

POINTING IN TİD (TURKISH SIGN LANGUAGE)

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DECLARATION OF ORIGINALITY

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ABSTRACT

Pointing in TİD (Turkish Sign Language)

This thesis examines the grammatical diversity of pointing signs in Turkish Sign Language (Türk İşaret Dili - TİD), identified through syntactic, morpho-phonological and prosodic evidence. As phonological cues can be subtle and challenging to detect with impressionistic methods, we also use Pose Estimation, a computer vision technique, to transform these cues into numeric ranges upon which hypotheses can be built. The distributional properties of pointing signs are meticulously analyzed using ELAN, allowing us to clearly differentiate primary categories, namely Locatives, Pronouns, Demonstratives, and Clitics. My categorization shows that spatial information, particularly horizontal (x) and vertical (y) axes, play a key morpho-phonological role in distinguishing between classes. The grammatical functions of pointing signs are explained through spatial features and syntactic properties. I argue that the phonologically strong Locative class utilizes the signing space to its fullest extent, while phonologically weaker and more functional classes, like Demonstratives, rely less on spatial parameters. Our approach integrates distributional evidence, advanced computer vision techniques and implications on grammaticalization to offer a detailed perspective on the roles of pointing in TİD.

ÖZET

Türk İşaret Dili'nde Gösterme İşaretleri

Bu tez, Türk İşaret Dili'ndeki (TİD) gösterme işaretlerinin dilbilgisel çeşitliliğini sözdizimsel, morfo-fonolojik ve prozodik kanıtlar aracılığıyla incelemektedir. Fonolojik ipuçları kimi zaman oldukça güç algılandığı ve izlenimsel yöntemlerle tespit edilmesi güç olduğundan, bu ipuçlarını sayısal aralıklara dönüştürerek üzerine varsayımlar kurulabilecek hale getiren bir yazılım tekniği olan Pose Estimation yöntemini de kullanıyoruz. Gösterme işaretlerinin dağılımsal özellikleri ELAN programı aracılığıyla detaylı şekilde analiz edilerek, ana kategoriler olan Yer Bildiriciler (Locatives), Zamirler (Pronouns), Göstericiler (Demonstratives) ve Klitikler (Clitics) net biçimde ayırt edilmiştir. Özellikle yatay (x) ve dikey (y) eksenler üzerinden taşınan mekânsal bilginin, sınıfları ayırt etmede temel bir morfo-fonolojik rol oynadığını görünmektedir. Gösterme işaretlerinin dilbilgisel işlevleri, mekânsal özellikler ve sözdizimsel yapılar üzerinden açıklanmıştır. Fonolojik olarak güçlü olan Yer Bildirici sınıfının işaret alanını en geniş şekilde kullandığını, buna karşılık fonolojik olarak daha zayıf ve işlevsel sınıfların, örneğin Göstericilerin mekânsal parametrelere daha az başvurduğunu ileri sürüyoruz. Bu çalışma, dağılımsal verileri, yazılım tekniklerini ve gramatikleşme süreçlerine dair çıkarımları bir araya getirerek TİD'deki gösterici işaretlerin işlevlerine dair ayrıntılı bir bakış sunmaktadır.

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*Each man's death diminishes me,
For I am involved in mankind.
Therefore, send not to know
For whom the bell tolls,
It tolls for thee.*

-John Donne (1624)

In memory of our martyrs, and of all the lives lost in the earthquake and fires.

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ABBREVIATIONS

TERMS RELATED TO SIGN LANGUAGES

ASL	American Sign Language
TİD	Turkish Sign Language
ISL	Israeli Sign Language
NSL	Nicaraguan Sign Language
DGS	German Sign Language
DSL	Danish Sign Language
BSL	British Sign Language
LSA	Argentine Sign Language
GSL	Greek Sign Language
IPSL	Indo-Pakistani Sign Language
LSB	Brazilian Sign Language

TERMS RELATED TO METHODOLOGY

CV	Computer Vision
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TERMS RELATED TO SYNTAX

WEC	Whole Entity Classifier
DP	Determiner Phrase
NP	Noun Phrase
VP	Verb Phrase
TP	Tense Phrase

TERMS RELATED TO MORPHO-PHONOLOGY

PoA Place of Articulation

TERMS RELATED TO PROSODY

PW Prosodic Word

PP Phonological Phrase

IP Intonational Phrase

LFT Lower Face Tension

TERMS RELATED TO LANGUAGE ACQUISITION

DHH Deaf or Hard of Hearing

DCHP Deaf Children of Hearing Parents

TERMS RELATED TO NON-MANUAL MARKERS

NMM Non-manual Marker

bl blink

eg eyegaze

ec eye contact

GLOSSING CONVENTIONS

IX Pointing Sign

IX₁ First Person Singular Pronoun

LOC Locative

PRO Pronoun

DEM Demonstrative

CLT Clitic

AUX Auxiliary

The extent of a nonmanual marker is represented by a continuous line that ends with the abbreviation of the marker. The symbol IX (indicating a pointing sign) may be combined with the abbreviations LOC, PRO, DEM, or CLT to reflect its grammatical function. This means that the pointing sign has been analyzed and categorized as a Locative, Pronoun, Demonstrative, or Clitic, respectively, based on its syntactic and morpho-phonological features.

To explicitly mark the initial and final frames of a pointing sign's articulation, the glosses include the labels (start) and (end). This convention is occasionally applied to lexical items as well. Signs illustrated with two frames are not disyllabic. Simply, their articulation is divided into two phases: the starting position of the hand and the final frame in which it remains visible.

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CHAPTER 1

INTRODUCTION

This thesis explores the linguistic functions of pointing signs in Turkish Sign Language (Türk İşaret Dili - TİD), with a particular focus on identifying the syntactic and morpho-phonological features that may distinguish seemingly similar pointing forms into distinct grammatical categories. These forms will be referred to by the following terms, all of which describe the phenomena under investigation here - “pointing sign”, “pointing”, “index”, “index sign”, and shortly “IX”.

The ability to point lies at the heart of human interaction. Pointing bridges entities and spaces, anchoring meaning in the physical dimension of communication. As one of the most intriguing products of the human mind, its significance spans fields such as language and cognition, and it has been the subject of extensive scholarly debate for over a century. Pointing has been recognized as a foundational component of human social cognition, a fundamental precursor to language (Kita, 2003), and a universal feature of human communication (Cooperrider et al., 2012).

Whether conveyed through the index finger, lips, chin, or eyes, pointing is ubiquitous across cultures and across the modalities in which human language is expressed (Kita, 2003). Its frequent presence in everyday interaction may make it appear deceptively simple to the untrained eye (Pfau, 2011). Upon closer examination, the intricate nature of these signs becomes evident. Pointing is, in fact, deeply integrated into the grammatical systems of sign languages, which are externalized in the visual-spatial modality.

While pointing may appear as an accompanying gesture in spoken languages, it serves as a primary channel for conveying *referential* and *locational* meaning in

sign languages. It is a highly structured linguistic tool, functioning on par with other grammatical elements. Although its surface form may appear uniform within a given sign language, pointing in fact has been observed to realize a range of distinct grammatical functions (Barbera & Zwets, 2013).

In sign languages, pointing signs are primarily used to express either entities or locations (Engberg-Pedersen, 2003; Senghas & Coppola, 2010). Firstly, in locational use, the act of pointing may function predicationally to construct expressions analogous to “There is an X,” highlighting an entity’s presence at a particular location. In example (1), the pointing sign marked as *IXa* is directed toward a peripheral area in the signing space. As the signer narrates the mouse’s action, they use a spatial location that corresponds to the position of the piano in the relevant fictional world (i.e., a cartoon), specifically, above the stairs to the right. The index sign in (1) thus realizes a locational function, indicating where the giant piano is physically situated.

(1) Locative Use of Pointing in TĪD

MOUSE RUN. NOT-WORK. GIANT-PIANO *IXa*.

“The mouse is running but it doesn’t work. There is a giant piano.”

Beyond locational functions, the two main classes within the nominal domain are (a) points that function pronominally, and (b) points that occur in a Noun Phrase. In pronominal use, a pointing sign may have a deictic function when directed at individuals present in the immediate, real physical environment. By extending the index finger toward a person or group of people, the signer selects referents in real time. This referential use is a universal feature of sign languages, integrated into their grammatical systems. There has been extensive discussion on whether sign languages exhibit a two-way, three-way, or no person distinction at all (Wilbur,

2013).¹ Although this interesting issue falls outside the scope of the present thesis, which simply aims to provide a general account of pointing uses in TİD, within the overall framework of the pronominal use of pointing signs, it is clear that these signs, in some grammatical environments, consistently function as person pronouns in TİD (Nuhbalaoğlu, 2013).

The pronominal pointing signs can also be used to indicate non-present entities. In such cases, the signing space is exploited on a more abstract level, creating a representational mechanism known as *referential loci*. Pointing is used to assign areas in the signing space to discourse referents, establishing referential loci for them which are symbolic locations that generally bear no relation to the referent's physical position in the real world. Later on in discourse, a pointing sign can be used anaphorically to refer back to these entities that have been established in designated areas of the signing space.

In example (2), both pointing signs are produced on the same side of the signing space. The pointing sign, *IX*, is directed at the ipsilateral area (the dominant hand-side of the signer); thus, a referential locus for the referent CAT is established there indicated with the referential index *-a*. The second pointing sign is used anaphorically to refer back to this CAT previously anchored to the referential locus *-a* by the first pointing sign. Therefore, the second *IX* has an anaphoric, pronominal use.

- (2) Establishment of referential locus (first *IX*) and its use by a pronominal point (second *IX*)
[IXa CAT] MOUTH SCRUB. [IXa] FOAM.

“That cat scrubs its mouth. It is blowing foam.”

¹ Some argue that sign languages lack person distinctions (Liddell 1990, 2003; McBurney 2002), while others propose a two-way (1st vs. non-1st; Meier 1990; Engberg-Pedersen 1993; Lillo-Martin & Klima 1990) or three-way (1st, 2nd, 3rd; Berenz 2000; Alibašić & Wilbur 2006) distinction.

Further observe in (2) that the first IX is immediately followed by the nominal sign ‘CAT’. This distribution indicates a demonstrative or determiner-like function for the IX - a distinction that will be further elaborated. In contrast, the second IX is signed between two verbal phrases, headed by SCRUB and FOAM respectively and thus it functions as a pronominal pointing sign. In this sense, a pronominal pointing sign differs from a demonstrative; it stands alone to refer to an entity, serving as the noun phrase itself, whereas, a demonstrative (or a determiner), must appear next to a noun within a Noun Phrase.

The challenge of labeling the first kind of indices in (2) more specifically calls for a theoretical discussion. Namely, it seems that [IX NP] constructions as in (2) function as definite descriptions; however, a closer examination is necessary to determine whether the index functions more like a *determiner* or a *demonstrative*. The distinction between determiners and demonstratives in sign languages has been addressed in the literature from various perspectives (see Abner, 2021; Bahan et al., 1995). One common proposal is that the main difference lies in the property of uniqueness. While determiners can be used with referents that are globally unique (e.g., the King of France), demonstratives such as “this” or “that” are not used in such contexts (Schwarz, 2009). Demonstratives require that the referent be familiar and anchored in the common ground (Roberts, 2003). Additionally, while demonstratives are referential, determiners are both referential and quantificational, allowing for co-varying interpretations, as in the example “the guy in the red shirt”, where the referent can change depending on who is wearing a red shirt (Koulidobrova & Lillo-Martin, 2016).

Due to the nature of the data used in this study, the pointing signs in [IX NP] or [NP IX] strings are labelled Demonstrative instead of Determiner. Since

participants were asked to describe the actions of two main fictional characters in video clips (namely, Tom and Jerry), it is highly likely that they presupposed these referents to be familiar to the addressee as well. Thus, the thesis data involves only pointing to familiar referents already anchored in the common ground of the signer and the addressee. Following this, there is no evidence as to whether these pointing signs would be felicitous in contexts requiring a global uniqueness or a quantificational reading. Grammaticality judgment tests would be necessary for a more in-depth theoretical analysis of the labeling of pointing signs that occur within an NP in TID. For these reasons, in this thesis, I will generalize all indices preceding or following an NP as Demonstrative.

Thus far, we have seen that pointing signs may function as a Locative, Pronoun, or a Demonstrative. There are various other possible grammatical roles, including agreement auxiliaries (Pfau & Steinbach, 2006). The challenge of categorization arises directly from the fact that many functions are realized by the same index form. However, it has been argued that the slightest alternations in morpho-phonological parameters like Place of Articulation (PoA), Orientation, and Movement make it possible to formally distinguish categories in which pointing signs are used (Engberg-Pedersen, 2003; Pfau, 2011). For instance, a contrastive feature within the Orientation parameter, such as palm-down versus palm-vertical, has been argued to mark a grammatical distinction between referential and predication uses of pointing signs (de Vos, 2015; Marsaja, 2008; Pfau, 2011). In addition to the morphological alternation capacity of the Orientation parameter, subtle modifications in the path of the Movement parameter (i.e., straight versus arched) may also signal whether a pointing sign is used in the nominal or verbal domain. As for the manner sub-parameter of the Movement, a tracing movement (de

Vos, 2015) is more closely related to a locational function whereas a jabbing movement (Zimmer & Patschke, 1990), or a repetitive motion (Pfau, 2011) is hypothesized to indicate a referential function.

A syntactic analysis may play just as important a role as the morpho-phonological characteristics in the disambiguation of grammatical classes of pointing signs. An exhaustive study of syntactic distributions, as well as morpho-phonological features of pointing reveals that a multi-layered analysis is essential for accurately capturing the grammatical diversity of pointing in sign languages.

Furthermore, the distribution of referential (i.e., nominal) and predication (i.e., locative) uses have been observed to follow certain trends in sign languages along a diachronic pathway. Thus, it is important to emphasize that studies on pointing offer valuable insight into grammaticalization, following a path from a gestural beginning to becoming a lexical item and, over time, a functional element. Within this trajectory, it is possible to observe various stages that evolve to express locations, person distinctions, the definiteness of referents, and eventually extending all the way to agreement markers (Pfau & Steinbach, 2006). These versatile signs may be undergoing semantic bleaching, decategorialization, and phonetic erosion, three processes that characterize grammaticalization across modalities (Heine and Kuteva, 2002).

In Turkish Sign Language, brief pointing acts, often nearly imperceptible at normal viewing speed, have been observed within nominal constructions in signers' utterances. These instances appear to have weakened, and thus become dependent on their syntactic hosts. They are classified as a weak demonstrative class. This thesis will argue that the weak demonstrative signs might have come to being as a result of

modality-independent grammaticalization processes, in line with Senghas & Coppola's (2010) findings on Nicaraguan Sign Language (NSL).

Despite extensive research on pointing in both spoken and sign languages, pointing in Turkish Sign Language (TİD) remains underexplored. By examining how morpho-phonological and syntactic properties of pointing signs makes them fall into distinct grammatical categories, and how prosody patterns with pointing, this study seeks to fill that gap. Through detailed manual annotation and an advanced state-of-the-art computer vision method, Pose Estimation, the analysis provides both qualitative and quantitative insights into these signs' linguistic functions. The analyses have led to the identification of four main grammatical categories of pointing signs in TİD, namely locatives, pronouns, demonstratives and clitics, each defined by a unique set of grammatical properties that come from morpho-phonology, syntax, and prosody.

Overall, the distinct linguistic functions of pointing signs hold significant potential for shedding light upon the long-sought answers about the language faculty, irrespective of modality, as well as providing insight into the modality-specific traits of sign languages.

The analyses in the thesis also follow a systematic comparison between native and nonnative signers. While native signers have been exposed to TİD from birth on, late signers have been exposed to TİD at a later stage. The results are evaluated within the framework of late language exposure and its effects on grammatical uses of pointing.

The structure of the thesis is as follows. Chapter 2 reviews the ongoing debate over the linguistic status of pointing, reviewing cross-linguistic findings on morpho-phonology, discussing grammaticalization, cliticization, and age of

acquisition effects. It further details recent research on T1D pointing signs, multiple studies on prosody and finally, computer vision (CV).

Chapter 3 presents the motivations and research questions of the study in detail. Chapter 4 explains the methodology, with sub-sections covering participants, tasks, procedures, manual annotations, and Pose Estimation. Chapter 5 presents the results, beginning with a frequency analysis in Section 5.1 and followed by syntactic (Section 5.2), morpho-phonological (Section 5.3) age of acquisition of effects (Section 5.4), and prosodic distribution analyses (Section 5.5), respectively. Finally, a summary table is provided in Chapter 6 followed by the grammaticalization discussions and conclusions.

CHAPTER 2

BACKGROUND

2.1 The linguistic status of pointing

Pointing signs in sign languages have sparked considerable theoretical debate across various linguistic subfields. Scholars have long sought to clarify the nuanced distinction between co-speech pointing gestures, typically found alongside spoken languages, and pointing signs, which are embedded in the grammar of sign languages (Liddell, 1990, 2003; Barberà, 2013; Barberà & Zwets, 2013; McNeill, 1992). While some researchers argue that pointing signs function like any other linguistic element, others contend that certain pointing signs retain gestural components, blurring the line between gestural and linguistic form (Liddell, 1995; Meier & Lillo-Martin, 2013).

Meier & Lillo-Martin (2013) and many other researchers have explored how pointing signs in sign languages form syntactic categories that have the same functions as deictic word classes in spoken languages, such as locatives, demonstratives, and pronouns. Meier and Lillo-Martin (2013) propose five criteria for evaluating the linguistic status of pointing signs: conventionality, indexicality, phonological compositionality, duality of patterning, and their role in marking grammatical distinctions such as plurality, possession and gender. They conclude that in spite of the gestural origins, pointing shows language-specific patterns in these criteria, suggesting its linguistic status.

