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The impact of interaction on variation in Zinacantec Family Homesign

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Emerging sign languages provide the opportunity to observe the process by which signers create and converge on a lexicon. Some studies report that emerging sign languages exhibit more lexical and sub-lexical variation than their longer-established counterparts, which has been interpreted as evidence for a lack of conventionalization. However, a growing body of recent literature takes the view that this variation is not random but rather shaped by the social organization of the signing community. The present study aims to test the hypothesis that variation is conditioned by frequency of interaction, focusing on Zinacantec Family Homesign ('Z sign'), a sign language developed over the past four decades by members of an extended family in an indigenous community of southern Mexico. The investigation takes into account both lexical variation and sub-lexical variation, across signers as well as within individual signers over time. These quantitative data are interpreted in terms of a model of the family as a sociolinguistic community that can be sub-divided according to patterns of interaction among different members of the family. This study contributes to the literature on variation in micro-community sign languages by examining the impact of interaction on the distribution variation at two levels of linguistic organization in an almost maximally small linguistic community.



1 Introduction

A burgeoning field of inquiry in sign language research seeks to elucidate how variation is shaped by the social organization of the signing community (Meir et al. 2012; de Vos & Pfau 2015; Schembri et al. 2018; Brentari et al. 2021; Lutzenberger et al. 2023). This development is part of the increasing amount of scholarship on ‘micro-community sign languages’ (used by small-scale rural communities), which stand in contrast to ‘macro-community sign languages’ (used by large-scale, urban communities).¹ Micro-community sign languages exhibit striking differences in linguistic organization from their larger, urban counterparts, which are potentially attributable to factors related to the composition of the signing community such as time-depth, population size, ratio of deaf to hearing signers, and the use of sign language in formal education. As a result, studies of micro-community sign languages have challenged earlier generalizations about the visual-modality based exclusively on macro-community sign languages (Aronoff et al. 2004; de Vos & Pfau 2015; Lutzenberger et al. 2021; 2023).

One ongoing area of debate is the nature of variation in micro-community sign languages. Several studies have reported that micro-community sign languages are characterized by a higher degree of unpredictable lexical and sub-lexical variability than their macro-community counterparts (Washabaugh 1986; Israel & Sandler 2009; Sandler et al. 2012). That is, signers frequently use different signs for the same concept, and even when they do use the same sign, the phonetic form of those signs is often highly divergent. These studies argue that this variability reflects a lack of conventionalization that can be attributed to the social conditions under which the languages developed. For instance, small communities may tolerate more variation since signers can simply memorize each other’s linguistic idiosyncrasies (de Vos 2011; Thompson et al. 2019).

However, these studies have been critiqued as displaying a bias in how they interpret variation in micro-community sign languages (Lutzenberger et al. 2023). Variation in macro-community sign languages, as in spoken languages, is typically explained in terms of sociolinguistic variables such as region, age, gender, or ethnicity (Lucas et al. 2001; Schembri et al. 2010; McCaskill et al. 2011; Stamp et al. 2014). Yet studies of micro-community sign languages have been quick to conclude that variation in these languages is essentially random, reflecting that they have yet to complete the process of conventionalization. This assumption is tied to a teleological view of language emergence in which there is a development from idiosyncratic gestural communication characterized by a high degree of variability towards full-blown languages with only structured sociolinguistic variation (Lutzenberger et al. 2023).

¹ Macro-community sign languages are also known as *Deaf community* or *urban* sign languages, while micro-community sign languages are also known as *village*, *rural*, or *shared* sign languages (see Moriarty & Hou 2023 for a critical overview of terminology for sign languages and signing communities).

Several recent studies have sought to show that variation in micro-community sign languages is a structured reflection of their linguistic ecologies, i.e. the social conditions in which they are used (Mudd et al. 2020; Lutzenberger et al. 2021; Horton 2022; Lutzenberger et al. 2023; cf. Nyst 2012). These studies take advantage of the small population and relative geographic boundedness of micro-community sign languages, which enable investigators to make detailed ethnographic observations about the communicative practices of the community, thereby enriching the interpretation of quantitative variation data. In all of these studies, patterns of communicative interaction—who signs with whom and how frequently they do so—have been shown to influence variation. These results suggest that at this early stage of conventionalization, patterns of interaction may have a larger impact on the extent to which signers converge on linguistic forms than social variables such as age, gender, or hearing status.

The present study aims to test the hypothesis that variation is conditioned by frequency of interaction, focusing on Zinacantec Family Homesign ('Z sign'), a sign language developed over the past four decades by members of an extended family in an indigenous community of southern Mexico (Haviland 2020a; German 2024a). The investigation takes into account both lexical variation and sub-lexical variation, across signers as well as within individual signers over time. These quantitative data are interpreted in terms of a model of the family as a sociolinguistic community that can be sub-divided according to patterns of interaction among different members of the family. This study contributes to the literature on variation in micro-community sign languages by examining the impact of interaction on the distribution of variation at two levels of linguistic organization in an almost maximally small linguistic community.

2 Emerging sign languages

In contrast to hearing children, nearly all of whom acquire at least one spoken language from birth, less than five percent of deaf children receive equivalent exposure to a signed language (see Mitchell & Karchmer, 2004 for US-based statistics). Deaf individuals who are unable to access spoken language and who have not acquired a conventional sign language due to isolation from an existing community of signers often create idiosyncratic sign systems to communicate with those around them (Goldin-Meadow & Feldman 1977). These *homesign systems* exhibit language-like structure in a variety of domains, including hierarchical structure at the levels of the word (Goldin-Meadow et al. 1994) and sentence (Goldin-Meadow, 1982), and strategies for negation and question formation (Franklin et al., 2011). Crucially, the structural properties of homesign systems are not observed in the gestures produced by the hearing caregivers of deaf children (Goldin-Meadow & Mylander 1984; Flaherty et al. 2021). Accordingly, these findings have been interpreted to indicate that the linguistic properties of homesign systems are generated by the deaf children themselves. These properties have been referred to as “resilient” properties of language” since they develop even in the absence of linguistic input (Goldin-Meadow 1982;

2003) and therefore potentially reflect innate features of the language capacity (but see Goico & Horton 2023 for a discussion of contested issues in homesign research). Notably, there are conflicting findings regarding whether homesigners possess a stable lexicon: Goldin-Meadow et al. (1994) find that they do, while Richie et al. (2012) find that they do not.

When deaf individuals who do not share a conventional language come together to form a new community, they are likely to develop a sign language (Meir et al. 2010; Brentari & Goldin-Meadow 2017; Le Guen et al. 2020). Notably, differences in lexical and grammatical organization have been reported across sign languages developed in communities that vary in such factors as geographic setting, population size, and the use of sign language in educational and professional contexts. These differences indicate that there may be a relationship between community structure and language structure (Meir et al. 2012; de Vos & Pfau 2015).

In recent years, however, linguistic and anthropological work has begun to encompass an increasingly diverse range of signing communities, leading some scholars to question claims of a straightforward relationship between community structure and language structure, as well as the ideologically- and politically-loaded nature of grouping sign languages into discrete categories based on the settings in which they developed or are used (Nyst et al. 2012; Kusters et al. 2020; Hou & de Vos 2022; Moriarty & Hou 2023). For example, different signing practices are sometimes placed on an evolutionary cline in which macro-community sign languages are considered ‘fully-developed languages’, and other kinds of sign languages (homesign, micro-community sign languages, etc.) are considered less than fully-developed (Nyst 2012; Kusters et al. 2020). Given their increasing ethnographic sensitivity, some researchers working with deaf and signing communities around the globe have shifted away from the perspective that language emergence is a linear, teleological process, and toward one that views the characteristics of a sign language as an adaptation to its linguistic ecology (Nyst 2012; Hou 2016; Horton 2022; Lutzenberger et al. 2023).

3 The impact of community characteristics on lexical and sub-lexical variation

A considerable body of literature has explored the impact of community characteristics on the structure of spoken languages. Scholars have pinpointed the following characteristics as those which are likely to impact linguistic organization: community size (Hay & Bauer 2007; Atkinson 2011; Dahl 2011; Wichmann et al. 2011), social network structure (Milroy & Milroy 1985), and the relative frequency of intra-group versus inter-group communication (Trudgill 1989; Wray & Grace 2007). These interrelated factors relate to the relative predominance of two modes of communication, referred to by Wray & Grace (2007) as “esoteric” and “exoteric” communication, in different linguistic communities. Communities in which esoteric communication predominates are generally smaller and therefore have denser social networks and a higher degree of social/

cultural homogeneity. As a result, there may be fewer opportunities for outsiders to enter the community and learn the local language as a second language; rather, most users of the language will have acquired it natively in childhood. Communities in which exoteric communication predominates have the opposite features: large, dispersed, diverse populations with higher proportions of adult second-language learners. Languages used by communities in which esoteric communication predominates often exhibit a high degree of grammatical and semantic complexity and irregularity. By contrast, languages used by communities in which exoteric communication predominates tend towards grammatical regularity and semantic transparency, due to the learning biases of children versus adults, respectively. Children, who make up the majority of language learners in predominately esoteric communities, tend to preserve irregularity. By contrast, adult learners, who are more numerous in predominately exoteric communities, favor regularity and compositionality. Similar proposals have been made by Lupyan & Dale (2010) and Trudgill (2011).

In the sign language literature, a related line of research investigates how lexical and sub-lexical variation are shaped by community size. The studies reviewed in the remainder of this section constitute an ongoing debate to which the present study attempts to contribute. The debate centers not only around the factors that influence variation, but also on issues of how to measure variation and interpret variation in light of differences in social organization across signing communities. In particular, does variation in micro-community sign language reflect a lack of conventionalization, or is variation systematic, as in larger communities?

Early studies reported that micro-community sign languages exhibit more lexical variation than would be expected of macro-community sign languages (de Vos 2011; Meir et al. 2012). Several potential reasons for this have been proposed. First, the small size of rural signing communities may allow signers to keep track of each individual's idiosyncratic lexical variants (de Vos 2011; cf. Thompson et al. 2019, who arrive at a similar conclusion via computational simulation of the effect of community size on lexical conventionalization). This may be reinforced by the fact that micro-community sign languages tend not to be used in formal education, resulting in less pressure to develop standards of form (de Vos 2011; Meir et al. 2012). Second, members of small communities share a greater degree of common ground, which may permit more variation since individuals may be able to recover the intended meaning of a sign from context. Relatedly, given that signed communication in such communities is primarily conducted face-to-face, signers can refer to locations or entities by pointing at them, obviating the need for conventional lexical items.

