During conversational interactions, polar questions and content questions are also often used to check, confirm and repair problems of understanding (Dingemanse et al. 2015). The previous literature on questions in signed languages has largely ignored repair-type questions, and addressee signing in general. The results of this study and other work on other-initiated repair perspectives in signed language interaction all highlight the importance of distinguishing the pragmatic functions or everyday use of questions in face-to-face conversation (Byun et al. 2020; Manrique 2017; Skedsmo 2021).

A major benefit of corpus-based investigations is the possibility to check the role of sociolinguistic factors in various identified patterns of use. The corpus data analysed here suggests that Birmingham and Manchester signers pattern more closely with each other than with London and Bristol signers, with respect to their use of manual *wh*-forms and eyebrow movements. This north/south England divide mirrors sociolinguistic patterns for how clause negation is signalled by signers from these regions (see Hodge et al. under review) and north/south England distinctions found in mouthing in BSL (Proctor and Cormier 2023). However, with the possible exception of region, there were no strong patterns that could be described by any of

the sociolinguistic variables accounted for in this study. We therefore conclude that most of the patterns for signalling questions may instead be driven by interactional demands such as repair described above rather than any sociolinguistic factors analysed here. A clear example of this is the increased use of mouthing and other non-manual signs, such as head movements and more marked use of eyebrows, in repair practices (see Manrique 2016, 2017, for more details). This is attributed to the distinct interactional demands associated with repair. In conversation analysis, repair refers to the processes by which participants address problems in speaking, hearing (signing and seeing) and understanding that arise during interaction (Manrique 2017). Participants often need to clarify or emphasise the entire message or part of it to ensure mutual understanding.

Another benefit is the possibility to conduct exploratory analyses on all data points annotated. We used MCA to identify any strong associations between the different strategies used to signal polar and content questions. MCA suggests that single manual and single mouthed English *wh*-forms are strongly associated and together account for a significant amount of the difference between content and polar questions. It also suggests an association between the presence/absence of eyebrow and head movements, but these associations do not strongly differentiate between content and polar questions. It is enough to say that both are present (or absent) in both types of questions.

We also used random forest analyses to assess whether individual strategies may predict whether a question is a polar or content question. The presence/absence of manual *wh*-forms and mouthed English *wh*-forms was strongly predictive of content questions compared to any other variables annotated and analysed here. In other words, these two forms of signalling are most important for differentiating between polar and content questions in BSL. Content questions are strongly signalled using manual and mouthed *wh*-forms, in contrast to polar questions, which are not. The random forest analysis also predicts that eyebrow and head movements do not distinguish between polar and content questions. Instead, signers' use of highly conventionalised manual and mouthed *wh*-question forms are what makes the difference.

Some of the findings from this study align with what has been claimed in earlier studies of polar and content questions in signed languages. For example, where there was a single eyebrow movement, we found a preference for content questions to use furrowed brows and for a preference for polar questions to use raised brows (Zeshan 2004, 2006). Yet we also found brow and head movements to be plurifunctional across question types, similar to more recent studies such as Lajolinna (2021) and Puupponen (2019). More specifically for BSL, we find consistencies with Deuchar (1984) and Sutton-Spence and Woll (1999), who observed that while raised and

furrowed eyebrows are typical of polar and content questions in BSL respectively, these can be overridden by other factors. Additionally Deuchar noted that a contrast with non-manual movements occurring just before the question may be more important than specific eyebrow positions. The BSL Corpus data appear to be consistent with these observations.

The main differences we find in the current study compared to earlier studies stem from using an interactional dataset, identifying not only grammatical functions, but also pragmatic functions that reflect language practices in conversation. Regarding the grammatical aspects of polar and content questions, we considered English mouthing in addition to manual question signs, in distinguishing content from polar questions. In relation to pragmatic functions, this study identifies multiple social actions such as repair practices, and whether a given question is answered or not, among other interactional aspects. This highlights the need to consider a wider range of factors in the study of questions in signed languages beyond those features already known to contribute to question signalling.