Fenlon et al. (2019) analyzed 574 pointing signs from British Sign Language signers (BSL Corpus) and 543 pointing gestures from American English speakers (Tavis Smiley Corpus, Cooperrider 2014), examining these instances in relation to

three linguistic characteristics: conventionalization, reduction, and prosodic integration. They found that, while both pointing signs and gestures show formal regularities, pointing signs are more consistent across uses, more reduced, and more closely integrated into prosodic structure than gestures. These findings suggest that pointing exhibits different formal and functional behavior depending on whether it appears in a sign language or co-speech context.

As the recognition of sign languages to be fully functional natural languages became prevalent, scholars began to revisit the gestural roots and features of sign languages, aiming to better understand the distinctive role gestures play within the structure of sign languages (Cormier et al., 2013). While some scholars continue to investigate the intricate relationship between gesture and language (e.g., Cooperrider et al., 2022), others delve into the complexity and integration of these signs within the grammar of sign languages, focusing on analyzing their specific linguistic functions both syntactically and phonologically (Pfau, 2011; Zimmer & Patschke, 1990; de Vos, 2015; Engberg-Pedersen, 2003).

Research has shown that pointing signs can express locative meanings or take part in the nominal domain as person pronouns, determiners or demonstratives (Cormier et. al, 2013; Emmorey, 2002; Friedman, 1975; Berenz, 2002; McBurney, 2002; Sandler, 1999; Zimmer & Patschke, 1990). Furthermore, pointing signs mark agreement with arguments of the verb when they are used as agreement auxiliaries in certain sign languages (Alibašić and Wilbur, 2006; Barberà, 2012; Meier & Lillo-Martin, 2013, McBurney, 2002). Lastly, pointing signs can take an array of discursive roles such as marking hesitations and interjections (Barberà & Zwets, 2013; Spijker et al., 2023). In this thesis, I will concentrate on grammatical uses of

pointing signs, only briefly mentioning discourse-level functions and leaving them to another study.

Various detailed analyses have emerged regarding the syntactic and semantic status of pointing signs, particularly within the nominal domain. For instance, American Sign Language (ASL) has been described as including both pre-nominal and post-nominal pointing signs that function as articles to mark definiteness (Wilbur, 1979; Hoffmeister, 1977), whereas others have argued that ASL lacks articles and Determiner Phrases (DP) altogether (De Vriendt & Rasquinet, 1989). Up to this day, the linguistic status of pointing signs that co-occur within a nominal phrase remains widely debated. Bernath (2009), for instance, emphasizes that ASL lacks articles that are omnipresent or obligatory, unlike those found in Germanic and Romance languages. Additionally, the optionality of indices has been viewed by some researchers as problematic for analyzing them as determiners, given that determiners are typically central to both syntactic structure and semantic interpretation, and are therefore not expected to be optional (Abner, 2021).

Zimmer and Patschke (1990) propose that ASL has determiners on both edges of a noun phrase (NP), based on their analysis of a phonological subset of pointing signs. Bahan et al. (1995), however, contradict this claim following a closer examination of indices within the NP. They argue that post-nominal pointing signs do not pattern like determiners but instead function adverbially, allowing for both definite and indefinite interpretations. In contrast, pre-nominal pointing signs are suggested to be true articles, obligatorily marking definiteness. More recently, Koulidobrova and Lillo-Martin (2016) have put forward the view that pointing in ASL functions as neither a definite article nor a pronoun within the nominal domain, but rather consistently operates as a demonstrative in all cases.

Similar to the ongoing debate on pointing signs inside the NP, pronominal pointing signs have also been controversial, particularly regarding their spatial use for marking persons. For instance, some researchers, such as McBurney (2002) and Liddell (1990, 2003), argue that person distinctions do not exist in sign languages. Others, including Engberg-Pedersen (1993), Meier (1990) and Lillo-Martin & Klima (1990), suggest that sign languages distinguish only between first and non-first persons. Furthermore, studies by Alibašić and Wilbur (2006) and Berenz (2000) propose a three-way distinction of first, second, and third persons.

Overall, these debates on pointing signs underscore their diverse linguistic functions, providing valuable insights into their role within the grammatical structure of sign languages and their implications for broader linguistic theory.

2.2 The morpho-phonological makeup of pointing signs

In addition to distributional evidence brought to bear for various analyses cited thus far, one should also turn to phonology to substantiate different categories of pointing signs, as the challenge of distinguishing these seems to extend to the phonological domain. This being said, the morpho-phonological distinctions between the grammatical categories can be quite subtle compared to spoken languages given the overlaps in formational features between categories (i.e., handshape, movement, orientation, location) (Ahlgren, 1990). Thus, it becomes imperative to carefully examine the alternations in morpho-phonological parameters that help to distinguish these pointing signs.

Many linguists have worked on the versatile morpho-phonological features for a grammatical analysis. Previous studies have shown that phonological parameters such as movement, handshape, palm orientation, and non-manual markers (NMMs) play a central role in distinguishing grammatical categories (Engberg-Pedersen, 1993;

Pfau, 2011; Marsaja, 2008; de Vos, 2015; Senghas and Coppola, 1999; Van der Kooij et al., 2006).

De Vos (2015) analyzed 1,000 pointing signs from Kata Kolok, an indigenous sign language used in northern Bali. She notes that in Kata Kolok, one out of six signs is a pointing sign and they are used as locatives, local pronouns, and temporal adverbs. In this language, locatives can be proximal (closer to the body midline) or distal (away from the body midline), each with distinct phonological features: proximal locatives involve a downward point in the signing space, while distal locatives are accompanied by squinted eyes and pursed lips. Additionally, locatives may be articulated with a tracing movement to indicate a path, ending with a non-manual completive marker, such as a lip smack.

Similarly, Engberg-Pedersen (2003) studied the formal properties of pointing signs in Danish Sign Language (DSL), estimating that, on average, nearly one in every four signs is a pointing sign. She observes that the pronoun and determiner are produced with a brief movement or a slight side-to-side motion of the index finger. The finger is relaxed and held horizontally. Typically, the hand and arm remain neutral. Pronouns and determiners are indistinguishable through phonology and can only be differentiated through their syntactic distribution.

(3) “My American father said to me, ‘Why don’t you sign up for volleyball.’”

V+	fr +	V+
1.p AMERICA FATHER DET+fr /	NOTIFY+1.p WHY NOT	DET+m
VOLLEYBALL /		

(4) “She understood the problem.”

+	V +	fr V +
PRON+fr	UNDERSTAND PROBLEM	PRON+fr /

- (+ Eye contact with the receiver
- V Eye blink
- / Boundary shown by visual “rhythm.”

(The letter or letter combination before the gloss for a verb refers to the agent or experiencer’s locus

and the letter or letter combination after the gloss refers to the patient or receiver’s locus: fr = forward right.)

(Engberg-Pedersen, 2003, examples (1) and (2), p. 273)

In (3), the pointing signs function as determiners in 'my American father' and 'volleyball.' In (4), the initial pointing sign is a pronoun constituting the topic of UNDERSTAND PROBLEM while the final pointing sign serves as a resumptive pronoun, often occurring at major discourse boundaries. Therefore, Engberg-Pedersen (2003) argues that while the pronouns stand alone, determiners are dependent on their noun hosts.

In DSL, both pronouns and determiners have undirected variants in which the index hand is briefly held without movement or the pointing occurs during a transition where the finger direction is not relevant. The undirected pronoun lacks a deictic element, making it referential but non-indexical. Importantly, Engberg-Pedersen (2003) argues that the frequent use of undirected variants in Danish Sign Language strongly suggests that pointing gestures have become integrated as signs with specific syntactic functions within the language.

Similarly, Pfau (2011) posits that pointing signs have multiple grammatical functions, such as indicating the location of an object or event, either in combination with nouns (e.g., ‘the house over there’) or in a predication role (e.g., ‘the house is

over there’). Additionally, within a Noun Phrase (NP), a pointing sign can be a determiner (e.g., ‘the house’) or a demonstrative (e.g., ‘this/that house’). Pfau notes that pointing signs can also be person pronouns, either referring to present referents or loci established in prior discourse for non-present referents.



Figure 1. Movement characteristics of proximal adverbial (a), distal adverbial (b), and demonstrative (c) in DGS (Pfau, 2011, Figure 4R.2., p. 150)

Pfau argues that the length and shape as well as the tenseness of the movement trajectory are significant. Using data from German Sign Language (DGS), he illustrates differences between a proximal adverbial with a short downward movement (his Figure 4R.2a), a distal adverbial with a long arc-shaped movement (his Figure 4R.2b), and a short, tense forward movement that often includes repetition (his Figure 4R.2c).

In line with Engberg-Pedersen’s findings on DSL, Pfau reveals that pronominal pointing signs in DGS also phonologically align with demonstratives. However, he observes a slight variation in their form: unlike demonstratives, pronominal pointing signs have a less tense movement that is not typically repeated, except when used contrastively.

Moving on to the analysis of hand orientation as one of the foremost phonological parameters, Pfau presents samples from languages such as Kata Kolok (Marsaja, 2008; de Vos, 2015), where nominal points for referencing people and

objects typically use a vertical palm, while locative points are signed with the palm facing down. Pfau highlights that DSL also makes use of a vertical palm when referring to nominals whereas the pointing signs in the predicate domain are signed with the palm down (see also Engberg-Pedersen, 2003).

Pfau compares data from NSL and Kata Kolok to examine how eyegaze functions as a nonmanual marker (NMM) distinguishing nominal and locative signs. He finds that in NSL, eyegaze is used to mark locative meanings but not nominal references, whereas in Kata Kolok, eyegaze is also used for nominal reference. Additionally, Pfau discusses findings from other studies such as Berenz's (2002) analysis of Brazilian Sign Language (LSB) which indicate that eyegaze can also differentiate pronominal types, specifically between second- and third-person pronouns.

After examining cross-linguistic data on phonological parameters in distinguishing nominal and locative functions, Pfau proceeds to explore the diachronic shifts in these uses of pointing signs. He interprets these phonological shifts as evidence for a modality-independent grammaticalization pathway, with NSL offering diachronic insight into the transition from locative to nominal functions. We will cite more detail on the grammaticalization processes in the next subsection.

2.3 Emergence and grammaticalization of pointing signs

Grammaticalization is the process where lexical items evolve into functional forms and later, into affixes. Heine & Kuteva (2002a:378) explains this process as involving three key mechanisms: first, "semantic bleaching," or the loss of meaning²; second,

² In this thesis, the term semantic bleaching is used in reference to grammaticalized items. While traditionally understood as the loss or weakening of lexical meaning during grammaticalization, von Stechow (1994) offers a formal semantic reinterpretation of the concept. He argues that rather than becoming meaningless, grammaticalized items shift from lexical to functional meanings, and gradually taking on higher semantic types. From this perspective, grammaticalized items are not

“deategorialization”, which reduces functional properties associated with categories; and third, “erosion”, or “phonetic reduction” which is an observable loss in the phonological components (see also Pfau & Steinbach, 2006).

Grammaticalization has been documented in many spoken and sign languages. Research by Sampson and Mayberry (2022) demonstrate that the ASL sign 'SELF' has undergone grammaticalization over the past 150 years, transforming from a simple lexical sign into a morpheme functioning as a copula, a semantically empty element that links the subject and the predicate. They propose the grammaticalization path below:

(5) deixis > demonstrative > pronoun > copula

(Katz, 1996, as cited in Sampson & Mayberry, 2022, Figure (28), p.337)

This progression suggests that the same forces driving linguistic change in spoken languages also influence change in sign languages. In spoken languages, an illustration of grammaticalization comes from Heine and Kuteva (2002).

(6) In Hausa:

a. Audù yanà cân

Audu 3.M.be there

‘Audu is over there.’

b. dabbōbin cân

animals that

‘those animals (over there)’

(Chadic, Nigeria; Cowan and Schuh 1976; as cited in Heine and Kuteva 2002:294)

semantically simpler or less complex, grammaticalization is not a path toward semantic reduction, but toward abstraction and structural integration. This thesis adopts von Stechow’s view, using the term to refer to this shift in semantic type and abstraction, rather than to a simple loss of meaning.

As seen in (6), Hausa is a language in which demonstratives evolved from their locative function. Similarly, in sign languages, the demonstrative function of the pointing sign may have emerged from the locative, supporting the idea that this grammaticalization process is not exclusive to spoken languages but it applies across modalities. Pointing signs are argued to further grammaticalize into pronouns, and auxiliaries (Pfau, 2011).

Evidence from several sign languages demonstrate that some auxiliaries can be traced back to index forms, suggesting a path from pronoun to agreement auxiliary (Pfau & Steinbach, 2006). In sign languages, including Argentine Sign Language (LSA) (Massone & Curiel, 2004), and Indo-Pakistani Sign Language (IPSL) (Zeshan, 2003c) agreement auxiliaries appear to have emerged from the co-occurrence of two distinct pronominal signs: the signer points first to the subject locus and then transitions smoothly to the object locus. Over time, *"the short movement towards a locus which usually characterizes pronominal signs is lost and the auxiliary consists of a hold-movement-hold sequence (i.e., one syllable)"* (Pfau & Steinbach, 2006, p. 68).

A key feature of these auxiliaries is their semantic bleaching, as similarly proposed by Heine and Kuteva (2002) for spoken languages. Aside from marking agreement relations, they carry no additional meaning. This transformation can be described as the fusion of two independent pronouns into a single prosodic word, which then functions to mark both subject and object agreement within the clause.

In-depth studies on pointing in emerging sign languages, such as NSL and Kata Kolok, have revealed how these signs systematically and gradually become a part of the grammatical structure of sign languages.

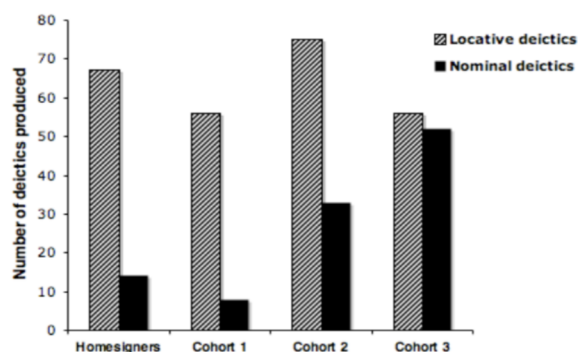


Figure 2. Locative and nominal pointing sign use across cohorts (Senghas & Coppola, 2010, Figure 7, p.14)

A key shift in this grammaticalization path documented by Senghas and Coppola (2010) is the gradual increase in points that no longer referred to physical locations but rather to non-spatial, referential entities, namely nominal points (e.g., pronouns and demonstratives). As the original locative content of pointing began to disappear, the pronoun and demonstrative uses took hold in NSL. This shift highlights a critical step in the grammaticalization process: the loss of locative meaning as pointing takes on more abstract, grammatical functions (see Figure 2).

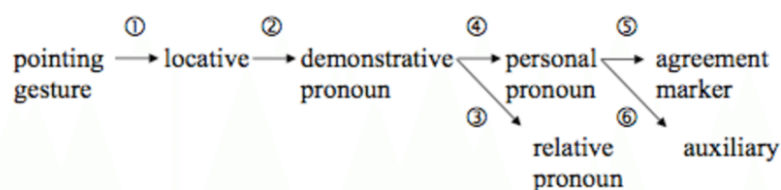


Figure 3. Grammaticalization of pointing signs (Pfau, 2011, Figure 4R.4., p. 155)

In line with Senghas and Coppola, Pfau and Steinbach (2006) also discuss how gestural pointing starts out as a locative in a grammatical system and gradually gains more functional roles across different nominal and verbal constructions. Pfau (2011) examines the grammaticalization trajectory across a wide spectrum of linguistic

functions for pointing signs. In his table cited above (see Figure 3), these signs evolve further into highly functional linguistic elements, such as agreement markers, and auxiliaries. However, this trajectory is not strictly linear, nor does it suggest that one form must always yield a single grammatical class. For instance, he suggests that both demonstrative and locative uses of the pointing sign could have emerged simultaneously from the same gestural source, highlighting that multiple interpretations are possible, and the grammaticalization process can follow diverse paths.

2.4 Cliticization of pointing

Clitics stand at the intersection of phonology, syntax, and morphology, reflecting transitional stages in grammaticalization. While the term clitic has been a controversial topic, the linguistic roles that are generally attributed to these items have been widely analyzed. Narrog & Heine (2021) define a clitic as *“a morpheme which is more bound than a word but less bound than an affix”* (p. 331).

Zwicky (1977) attempts to provide the first crosslinguistic study of clitics by analyzing numerous unrelated languages. He explains that clitics are phonologically weak elements that cannot stand alone and need to attach to adjacent, stress-bearing words as they lack stress. Despite their phonological dependence, clitics retain regular syntactic behavior, similar to their full, stressed counterparts. Clitics can be function words, such as definite markers or auxiliary verbs, which assimilate into the neighboring words. In sum, this phonological dependence distinguishes clitics from fully independent words.

In sign languages, Kegl (1986) gave a detailed analysis of clitics in ASL, highlighting that pointing signs which are used as pronouns can be cliticized leftward

onto any adjacent word. Furthermore, Gökgöz (2020) has also identified that pronouns can cliticize to a lexical host in TİD, which we will explain in the following section.

Studies on Danish Sign Language provide further insight into the properties that are observed in clitics although the researchers do not directly use the term ‘clitic’ for labeling these forms; they prefer ‘undirected variants’, as mentioned above (Engberg-Pedersen, 1993). In these cases, the index hand is briefly held still or emerges in a transition movement. Due to their phonological weakness, their appearances are often so short that they can only be clearly observed in slow motion.

Another mention of clitic constructions among pointing signs comes from ISL. Sandler (1999) argues that there are two different types of cliticization, namely Handshape Assimilation and Coalescence.

As for cliticization due to Handshape Assimilation, Sandler (1999) shows that when a first-person pronominal pointing sign performed with the index finger on the chest precedes a verbal element articulated with two fingers, the index point is assimilated and realized with two fingers on the chest instead.

Coalescence takes place when a pointing sign is simultaneously articulated by the dominant hand midway through the production of the host sign, which continues to be signed by the non-dominant hand (see Figure 4).