However, these conclusions were based on limited evidence. De Vos (2011) focused on one domain of the lexicon, color terminology, and found that Kata Kolok (KK, a rural sign language of Indonesia) has far fewer conventionalized color terms than larger, urban sign languages. Her analysis does not extend to the lexicon of this language in general. Meir et al. (2012) compared Israeli Sign Language (ISL) and Al-Sayyid Bedouin Sign Language (ABSL), two sign languages

of approximately equal time-depth, both used in Israel. However, ISL is used by a relatively large, national Deaf community, while ABSL is used by residents of a single village who practice endogamous marriage, which contributes to the maintenance of a high incidence of genetic deafness (Kisch 2012). They report more lexical variation in ABSL but provide only anecdotal evidence for this claim.

Later studies that incorporate quantitative measures of lexical variation challenge the notion that there is a straightforward relationship between community size and degree of lexical variation. Lutzenberger et al. (2023) conducted a quantitative comparison of British Sign Language (BSL), Israeli Sign Language (ISL), and Kata Kolok (KK). Their results suggest a need to distinguish variation at the *global* versus *local* level, that is, across the whole community versus within subgroups of the community. BSL (the largest language) has the most variation at the global level, but the least variation at the local level. By contrast, ISL and KK exhibit less variation at the global level and more variation at the local level, although the distinction between the global and local levels was less pronounced in these languages. Thus, community size did not directly impact the overall amount of variation in each language, but the distribution of variation at global versus local levels.

In a similar vein, Horton (2022) examined lexical similarity in young sign languages used in Nebaj, Guatemala. She describes three types of *sign ecologies* based on the frequency with which signed interaction occurs. *Individual ecologies* are families with a single deaf individual. In these ecologies, the deaf individual may only sign regularly with one or two hearing individuals. *Low-frequency ecologies* and *high-frequency ecologies* include multiple deaf individuals who are either members of the same family or peers at school. In low-frequency ecologies, deaf individuals do not interact every day. In high-frequency ecologies, deaf signers interact daily, either because they reside in the same household or attend school together. Horton first calculated the baseline rate of lexical similarity for all signers in the community. She then compared the community-wide similarity to the rates of similarity in different ecologies. She found that rates of lexical similarity in individual ecologies were equivalent to or lower than community similarity. Similarly, similarity rates in low-frequency ecologies were equivalent to community-wide similarity rate. By contrast, similarity rates in high-frequency ecologies were significantly higher than the community-wide similarity rate. From these results, Horton concludes that a shared lexicon emerges only with frequent, regular, and direct interaction. Signers who do not interact, or even those who interact but only at irregular intervals, do not exhibit higher-than-baseline levels of lexical similarity. Taken together, the results of Horton (2022) and of Lutzenberger et al. (2023) demonstrate that there is no straightforward relationship between the overall amount of lexical variation in a language and community size. A potentially more interesting line of investigation is how the internal social organization of a community impacts the shape of variation.

In some contexts, however, lexical convergence may not require direct interaction. Reed (2021) showed that geographically dispersed deaf individuals in the Western Highlands of Papua New Guinea exhibit a significant degree of lexical similarity, likely because their mutual hearing contacts served as vehicle for the spread of signs throughout the region. Thus, even in the absence of direct contact between deaf people, the development of a lexicon is intimately linked to the social networks in which they are embedded.

The proposed impact of community characteristics on language structure is not limited to lexical variation but extends into variation at the sub-lexical level. Israel, Sandler and colleagues (Israel 2009; Israel & Sandler 2009; Sandler et al. 2011) compared the amount of sub-lexical variation in three sign languages used by communities of different sizes, from largest to smallest: American Sign Language (ASL), ISL, and ABSL. They found that community size is inversely correlated with the amount of sub-lexical variation, with more variation in smaller communities than in larger communities (i.e. $ABSL > ISL > ASL$). The language used by the smallest community, ABSL, exhibited so much sub-lexical variation that Sandler et al. (2011) concluded that it lacks phonological structure. They argue that ABSL signs are not based on a set of abstract, contrastive phonological features, but rather on a holistic “iconic prototype”. For instance, the sign DOG is iconically based on the snapping of a dog’s jaws, but the articulation of the sign varies dramatically across signers.

The conclusions of Israel, Sandler and colleagues should be interpreted with caution, however, since they are based on a rather limited data set. The data include signs for 15 common concepts, produced by 10 signers of each language. The sets of concepts for each language overlapped but were not identical. Their sample size was too small to establish statistical significance of the reported association between community size and amount of sub-lexical variation, though the authors note that this pattern was robust not only for individual sub-lexical features but also for a global measure of variation. A further methodological issue, pointed out by Lutzenberger et al. (2021), is that they examined sub-lexical variation only the most common lexical variant for a concept (e.g., they included one sign for ‘dog’ based on the jaws of the animal, but not another sign based on its ears). This may exaggerate the degree of variation since the more frequent a lexical variant is, the more opportunities there are for sub-lexical variation.

Lutzenberger et al. (2021) addressed these issues in their investigation of variation in Kata Kolok. They introduced a *variation index* that incorporates both lexical and sub-lexical variants for a given concept and can be weighted by either token frequency (how many times a variant was produced) and signer frequency (how many signers produced a variant). Weighting the variation index in these ways increased the ecological validity of the measure: the token-weighted variation index revealed a tight relationship between frequency and variation, while the signer-weighted variation index illustrated how variants were distributed across signers. Although the

results did reveal substantial variation, the authors were careful to point out that many signs exhibited no variation and much of the variation came from a minority of signers.

The studies reviewed in this section reveal two different ideological orientations toward the relationship between variation and the underlying system of language. One camp seems to assume that variation in a young sign language indicates a lack of conventionalization. A second camp, resisting this assumption, seeks to identify systematicities underlying that variation. These two perspectives are not necessarily at odds. A language may exhibit a high degree of variation overall while certain social networks within the community may be converging on their own standards of form.² For instance, Safar et al. (2018: 488) report significant variation in the numeral systems of Yucatec Maya Sign Languages but also demonstrate that it is “systematic inter- and intracommunity variation as a result of linguistic and sociolinguistic factors.”

Similarly, one’s conception of the signing community frames their predictions about variation. Assuming a homogenous community, one might predict a uniform distribution of variation across signers. However, if one acknowledges that there are smaller social groups within the community, then one would expect more variation across those subgroups but less variation—i.e. more conventionalization—within them. Compare how Hou (2016) characterizes the signing practices of San Juan Quiahije Mexico with how Sandler et al. (2011) characterize those of the Al-Sayyid Bedouin community. In both communities, more lexical variation is reported across families than within families. Hou describes the signing practices of the San Juan Quiahije community as a “constellation of family sign languages” (Hou 2016: 2)—that is, independent languages with their own lexicons. By contrast, ABSL is framed as a single language with an extreme amount of variation overall, but “lexical uniformity within families” (Sandler et al. 2011: 532). The former study foregrounds uniformity within families, while the latter highlights variation across families. These different emphases might be justified depending on the structure of social life in each community. Hou argues that signing families in Quiahije inhabit a “loosely connected social network” (Hou 2016: 20); it thus makes sense to consider each family to have their own language. By contrast, it is difficult to gauge to what extent ABSL variation can be explained by the social organization of the community, since this has not been adequately described in linguistic studies (Kisch 2012).

4 Zinacantec Family Homesign

The focus of this study is Zinacantec Family Homesign (‘Z sign’), a sign language developed by deaf and hearing members of an extended family from Zinacantán, a Tsotsil (Mayan) speaking community of the highlands of Chiapas, Mexico (Haviland 2020a; German 2024a). A skewed kinship diagram for the family is shown in **Figure 1**. Each member is identified by a pseudonym,

² I thank Lauren Reed for suggesting these points to me.

their age as of 2025, and a rough indication of their signing ability. The position of each signer is aligned with their year of birth as indicated along the vertical timeline on the left side of the diagram. Z sign began with the birth of the first deaf individual in the family, Jane, in 1976 (Haviland 2011). Unable to access the Tsotsil spoken by her caregivers, Jane began to develop homesigns. The second and third deaf siblings, Frank and Will, were born in 1982 and 1988, respectively. Among the hearing members of the family, there is a clear division between those who are younger than Jane and those who are older. Those who are younger than Jane (Terry, Rita, Vic, Pat, and David) all acquired Z sign from birth or early infancy and grew up using it as a home language. They are fluent signers who can communicate comfortably with the deaf siblings about a range of topics. By contrast, older hearing members of the family, such as the deaf siblings' father Martin, and their older sisters, have only minimal signing skills. Though they can communicate with the deaf siblings at a basic level, they struggle to understand what the fluent signers say to each other (Haviland 2020a).

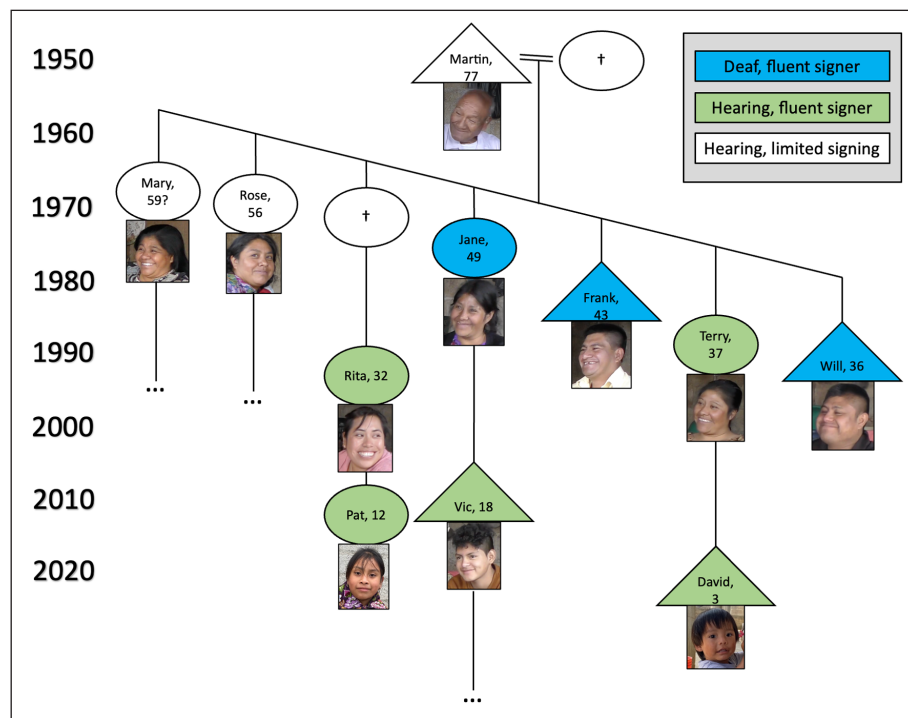


Figure 1: A partial family tree for the focal family as of 2025.