Overall, the patterns of question signalling we find in BSL mirror patterns identified for many spoken languages that use conventional *wh*-question forms (whether lexical items or mouthing) to differentiate content from polar questions. In terms of facial expressions and head movements, the fact that multiple eyebrow and head movements (rather than single, particular movements) distinguish polar from content questions suggests that these features are complex and plurifunctional. This may also relate to brow and head movement used by both signers and non-signers when asking questions (Campbell et al. 1999). This study has also shown that to have a better understanding of questions it is crucial to look at questions within an interactional context and not as isolated occurrences limiting the functions of question formats to confirming or asking for new information. As it has been shown in previous studies (e.g., Manrique 2016), problems of understanding are common in everyday interaction and prompt the use of question-like formats that play a different role in communication (e.g., *Huh? What? Could you repeat that?*).

While this study focused on the syntactic and semantic aspects of question signalling in BSL, we also considered the pragmatic context, specifically whether a given question initiated an adjacency pair by requesting a response from another interlocutor. This has been relevant for considering differences between 'proper' questions in conversation in spoken language literature, based on conversational structure units as question-answer sequences (Sacks et al. 1974). For example, whether questions request information or request confirmation from another person during interaction is important, compared to rhetorical questions or question-answer sequences that are re-enacted within a depiction of a previous interaction that do not seek a response from the current interlocutor.

Although such questions in the BSL Corpus dataset were not analysed here, we can confirm there were no syntactic or semantic differences to the findings outlined above, i.e., the same patterns described above for polar and content questions are also present in rhetorical and enacted questions. However, from a conversation analytic approach, these types of questions represent distinct practices that influence the unfolding of interaction and the roles of the participants (see Heritage 2010; Stivers and Enfield 2010). As Schegloff (2007) and Heritage (2012) have highlighted, the context and interactional purposes of questions significantly impact their role and function within conversation. Understanding the nuances and variations in question practices is crucial for a comprehensive analysis of conversational dynamics and the diverse functions that questions can serve (Clayman and Heritage 2002). This will form the basis for a later study building on the current dataset.

6.3 Limitations

This study has two main limitations. The first limitation relates to the type of data collected, which involved dyadic interactions filmed in a language lab environment. Future studies should continue contributing and building on our understanding of everyday interaction in signed languages by looking at both dyadic and multiparty interactions and across different social contexts, including those where participants engage in other social actions while interacting in more natural settings, such as eating together, working together, etc. (see e.g. Danet et al. 2023; Manrique 2016; Shaw 2019). The second limitation relates to the focus on quantitative methods of analysis. This leaves some open questions unanswered, which might benefit from complementary qualitative approaches such as Conversation Analysis and Interactional Linguistics. These approaches would be useful for clarifying further the quantitative findings described here, bringing new insights into the discussion and understanding of questions in signed languages more generally.

These two limitations are related. For example, this study found that polar and content questions in BSL may be signalled with all types of eye, eyebrow and head movements. However, we do not yet know if these different non-manual movements might be essential for different types of conversational functions. Examples might include standard questions when asking someone else for new or more information versus initiating repair on someone else's prior turn due to problems of seeing or understanding (Manrique 2016, 2017). Each function employs different conversational practices that might provide a better understanding of the use of non-manual movements in relation to the use of question-like formats, compared to syntactic or other factors that have been prioritised in the signed language literature so far (see Manrique 2016, 2017).

7 Conclusions

Quantitative analysis of conversational data in the BSL Corpus suggests that grammaticalisation (cf. "marking") does not explain signer's choice of non-manual movements for signalling polar and content questions. Non-manual eye, eyebrow and/or head movements do not distinguish between content and polar questions. Instead, English *wh*-question mouthing and manual BSL *wh*-signs are the strongest indicators of polar and content questions. Furthermore, content questions are more likely to be signalled with two or more manual and/or non-manual strategies, while polar questions are more likely to be signalled with just one strategy. Sociolinguistic variables such as region, age and gender do not really explain this variation. It is the presence or absence of conventionalised *wh*-forms that most strongly differentiates content from polar questions in BSL, and these can be signed and/or mouthed. These findings paint a more complex picture of question signalling than has been previously reported for BSL or other signed languages, especially for the signalling of content questions, while also illustrating how signed language corpora can assist the usage-based description and analysis of questions from both grammatical and interactional perspectives.

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Author contribution: KC, GH and EM conceptualised and designed the study. GH, MB and EM annotated, revised and processed the question study data. BW and GH performed the statistical analysis. GH created the example figures. GH wrote the first draft of the manuscript, BW wrote the statistical analysis, KC and EM contributed extensively to further drafts. All authors contributed to interpreting the results and revising the reviewed manuscript.

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