Figure 4. Coalescence in ISL
(Sandler, 1999, Figure 18, p. 241)

During the Coalescence process, the pointing sign loses its syllabicity and encliticizes onto the host sign SHOP which is normally two-handed. The clitic is interpreted as fulfilling a deictic function conveying the meaning ‘there’ in ISL; however, this type of Coalescence can also be observed with person pronouns or possessive pronouns (Sandler, 1999).

Sandler explains that Coalescence is not affordable through spoken language phonetics, which would require an anatomically impossible ability to simultaneously produce and perceive multiple articulations at distinct places within the vocal tract.

Despite comparatively more extensive research on spoken languages, clitics remain largely unexplored in sign languages. Pointing signs hold the potential to unlock deeper insights into their linguistic intricacies and enrich our understanding of modality-dependent and independent traits of grammatical mechanisms in the visual-spatial modality.

2.5 Pointing signs in Turkish Sign Language (TİD)

In Turkish Sign Language (TİD), pointing signs fulfill a variety of linguistic functions, such as person pronouns, locative/demonstrative pronouns, and determiners (Gökgöz, 2020). A pointing sign could appear with a noun, showing properties of a determiner. When a pointing sign substitutes the noun phrase, these constructions are considered pronouns.

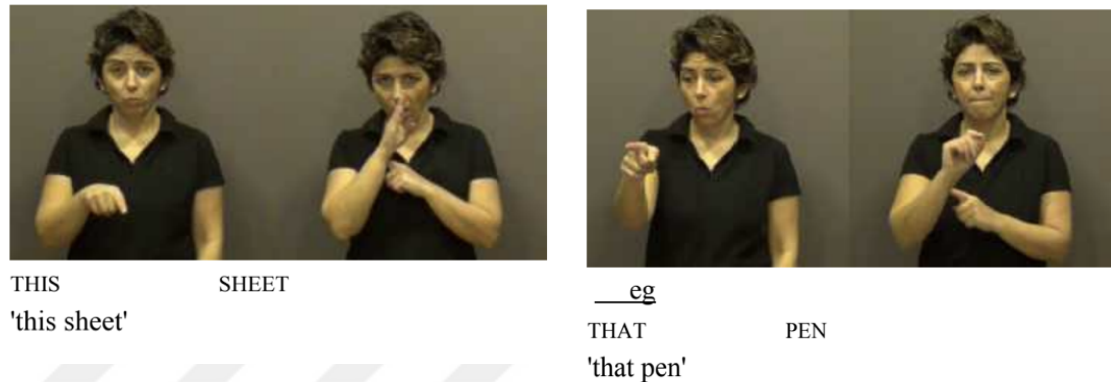
A pointing sign (IX) can act as a definite article when referring to a previously introduced referent (7). In contrast, the numeral "ONE" can be used as an indefinite article. Gökgöz (2020) outlines how TİD marks definiteness and indefiniteness through these pointing signs.

(7) SEA REED [MAN IXdef] HOLD.RIFLE WAIT

'The man is holding a rifle and waiting in the reeds by the lake.'

(Gökgöz, 2020)

A demonstrative is argued to precede a noun in a noun phrase, sometimes accompanied by non-manual markers. Gökgöz (2020) suggests that while the proximal demonstrative 'this' is signed in front of the signer's chest, the distal demonstrative 'that' is generally signed on more peripheral places.



Pronouns in TİD are typically expressed through pointing signs directed toward the signer or outward from the signer's body. Nuhbalaoğlu (2013) argues that there is a three-way person distinction in TİD: the first person is indicated by pointing to the signer's chest, while second and third persons are marked by outward-pointing signs. Pronouns in TİD do not carry any marking for gender, nor do they inflect for case. However, they reflect number distinctions, including singular, plural, and dual. TİD further distinguishes between inclusive and exclusive forms of "we" and "two of us", capturing whether the addressee is included in the referential set. Altogether, these features point to a pronominal system that encodes fine-grained referential distinctions through formational and spatial parameters.

Despite these valuable initial accounts of TİD, the linguistic properties and multifunctionality of pointing signs remain underexplored. The current study addresses this gap through a more comprehensive and systematic investigation.

2.6 Prosody of pointing signs

Prosodic phonology examines how morpho-syntactic features can be mapped on the suprasegmental features of languages. It studies the hierarchical relations formed between the constituents, along with the prominence and varying levels of closeness of constituents within this hierarchy. In this thesis, I will adopt the prosodic hierarchy proposed by Nespor & Vogel (1986) and will build on the arguments proposed by Nespor & Sandler (1999) on Israeli Sign Language (ISL) as well as Brentari and Crossley (2002) on ASL.

The hierarchy established by Nespor and Vogel (1986) is presented in (9). The main idea suggested through this schema is that the string of words in a sentence is

composed of sub-constituents and these sub-components follow a hierarchical composition. That is, no intermediary stage within this schema can be skipped.

(9) mora < syllable < foot < prosodic word < clitic group < phonological phrase < intonational phrase < phonological utterance

To distinguish these levels in sign languages, Nespor and Sandler (1999) emphasized the role of the dominant (H1) and the non-dominant (H2) hand, while Brentari and Crossley (2002) focused on facial non-manual markers.

The main focus in this thesis will be on understanding the prosodic word for the purposes of studying pointing. A prosodic word usually aligns with a single morphological word; however, it can also include elements like clitics or affixes that are added post-lexically but behave as part of the same phonological unit (Sandler, 1999).

The prosodic word is proposed to be subject to various constraints that reflect the physical articulatory affordances of sign languages, such as Monosyllabicity, Symmetry, Place and Selected Finger (SF) Constraint (Sandler, 1999). Drawing on Optimality Theory, Sandler demonstrates that these constraints are violable and ranked differently at lexical and post-lexical levels. For instance, compounds prioritize Symmetry over Monosyllabicity, while post-lexical clitic constructions may reverse this ranking to favor the optimal monosyllabic form. Importantly, cliticization, whether through coalescence or handshape assimilation, results in forms that can be labeled as prosodic words. This phenomenon is argued to be shaped by universal pressures for phonological optimization.

Prosody has been described to signal the structure of prosodic units via rhythm, pauses, pitch, loudness and duration in spoken languages. Meanwhile, in sign

languages, there are a number of manual and non-manual cues to mark different prosodic levels.

According to Nespor & Sandler (1999) the domain of a phonological phrase is strongly cued by the non-dominant hand (H2) spread; however, Brentari & Crossley (2002) argue that H2 spread is only a redundant cue, with non-manual markers being the primary indicators. They exhaustively list the possible ways signers may signal the boundaries between these units by using non-manuals. Lower face tension (LFT), blinks, gaze as well as head-body orientation may all be strong cues for prosodic boundaries. Table 1. Criteria for PW, PP, and IP prosodic constituents in ASL

Table 1. Criteria for PW, PP, and IP Prosodic Constituents in ASL

	lower face/LFT	lengthening	blinks
P word	no change	no	no
P Phrase	change	yes	no
I Phrase	NA	yes	yes

(Brentari & Crossley, 2002, Figure 26, p. 127)

Extending Baker and Padden (1978) who suggested that eyeblinks occurred at constituent boundaries, Wilbur (1994) identified two different types of eyeblinks; periodic blinks that occur at the Intonational Phrase boundaries, and voluntary blinks that take place with a lexical sign. Markers for different levels are summarized in Table 1 adopted from Brentari & Crossley (2002).

In ASL, a prosodic word (PW) is typically characterized by the absence of changes in LFT, no lengthening and no inhibited eyeblinks. In contrast, a Phonological Phrase (PP), containing multiple PWs, often involves a shift in LFT, possible lengthening of manual signs, but still no blink. An Intonational Phrase (IP), the higher prosodic unit comprising several PPs, is signaled by a blink at the right or left edge of

the IP signaling its boundary. Although LFT and other facial expression changes continue to be present at the IP level, they are not distinctive enough to reliably mark IP boundaries. Thus, LFT is considered not applicable (NA) as a diagnostic for IPs. In other words, while LFT offers robust cues at the PW and PP levels, being marked by continuity (PW) or change (PP) across constituents, it does not systematically correlate with identification of an IP as Table 1 shows.

These findings carry significant implications for our understanding of diachronic change in sign languages. The observation that forms tend to exhibit only a single value for Lower Face Tension (LFT) aligns with a broader tendency across phonological parameters, such as handshape, movement, and place of articulation, to converge on a single, contrastive specification as forms become lexicalized. This suggests that non-manual features, like their manual counterparts, are shaped by structural pressures toward simplification during the lexicalization process. Within an Optimality theory framework, constraints such as Monosyllabicity, Symmetry, Place, and the SF guide the well-formedness of signs. The convergence toward single values across parameters both manual and non-manual, can be viewed as a modality-specific expression of universal constraint-based pressures that govern phonological organization.

In this thesis, the diachronic implications of prosodic patterns will play an important role in the overall discussion. Studying the prosodic structure of pointing signs is critical, as prosody interacts with both phonology and syntax, two core domains through which pointing signs are analyzed in this thesis. Thus far, there has been no comprehensive research examining the prosody of TİD, and consequently, little is known about its overall prosodic structure. The analysis presented here aims

to identify where pointing signs fall within the broader prosodic organization of TİD, leaving a more extensive analysis for future research.

To date, one of the few studies addressing the prosodic behavior of pointing signs in TİD is Gökgöz (2020), which offers important observations on the prosodic integration of pronominal forms. As outlined by Gökgöz, the cliticized form of pronominal pointing signs in TİD attaches to the verbal host and forms a single prosodic unit with it. Below in (10), the first index is accompanied by a closed mouth, a change in this lower face NMM is observed just as the mouthing ‘beğendim’ (I liked it) starts to be articulated. This mouthing, which imitates the corresponding Turkish word for ‘LIKE’ spans the entire prosodic word including the second index, marking it as a cohesive unit. Therefore, a pronominal pointing sign can either form a PW with a host or form a PW independently, without attaching to any hosts.

(10)	Mouth-closed	/Beğendim/
	IX1	LIKE IX3a
	(Prosodic Word)	(Prosodic Word)

(Adapted from Gökgöz, 2020, p.100)

2.7 Language development and late exposure

Language acquisition of children who are Deaf or Hard of Hearing (DHH) faces significant challenges worldwide. One of the most influential obstacles is that 90% of deaf children are born into hearing families (Lillo-Martin & Henner, 2021; Mitchell & Karchmer, 2004). Although some deaf children receive cochlear implants from birth, not all are able to use them effectively due to physiological reasons. Furthermore, cochlear implants do not offer a comprehensive solution for most Deaf children of

hearing parents (DCHP), who may still be deprived of natural language input during the critical early years of development (Hall, 2019).

Most Deaf children are born to hearing parents who have no prior exposure to sign languages or the Deaf community. In such cases, families often follow medical advice that favors oralist methods and discourages the use of sign language. Such an approach can result in a fundamental clash between the child's perceptual orientation and the modality of language exposure, visual-gestural versus auditory vocal, which in turn undermines the conditions required for natural language development. As a result, Deaf children may lack consistent and accessible linguistic input during the critical period (Humphries et al., 2016).

In a slightly better scenario, families choose to learn a sign language and provide their children input in the visual-spatial modality. However, there will be a delay in the input as it will take time for the family to become fully fluent in a sign language. Therefore, the process may not be on par with typical language acquisition. From the age of 4, DCHP may be sent to a deaf school. However, a deaf school in Turkey does not guarantee a high quality TİD education either, as most teachers are not deaf and have learnt TİD as a second language (Ilkbasaran, 2015).

The age of first exposure to a sign language might change among late signers. However, once a certain threshold is passed, the effects of delayed input may cause lasting consequences, even if consistent exposure to a sign language follows. Mayberry and Eichen (1991) provide strong evidence that delayed exposure to a first language has long-lasting detrimental effects, even when individuals later receive many years of consistent sign language input. Even with decades of subsequent use, late learners do not attain the same levels of grammatical processing and comprehension as native or early signers. More specifically, delayed input has been

associated with limitations in phonology (Mayberry & Fischer, 1989) and morphosyntax (Kayabaşı & Gökgöz, 2022).

In sum, several comprehensive studies have explored how the age of first language exposure impacts acquisition (see Mayberry & Eichen, 1991; Mayberry & Fischer, 1989; Kayabaşı & Gökgöz, 2022; Hall, 2019; Humphries et al., 2016). Despite extensive research in this field, many questions remain regarding the full impact of Age of Acquisition (AoA) on language development, and especially its specific effects on the use of pointing signs in sign languages remain underexplored. This thesis seeks to address this issue through a close look into pointing signs. We investigate whether delayed language input has differential consequences for the production of grammatical functions of pointing.

Given the critical role of early language access in grammatical development, a comparison between native signers (exposed to a sign language from birth) and late signers (exposed later in life) offers valuable insight. We focus specifically on how each group employs pointing signs across grammatical categories in TİD. In doing so, this study contributes to our understanding of how delayed input may shape the linguistic functions of pointing in sign language grammar.

Studying the effects of Age of Acquisition is crucial for raising awareness and encouraging policy-level changes that ensure deaf children have equal access to sign language from an early age. Researchers have a responsibility to provide the scientific foundation needed to inform protective measures for children at risk of language deprivation. Ultimately, communication and social cognition constitute fundamental components of human development and are essential for meaningful participation in society.

2.8 Computer vision

Computer vision (CV) technologies make it possible to extract structured information from visual input by tracking, or analyzing movement. The use of CV has been increasing across many fields within the past decade. In sign language research, where meaning is built through layered movements of the hands, face, and body, these tools have opened up important new possibilities.

In spoken language research, instrumental methods have long been used to capture subtle variation in sound production (e.g., Lieberman 1963). Sign language linguistics has lacked equivalent tools for examining articulatory properties in a systematic way. Therefore, most analyses have depended on manual annotation, which is not only time-consuming but also highly dependent on the researcher's interpretation (Trujillo et al., 2018).

One approach to addressing this gap has been the use of motion capture (mocap) technology. These systems track body movement using tools such as special suits or small markers that reflect infrared light, which are attached to key points on the body. When captured by motion-sensing cameras, these markers allow researchers to reconstruct how signs are produced in three-dimensional space with a high degree of precision (Jantunen et al. 2012). With the advance of technology, some mocap technology, such as Kinect, eliminated the need for markers or reflectors on the body of the signer, creating a rather non-invasive environment (see Trujillo et al., 2018; Stamp et al., 2024).

Stamp et al. (2024) conducted a study on Israeli Sign Language (ISL) using Kinect Version 2, to measure phonetic reduction. A similar approach was taken by Flaherty et al. (2023), who used Kinect-based motion tracking to document changes

in the size of signing space in NSL measuring wrist trajectories to quantify articulatory range.

Despite the precision of calculations, mocap systems come with limitations: they require controlled environments, expensive devices (e.g., bodysuits, sensors, or 3D cameras), and are not suitable for working with pre-recorded data (see Jantunen et al. 2012; Börstell, 2023).

Computer vision-based pose estimation provides a more accessible alternative. Instead of sensors or suits, it can work directly with video data, using pre-trained models to identify and track body landmarks, hands, joints, and facial features (Börstell, 2023). The calculations are made frame by frame, using the coordinates in each frame. Tools like OpenPose (Cao et al., 2019) and MediaPipe (Lugaresi et al., 2019) have made it possible to extract this kind of data from video recordings (Kuznetsova & Kimmelman, 2024). The shift from motion capture to CV-based tracking reduces equipment demands and allows for the analysis of larger datasets.

That said, the use of computer vision in sign language linguistics presents specific challenges. Unlike motion capture systems, which directly record three-dimensional movement using depth sensors or multiple cameras, CV-based methods must infer 3D motion from 2D video input, making them less reliable for capturing depth-related features (Pouw et al., 2020).

Another issue is the lack of a standardized, machine-readable system for representing signs, unlike spoken languages that benefit from established transcription systems such as the IPA or orthographic conventions (see Crasborn, 2015). This absence has made it more difficult to apply automated or computational methods to sign language data (Börstell, 2023). However, the development of

reliable body-tracking algorithms has opened up new possibilities. Studies by Börstell (2023), Pouw et al. (2020), and others show that these tools can support meaningful phonological and grammatical analysis.

Pose estimation also brings important practical benefits. Manual annotation of signing data can be time-consuming, and in some cases, variation in labeling may arise, especially when dealing with gradient features or fine spatial distinctions. CV offers a way to streamline the annotation process. It can provide more consistent measurements across large datasets and still account for individual variation among signers. Fragkiadakis (2022), for instance, developed the DistSign tool, which uses OpenPose to track wrist trajectories in American Sign Language (ASL) and Ghanaian Sign Language (GSL). The tool applies Dynamic Time Warping to compare the movement paths of different signs, enabling the detection of formal similarities and differences across and within languages.

Still, there are clear limitations. The tracking of non-manual markers, such as eyebrow movement or head tilt, remains a major challenge. These features involve small articulators and subtle cues. Kimmelman et al. (2024) tested MediaPipe Holistic against OpenFace for tracking eyebrow position, pursuing the inquiry whether the results would be precise enough to support linguistic analysis. Their results showed that MediaPipe's output was too distorted to capture even clearly distinct eyebrow positions. As noted in Kimmelman et al. (2024), the main difficulty lies in detecting fine, low-intensity movements that involve subtle cues visible to human annotators but fall beyond the resolution of current computer vision models.

These findings underscore a key limitation of current pose estimation tools: while they can facilitate large-scale analysis and support new types of quantitative inquiry, they cannot yet fully substitute for manual annotation. Certain dimensions of

sign language structure are still better accessed through human perception and linguistic judgment.

For this reason, the present study adopts a combined approach. Manual annotation is done for several phonological parameters while pose estimation is used to extract and measure spatial properties of pointing signs. This integration of quantitative and qualitative analysis aims to produce a fuller and more reliable account of the morpho-phonological behavior of pointing signs in Turkish Sign Language.