I have been working with the Z signers since 2017. This includes 30 weeks of fieldwork (distributed over six trips ranging from two to six weeks in duration), during which I lived with the Z signers in their home. This allowed me to combine formal elicitation tasks with observation of their daily communicative habits. By studying both the linguistic properties of Z sign and the

social context in which it is used, I have aimed at a holistic understanding of both the language itself and the social lives of the individuals who use it.

Research on Z sign was initiated by John Haviland in 2008. Haviland's research, conducted from a linguistic anthropological perspective, has shed light on some of the emergent grammatical properties of the language, including strategies for distinguishing nouns from verbs (Haviland 2011; 2013c), spatial language (Haviland 2013a), the grammaticalization of gestures and facial expressions drawn from the hearing community (Haviland 2015; 2019), and the role of eye gaze in turn-taking (Haviland 2020b). Later work on Z sign has explored how variation in the number of language models each signer had in early childhood impacts the expression of motion and encoding of argument structure (German 2023; 2024a).

In addition to the structure of Z sign itself, Haviland has also examined how the Z signers' attitudes toward linguistic variation relate to social divisions within the family. The signers make overt judgments about what constitutes correct usage of Z sign, who in the family has the authority to enforce norms of sign usage, and what kinds of social meaning variation indexes (Haviland 2013b; 2016; German 2024a). For instance, the eldest deaf sibling Jane is regarded as a poor signer, and her relatives call her a *chich me`el*—a “foolish (or linguistically incoherent) old lady” (Haviland 2013b: 188). By contrast, the youngest deaf signer Will is deemed a skilled signer and is accordingly considered *p`ij* ‘clever’ (Haviland 2013b: 162). Thus, despite its almost maximally small size and shallow time-depth, this family exhibits the characteristic features of a ‘speech’ community, in the sense of Gumperz (1968: 463): “a social group which may be either monolingual or multilingual, held together by frequency of social interaction patterns and set off from the surrounding areas by weaknesses in the lines of communication.”

German (2024a;b) has proposed a model of the focal family as a sociolinguistic community (**Figure 2**; signers are listed from oldest to youngest from left to right). This model takes into account the fact that linguistic communities are not homogenous in terms of knowledge of the language, but in fact are characterized by variation that correlates with social stratification (Labov 1966). This model, which draws on observations of everyday communication in this family, attempts to formalize the “organization of diversity” (Hymes 1972: 51) in this family with regard to the use of Z sign. In other words, the model is intended to predict the distribution of linguistic variation.

The model is divided into three sociolinguistic ‘strata’. The inner stratum includes the *core signers*: the three deaf siblings (Jane, Frank, and Will) and the two hearing adult signers (Terry and Rita) who grew up with the deaf siblings. These five individuals grew up together and are lifelong daily signers. The *intermediate signers* occupy the middle stratum. These are the hearing children of the core signers who acquired Z sign from infancy (Haviland 2022; Horton et al. 2023). They are also fluent signers. However, they are distinguished from the core signers

because they do not have deaf signing peers, and since they are a generation younger than the core signers, they do not share as much of the extensive common ground that the latter do. They might be considered heritage signers of Z sign (cf. Gagne 2017 on heritage signers of Nicaraguan Sign Language). Finally, the outer stratum corresponds to the *peripheral signers*: older hearing relatives of the core signers who are not fluent signers of Z sign, but who might be considered second-language learners of the language.

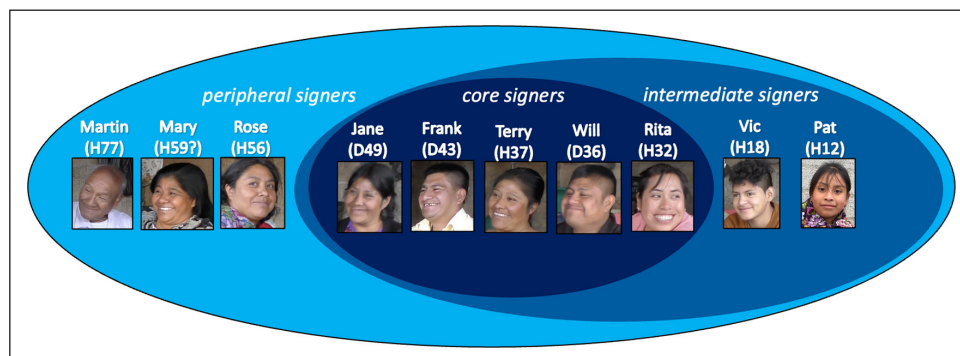


Figure 2: A sociolinguistic model of the Z sign family, divided into three sociolinguistic strata: core signers (C), intermediate signers (I), and peripheral signers (P).

These three strata serve as a proxy for the amount of signed interaction different members of the family engage in. The core signers sign to each other with the highest frequency (daily) and share the most context. They regularly engage in in-depth conversations about a broad range of topics. The peripheral signers use sign relatively infrequently, and even then, only for communicating about basic matters (e.g., the location of objects, when events are going to take place, where individuals are going, etc.). The intermediate signers, as the name suggests, fall between the core and peripheral signers. They grew up signing on a daily basis, but they also went to school and therefore spent a significant amount of time outside of the presence of their deaf relatives using spoken languages (Tsotsil and Spanish) and forming social relationships outside of the family.

It is helpful to consider this family in terms of the distinction between communities that predominately engage in “esoteric” versus “exoteric” communication (Wray & Grace 2007). Communication among the core signers (and to a lesser extent, between the core and intermediate signers) can be characterized as maximally esoteric, given the extensive common ground that they share. By contrast, communication between core and peripheral signers is more exoteric, since two of three peripheral signers (Rose and Mary) are not in daily contact with the deaf signers. Martin is in daily contact with his deaf signers, but his minimal signing skills restrict the complexity of their interactions.

The “three-strata” model is an idealization intended to capture the broadest and most significant divisions among the Z signers. As such, it glosses over many particularities about individual signers’ experiences and relationships to each other that may prove useful in interpreting the quantitative results of this study. For instance, hearing status and gender conspire to yield divergent social experiences, including differences in how frequently an individual uses Z sign in different domains of life and with whom. The crucial difference the deaf and hearing members of the family is that the former use Z sign as their primary and exclusive means of communication, while the latter are first and foremost users of spoken language, who also sign with their deaf relatives.³ Accordingly, one might expect that the deaf signers would exhibit greater lexical consistency with each other than with the hearing signers (see Mudd et al. 2020 on variation based on hearing status in Kata Kolok). However, the gendered division of labor in Zinacantán (Devereaux 1987) means that individuals spend more time with others of the same gender. Jane, Terry, and Rita stay at home where they collaborate on domestic tasks. By contrast, Frank and Will work seasonal jobs outside of the home, sometimes locally and sometimes in far-flung places like the state capital where they may stay for extended periods of time. The different contexts in which the men and women of this family use Z sign could lead to gender-based lexical and/or sub-lexical variation (cf. Mudd et al. 2021 on gender-based lexical variation in Kata Kolok, and Morgado 2024 on the impact of gender on patterns of interaction among deaf people in Guinea Bissau).

The model also fails to account for the nuanced relationships among the core signers. First, the deaf brothers have a very close relationship, which is reflected in the fact that they often *chk’opoj ta sat no`ox* “speak with the face alone” (Haviland 2020b: 21, quoting Terry), minimizing the use of manual signs while capitalizing on facial expressions and eye gaze in order to obscure their conversations from other members of the family; indeed Rita reports that she cannot always understand this secretive way of signing (German 2024a: 70). Second, Terry is a sibling to the deaf signers, so she has a closer relationship to them than does Rita, their neice. Rita also attended school, unlike Terry, and spent about two years as a teenager living and working in another state of Mexico. Thus, compared to Rita, Terry has spent more time in the presence of her deaf siblings at home. Finally, Jane occupies a subordinate position among the core signers, which is related to her being viewed as a poor signer, as described above.

The intermediate signers, Vic and Pat, share a sibling-like relationship. Remarkably, as young children, they would sign to each other as a form of play (German 2024a). However, in 2022 and 2023, Vic left Zinacantán with his deaf uncles to go and work in the state capital. Although the uncles have since returned home, Vic has settled in the capital where with his partner and

³ Terry, Rita, Vic and Pat occasionally sign with each other to exclude non-signers from private conversations.

newborn child. He visits infrequently, and it remains to be seen whether his signing will undergo attrition as he continues to live apart from his deaf relatives.

Finally, there are also important differences between the three peripheral signers Martin, Mary, and Rose. Martin is the father of the deaf siblings, while Mary and Rose are their older sisters. Rose is closest in age to the deaf siblings, which may have led to her being socially closer to them. Indeed, Rose is a noticeably better signer than Martin or Mary. Their younger sister Terry, a core signer, attributes this to the simple fact that Rose makes more of an effort to communicate with her deaf siblings than either Martin or Mary does, even though she almost always speaks while she signs. Martin is the only peripheral signer who has the opportunity to sign every day since continues to live with the deaf signers. Nonetheless, his signing skills remain minimal.

The predictions of this study regarding the impact of interaction on lexical and sub-lexical variation are framed in terms of the three-strata model, which serves as a rough indication of frequency of signed interaction. Based on previous studies that report that higher frequency of signed interaction reduces variation in micro-community sign languages (Osugi et al. 1999; Mudd et al. 2020; Horton 2022), we would expect the core signers, who have the highest frequency of signed interaction, to exhibit low levels lexical and sub-lexical variation compared to the peripheral signers, who engage in signed interaction relatively infrequently. The intermediate signers should exhibit more variation than the core signers but less than the peripheral signers. An alternate hypothesis, based on de Vos (2011) and Thompspon et al. (2019), is that in such a small community, there will be a high degree of idiosyncratic variation and no discernible patterns in how that variation is distributed.