CHAPTER 3

CURRENT STUDY

While pointing in sign languages has its roots in gesture, the present thesis sets aside its gestural origins to focus on the formal diversity of pointing in Turkish Sign Language (TİD). As a relatively less explored sign language compared to ASL and other Western sign languages, TİD offers numerous linguistic puzzles yet to be unraveled. This study focuses on one such puzzle: the grammatical uses of pointing signs in this language.

To date, there have been very few analyses of the varied uses of pointing signs in TİD, as previously noted, a gap this research aims to address by presenting an in-depth evaluation of possible grammatical functions. By examining the linguistic characteristics of pointing signs in TİD, this study contributes to ongoing discussions about their roles, offering insights into broader linguistic research through implications for grammaticalization, cliticization, as well as Age of Acquisition (AoA) effects, which will be detailed below.

The analysis presented in this study is three-fold. First, the syntactic distribution of pointing signs is examined to understand their functional roles. Second, a morpho-phonological analysis investigates articulatory variation across grammatical categories. Third, prosodic features, particularly the role of non-manual markers (NMMs), are analyzed to determine their alignment with syntactic and morpho-phonological distinctions.

The syntactic distribution of these pointing signs plays a significant role in illuminating their functional properties. Thus, a close investigation into a range of syntactic positions filled by pointing signs is conducted. By examining the syntactic

relations between pointing signs and preceding or following linguistic items, the nature of their grammatical function can be more easily revealed.

We believe that pointing signs in TĪD are not randomly scattered across the signing space, but instead follow a systematic distribution. Therefore, we hypothesize that pointing signs with the same grammatical functions cluster in similar spatial regions. To investigate this, a morpho-phonological study has been conducted, focusing on Space Use along with four other key parameters: Movement, Strength, Palm Orientation, and Non-manual Markers (NMMs). Drawing on existing literature concerning contrastive morpho-phonological features, this thesis aims to answer the following research questions regarding articulatory phenomena: (i) assuming that space is systematically organized, what types of spatial divisions may underlie categorical distinctions; (ii) whether movement configuration (e.g., arched versus straight) realizes a distinctive grammatical function; (iii) whether the visibility and precision of a pointing sign are solely dependent on signing speed and duration, or whether other factors contribute to a sign being interpreted as ‘phonologically weak’; (iv) whether orientation configurations, such as palm-up versus palm-down, can serve as primary contrastive features or should instead be regarded as secondary; and (v) what types of nonmanual markers tend to co-occur with pointing signs, and whether specific combinations of facial cues are more closely associated with certain grammatical categories.

Finally, and importantly, this study examines how pointing signs interact with the prosodic structure of TĪD, uncovering their prosodic behavior. Analyzing prosody offers insight into the syntactic relationships between lexical items on the surface, prominence of linguistic elements, as well as the internal hierarchy of constituents. This thesis specifically investigates the role of non-manual markers

(NMMs) in mapping the prosodic structure of TİD onto pointing signs. As a result, prosodic analysis provides additional support for the fundamental distinctions between grammatical categories, as initially identified through syntactic and morpho-phonological analyses.

A total of 977 pointing signs were identified for analysis. These signs were produced during cartoon narrations by 25 participants: thirteen native signers who acquired TİD from birth, and twelve signers who were first exposed to TİD between the ages of 4 and 17. In total, 610 pointing signs came from the native group and 367 from the late signers.

Of these 977 signs, 866 were examined in detail. A total of 82 constructions could not be analyzed further due to various factors³, and an additional 29 signs, including possessives and reflexives, were excluded from the analysis. In Turkish Sign Language (TİD), possessives are typically produced with two fingers and reflexives with the full hand on the torso. According to Battison (1978), signs can be articulated in five primary locations: the head, torso, arms, non-dominant hand, various parts of the body, and the signing space in front of the signer. This thesis focuses specifically on pointing signs that utilize the signing space. Since the study is limited to pointing produced with the index finger in variable spatial locations, signs anchored to fixed bodily regions or employing different hand configurations were excluded.⁴ This controlled approach, maintaining a constant handshape and

³ Eighty two pointing signs could not be analyzed as the surrounding items were missing from the translations. Therefore they did not fit into any structural pattern in the syntactic analysis, rendering further analysis unreliable.

⁴ Pointing signs articulated with a B-handshape were excluded from the analysis, as the study focused solely on index-finger pointing. However, it was observed that the full hand was more commonly used when referring to the computer screen where the cartoon clips were shown. For instance, participants often signed “*This is funny*” using a B-handshape rather than an index finger, suggesting that this form may function as a discourse marker.

excluding signs with predetermined PoA, permits a more focused investigation of the other parameters that differentiate visually similar pointing forms. Likewise, pointing signs used to label body parts were omitted, as their location is consistently tied to the referent and they appear to undergo lexicalization processes that fall outside the scope of this study.

The omitted group also included signs with additional morpho-syntactic complexity. One such category was *buoys*, described by Liddell (2003) as constructions where the dominant hand articulates while the non-dominant hand is held motionless. In some instances, an index finger point was directed toward the stationary weak hand shaped in a '1'-handshape, marking a discourse referent. Since this type of pointing also targets a fixed location on the weak hand, it falls outside the scope of this analysis.

Another noteworthy exclusion involves a potentially emerging construction in T1D, characterized by consecutively articulated pronouns that display reduced movement. This construction is interpreted as a potential auxiliary form, a grammatical category not previously described for T1D. Due to their limited frequency in the dataset, these forms will be briefly noted in the results chapter but fall outside the primary focus of the present analysis (See the Appendix for more detail on these pointing signs).

Notably, none of the pointing signs in the dataset are directed at present referents in the physical environment. Therefore, this study focuses exclusively on abstract pointing, referring solely to non-present referents.

To ensure objectivity in the analysis, both manual annotations and computational techniques were employed. In particular, a state-of-the-art computer vision method, Pose Estimation (see Dubey and Dixit (2023) for a recent survey),

was incorporated to calculate articulatory distinctions, yielding solid numerical results for linguistic discussion.

After the completion of annotations and calculations, this thesis turns to exploring how pointing signs may differ across native and late signers. More specifically, to unravel any potential Age of Acquisition (AoA) effects, we address the following questions: (i) Do native and late signers differ in how frequently they use pointing signs? (ii) Are there any differences in how the pointing signs are distributed across grammatical categories between the two groups? (iii) And finally, do the groups differ in how pointing signs are realized morpho-phonologically?

Beyond the synchronic analyses outlined above, this thesis also engages with theoretical questions concerning the grammaticalization of pointing signs. As we mentioned above, pointing signs in the literature are extensively discussed within the grammaticalization framework, serving as supporting evidence for possible grammaticalization pathways (e.g., Senghas and Coppola, 2010; Pfau and Steinbach, 2006). Since this thesis does not analyze diachronic data, an indirect discussion on grammaticalization is offered by interpreting the observed grammatical elements as potential outcomes of these pathways in TID. With a primary focus on cliticization as a facet of grammaticalization, this study uncovers a previously undocumented phenomenon in TID: the emergence of cliticized demonstratives which is analyzed within a broader cross-linguistic framework.

CHAPTER 4

METHODOLOGY

This chapter outlines the methodological framework of the study, including participant profiles, data collection procedures, and the techniques used for syntactic, morpho-phonological, and prosodic analyses. The dataset consists of narratives by native and late signers describing Tom and Jerry cartoon clips, originally collected for a previous study (Keleş et al., 2023). Narratives from thirteen native signers and twelve late signers were examined in depth. Pointing signs were identified, and features potentially involved in distinguishing their grammatical roles were manually annotated using ELAN.

Parameters such as syntactic position, place of articulation (PoA), orientation, movement, non-manual markers (NMMs), and prosodic cues were each analyzed on separate tiers. Pointing signs that clustered in similar spatial regions, shared formal properties, and had a common syntactic patterning were grouped into categories. After the initial impressionistic categorization, Pose Estimation was employed for further validation. Specifically, the Euclidean distance between the x- and y-axis coordinates of each pointing sign's start and end points was calculated, and distance ranges were determined for each grammatical category. These numeric measures were then grouped according to the pre-established grammatical categories, yielding quantitative ranges for each category. This approach provides numerical support for the primary impressionistic categorizations and enables a more objective basis for subsequent analysis.

4.1 Participants

The data used in this study were originally collected for another study held at Bogazici University (Keleş et al., 2023). A total of 32 signers, 16 native adult signers and 16 nonnative adult signers participated in the experiments at the Sign Lab at Boğaziçi University in Istanbul, Türkiye. All individuals who participated in the study were based in Istanbul during data collection and were part of the Deaf community. A consent form and a questionnaire were introduced to the participants and their ages of acquisition are thus confirmed. In this thesis, I will only interpret data coming from 13 native signers and 12 nonnative signers.⁵

4.2 Data collection

Each signer was shown ten short excerpts from the cartoon Tom and Jerry and was asked to narrate each clip after viewing it, either facing the camera that recorded the narrations or facing the deaf research assistant sitting across the participant. After the narration of each excerpt, the signers could play the following clip using the computer placed in front of them.

4.3 Data annotation and analysis

The data were analyzed through a multi-step approach. First, pointing signs were identified within the narrations, and their syntactic distributions were annotated. Next, a detailed morpho-phonological analysis was conducted by manually annotating features such as space use (i.e., PoA), movement, and accompanying non-

⁵ Due to missing translations and the presence of unparseable signs throughout the narrations of three native signers, these data were excluded from the analysis.

manual markers (NMMs) as separate tiers using ELAN. Additional tiers, such as Strength, were later introduced based on emerging patterns during the annotation process.

Following manual annotations, video recordings were trimmed to isolate each pointing sign's start and end locations. These segments were processed using Pose Estimation to quantify variations in the spatial articulation of signs.

The primary objective of the study was to investigate the linguistic functions of pointing signs in TlD and to categorize them into distinct grammatical classes. The combined syntactic and morpho-phonological analyses leading to a prosody study enabled a systematic comparison across pointing categories. The subsequent sections present the annotation tiers in detail and report the findings based on this multi-layered analysis.

4.3.1 Impressionistic-manual annotations

Initially, we have conducted a meticulous impressionistic examination of the signers' narrations, and annotated each pointing sign using ELAN. I centered the subsequent analysis on the syntactic distribution of pointing signs using the Position tier. With this method, the grammatical roles of the pointing signs were initially identified based on their syntactic positions within sentences and their relationships with surrounding constituents.

To investigate the morpho-phonological behavior of each potential category, we have studied various parameters. Based on previous cross-linguistic work, my initial hypothesis was that Space Use, Orientation, and Movement would serve as primary distinctive morpho-phonological markers. However, detailed analysis revealed that Non-Manual Markers (NMMs) also exhibited specific patterns,

prompting the inclusion of dedicated tiers for NMMs. Additionally, I introduced a Strength tier, reflecting the syllabicity of an index sign after identifying a distinct weak form.

A single tier for Space Use turned out to be insufficient to capture all possible articulatory locations. Therefore, I divided this parameter into two distinct tiers: Horizontal Space (H-Space) and Vertical Space (V-Space). Figure 6 shows the tiers used in ELAN annotations with example annotations in each tier. The following subsections provide a detailed explanation of the annotations done within each tier.

Pointing [90]	point
Position [90]	VP_
H-Space [90]	Left
V-Space [90]	Down
Strength [90]	Strong
Palm Orientation [90]	Downward
Movement [90]	Straight
NMMs (Head) [90]	Down
NMMs (Mouth) [90]	Open
NMMs (Eye) [90]	Gaze
Category [90]	Pronoun

Figure 6. ELAN annotation sample

4.3.1.a Pointing

In this tier, I annotated the presence of each pointing sign throughout the narrations. This tier primarily functioned as an identifier, serving as the foundation for all subsequent layers of annotation. In the translation tiers, some pointing signs had already been labeled with Turkish equivalents such as 'BU' (this), 'O' (that), or 'ORADA' (there) which correspond to demonstratives and locatives. However, many

instances of pointing were absent from the translation tiers, having been overlooked during the initial translation process which is undertaken for general use of the data in the videos for other studies.

4.3.1.b Position

I created this tier for syntactic analysis and examined each pointing sign according to its syntactic position. After examining the data carefully, six options were revealed to be readily available in the data. Therefore, I annotated each pointing sign as occupying one of the six possible positions: preceding or following a noun phrase (`_ NP` or `NP _`), preceding or following a verb phrase (`_ VP` or `VP _`), or appearing simultaneously with these constituents, such cases are shown solely with the abbreviations (NP, VP).

4.3.1.c Strength

In this tier, I analyzed the phonological strength of each pointing sign by assigning one of two values: Weak or Strong. These values were determined based on whether the sign exhibited syllabic properties. Pointing signs that were syllabic received the value Strong, while those lacking syllabicity were labeled Weak.

To determine whether a pointing sign was syllabic, we primarily examined the presence of movement, which is widely regarded as the most salient phonological parameter for defining syllables in sign languages (Brentari 1998; Sandler 1993). It is further claimed that “a movement is obligatory for the definition of a syllable in TİD.” (Gökgöz, 2018, p.33). Accordingly, a syllabic pointing sign was expected to involve both a start location and a target end location, thus requiring movement between the two.

We identified several types of syllabicity loss in pointing signs. These included forms that occurred during transitional phases, were undirected in the central signing space, or exhibited patterns of assimilation or coalescence. All of these forms showed minimal space utilization. While the specific distinctions between these types are discussed in the results chapter, what unites them under the category of “weak pointing” signs is the reduction of at least one core phonological or prosodic feature, movement, handshape, or temporal independence, thus leading to diminished syllabicity and, in turn, diminished phonological strength.

Weak pointing signs shared several phonological characteristics: they tended to be lax, shorter in duration, more difficult to perceive at normal signing speed, and often appeared adjacent to or simultaneous with other linguistic elements. In contrast, strong pointing signs exhibited more tenseness and precision in their articulation, independence from the surrounding signs, along with a clearly perceptible movement path from a start to a target location in the signing space.

These categories were defined based on articulatory criteria alone, without reference to grammatical function. However, the interaction between phonological weakening and grammatical function will be addressed in detail in the results and discussion sections.

4.3.1.d Horizontal Space and Vertical Space (H-Space and V-Space)

With these tiers, I analyzed the phonological parameter of Space Use. Since depth (z-axis) analysis was not feasible in this study⁶, use of space was analyzed from a 2-Dimension (x and y-axes), as can be seen in Figure 7.

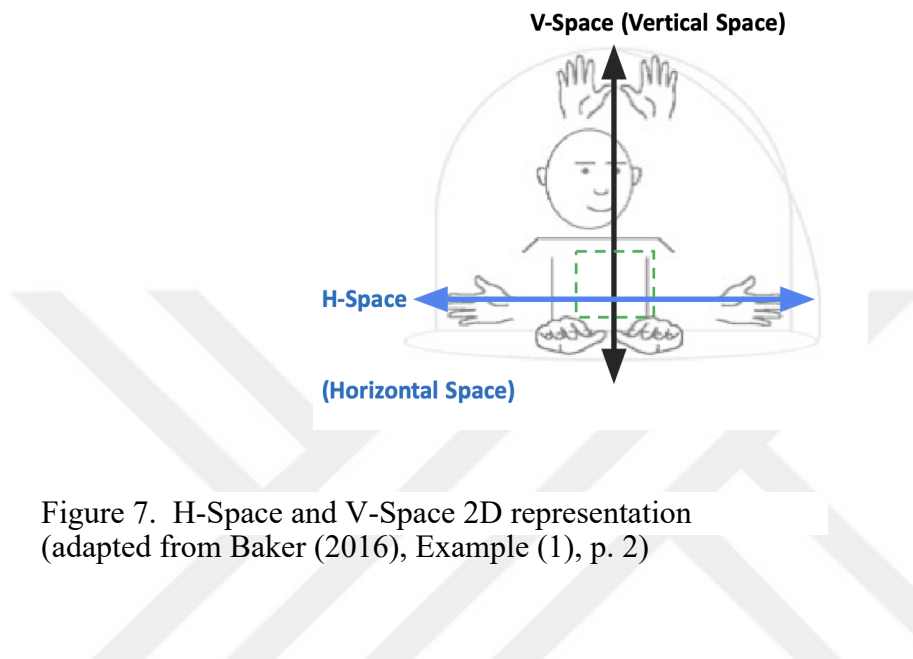
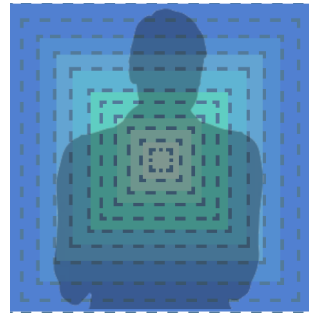


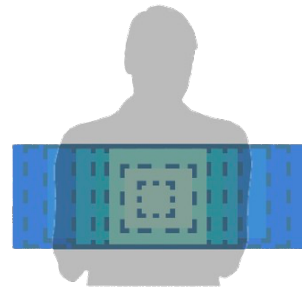
Figure 7. H-Space and V-Space 2D representation (adapted from Baker (2016), Example (1), p. 2)

Horizontal Space (x-axis) indicated whether a point moved Left, Right, or remained in the Center. Vertical Space (y-axis) showed whether a point moved Up, Down, or stayed on the Midline (see Figure 8).

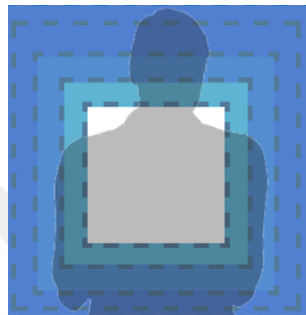
⁶ For future research, an analysis that will also capture the z-axis can potentially reveal more insight into the grammatical functions described in this paper.



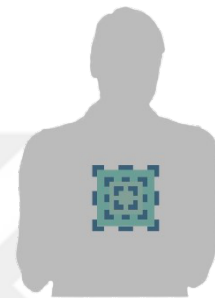
(a) The Signing Space



(b) The H-Space



(c) The H- and V-Space



(d) No Space Utilization

Figure 8. Space use representation

As illustrated above in Figure 8b, pointing signs may utilize only the H-Space, meaning they cover distance primarily along the x-axis. V-Space is considered to be used when the index finger moves upward or downward. However, such movement typically includes a slight shift to the left or right, meaning it does not follow a strictly vertical path and therefore still involves H-Space use (Figure 8c). In contrast, some pointing signs appear to lack space use altogether (Figure 8d); in these cases, the sign remains centered at mid-level with no observable movement. Another type of pointing sign shows movement from a designated area in space back toward the center, which will later be argued to involve no spatial utilization as well.