5 Methodology

The data for the analyses of lexical (Section 6.1) and sub-lexical variation (Section 6.2) were elicited using a picture-naming task consisting of 150 images of items with which I expected the Z signers to be familiar. A full list of stimuli is available in Appendix 1. I included the following categories of items: *animals, fruits and vegetables, tools, prepared foods, and weather events/astronomical objects*. In most cases, I used stock images downloaded from the Internet in which the item is positioned against a blank white background to minimize the likelihood of extraneous comments about other aspects of the images, a problem that has been reported in other studies (e.g., Mudd et al. 2021). Participants appeared to have had no trouble recognizing the items.

The task was divided into three blocks of about 50 items each. The stimulus images were organized into a PowerPoint presentation and presented to the participants one by one on a laptop computer. The task was conducted using a ‘director/matcher’ paradigm (cf. Safar & De

Vos 2022; Horton 2024), in which one individual ('director') described the stimulus images to a second individual ('matcher'), who was then asked to identify the target image from an array of four images. The matching array was presented on the laptop, and the matcher was asked to point to the image of the item they thought had been described. Elicitation sessions were filmed with two cameras that captured front and back angles of both participants. The screen of the laptop was also captured on camera, so that the matcher's selections could be reviewed at a later time.

Of the four images in the matching array, three were foils. I chose foils that were conceptually related to the target item or which I knew from prior experience were signed in a similar manner to the target item. For instance, the foils for 'corn plant' included an ear of corn, a corn field, and loose corn kernels. If the matcher failed to identify the target image, I asked the director to describe the target again, repeating this process until the matcher correctly identified the image by pointing to it on my laptop screen. In the present study, however, I only consider director's initial descriptions, defined as the sign or sequence of signs produced immediately after the director was shown the stimulus image until they returned their hands to rest, attempted to confirm the matcher's understanding, or the matcher intervened.

The selection of director/matcher pairs was subject to participant availability and varied across the three blocks of the task since a participant would complete at most two blocks of the task in a single elicitation session. In most cases, a core signer served as the matcher (82.5% of pairs), but occasionally an intermediate signer (10% of pairs) or a peripheral signer (7.5% of pairs) did so. Rate of correct identification of the target concept after the first response was high when both participants were core signers (mean = 88%, SD = 6%), but lower when either the director or matcher was an intermediate or peripheral signer. See Appendix 2 for rates of correct identification across all strata.

All Z signers except Mary completed the lexical elicitation task twice. Most signers completed the task first in July-August 2022 and again in July-August 2023. Rose first completed the task in 2022 and then again in 2025, although in the latter year, I had time only to run two of the three blocks of the task with her (101/150 items). I had only one opportunity to work with Mary, so only one set of responses are available for her.

The two films for each elicitation session were synchronized in ELAN for ease of viewing (Wittenburg et al. 2006). However, signers' responses were transcribed and analyzed in Microsoft Excel. The following features indicated in the transcription: (i) iconic strategy, (ii) handshape, (iii) gloss of the iconic motivation of the sign. Iconic strategies included *handling*, *instrument*, *object*, *constructed action*, and *body part* (Padden et al. 2013; Hwang et al. 2017). See Appendix 3 for examples of how responses were transcribed in Excel. I do not directly analyze the iconic strategies that the Z signers use in this paper. However, iconic strategies were included in the

criteria for evaluating lexical similarity (see Section 5.1 below). Handshape was coded in terms of the number of selected fingers and joint configuration (Brentari 1998); further details about handshape coding are given in Section 5.2 below. Finally, a rough gloss of the iconic motivation underlying the sign was given. For instance, a sign that represents the use of a knife might be glossed SLICE.⁴ Signers' responses frequently included pointing signs directed towards exemplars of items represented in the elicitation stimuli or towards locations associated with those items. Such pointing signs were transcribed but excluded from the calculations of lexical and sub-lexical similarity described below, following Horton (2022). All statistical analyses were performed using R version 4.5.0 (R Core Team 2025). ANOVAs were conducted in base R, while regressions were conducted using the *lmerTest* package (Kuznetsova et al. 2017).

5.1 Calculating lexical similarity

Signers' responses typically consisted of multiple signs (mean = 2.29 signs). This presents an analytical challenge to comparing responses since lexical similarity cannot be calculated by simply deciding whether the signers produced the same sign for a given item. For the present study, signers' responses were compared using the Jaccard similarity index, following previous studies (Mudd et al. 2021; Horton 2022; Lutzenberger et al. 2023). The Jaccard index is a measure of the similarity of two sets, calculated by dividing the number of items in the intersection of the sets by the number of items in the union of the sets (Fletcher & Islam 2018; Jaccard 1912). Including all signs produced by a signer avoids the problems associated with the researcher making judgements about which signs should be included. Nonetheless, it is quite likely that such responses are not simple lexical items, but phrasal descriptions of the stimuli. This is a limitation of the methodology in that we may not be directly accessing "the sign" for a concept. Future work should compare the elicited descriptions with data from spontaneous conversation.

For instance, consider the following responses for 'avocado' (**Figure 3**). Jane described 'avocado' as SPLIT MASH, while Will described the same item as SMALL-ROUND MASH. The union of these two sets contains three signs (SPLIT, SMALL-ROUND, MASH) while the intersection of the sets contains one sign (MASH). The Jaccard index for the two responses is therefore $1/3$ or 0.33. For each pair of signers, the average of all Jaccard indexes for the 150 test items was calculated. I will refer to this value as the *similarity score* for that pair of signers. This method of comparison was used to evaluate lexical similarity across signers as well as lexical stability of individual signers over time.

⁴ The conceptual component underlying a sign was usually clear to me given my familiarity with Z sign. Otherwise, I asked Terry or Rita to provide Tsotsil and/or Spanish gloss.

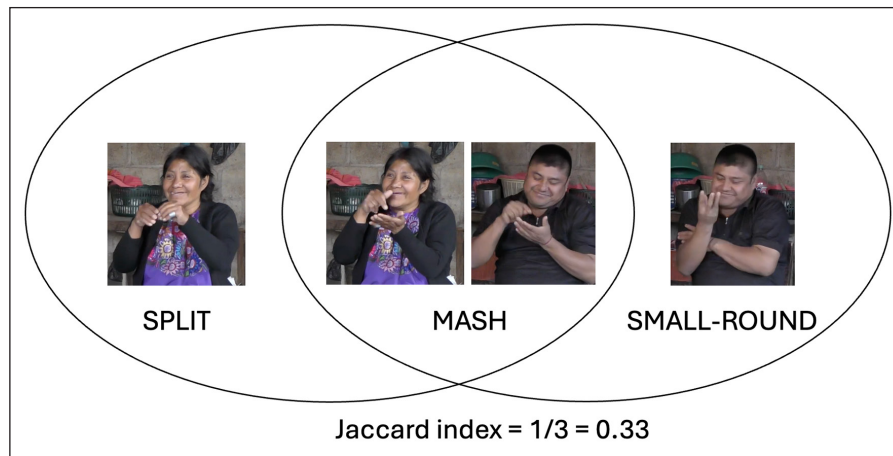


Figure 3: Sample calculation of a Jaccard index for two responses for ‘avocado’.

The calculation of Jaccard indexes depends on the ability to identify two sign tokens as instances of the same sign. This is a tricky endeavor given that micro-community sign languages may permit more sub-lexical variation than older sign languages (Israel & Sandler 2009). Consider the two tokens of the sign MASH produced by Jane and Will in **Figure 3**. Each signer produced the sign with a different handshape (i.e., different numbers of selected fingers and different joint configurations). In an older sign language, these handshapes might be phonologically contrastive. Given this degree of sub-lexical variation, some studies of micro-community sign languages have opted to eschew comparing signs at the level of sub-lexical features in favor of comparing signs in terms of their underlying iconic motivation (Mudd et al. 2021), also referred to as the “conceptual component” of the sign (Richie et al. 2014; Horton 2022). I also adopt this methodology, but I additionally required that the signs incorporate the same iconic strategy to be considered ‘the same’ (cf. Quam et al. 2022). For instance, ‘knife’ might be signed with either the handling strategy (the hand represents how one grasps the handle of a knife) or instrument strategy (the hand represents the blade of a knife) (**Figure 4**). In this study, signs with different iconic strategies are considered to be based on different iconic motivations.

It is worth noting that this task was designed to be challenging. It included items that participants do not encounter everyday (e.g., armadillos, squash blossoms). Furthermore, the addressee was required to identify the target item from an array of potentially confusable foils. Both factors likely encouraged signers to produce longer descriptions than would be required in everyday conversation (mean response length = 2.29 signs). Consider the responses for ‘avocado’ in **Figure 3**. The sign MASH, produced by both signers, is the usual sign for ‘avocado’. However, this sign is formationally similar, if not identical to signs for ‘candle’ and ‘sewing machine’. The signers probably added SPLIT and SMALL-ROUND to distinguish between these homophones. This results in a lower Jaccard similarity score (0.33) than if both signers had just produced the usual sign MASH (1.00). Thus, the results reported below likely represent an underestimate of

the amount of lexical similarity among the Z signers. That said, long responses were quite rare: 96% of responses comprised less than 5 signs. The longest response was 9 signs, and the second-longest was 6 signs.



Figure 4: Two signs that depict the use of a knife with different iconic strategies. Left: handling strategy. Right: instrument strategy.

5.2 Calculating sub-lexical similarity

For the analysis of sub-lexical similarity, I compared the phonetic form of tokens of the same sign produced in response to the same stimulus item by two different signers. Recall from the analysis of lexical similarity that the identification of two forms as tokens of “the same sign” was based on their iconic motivation, which in turn was based on the action or characteristic that the sign depicts. This depends especially on the movement and location of the sign. For instance, EAT is signed by moving the hand toward the mouth, but the handshape may vary. In other words, the movement and location were taken into consideration in deciding what counts as the same sign. While the movement of a sign can vary in repetition, size, and speed, these differences were not as salient as variation in handshape. Therefore, the present analysis focuses on handshape only, but future studies should address the other sub-lexical parameters.