4.3.1.e Palm orientation

I created this tier to analyze the role of palm orientation in yielding functional differences among pointing signs. I decided to create multiple values to cover an array of possibilities (Figure 9). The value Downward is selected when the palm faces fully downward, while Vertical is chosen when the hand is held perpendicular to the ground. Slightly Rotated indicates a palm that is not fully vertical but closer to a vertical position, and Pronated describes a palm closer to a downward orientation.⁷

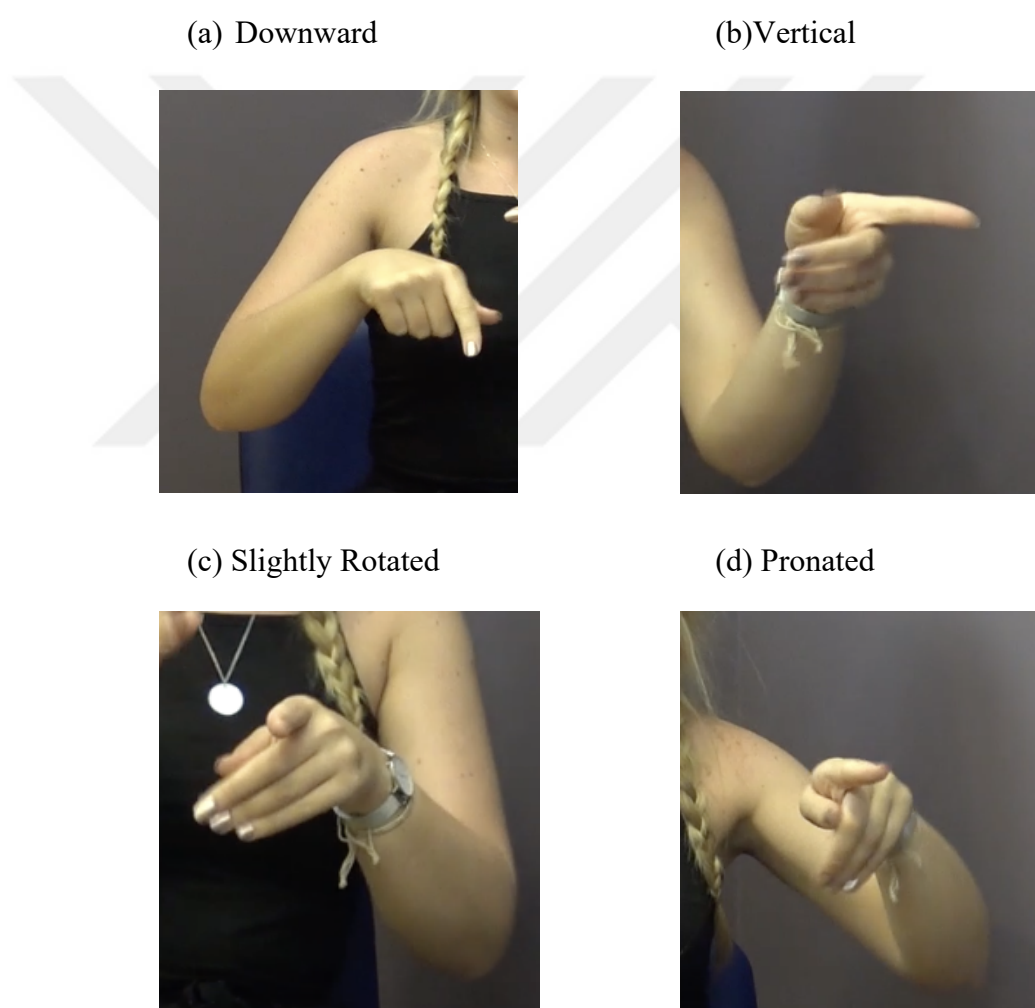


Figure 9. Palm orientation configurations

⁷ Orientation is a complex phonological parameter to capture in two dimensions. I presented a continuum from vertical to downward orientation and annotated the pointing signs accordingly.

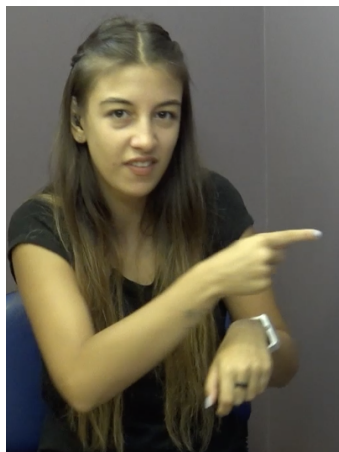
4.3.1.f Movement

This tier captures the movement configuration of each pointing sign. Movements are categorized as Straight, Arched, or None. A straight movement refers to a linear trajectory, while an arched movement is slightly curved, often ending with a precise placing movement, adding potential information for grammatical distinctions.⁸

4.3.1.g Non-manual markers (Eyes)

I divided non-manuals into two distinct tiers: Eyes, and Mouth, to capture their varied configurations. The Eyes tier includes values such as Eye Contact, where the signer looks at the interlocutor (Figure 10a), Eyegaze, which involves directing the gaze to a specific area in the signing space (b), and lastly, Blink, where the pointing sign coincides with the closure of the eyelids (c).

(a) Eye Contact



(b) Eyegaze



⁸ Movement could also be observed during transition phases. In some of the cases where the boundaries were not clear-cut, pointing signs' movements were annotated as Other. These annotations will also be revisited.

(c) Blink

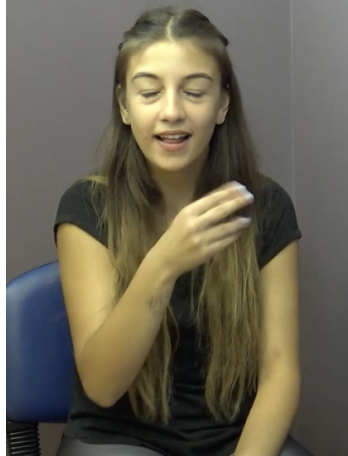


Figure 10. Eye configurations

4.3.1.h Non-manual markers (Mouth)

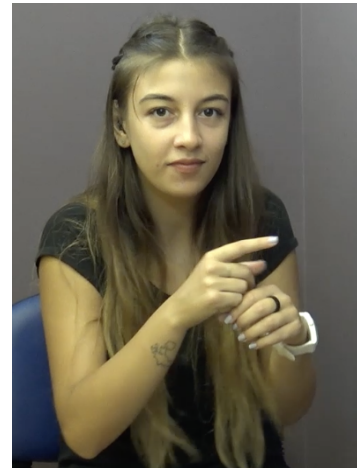
This tier documents lower-face non-manual configurations, including Open (lips apart), Closed (lips together), Mouthing (when lip movements mimic spoken words or syllables), and Mouth Gesture (when specific facial expressions accompany a sign).⁹

⁹ The Mouth values vary to a great extent. A Mouth Gesture was differentiated from any facial expression which was irrelevant to the referent. To be categorized as Mouth Gesture, the expression should be linked with a property of the referent, the event realized by that referent (nominal uses) or the event itself (locative uses). Therefore, signers' neutral face expressions (such as a slight smile while narrating) were categorized as Other. I will return to these annotations to provide a more comprehensive analysis of all configurations.

(a) Open



(b) Closed



(c) Mouthing



(d) Mouth Gesture

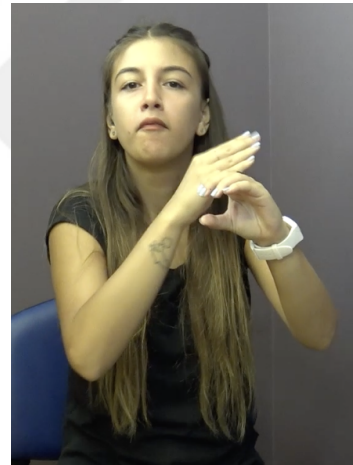


Figure 11. Mouth configurations

Although the linguistic status of mouthing remains a subject of debate, several scholars have proposed that mouthings are borrowings from spoken languages that have become integrated into the lexical and morpho-syntactic structure of sign languages (Crasborn et al., 2008). Boyes Braem (2001), for instance, describes mouthings as silent articulations of spoken language words. She further observes that mouthings are not always confined to a single sign but may extend over multiple signs. This spreading has been argued to operate at the prosodic

level, potentially serving to group constituents within a clause (Boyes Braem, 2001; Crasborn et al., 2008). We will come to this proposal later on in the prosody discussion.

In Figure 11c, the signer's lips are shaped to reproduce the initial sound of the Turkish word 'FARE' (mouse), more specifically, the labiodental fricative /f/. The lower lip is clearly raised to meet the upper teeth. This visible configuration illustrates how mouthings can align closely with the phonetic shape of spoken words, even though they are produced silently alongside the manual sign. Some mouthings are not limited to the lexical sign but spread over to a preceding pointing sign. In Figure 11c, the index handshape is assimilated into the handshape of the lexical sign FARE (mouse); however, there is still a clear movement for demonstration purposes. Therefore, we annotate it as a pointing sign that coincides with a mouthing.

Liddell (1980) argues that adverbial mouth gestures refine the meaning of manual signs by marking manner and intensity. Although various subtypes of mouth gestures have been identified in the literature, such as adverbial, enacting, semantically empty, and whole-face gestures (Crasborn et al., 2008), this thesis adopts the broader term Mouth Gesture without distinguishing between the subtypes.

In Figure 11d, the signer's mouth is clearly shaped in a way that does not correspond to a spoken word but appears to modify the meaning of the accompanying sign. This kind of configuration reflects what Liddell (1980) describes as a mouth gesture marking the manner of the action and is therefore annotated as a mouth gesture in our analysis.

4.3.1.i Category

The categorical distinctions among pointing signs in this study were not imposed a priori but emerged through systematic annotation and observation. The relevant morpho-phonological and syntactic tiers are introduced preceding this section; here, I elaborate on how those annotations led to the establishment of four distinct grammatical categories.

While annotating pointing signs in ELAN, I initially selected values for each morpho-phonological and syntactic tier independently. As the annotation process progressed, clear distributional patterns began to emerge, most notably in the signs' use of space. My first impression was that some pointing signs extended farther across the signing space, often reaching into the peripheries, while others remained restricted in their spatial use. These signs, which involved broader articulation across the signing space, were consistently used to indicate where something was happening, rather than to refer to entities. This observation led to the establishment of the first category: Locatives.

In contrast, pointing signs that occurred at the beginning of a narration, where referents are typically introduced, never had a wide spatial range. Instead, these initial referential expressions were articulated with pointing signs along the horizontal axis. Because loci in TID can be established on either the ipsilateral or contralateral side of the horizontal axis, this horizontal deployment was expected for referential pointing signs. However, within the set of pointing signs along the horizontal axis, a consistent syntactic split was observed: some occurred before nominal phrases, while others preceded verbal phrases. This observation prompted the division of these referential signs into two categories: Demonstratives and Pronouns.

During this stage of analysis, I also encountered a group of pointing signs that syntactically behaved like Demonstratives but showed a striking reduction in spatial articulation. These signs lacked clear directional movement and did not make use of the signing space in the way Demonstratives typically did. Similar forms have been discussed in the literature, such as undirected variants in Engberg-Pedersen (1993), and phonologically reduced or dependent forms in Cormier et al. (2013). However, in my data, this type of behavior was not only frequent but also showed internal variation. There were multiple, patterned ways in which space use was reduced. Given both their prevalence and the systematic nature of their patterns, I introduced a separate grammatical category: Clitics. While they share syntactic properties with Demonstratives, their consistent phonological reduction warranted their treatment as a distinct grammatical class in this study.

Thus, the initial categorization of pointing signs was based primarily on their contextual interpretation, syntactic position, and space use. The evaluation of space use entailed the analysis of movement and strength, as these parameters are functionally intertwined. Following this initial categorization, each sign was further annotated across a full set of morpho-phonological tiers, including Orientation, and Non-Manual Markers (NMMs), to examine broader interactional patterns within and across categories.

Following the completion of multi-tier annotation for each pointing sign, we then returned to study the Category tier as a final layer of analysis. This tier was not simply an annotation tag but a synthesis of all prior tier selections. The decision to assign an index sign to one of the four categories was informed by the co-occurrence of specific morpho-phonological and syntactic features, as well as discourse context within the narrative. For example, signs labeled as Locative were consistently

phonologically strong and involved V-space use (typically Up or Down), and straight movement. Additionally, it had a contextual interpretation as indicating places rather than entities. A single annotated value was never treated as strictly determinative of a category. Instead, the assignment always relied on a holistic analysis that took into account the sign's contextual function within the signer's narration. Each pointing sign was interpreted with reference to the broader discourse, considering what the signer was watching, describing, or referring to at that moment. This interpretive process aimed to determine what the pointing sign was targeting, whether a referent or a location, and thereby identify its grammatical function.

In summary, the grammatical categories assigned to pointing signs in this study emerged from formal and functional properties observed in the data. The Category tier represents an interpretive layer grounded in cumulative annotations and analyses across multiple features.

4.3.1.k Prosody

In sign language prosody, a prosodic word (PW) typically aligns with a single morphological word, but it may also encompass clitics or other post-lexical elements when they form a unified phonological unit (Nespor & Vogel, 1986; Sandler, 1999). In this study, the prosodic structure of pointing signs was analyzed to determine whether they formed a PW independently or as part of a broader prosodic domain with neighboring linguistic items.

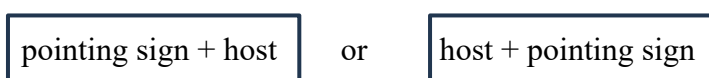
A prosodic break refers to a perceptible boundary between two prosodic units, typically marked by changes in non-manual markers (NMMs), including shifts in head position, gaze direction, or facial expression (Brentari & Crossley, 2002).

These breaks serve as cues to prosodic word boundaries and are particularly relevant in visually marking the syntactic and phonological alignment of signs.

Accordingly, pointing signs were annotated as in a separate prosodic word when such breaks were observable. These included clear shifts in NMMs, such as lower face tension (LFT), changes in eye configuration (e.g., blinking, gaze shifts), or head/body tilts. When a pointing sign was preceded or followed by such a shift, it was considered prosodically independent from adjacent signs, resulting in two distinct PWs.

In contrast, if no change in NMMs was observed, the pointing sign was treated as prosodically integrated with a neighboring sign. These were annotated either as in the same prosodic word with the following sign or with the preceding sign, depending on their alignment in the utterance. In such cases, consistent facial expression, stable head positioning, and continuous body orientation were used as indicators of prosodic cohesion. These cases were considered to constitute a single PW.

(a) In the Same Prosodic Word (One PW):



(b) In a Separate Prosodic Word (Two PWs):

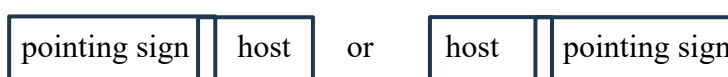


Figure 12. Prosodic word(s) with pointing signs

Figure 12 schematically represents how pointing signs align prosodically with surrounding lexical items. Figure 12a illustrates cases where the pointing sign and its adjacent host form a single prosodic word (PW), either in pre-nominal or post-nominal configuration. Figure 12b demonstrates configurations where a prosodic boundary separates the pointing sign and the host, resulting in two distinct PWs. These representations visually capture the central analytic distinctions in this study: whether a pointing sign is prosodically integrated with its surrounding structure or it forms an independent prosodic unit.

In Figure 13, the diagnostic cues used to identify prosodic breaks are categorized as follows: changes in Lower Face Tension (LFT), eye configurations, and head/body tilt. Any muscle movement around the corners of the mouth, including all mouthing and mouth gestures, is regarded as a lower face tension (LFT) change (Crossley, 2001). Following Brentari and Crossley (2002), we interpret LFT shifts as strong indicators of prosodic word boundaries.

Eye configurations include eyeblinks, eyegaze, sustained eye contact, or any expressive movement involving the eyes. Even the slightest transition between such states was treated as a potential prosodic marker. Finally, head and body tilt refer to visible rotation or angular shifts in the head or torso. Although these movements frequently co-occur, there are also instances in which only one component (either head or torso) shows change. In such cases, the movement alone was sufficient to warrant prosodic boundary annotation.

(a) LFT Change

(PW) (PW) (PW)



SLIDE

IXLOC

PIANO

‘(The carpet) is sliding. There is a piano.’

(b) LFT Change, Eye Configuration & Head Tilt

(PW) (PW) (PW)



MOUSE

IXDEM(start)

IXDEM(end)

CAT

‘That mouse, (the) cat...’

Figure 13. Different types of prosodic breaks

During annotation, I also encountered cases where pointing signs occurred during hesitations, self-corrections, or while searching for referents in the discourse. These were often characterized by upward finger posture and prosodic breaks

marked by facial or bodily cues. Such articulations were not considered representative of the category's typical prosodic behavior but rather reflect intra-linguistic functions, serving as discourse markers. Accordingly, I annotated them as in a separate prosodic word for different reasons.

4.3.2 Pose Estimation

Following detailed manual annotations, it became evident that one of the primary morpho-phonological parameters distinguishing the grammatical classes was their use of space. More specifically, the most salient contrastive feature among categories appeared to lie in the distance that pointing signs covered from their start to end locations across the horizontal and vertical dimensions.

To further test this observation, I applied Pose Estimation, a cutting-edge and cost-effective computer vision technique that serves as an alternative to traditional motion capture systems. To implement this approach, I utilized the OpenCV and Mediapipe libraries in Python. OpenCV was employed to process the participant video recordings, while Mediapipe was used to identify and extract body landmarks for precise tracking. I then developed a custom Python script to calculate the morpho-phonological parameters of each pointing sign, focusing specifically on the spatial distance covered by the index fingertip during articulation.