The question here is simply whether two signers use the same handshape when producing the same sign in response to the same stimulus item. By ‘the same handshape’ is meant that the signs have the same selected fingers and the same joint configuration, which are the basic features of handshape proposed by Brentari (1998). Selected fingers are the ‘active’ fingers that may make contact with the place of articulation or undergo a change in joint configuration. Joint configuration refers to the posture of the joints (e.g., straight, bent, curved, etc.). Note that these fine-grained phonetic distinctions are based in phonological theory, and do not necessarily correspond to differences that would be perceived by the Z signers. It may be that I am distinguishing handshapes that the signers consider to be the same, which would lead to an overestimation of variation.

Since most responses contained multiple signs, I considered each sign that both signers produced as a separate data point, scored either 1 for “same handshape” or 0 for “different handshape”. Consider Frank and Will’s responses for ‘bread’ (**Figure 5**). Both produced the signs COFFEE, DUNK, and EAT.⁵ They used different handshapes for COFFEE. Frank (top) produced the sign with the forefingers and the thumb fully extended and spread apart. Will (bottom) produced the sign with his forefingers bent at the base knuckle and the thumb tucked underneath. For DUNK, both signers used the same handshape (index finger pressed against the thumb to form a “pinching” configuration).⁶ They also used the same handshape for EAT. Thus, these two responses yielded three separate comparisons, assigned values of 0, 1, and 1, respectively. The *handshape similarity score* for a pair of signers is the average of all such comparisons, i.e. the proportion of signs that they produced with the same handshape. Taking these three signs as an example, the similarity score for the two signers would be 2/3 or 0.67. One additional consideration is that handshape may change during the production of a sign. In these cases, two signs must share both the same initial and final handshape to be counted as having the same handshape.



Figure 5: Responses for “bread” containing the signs COFFEE, DUNK, and EAT, respectively. The signers use different handshapes for COFFEE, but the same handshapes for the DUNK and EAT.

⁵ The two signers shown in **Figure 9** produced the signs in different orders, with COFFEE either first or last in the sequence. However, the order of signs is not considered in the present analysis.

⁶ A reviewer questions whether these two signs can be considered ‘the same’ given that one signer produces it with a passive non-dominant hand, while the other uses only one hand. The omission of the non-dominant hand is an example weak-hand drop, a phonological process attested in various sign languages (Battison 1974; Brentari 1998; van der Kooij 2001; Nishio 2009). Notably, iconic signs (like DUNK) are more susceptible to weak hand drop in ASL (Becker 2021). The variation in handedness observed with DUNK is consistent with patterns in other sign languages, so I do not consider it a basis for counting these tokens as different signs.

6 Results

The data for this study consist of 2775 responses, comprising a total of 6353 signs. In the following sections, I present the results for lexical similarity (Section 6.1), followed by the results for sub-lexical similarity (Section 6.2).

6.1 Lexical similarity

The analysis of lexical similarity is based on 11,457 observations, that is, Jaccard indexes calculated by comparing two signers' responses to the same item. See Appendix 4 for the distribution of Jaccard indexes by item.

The mean lexical similarity score for a pair of signers was 0.37 ($SD = 0.09$). Lexical similarity scores (averaged across time points) for all pairs of signers are presented in the form of a similarity matrix in **Figure 6**. As a visual aid, each cell has been shaded according to the similarity score for that pair of signers; darker shades represent higher scores. The highest scores appear to be concentrated among the core signers (Jane, Frank, Terry, Will, and Rita), with slightly lower scores among the intermediate signers (Vic and Pat), and the lowest scores among the peripheral signers (Martin, Mary, Rose). To assess the statistical significance of these differences, I conducted a one-way ANOVA comparing the average similarity scores of pairs the following groups:

- Two core signers (“CxC”)
- A core signer and an intermediate signer (“CxI”)
- A core signer and a peripheral signer (“CxP”)
- An intermediate signer and a peripheral signer (“IxP”)⁷

	Martin	Mary	Rose	Jane	Frank	Terry	Will	Rita	Vic	Pat
Martin										
Mary	0.20									
Rose	0.24	0.31								
Jane	0.29	0.28	0.39							
Frank	0.24	0.28	0.39	0.48						
Terry	0.29	0.30	0.37	0.53	0.48					
Will	0.25	0.27	0.36	0.46	0.53	0.48				
Rita	0.28	0.22	0.33	0.42	0.41	0.48	0.43			
Vic	0.24	0.27	0.36	0.38	0.41	0.49	0.41	0.41		
Pat	0.28	0.31	0.35	0.38	0.38	0.43	0.39	0.42	0.46	

Figure 6: Lexical similarity scores (average of scores at Time 1 and Time 2).

⁷ For this analysis, the scores for each pair at Time 1 and Time 2 were counted as separate observations. The results for each time point are presented separately in Appendix 5.

The groups *IxI* and *PxP* contained too few observations to be analyzed reliably with ANOVA, so they were excluded from the analysis.⁸ Similarity scores differ significantly across groups ($F(3,71) = 49.77, p < .001$). Post hoc pairwise comparisons (Tukey HSD) suggest that similarity scores of *CxC* pairs are significantly higher than similarity scores of *CxI* pairs, which are in turn higher than those of *CxP* or *IxP* scores. The latter two groups do not differ significantly. The results are shown in **Figure 7**.

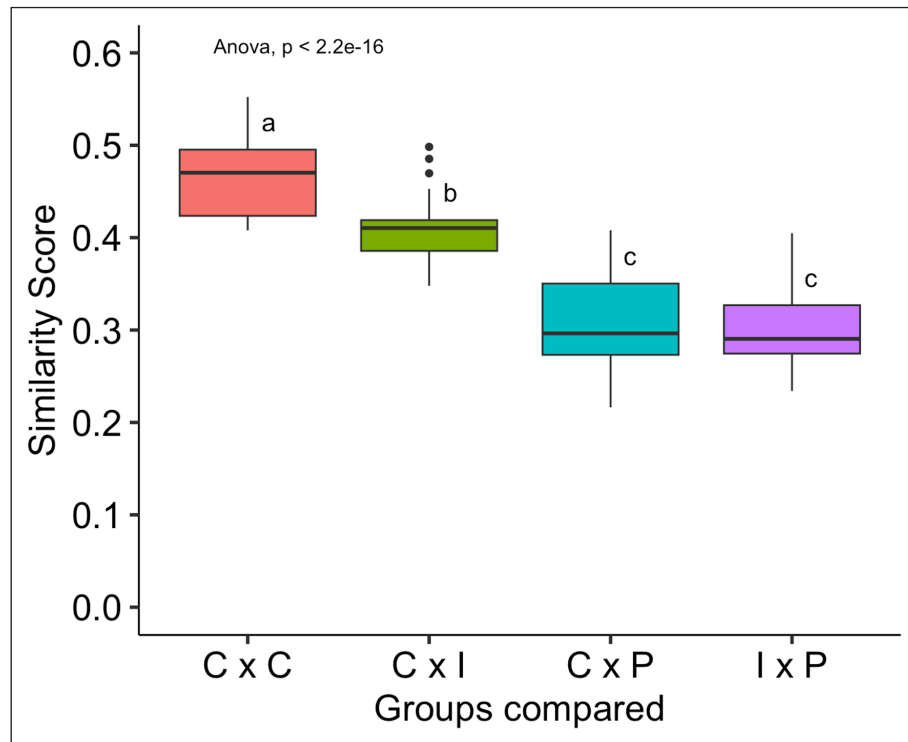


Figure 7: Lexical similarity across the three sociolinguistic strata of Z signers (C = core signer; I = intermediate signer; P = peripheral signer). The letters over the boxes indicate three significantly different groups.

These results confirm the hypothesis that lexical similarity is distributed according to the three-strata model of the family: the greatest degree of lexical similarity is found among the core signers while the lowest degree is found among the peripheral signers. The results are particularly reminiscent of those of Horton (2022), who examined lexical similarity in high-frequency, low-frequency, and individual homesign ecologies.⁹ She found that high-frequency

⁸ Scores for *IxI* pairs (0.42 and 0.53) fall within the range of scores for *CxC* pairs (range = 0.41–0.55) but above the range of scores for *CxP* pairs (0.22–0.41). Scores for *PxP* pairs (range = 0.20–0.31) are the lowest of all.

⁹ The ecologies in Horton's (2022) study included families with multiple deaf signers as well as peer groups of deaf children who attended school together. These two ecologies did not differ.

ecologies exhibit higher rates of lexical similarity than low-frequency and individual ecologies. High-frequency ecologies had median similarity scores ranging from 0.354 (SD = 0.04) to 0.397 (SD = 0.06); median scores for low-frequency ecologies ranged from 0.257 (0.06) to 0.274 (0.04); and median scores for individual ecologies ranged from 0.206 (0.03) to 0.252 (0.06). The Z sign family is a high-frequency ecology, per Horton's definition, because it has multiple deaf signers who interact with each other daily. The median similarity score for the Z sign family is 0.388 (SD = 0.09), which is comparable to Horton's high-frequency ecologies.

However, it is more revealing to consider each of the three strata separately. The core signers have a median similarity score of 0.47 (SD = 0.05). This is much higher than the high-frequency ecologies of Horton's study. This is likely because the core signers are adults, while Horton worked mostly with children. Adults have had more time to work out stronger lexical conventions than children. The median similarity score for pairs of a core signer and a peripheral signer was 0.30 (SD = 0.05). This falls between the scores for high- and low-frequency ecologies. The median similarity score for pairs of two peripheral signers was 0.24 (SD = 0.03). This falls within the range of scores for individual ecologies. Thus, the similarity scores for core signers reflect the high frequency with which those individuals interact using Z sign, while the scores for peripheral signers reflect that these individuals never sign with each other.

Within each stratum, there are hints of further stratification. Among the core signers, the four siblings (Jane, Terry, Frank, and Will) have higher rates of overlap with each other (range = 0.48–0.55) than with their niece Rita (range = 0.41–0.48). This difference makes sense in light of Rita's distinct social and educational experiences, outlined in Section 4. The form and content of Rita's responses also shed some light on why her scores seem to be lower. Rita often provides additional information that the siblings do not. For instance, all core signers described 'winter squash' as something large and round that one chops: LARGE-ROUND CHOP (two signs). Rita additionally mentioned a sweetened squash dish that is given out during certain holidays by *mayordomos* (officials responsible for organizing festivals): LARGE-ROUND CHOP MAYORDOMO GIVE-OUT (four signs). Examining the average response length of the core signers reveals that this is not an isolated example, but a general pattern: Rita's average length of response was 2.86 signs while the four siblings averaged between 2.22 and 2.43 signs. Rita's verbosity may be related to the fact that she is the only core signer who attended school, which may have instilled in her the habit of giving detailed explanations. As the matcher, she would often demand that the director elaborate before attempting to identify the matching target concept.

Among the peripheral signers, there is a clear difference between Martin and Mary on the one hand, and Rose on the other. Martin and Mary are the members of the family who diverge to the greatest degree from the core signers. Similarity scores for Martin and Mary with the core signers ranged from 0.23 to 0.31, while scores for Rose with the core signers ranged from 0.31 to 0.41. As mentioned in Section 4, this difference may lie in the fact that Rose is closer in age to

the core signers than Martin or Mary. Thus, she would have been exposed to Z sign at a younger age and may also have had closer relationships with her deaf siblings (cf. Coppola & Carrigan on the impact of age of exposure on comprehension of homesign).¹⁰

These impressions can be visualized using hierarchical clustering, following Lutzenberger et al. (2023). Note that hierarchical clustering relies on *distance* scores, rather than similarity scores. Lexical distance is calculated by subtracting the lexical similarity score for each pair of signers (the values from **Figure 6**) from 1. A lexical distance of 1.00 would mean that two signers produced no signs in common for any item, while a distance of 0.00 would indicate that all their responses were identical. The clustering process iteratively groups individuals into clusters based on lexical distance, beginning with the pair of signers separated by the shortest distance—in this case, Frank and Will. Then, distances are re-calculated by comparing the Frank-Will cluster to each of the other signers. This is computed as the average of (a) the distance between each individual and Frank, and (b) the distance between each individual and Will. The process repeats in this manner until all signers have been clustered. The result is represented as a dendrogram (**Figure 8**). Each signer is shown on the x-axis. The length of the vertical ‘branches’ corresponds to lexical distance as indicated on the y-axis.

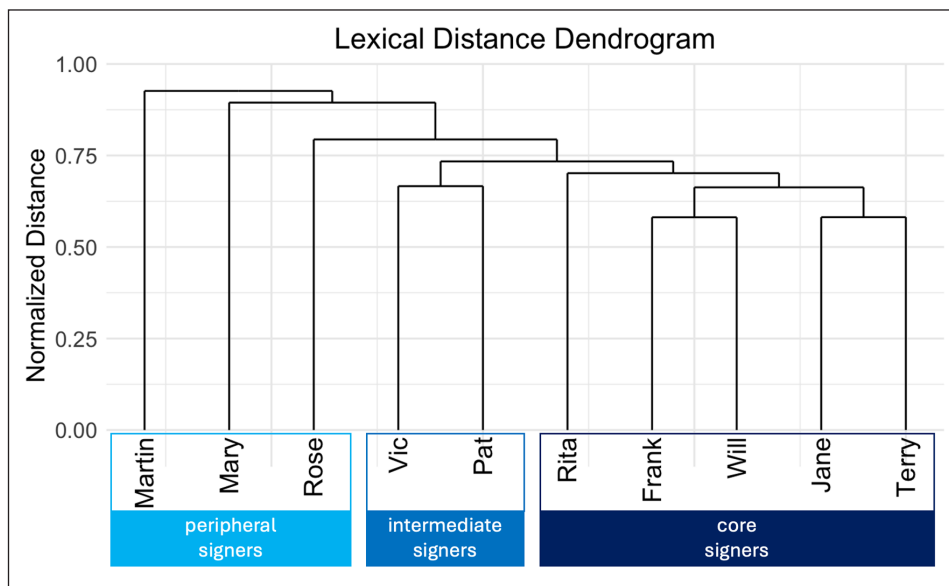


Figure 8: Dendrogram generated based on lexical distances.

¹⁰ During the task Rose lamented in Tsotsil, *Ep xa me lijch'ay!* 'I have forgotten so many [signs]!', suggesting that she considers herself to have been a better signer in the past when she had more frequent contact with her deaf siblings.

Several aspects of the dendrogram merit comment. First, its overall structure preserves the distinction between core, intermediate and peripheral signers. The core signers form their own cluster, as do the intermediate signers. This indicates that each group has their own distinct lexical preferences. At the next level up, the core and intermediate signers form a larger cluster, apart from the peripheral signers. Thus, despite their differences from each other, the core and intermediate signers are more similar to each other than they are to the peripheral signers. By contrast, the peripheral signers do not form a cluster, indicating that these three signers lack shared lexical preferences. This is consistent with the fact that they do not sign with each other. Rather, Rose (the youngest peripheral signer) is closest to the core-intermediate cluster, followed by Mary and finally Martin (the oldest peripheral signer). Thus, the degree to which each peripheral signer converges with the core/intermediate signers corresponds to his or her proximity to them in age.

The internal structure of the core cluster is also revealing. The four siblings (Jane, Frank, Terry, and Will) form a sub-cluster to the exclusion of their niece Rita, confirming that the latter diverges from the former. The sibling cluster can be further sub-divided: the sisters form one cluster and the brothers form another, potentially reflecting the effect of gender discussed in Section 4, whereby individuals interact more with others of the same gender.

6.1.1 Lexical stability over time

Having established that lexical variation exhibits a systematic distribution among the Z signers, we further ask whether the lexicon is stable over time. We will address stability from two different perspectives. The first concerns the stability of the distribution of variation: did the degree of lexical similarity between two signers remain constant across Time 1 and Time 2 (2022 and 2023 for most signers)? To address this question, a Pearson correlation coefficient was computed to assess the relationship between lexical similarity at Time 1 and lexical similarity at Time 2, revealing a significant positive correlation ($r(34) = 0.86, p < .001$). This suggests that lexical variation in Z sign is stable over time.

However, there are some pairs of signers for whom there was a notable increase in lexical similarity across time points. Interestingly, all were pairs involving the youngest signer in the family, Pat, who had just turned 10 when she first completed the lexical elicitation task. At that time, she did not produce certain conventional signs that all core signers did, such as TELEVISION, TOMATO, and CAT. However, a year later, she did produce those signs, and this is reflected in her higher similarity scores that year.¹¹ This increase across years may reflect

¹¹ A reviewer notes that it is odd that a ten-year-old would not know such common signs and suggests that Pat failed to produce the expected signs out of shyness. In the videos, she does not appear to be shy. In some cases, it is clear that she is genuinely struggling to figure out how to describe the target item (e.g., she searches the room for something to point at). Nonetheless, I agree that it is odd that she did not know those signs. I would suggest that since Pat is comparable to a heritage learner of Z sign, she may exhibit atypical patterns of acquisition.

Pat's ongoing acquisition of the lexicon of Z sign. When Pat's data are removed, the correlation between similarity scores at Time 1 and Time 2 is even stronger ($r(26) = 0.96, p < .001$). Thus, in general, the distribution of variation among the Z signers is stable over time, with one exception that can be attributed to the youngest signer more closely approaching adult norms over time.

Another way to assess the stability of the lexicon is to examine lexical similarity within each signer over time. Accordingly, “self-similarity” scores were calculated by comparing each signer's responses at Time 1 with his or her responses at Time 2, for a total of 1,232 observations. **Figure 9** displays the self-similarity scores for each stratum. The core signers display the highest similarity scores ($M = 0.60, SD = 0.05$), followed by the intermediate signers ($M = 0.56, SD = 0.01$), and the peripheral signers ($M = 0.46, SD = 0.01$). These results indicate that the core and intermediate signers' descriptions remained highly consistent across time points, while those of the peripheral signers were less consistent.

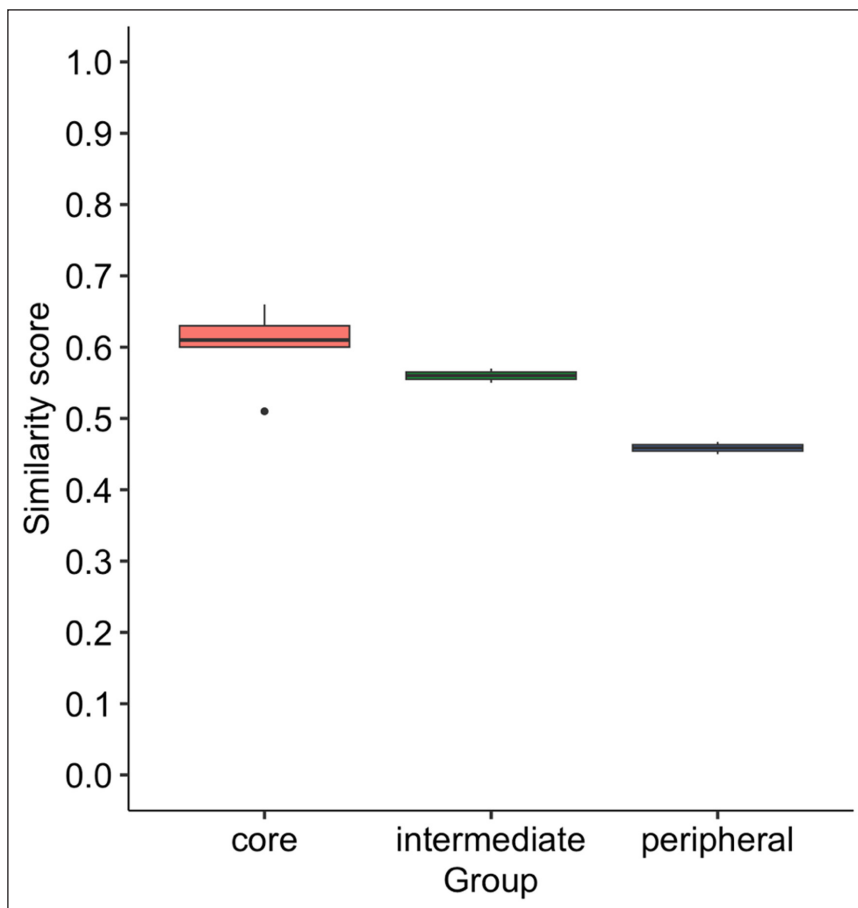


Figure 9: Lexical self-similarity scores for core, intermediate, and peripheral signers.