The video data provided to Pose Estimation was carefully trimmed for each token to include only the relevant pointing sign, from the first frame in which the index finger was clearly selected, to the final frame where it remained visible. This ensured that only the core movement of the pointing sign was included in the calculations.

The Python script primarily tracked the right index fingertip, but it was adapted to monitor the left fingertip when the right hand was not visible. Furthermore, a value of zero was assigned whenever the fingertip moved completely out of the camera frame and became untraceable.

The movement was calculated based on the change in fingertip position along the x- and y-axes between the start and end of each index sign, using the two-dimensional Euclidean distance formula:

(11)

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

where (x_1, y_1) and (x_2, y_2) represent the x- and y-coordinates of the index fingertip at the initial and final frames, respectively.

A specific challenge in tracking spatial articulation was distinguishing targeted movement from movement that occurs in transition phases. In several cases, a noun phrase was produced at a specific location in the signing space, away from the torso. This lexical item was sometimes followed by a weak pointing sign, articulated as a minimal lift of the index finger while the hand moved back toward the center. This type of movement was not directed toward a spatial target and is fundamentally different from a pointing sign that establishes or traverses a referential locus. Without a consistent reference point, specifically, the center of the torso, such movement could easily be misclassified as deliberate spatial use. To avoid misclassifying these transitional movements as spatially-directed pointing signs, I anchored spatial measurements to a consistent reference point: the center of each signer's torso. This made it possible to distinguish directed pointing signs from weak, non-referential movements that occurred as the hand moved back toward the center. This adjustment was essential to prevent Pose Estimation from interpreting

these transitional forms as intentional spatial distances, thereby preserving the accuracy of the analysis.

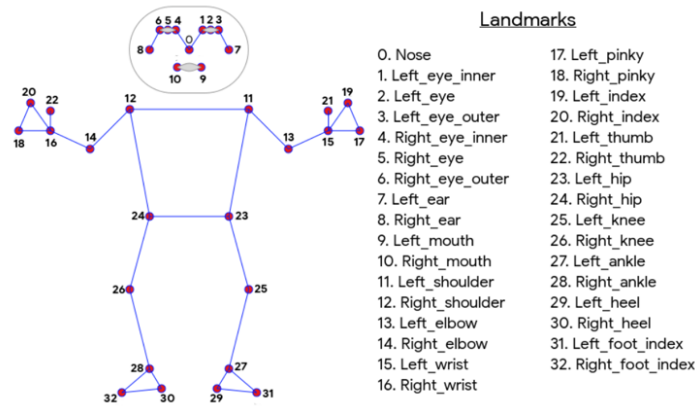


Figure 14. Mediapipe body landmarks
(Figure from Google Developers, 2024)

To operationalize this adjustment, I defined a signer-specific reference point based on the center of the torso. This point was calculated individually for each signer by identifying the positions of the left and right shoulders using Mediapipe and computing their midpoint (see Figure Establishing this dynamic center for each participant was necessary to account for individual variation in body proportions; using a fixed central point across all signers would have introduced inconsistencies in the spatial analysis.

Using this method, I analyzed a total of 548 pointing signs distributed across four grammatical categories: Demonstratives (314), Clitics (110), Pronouns (82), and Locatives (42). Each sign had already been manually annotated according to category, and during video trimming, each clip was labeled accordingly. This allowed the Pose Estimation output to be directly linked to the corresponding grammatical label. The Python script was designed to automatically read these labels and group the calculated distance values by category. As a result, the final graph

presents the mean spatial distance covered by pointing signs within each grammatical class, allowing for direct visual comparison across categories.

To facilitate comparability, all computed distances were normalized to a 0–0.5 scale. This standardization enables both visual and statistical comparison of spatial properties across grammatical categories.

The results obtained through Pose Estimation not only visualize mean spatial values per grammatical category but also provide a precise basis for hypothesis testing. By converting morpho-phonological properties into numeric data, this approach offers a robust method for comparing pointing data systematically in TID.

CHAPTER 5

RESULTS

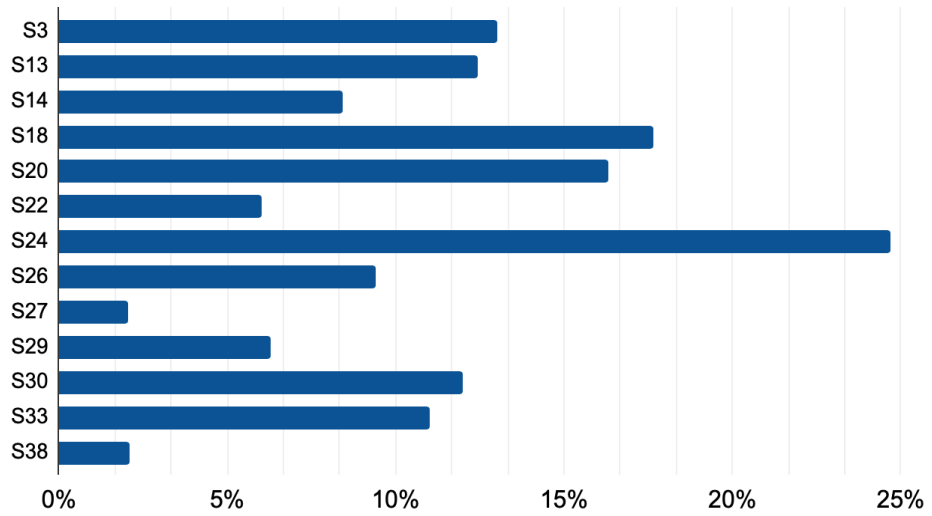
5.1 Frequency

First, I analyzed the pointing signs by calculating their ratio within the total number of signs produced by each signer during the narration. This was conducted by dividing the number of pointing signs by the total signs produced. While some pointing signs were initially annotated as 'BU' (this) within the translation tier, others were more difficult to detect and were therefore initially missing. To address this, I included any additional pointing signs that had not been annotated in the original count.

Signers produced an average of 75 pointing signs out of 743 total signs, comprising roughly 10% of the narration. Following a frequency distribution across grammatical categories, it has been found that pointing signs consisted of 7.84% Locatives, 15.69% Pronouns, 52.89% Demonstratives, and 22.06% Clitics.

These results are consistent with cross-linguistic findings on pointing frequency. For instance, Engberg-Pedersen (2003) reports that, in Danish Sign Language discourse, "on average, almost every fourth sign in signed discourse is a pointing sign (p. 271)." Similarly, de Vos (2015) finds that in Kata Kolok, a village sign language of Bali, one out of every six signs is a pointing sign. Although the exact ratios vary depending on the language and the genre of discourse analyzed, the overall prevalence of pointing signs in my TID data aligns with these cross-linguistic observations, reinforcing the fundamental role of pointing across sign languages.

(a) Pointing Sign Ratio by Participant (Native Signers)



(b) Pointing Sign Ratio by Participant (Native Signers)

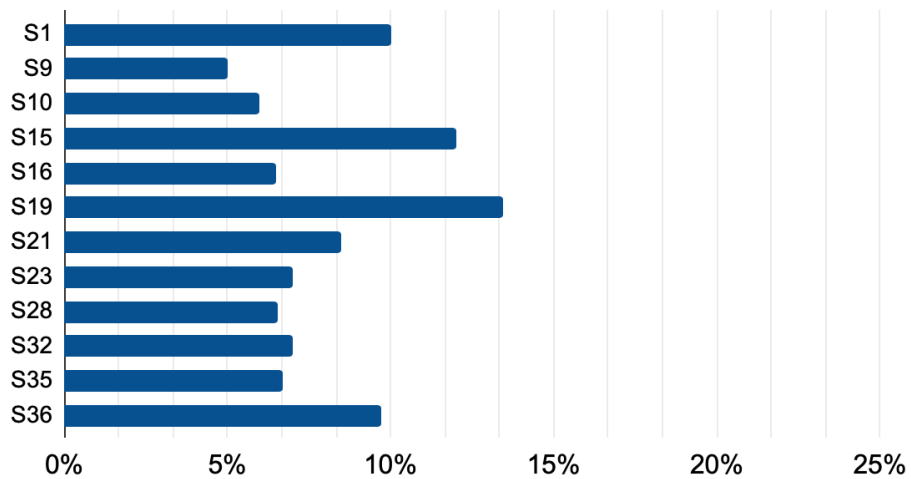


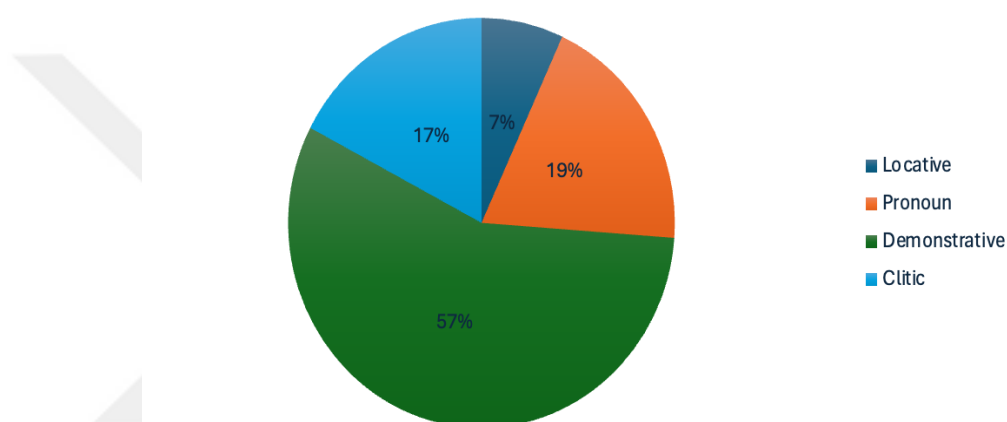
Figure 15. Pointing sign ratios by participant

Figures 15a–b display pointing sign ratios for individual participants across both groups. A Wilcoxon rank sum test revealed no significant difference in overall pointing ratios between native and late signers ($p = .560$). Nevertheless, the native group exhibited substantially greater intra-group variability (variance = 0.00427) compared to the late group (variance = 0.00069), suggesting more individualized use

of pointing. This variation may be shaped by factors such as narrative style or referential strategy, which will be addressed in the following section.

Despite these individual differences, both groups demonstrated similar proportions of use, and the overall distribution of grammatical categories remained consistent, with Demonstratives constituting the majority class in each group (see Figure 16).

(a) Distribution of Grammaticatical Categories Among Native Signers



(b) Distribution of Grammaticatical Categories Among Late Signers

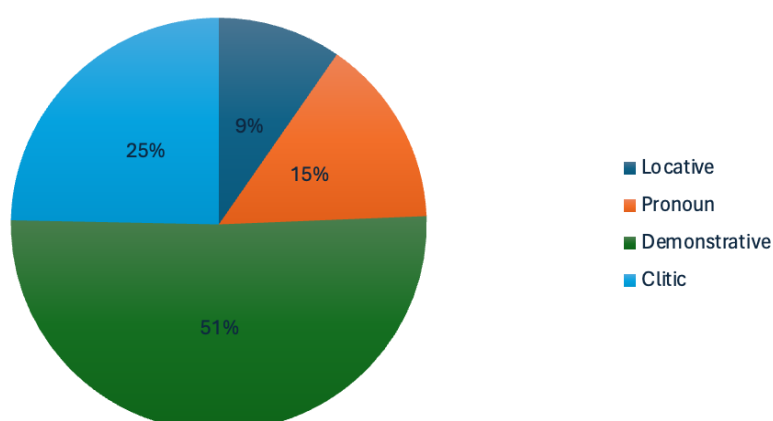


Figure 16. Distribution of pointing categories

A chi-square test of independence revealed a significant association between signer group and pointing sign type, $\chi^2(3) = 10.81, p = .013$. To determine which categories contributed to this effect, separate chi-square tests were conducted for each pointing category. After Bonferroni correction, only Pronouns and Demonstratives showed statistically significant differences between native and late signers (*adjusted ps* < .001), while no such differences were observed for Locatives or Clitics. A more detailed comparison of native and late signers' pointing use will be presented in section 5.4.

5.1.1 Preliminary discussion of pointing frequencies and distribution of grammatical categories

The most frequent use of pointing signs in the dataset falls under the Demonstrative class, which accounts for more than half of all observed occurrences. This group is followed by Clitics, then Pronouns, with Locatives comprising the smallest portion, less than ten percent of the total. The difference in the distribution between nominal and locative uses may be attributed to the availability of alternative strategies for expressing locational information in TID. For example, signers may use Whole Entity Classifiers (WECs) for locative predication, which can visually represent objects in spatial relation to one another without relying on pointing.

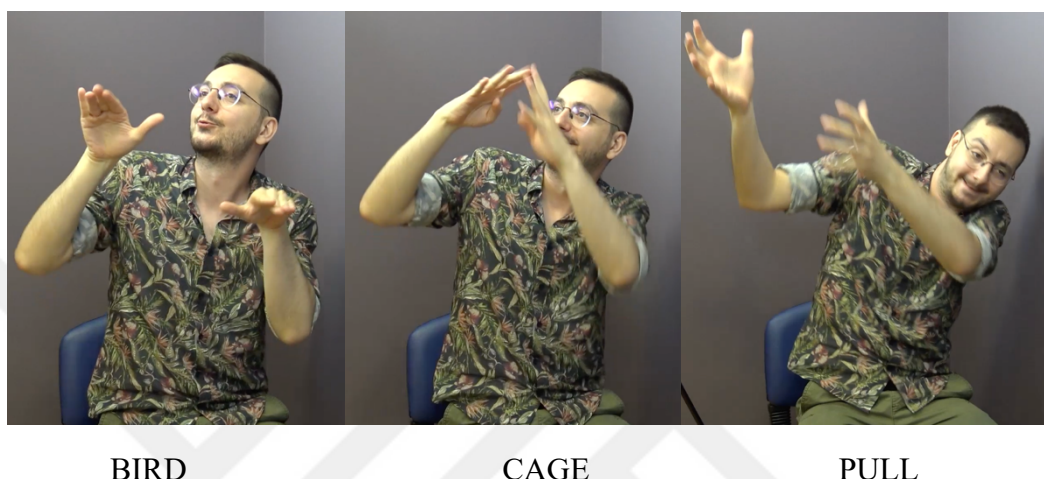


‘The cat chases the mouse. The mouse enters the pipe. The cat enters the pipe as well. It (the cat) goes down the pipe.’

Figure 17. Whole Entity Classifier (WEC) with locational information

In Figure 17, the use of WECs is illustrated. In the first three frames, both the mouse and the cat are represented by the whole entity classifiers (1-handshape that combines with the verbs, MOVE and CHASE), without any lexical signs for ‘MOUSE’ or ‘CAT’. In the subsequent frames, the cat’s location, specifically its movement into and down the pipe, is conveyed through a whole-hand classifier performing a downward tracing motion. These constructions appear to serve the referential as well as locational functions typically carried by pointing signs, making their use unnecessary in this context.

Additionally, locational meaning can be embedded within the placement of a noun itself. In Figure 18, instead of using a locative pointing sign to indicate the position of the bird and cage within the narrative, the signer articulates the lexical sign for ‘BIRD’ and ‘CAGE’ consecutively in the same designated area of the signing space.



‘There is a bird in the cage. (The cat) pulls the cage.’

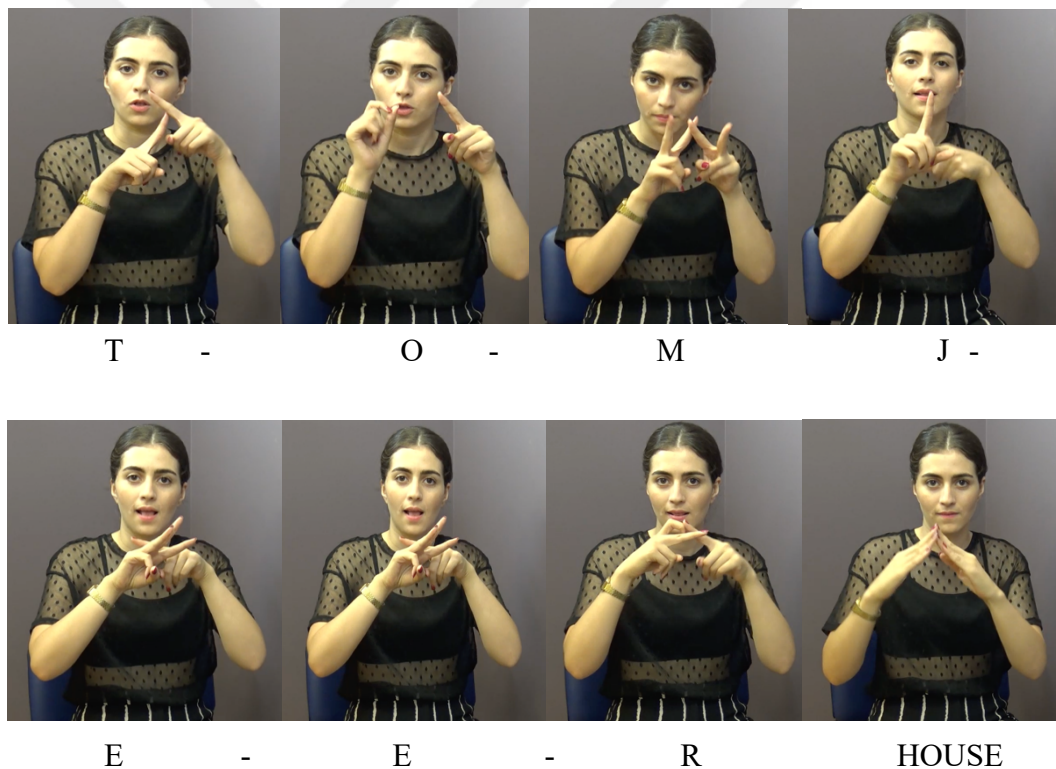
Figure 18. Lexical sign articulation with locational information

By articulating the noun in a specific area, the signer can simultaneously introduce both the referent and locational information, thereby eliminating the need for a separate locative pointing sign. In contrast, Demonstrative pointing signs serve more rigid referential and contrastive functions, which are less easily substituted by other spatial grammatical strategies.

While these patterns reflect the general tendencies observed in the dataset, it is important to consider that categorical distributions may vary across different discourse genres. For instance, in dialogue or interactive contexts, we might expect a higher frequency of pronominal points, potentially influencing the proportional distribution of grammatical categories. Nonetheless, the overall pointing ratios observed here align closely with cross-linguistic findings reported for other sign

languages (e.g., Engberg-Pedersen, 2003; de Vos, 2015). This convergence suggests that, despite the narrative framing of the task, the current data may offer a naturalistic reflection of pointing use in TlD.

The differences in overall pointing use, and particularly the notably lower ratios observed for some signers, may stem from several factors. One possibility is the fingerspelling of referents in the narrative, which may reduce the need for pointing signs (see Figure 19). Although fingerspelled forms sometimes pattern like nominal phrases and can be observed following an index sign, their use coincides with fewer pointing signs overall.

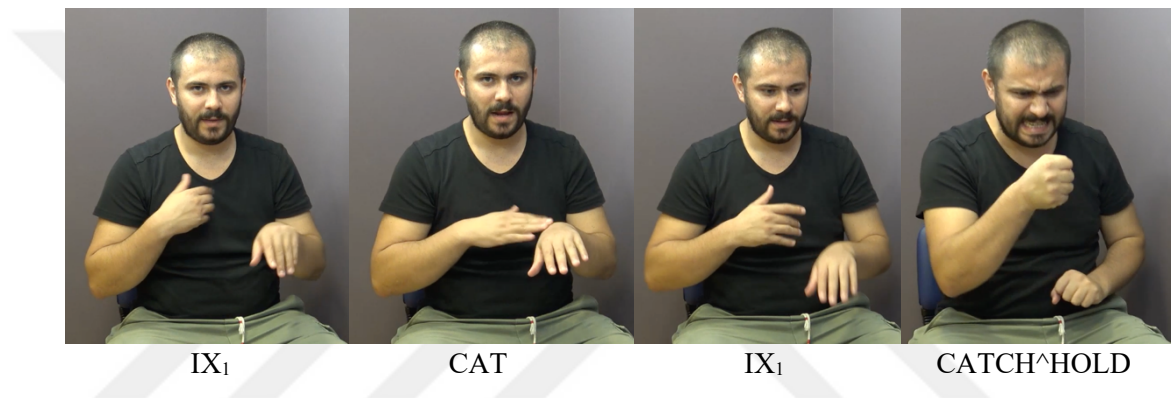


‘Tom and Jerry are home.’

Figure 19. Finger-spelling of lexical items

Another contributing factor could be the use of role shift. When signers adopt the perspective of a referent, they may enact the referent’s behavior or state rather

than explicitly produce lexical signs such as 'mouse' or 'cat.' This shift in narrative style can also reduce the need for pointing on the horizontal plane as the first singular pronoun is signed on the chest and ensuing reference shifts to a third person. Figure 20 shows the production of a first-person pronominal pointing, while getting into character (shifting to a third person); however, this strategy does not appear to be obligatory, as signers often transition into a character perspective without explicitly marking the shift. In either case, no pointing sign on the horizontal signing space that is referential with a third person is used.



‘(I am) the cat. I (the cat) have caught the mouse and am holding it.’

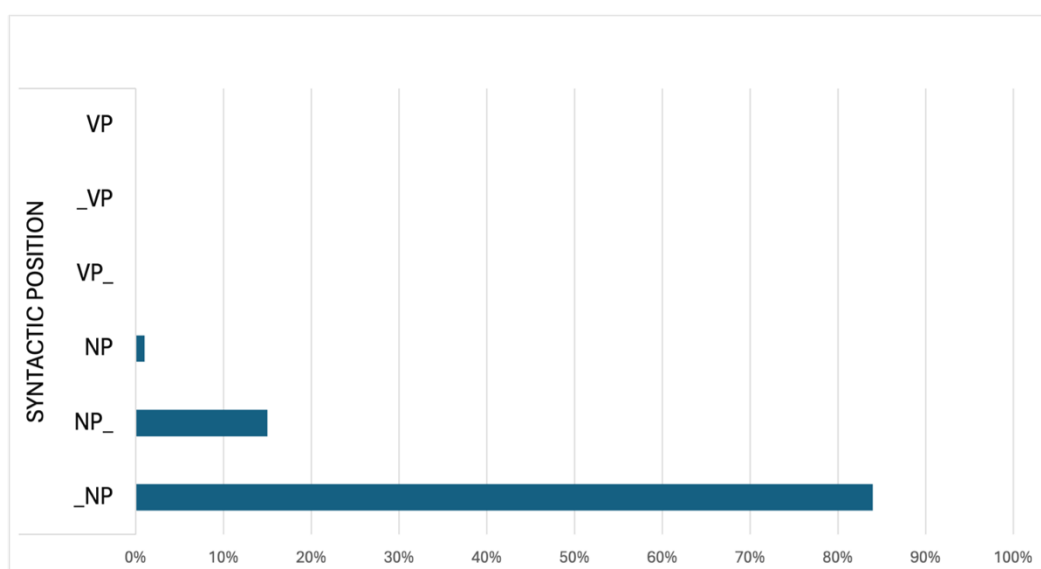
Figure 20. Role-shift

Overall, the frequency analysis provides initial evidence that pointing signs in TĪD are distributed along consistent grammatical lines, with Demonstratives forming the core usage pattern. Although some variation in the general use of pointing signs across participants is observed, this can be attributed to narrative strategies such as fingerspelling and role shift. These findings set the stage for the upcoming sections, where the morpho-phonological, syntactic, and prosodic characteristics of each grammatical category will be analyzed in exhaustive detail.

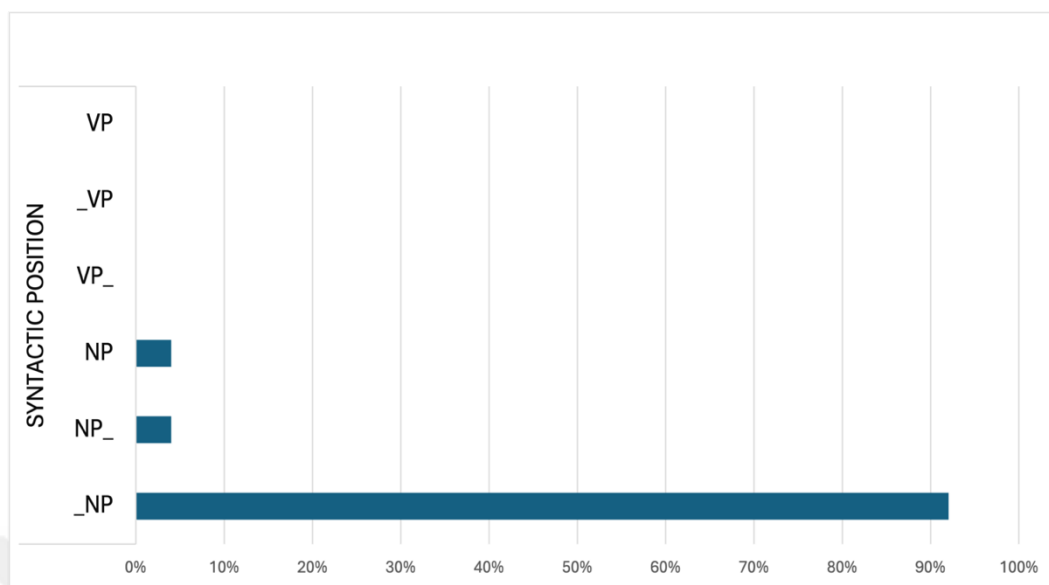
5.2 Syntactic distributions

Analyzing the syntactic properties of pointing signs is essential for understanding their grammatical functions in TĪD. As I mentioned in the Methodology Section, to conduct a detailed syntactic analysis, I developed a Position tier, which captured the position of each pointing sign relative to surrounding constituents. This tier enabled the systematic annotation of syntactic position, allowing for more accurate predictions about the grammatical categories of pointing signs since examining the grammatical relationship between a pointing sign and its surrounding elements reveals key insights into its linguistic role. The syntactic positions occupied by pointing signs in TĪD can be summarized as follows: pre-nominal (__ NP), post-nominal (NP __), simultaneously with a nominal phrase (NP), pre-verbal (__ VP), post-verbal (VP __), and simultaneously with a verbal phrase (VP). The figure below presents the distribution patterns across grammatical categories.

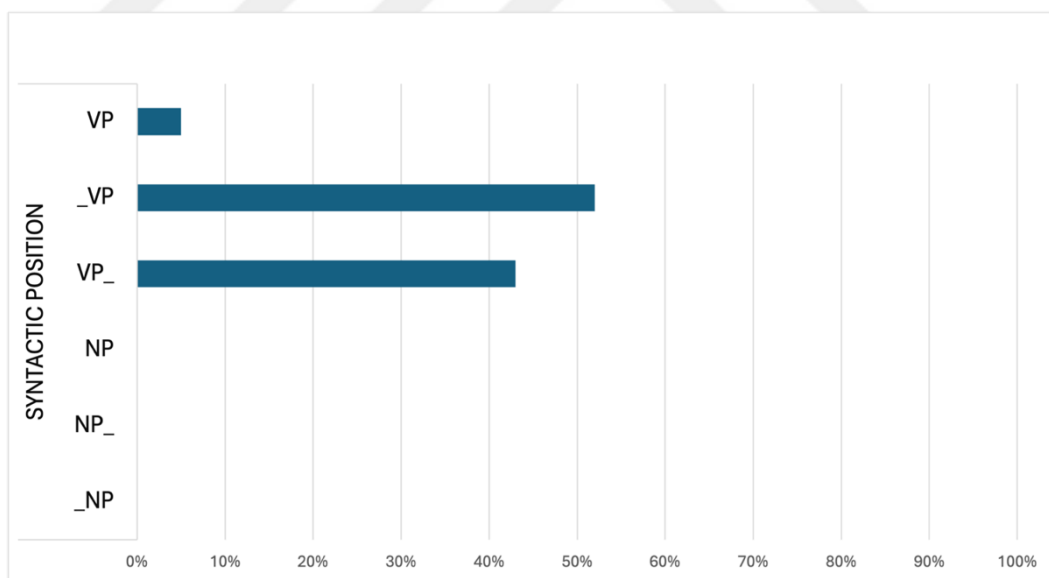
(a) Demonstratives



(b) Clitics



(c) Pronouns



(d) Locatives

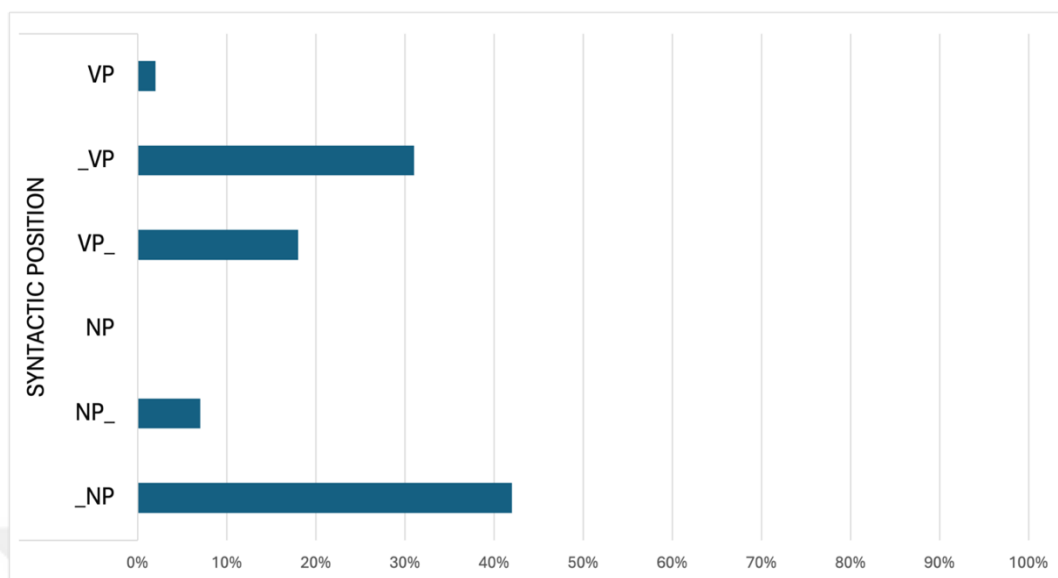


Figure 21. Syntactic Distributions of Grammatical Categories

Demonstratives predominantly appear in the pre-nominal position (84%), with post-nominal occurrences accounting for 15%. They also co-occur simultaneously with noun phrases in 1% of cases. Clitics show a similar distribution, with an even stronger preference for the pre-nominal position (92%) and limited post-nominal use (4%). Additionally, 4% of Clitics appear simultaneously with noun phrases. Pronouns never emerge surrounding noun phrases but appear before a verb phrase in 43% of instances and after a verb phrase in 52%. They also occur simultaneously with verb phrases in 5% of cases. Locatives are distributed across five syntactic positions, with the highest proportion in the pre-nominal position (42%), followed by post-verbal (31%) and pre-verbal (18%) positions. They also appear post-nominally (7%) and, though rarely, simultaneously with verb phrases (2%).

Data from the Position tier show that pointing signs may either precede, follow or co-occur with a nominal phrase (NP) in their Demonstrative

function (12). Phonologically reduced forms of pointing, analyzed as Clitics, occur in the same syntactic positions (see Figures 18a and 5b).

(12) Demonstrative/Clitic use of a pointing sign

(a) FALL, [IX CAT]

‘That cat fell.’

(b) [CAT BLACK IX], RUN

‘That black cat is running.’

As shown in (12), Demonstratives and Clitics typically appear adjacent to noun phrases in (___ NP) or (NP ___) orders. In (13), the pointing sign follows a verb phrase (VP), illustrating a pronominal use. The first verb ‘ESCAPE’ is performed by the mouse which is articulated with a lexical sign. A pointing sign is directed at the *a*-locus associated with the cat before the second verb ‘WASH’.

(13) Pronominal use of a pointing sign

MOUSE_a ESCAPE, [IX_b] WASH

‘The mouse escaped, the cat washed its paw.’

In (14), the various syntactic positions that can be occupied by the locative pointing signs are exemplified. In each of these positions, the pointing sign remains clearly distinguishable from the surrounding elements, exhibiting syntactic independence. Although the positional distribution of Locative pointing signs overlaps with that of Pronouns, Demonstratives, and Clitics, their morpho-phonological articulation is clearly distinct. This morpho-phonological distinction will be further elaborated in Section 5.3.

(14) Locative use of a pointing sign

(a) [IX], PIANO

‘There is a piano up there.’

(b) PIANO, [IX]

‘There is a piano up there.’

(c) CAT RUN, [IX]

‘The cat is running there.’

(d) MOUSE, [IX], JUMP

‘The mouse jumps there.’

It is important to note that during the analysis, the intricate interplay between prosody and syntax became particularly evident. In (12), although the pointing sign is preceded by a VP, a clear prosodic break occurs between the verb and the pointing sign, indicated with a comma here. Consequently, the pointing sign appears to group more closely with the following NP. The perceived syntactic closeness between constituents is strongly signaled by prosodic cues such as lower face tension, blinks, gaze, and head-body orientation (Brentari & Crossley, 2002), which will be discussed in greater detail in Section 5.5.

5.2.1 Preliminary discussion of syntactic distributions

Analyzing the syntactic behavior of pointing signs reveals important distributional differences across grammatical categories. Overall, the syntactic versatility of pointing signs reflects their distinct grammatical roles in T1D.

In light of the data provided above, we can interpret the syntactic properties of pointing signs for each group. The pointing signs categorized as Demonstratives show high rates of pre-nominal and post-nominal positioning. As demonstratives in a language operate within NPs, this result is expected. They never appear immediately before or after a verbal phrase, as a demonstrative pointing sign alone is not sufficient to function as the subject, that is, a complete NP of a TP (Tense Phrase).

Therefore, this type of pointing does not occur in isolation due to its syntactic dependence. A demonstrative must occur in relation with an NP to fulfill its function of indicating an entity by selecting or establishing a referent in the signing space.

Clitics display the same syntactic properties as Demonstratives, with the only difference being a slight decrease in post-nominal occurrences. The increased tendency toward pre-nominal positioning may be attributed to several factors. Notably, post-nominal pointing signs tend to be phonologically more salient, contra how clitics behave. In fact, 117 out of 138 post-nominal points were annotated as Strong, reflecting tendency toward articulatory prominence in phrase-final position.