I performed a linear mixed-effects regression to test the effect of group (core, intermediate, peripheral) on self-similarity scores, with random effects for participant ($SD = 0.03115$) and item ($SD = 0.11381$). Compared to the core signers, the peripheral signers had significantly lower self-similarity scores ($\beta = -0.142$, $SE = 0.03426$, $p = .0017$). However, the intermediate signers did not have significantly lower scores compared to the core signers ($\beta = -0.046$, $SE = 0.03312$, $p = .199$).

Rita stands out among the core signers as having a lower self-similarity score (0.51) than the four siblings (range: 0.60–0.66). She even scored lower than both of the intermediate signers (range: 0.55–0.57). As noted previously, Rita produces longer responses than other signers. This means that there are more opportunities for variation, as there are more signs that she would have to produce in both years to achieve a high self-similarity score. Her longer responses included additional details about the target referent that other signers did not provide, but she tended not to provide these extra details in both years or she would provide different details in each year. Returning to the example of ‘winter squash’, described by all core signers as LARGE-ROUND CHOP, Rita added MAYORDOMO GIVE-OUT at Time 1 (because squash is given out by *mayordomos* during certain holidays) but at Time 2, she added BOIL (the typical method of cooking squash). This might suggest that LARGE-ROUND CHOP is the usual way to refer to squash, while the additional details provided by Rita represent task effects (i.e. she was being over-explicit due to the decontextualized nature of the task and the need to distinguish between the conceptually-related foils).

The peripheral signers were much less consistent than either the core or intermediate signers. This suggests that they were not constructing their responses from a conventionalized lexicon (as the core and intermediate signers likely were) but were instead producing *ad hoc* descriptions of the stimulus items. For instance, while all core and intermediate signers described ‘avocado’ with the sign MASH (sometimes along with the signs SMALL-ROUND and SPLIT), the peripheral signers’ responses were much more varied, including lengthy descriptions of slicing an avocado then eating it. Only one peripheral signer, Rose, produced the sign MASH, and she only did so at Time 2. These findings stand in stark contrast to the finding of Richie et al. (2012) that Nicaraguan homesigners are not more lexically consistent than their hearing communication partners. This is likely because there are multiple deaf individuals in the family, who put pressure on each other to be consistent in how they refer to things. The homesigners studied by Richie et al. (2012), each of whom was the only deaf individual in their family, experience less of such pressure.

6.2 Sub-lexical similarity

The analysis of sub-lexical similarity is based on 7,819 observations, i.e. pairwise comparisons of tokens of the same sign produced by two different signers in response to the same stimulus item.

However, the number of comparisons varies greatly across pairs of signers (mean = 97, range: 51–150 per year) since the frequency with which two signers described a stimulus item with the same signs varies significantly, as shown in the previous section.

Handshape similarity scores (averaged across time points) for all pairs of signers are presented in the form of a similarity matrix in **Figure 10**. Each cell has been shaded according to the similarity score for that pair of signers; darker shades represent higher scores. The highest scores appear to be concentrated among the core signers (Jane, Frank, Terry, Will, and Rita), with slightly lower scores among the intermediate signers (Vic and Pat), and the lowest scores among the peripheral signers (Martin, Mary, and Rose). A one-way ANOVA revealed significant differences across groups ($F(3,71) = 19.93, p < .001$). Post-hoc (Tukey HSD) tests revealed that scores for *CxC* pairs are higher than scores for *CxI* pairs, which are in turn higher than *CxP* and *IxP* pairs (**Figure 11**). Scores for *CxP* and *IxP* pairs are not significantly different. Although not included in the statistical analysis due to low sample size, scores for *IxI* pairs ($M = 0.67, SD = 0$) fall within the range of scores for *CxC* ($M = 0.68, SD = 0.05$) and *CxI* ($M = 0.62, SD = 0.05$) pairs. Scores for *PxP* pairs ($M = 0.40, SD = 0.04$) are the lowest of all groups.

	Martin	Mary	Rose	Jane	Frank	Terry	Will	Rita	Vic	Pat
Martin										
Mary	0.41									
Rose	0.42	0.36								
Jane	0.49	0.49	0.50							
Frank	0.45	0.52	0.46	0.69						
Terry	0.46	0.46	0.55	0.66	0.67					
Will	0.48	0.48	0.46	0.73	0.73	0.68				
Rita	0.55	0.41	0.53	0.66	0.64	0.64	0.71			
Vic	0.45	0.40	0.51	0.66	0.60	0.65	0.71	0.64		
Pat	0.51	0.31	0.45	0.65	0.55	0.58	0.61	0.60	0.67	

Figure 10: Sub-lexical similarity (average of scores at Time 1 and Time 2).

These results confirm that sub-lexical variation is distributed according to the three-strata model of the family. There is a strikingly high degree of handshape similarity among the core signers, and to a slightly lesser extent, between the core and intermediate signers. By contrast, the peripheral signers diverge considerably from both the core and intermediate signers. The divergence of the peripheral signers from the core and intermediate signers indicates that the latter two groups are not using the same handshapes by chance; rather, they are more likely choosing handshapes based on language-specific standards of form (which they sometimes enforce through overt correction; German 2024b).

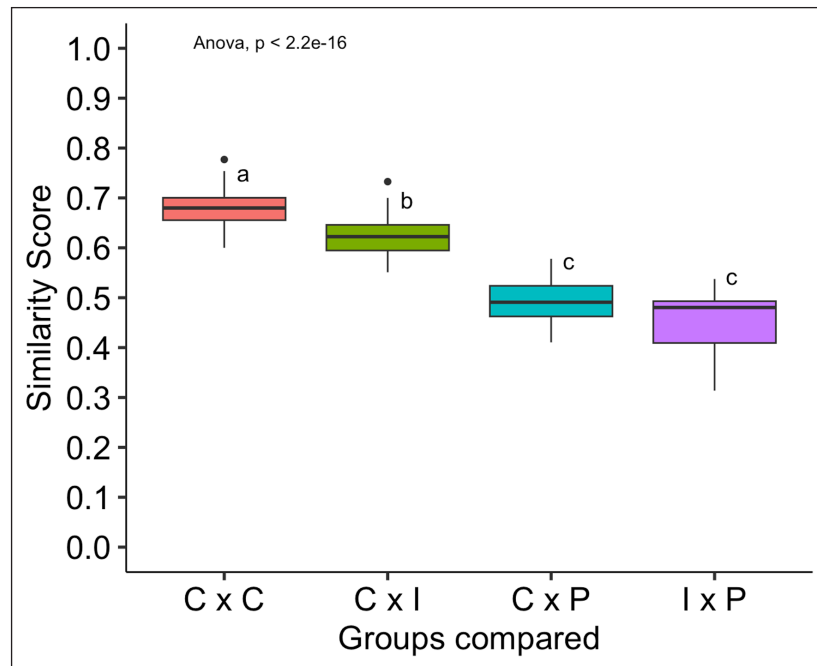


Figure 11: Handshape similarity across the three sociolinguistic strata of Z signers (C = core signer; I = intermediate signer; P = peripheral signer). The letters over the boxes indicate three significantly different groups.

Next, we apply hierarchical clustering to the handshape variation data. Since hierarchical cluster is based on distance scores, handshape similarity scores (**Figure 10**) were subtracted from 1. The results of clustering based on handshape distance are shown as a dendrogram in **Figure 12**. The overall structure of the handshape distance dendrogram is similar to the lexical distance dendrogram (**Figure 8**): the core and intermediate signers form their own separate clusters, before merging into a larger cluster at the next level up. The peripheral signers do not form a cluster. Rather, Rose clusters with the core/intermediate signers, followed by Martin and finally Mary (these latter signers are in opposite positions relative to the lexical distance dendrogram). The comparable structures of the two dendrograms validate both the utility of the three-strata model for predicting the overall distribution of variation in Z sign as well as the ethnographic observations upon which the model is based.

Within the core cluster, the four siblings (Jane, Frank, Terry, and Will) form a sub-cluster apart from their niece (Rita), just as in the lexical distance dendrogram. Again, this likely reflects the time that Rita spent away from her aunts and uncles in her childhood/adolescence. However, the two dendrograms diverge in the organization of the sibling cluster. In the lexical distance dendrogram, the siblings were divided by gender. Based on handshape, however, the three deaf siblings form a cluster apart from their hearing sister Terry. Thus, handshape preferences seem to be slightly more uniform among the deaf signers compared to the hearing signers, although the

differences are admittedly small. Finally, among the deaf siblings, Jane and Will form a cluster apart from Frank. This is an unexpected result given (1) Frank and Will's close relationship, and (2) their sharply negative assessments of Jane's signing (Haviland 2013c; 2016; German 2024a;b).

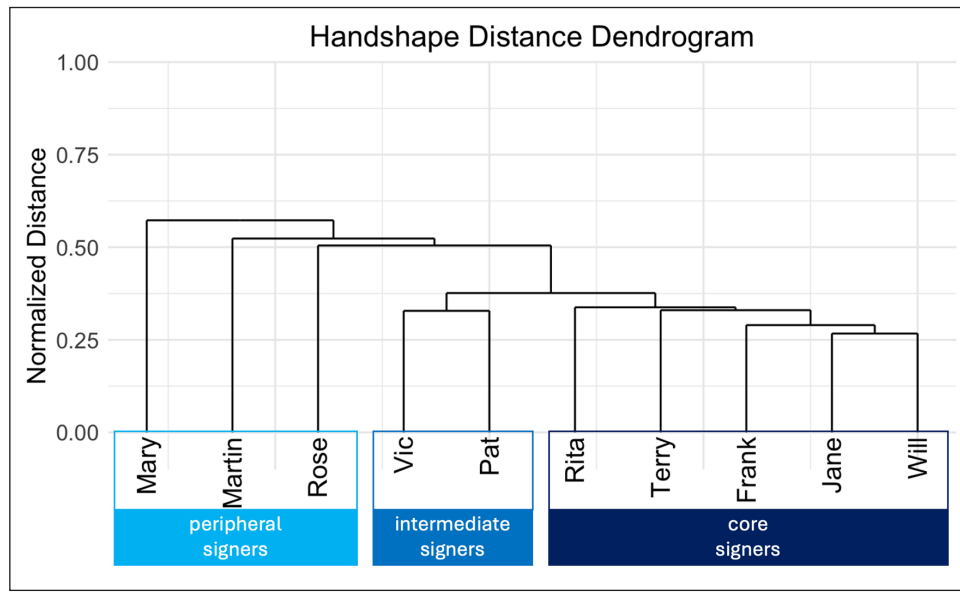


Figure 12: Dendrogram based on handshape distances.

However, we must be cautious not to assign undue significance to the internal organization of the core cluster, since the differences among the three deaf signers, on the one hand, and between Terry and Rita on the other, are negligible. Consider that the handshape distance between for Jane and Will is 0.267 based on comparisons of 247 pairs of signs, while the distance between Frank and Will is 0.268, based on comparisons of 289 pairs signs. Despite the miniscule difference between the two pairs, the clustering algorithm first clusters Jane and Will as the closer pair. However, if Jane differed from Will in only one more sign, then she and Frank would swap positions in the dendrogram. Similar considerations apply to Terry and Rita. Thus, we must be careful not to over-interpret differences among the deaf signers or between the two hearing signers. Nonetheless, I am more confident in the result that the deaf signers form a cluster apart from the hearing signers, given the greater distance between those groups than within them.

6.2.1 The stability of the distribution of variation over time

Next, we explore whether the distribution of handshape variation is stable over time. We first address the stability of the distribution of variation: did the degree of handshape similarity between two signers remain constant across Time 1 and Time 2 (2022 and 2023 for most

signers)? To address this question, a Pearson correlation coefficient was computed to assess the relationship between lexical similarity at Time 1 and lexical similarity at Time 2, revealing a significant positive correlation $r(34) = 0.90, p < 0.001$. This suggests that sub-lexical variation in Z sign is stable over time.

Finally, to assess the degree to which each Z signer's use of handshape is consistent over time, handshape similarity scores were calculated by comparing each signer's responses at Time 1 with their responses at Time 2. The data include a total of 1,067 comparisons. **Figure 13** displays the "self-similarity" scores for the core, intermediate, and peripheral signers. The core signers display the highest similarity scores ($M = 0.80, SD = 0.05$), followed by the intermediate signers ($M = 0.72, SD = 0.03$) while the peripheral signers score the lowest ($M = 0.61, SD = 0.13$). These results indicate that the core signers are highly consistent in their choice of handshape across time points.

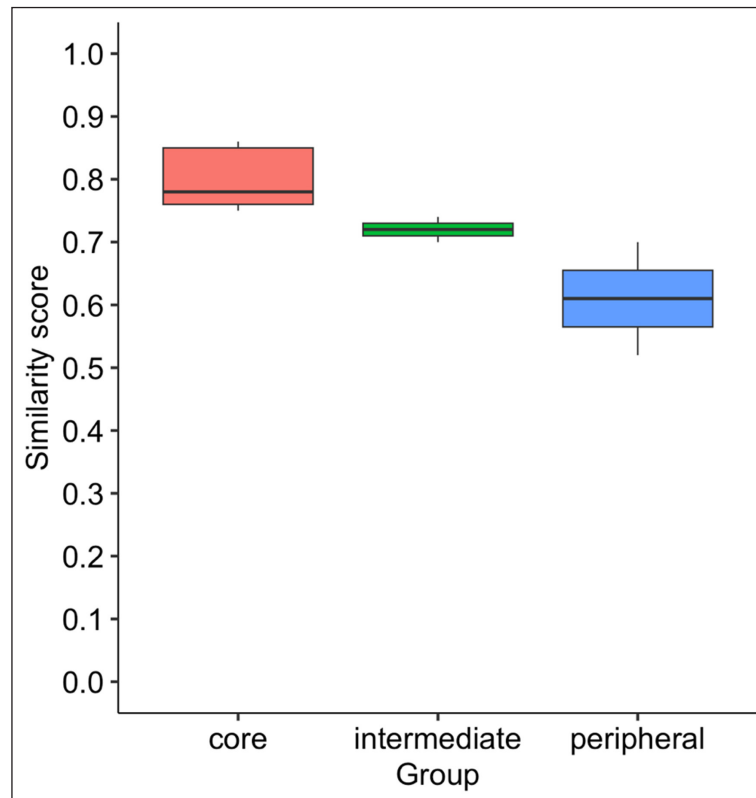


Figure 13: Handshape self-similarity scores for core, intermediate, and peripheral signers.

I performed a binary logistic mixed-effects regression to test the effect of group (core, intermediate, peripheral) on self-similarity scores, with random effects for participant ($SD = 0.2194$) and item ($SD = 0.7835$). The results show that compared to the core signers, the

peripheral signers had significantly lower self-similarity scores ($\beta = -0.9588$, $SE = 0.2613$, $p < .001$). The intermediate signers did not have significantly lower scores compared to the core signers ($\beta = -0.3707$, $SE = 0.2629$, $p = .159$).

7 Discussion

Some studies have suggested that variation in emerging and micro-community sign languages indicates a lack of conventionalization (Israel & Sandler 2009; Sandler et al. 2012), while others have maintained that this variation is a reflection of patterns of interaction in the community (Osugi et al. 1999; Mudd et al. 2020; Mudd et al. 202; Reed 2021; Horton 2022; Lutzenberger et al. 2021; Lutzenberger et al. 2023). Accordingly, this study has explored the degree of conventionalization at the lexical and sub-lexical levels of Z sign, a family sign language, in relation to patterns of interaction among signers. The results revealed that individuals who sign with each other frequently exhibit higher degrees of lexical similarity (convergence on what iconic motivation(s) are used to represent a referent) and sub-lexical similarity (convergence on the specific handshape of signs) than individuals who sign with each other less frequently. Furthermore, diachronic comparisons showed that the distribution of variation is stable over time. The results indicate that the impact of interaction is discernible at a finer level of granularity than has been examined in prior studies, namely among subgroups of a single extended family.

However, frequency of interaction cannot be the only factor driving signers to converge, given prior work on homesign that has found that daily communication is not sufficient for the development of a shared system (Richie et al. 2012; Carrigan & Coppola 2017). Rather, individuals' willingness to engage with each other, what Green (2024) refers to as a 'moral orientation' towards mutual understanding, may be key. Among the deaf Z signers, for whom sign is their only means of communication, there is a strong pressure to establish conventional signs in order to maximize understanding. By contrast, because hearing individuals are first and foremost users of spoken language, their commitment to engagement with deaf individuals—and therefore their sensitivity to the pressure to adhere to standards of form in sign—can vary dramatically. This may account for differences between the three strata of signers. The core and intermediate signers expect each other to be proficient producers and receivers of Z sign, and they actively negotiate the form and meaning of signs through explicit metalinguistic discussion (German 2024b). By contrast, they do not expect this of the peripheral signers, who do not seem concerned to become skilled signers. This may explain why peripheral signer Martin has not converged with his deaf children as much as the hearing core and intermediate signers, even though they have all lived in the same household for decades.

The core signers' consistency in their production of handshape suggests, along with metalinguistic comments made by the signers during the task (German 2024b), that they have

developed standards of form for handshape, consistent with prior work on child homesign (Singleton et al. 1993). It seems Z signs are not iconic wholes that lack phonological structure, as Sandler et al. suggest for ABSL, but are based on specific articulatory targets for signs. Nonetheless, I have identified only three minimal pairs for handshape in Z sign, potentially indicating that like in ABSL, the handshape component does not participate in a system of phonemic contrasts. The development of consistent handshape targets may be the first step towards the emergence of phonemic contrasts. Importantly, a paucity of minimal pairs does not mean that phonology is absent altogether. Brentari et al. (2012, et seq.) have demonstrated that homesigners resemble signers of established languages, not hearing gesturers, in terms of the distribution of phonological complexity across morphologically-distinct types of handshapes. Thus, though minimal pairs may be rare, signers of emerging systems use handshapes in a more systematic and constrained manner than gesturers.

Ultimately, this study raises theoretical questions about the relationship of variation to the underlying system of language, especially in the study of emerging languages. How much variation should we expect from a “full-fledged” language? When should we expect variation to reflect social factors, and when should we conclude that it reflects a lack of conventionalization? The finding of this study is that even in one of the youngest and smallest linguistic communities—a single signing family—there is already a considerable degree of conventionalization at multiple levels of linguistic organization. It is quite possible that Z sign exhibits more variation than other sign languages, but the important point is that this variation is not random, but predictable based on the internal organization of the signing community.

Nonetheless, the conclusions that can be drawn from this study are tempered by two limitations. First, it is not clear how well elicited descriptions represent how the Z signers refer to things in natural conversation. The responses examined here are certainly longer than spontaneously-produced referring expressions. Second, unlike prior studies (Israel & Sandler 2009; Lutzenberger et al. 2021), the analysis of sub-lexical variation took into account only one parameter (handshape). Other parameters may exhibit distinct patterns of variation, which must be examined in future work.

8 Conclusion

This study examined lexical and sub-lexical variation in Z sign, a family sign language used by deaf and hearing members of an extended family in southern Mexico. Based on extensive ethnographic fieldwork, the family is modeled as a stratified sociolinguistic community in which different individuals sign with each other more or less frequently. Patterns of lexical and sub-lexical variation were shown to vary according to those sociolinguistic strata, suggesting that variation at both levels is conditioned, at least partially, by frequency of interaction. These

results demonstrate that an almost maximally young and small sign language can reach high rates of conventionalization at different levels of linguistic organization, while still exhibiting systematic variation. This study contributes to ongoing discussions in the fields of sign language emergence and typology regarding the relationship between community characteristics and linguistic structure.

Supplementary files

Supplementary files for this article can be found here: <https://osf.io/vyax7/files/m84fq>

They include:

- Appendix 1. List of stimuli
- Appendix 2. Rates of comprehension
- Appendix 3. Sample responses for ‘avocado’
- Appendix 4. Jaccard indexes by item
- Appendix 5. Similarity scores at each time point

Ethics and consent

Initial approval for this study was granted by the Institutional Review Boards at the University of Texas at Austin in 2019 (protocol 2019010119) and the University of Chicago in 2024 (protocol IRB24-1661).

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Competing interests

The author has no competing interests to declare.

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