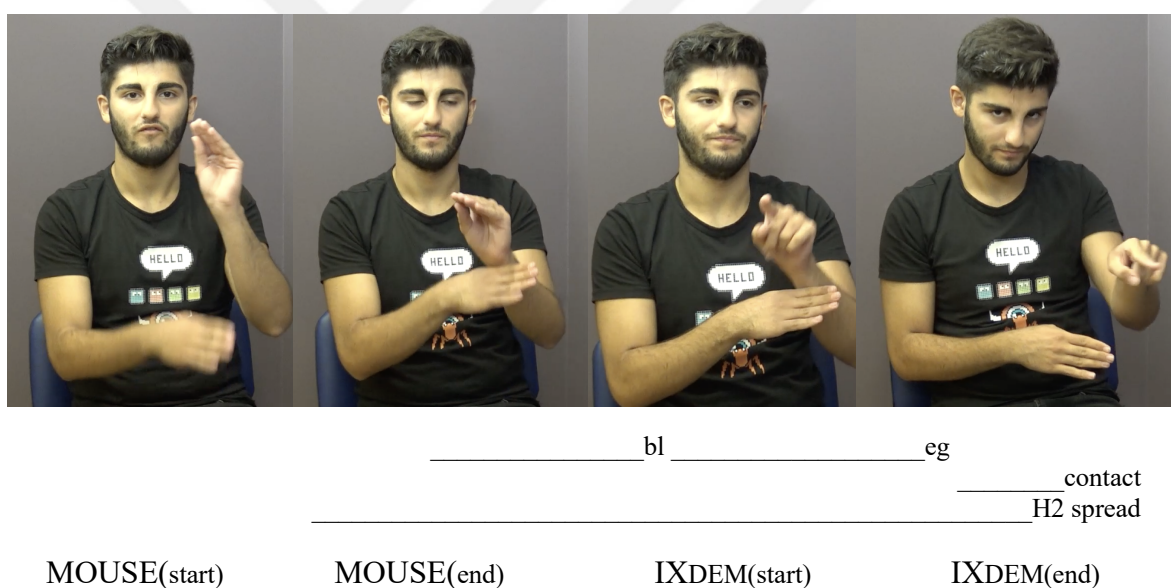


Figure 22. Post-nominal demonstrative pointing sign

In Figure 22, a demonstrative pointing sign is produced immediately following the noun ‘MOUSE’. The non-dominant hand (H2) spreads over the articulation of the pointing sign (note that the signer is left-handed). Moreover, a blink (bl) occurring with the final frame of the lexical item is followed by an eyegaze (eg) that coincides with the onset of the pointing sign. This is further accompanied by

eye contact and a deliberate placement of the index finger in H-space. This pointing sign is held still and therefore seems to display a lengthening feature.

This observation aligns with broader findings on phrase-final prominence in sign languages. Nespor and Sandler (1999) propose that phrase-final constituents are prosodically prominent, often associated with focus. Supporting this, Karabüklü and Gürer (2022) report that focused signs in TİD display increased manual duration. Similarly, Sandler (1999a) discusses right-edge prosodic lengthening in Israeli Sign Language (ISL), especially in relation to H2-spread. Although these findings suggest a general trend toward phrase-final prominence, our data show that this is not strict: approximately 15% of post-nominal pointing signs were weak and categorized as Clitics. Further research is necessary to clarify the conditions under which post-nominal pointing signs are phonologically reduced.



IXCLT

MOUSE

IXDEM

‘That mouse’

Figure 23. Pre-nominal and post-nominal pointing sign (sandwich construction)

In Figure 23, two pointing signs can be observed, one occurring before and the other after the noun phrase. Zimmer and Patschke (1990) propose that ASL allows determiners on both the left and right edges of the NP, based on their phonological analysis of pointing signs. However, Bahan et al. (1995) offer a

different perspective, arguing that post-nominal pointing signs do not function like determiners but rather operate adverbially, supporting both definite and indefinite interpretations. Pre-nominal pointing signs, by contrast, are proposed to be true articles that obligatorily mark definiteness.

While the current study observes pre- and post-nominal pointing signs surrounding NPs in TlD, further research is needed to determine whether their functional status differs. The overall greater phonological strength of post-nominal pointing signs in TlD suggests a potential difference in functions that call for closer investigation.

Relatedly, in line with the observations of Abner (2021), I have also found that demonstrative indices are highly optional and may or may not co-occur with a nominal. This raises the further question of whether a semantic distinction exists between the interpretation of a bare NP and an NP accompanied by an IX at all, a topic that remains open for future research.

On the other hand, Pronouns display a distinctly different syntactic distribution from Demonstratives and Clitics. Pronominal pointing signs never co-occur with noun phrases but instead behave as fully independent constituents, occupying syntactic positions typical for full NP arguments. They are observed preceding VPs in over 40% of cases, following VPs in over 30%, and occurring as isolated elements, especially at utterance-final positions (over 10%). If Pronouns are definite descriptions involving NP ellipsis as suggested by Elbourne (2005), they would not co-occur with full noun phrases in the syntactic structure like we observe here.

The complementary distribution between Pronouns and Demonstratives suggests that, while both constructions function referentially, they do so through

distinct syntactic mechanisms. Demonstratives operate within NPs, whereas Pronouns form the entire NP themselves. This finding is consistent with Engberg-Pedersen's (2003) observation that pronouns and determiners must be differentiated based on their syntactic distribution. The syntactic behavior of pronominal pointing signs will prove to be highly important and will be discussed in later sections, particularly with respect to their morpho-phonological properties.

Locative pointing signs demonstrate the widest syntactic range, appearing across five possible annotated positions: preceding or following NPs, preceding or following VPs, and simultaneously with a VP.¹⁰ Approximately 40% of Locatives appear pre-nominally, while over 20% occur pre-verbally. Locatives also frequently appear as separate constituents. Their flexible syntactic behavior reflects their grammatical versatility, distinguishing them from the more tightly NP-bound categories of Demonstratives and Clitics.

When examined together, the syntactic patterns reveal a hierarchy of flexibility across pointing categories. Locatives exhibit the broadest range, functioning both as modifiers and adjuncts. Pronouns behave as fully independent NPs interacting with VPs or the entire sentence, while Demonstratives and Clitics are restricted to the nominal domain. Clitics, in particular, show the narrowest syntactic range, primarily occupying pre-nominal slots. These findings underscore important structural differences between the established pointing categories in TĪD and provide a foundation for further analysis of their morpho-phonological and prosodic characteristics.

¹⁰ When adjacent to noun phrases, Locatives may function as predicates, forming the verb phrase (VP) of the sentence. Alternatively, they may serve as predicative modifiers, e.g., *the cat over there*, which can be analyzed as reduced relative clauses.

5.3 Morpho-phonological distributions

This section presents the morpho-phonological distributions of pointing signs, based on a two-dimensional spatial framework that distinguishes between Vertical Space (V-Space) and Horizontal Space (H-Space). In some categorical divisions, syntactic features seem to play a more prominent role in determining function. However, the spatial annotations did reveal distinct distributional patterns across grammatical categories as well. In addition to spatial use, other morpho-phonological parameters, including palm orientation, movement, strength, and non-manual markers (NMMs), were systematically analyzed. Each of these features contributes to identifying the functional role of a pointing sign.

Following subsections detail the distributional findings derived from each morpho-phonological annotation tier created in ELAN (Section 5.3.1), encompassing both manual and non-manual features. Percentages of selected values within each tier, such as space use (H- and V-Space) or other articulatory features regarding strength, movement, and palm orientation, are visualized in category-specific graphs to reveal systematic tendencies. Likewise, the distribution of non-manual markers is presented separately, with dedicated graphs.

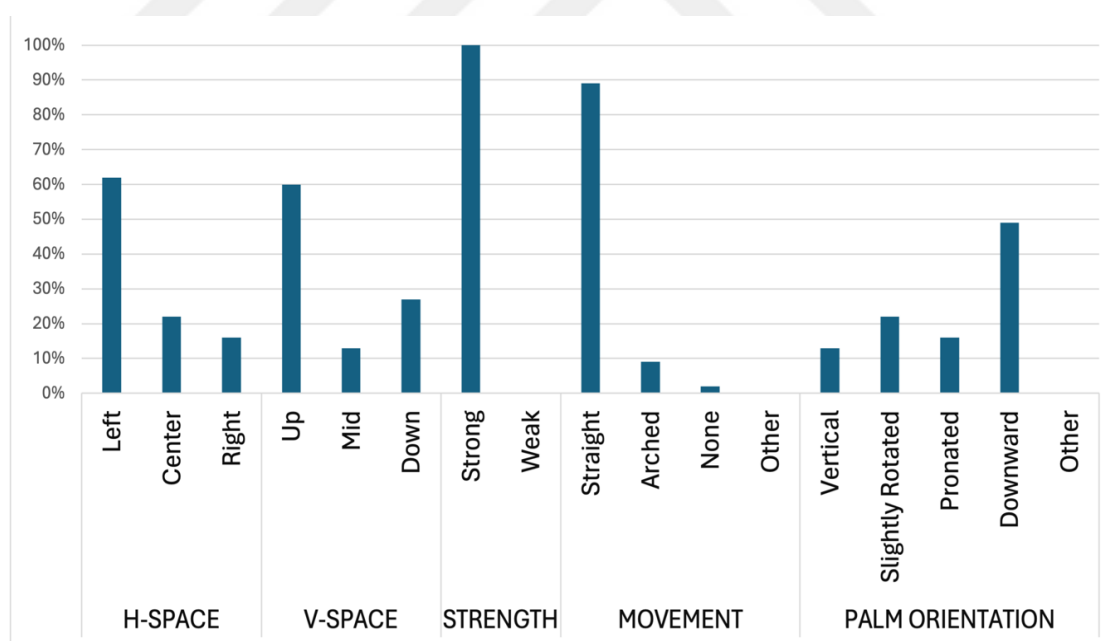
Section 5.3.2 turns to the results derived from Pose Estimation, focusing on the quantitative measurement of the morpho-phonological parameters H-Space and V-Space. In the final sub-section (5.3.3), we discuss the findings from both analyses. Taken together, these impressionistic observations and quantitative results are integrated to offer a comprehensive discussion of the characteristics shaping the grammatical distinctions of pointing signs.

5.3.1 Impressionistic manual annotations

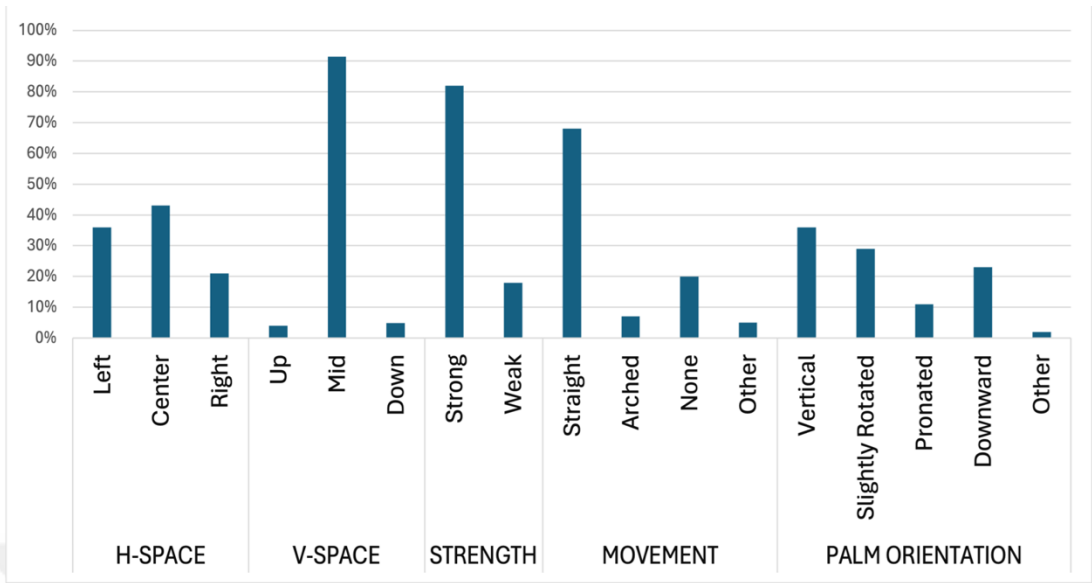
The graphs below present the morpho-phonological composition of each grammatical category. As detailed in the Methodology chapter, each annotation tier corresponds to a distinct morpho-phonological parameter. To enhance clarity, manual parameters and non-manuals are displayed in separate graphs for each category.

The section proceeds with distributional results of strength, movement, palm orientation and NMM parameters. This is followed by a detailed examination of the H- and V-Space parameters, supported by representative examples from the data. Finally, a comprehensive description of Clitics and their spatial behavior is presented, with illustrative instances for each subtype.

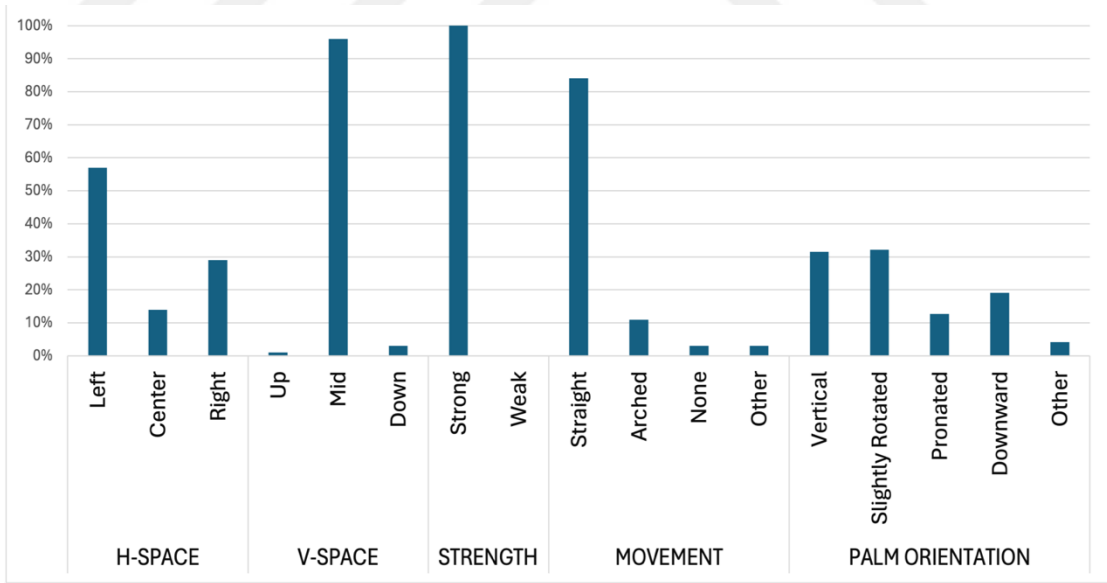
(a) Locatives



(b) Pronouns



(c) Demonstratives



(d) Clitics

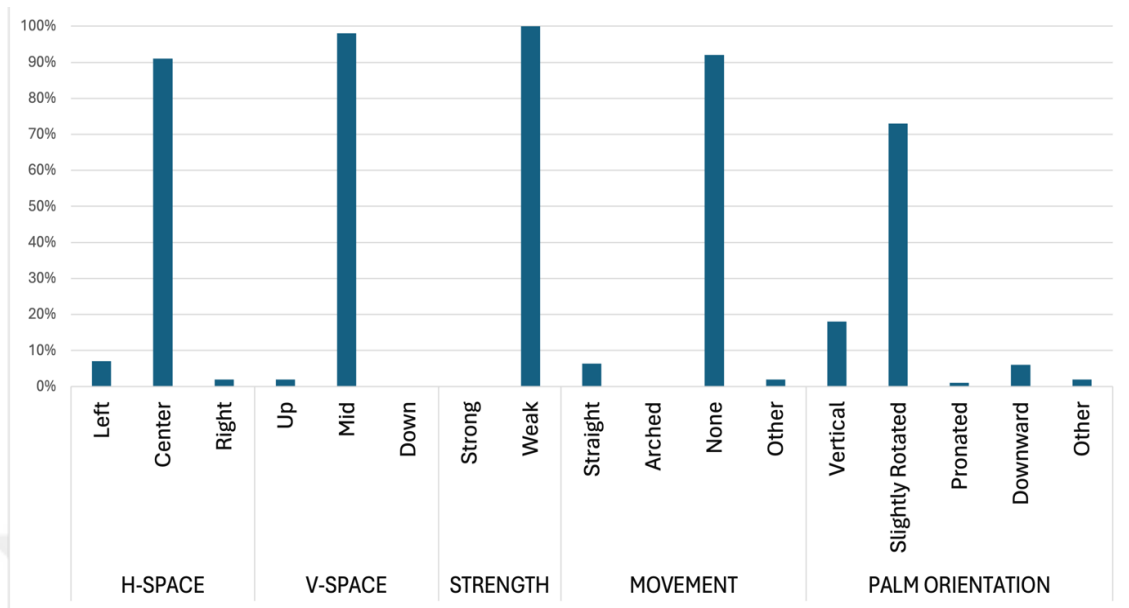
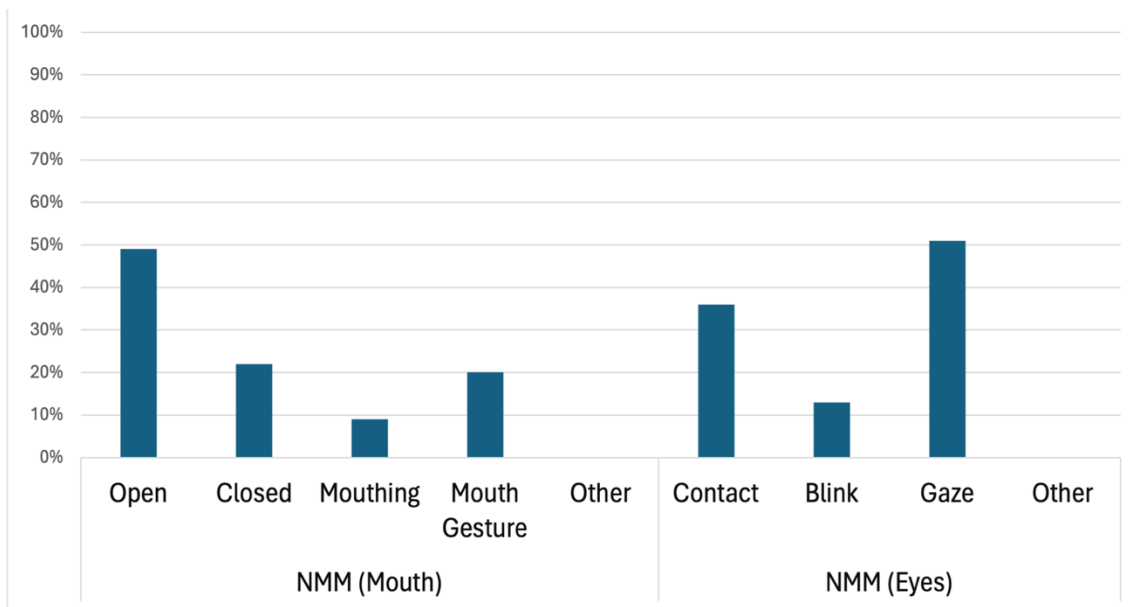
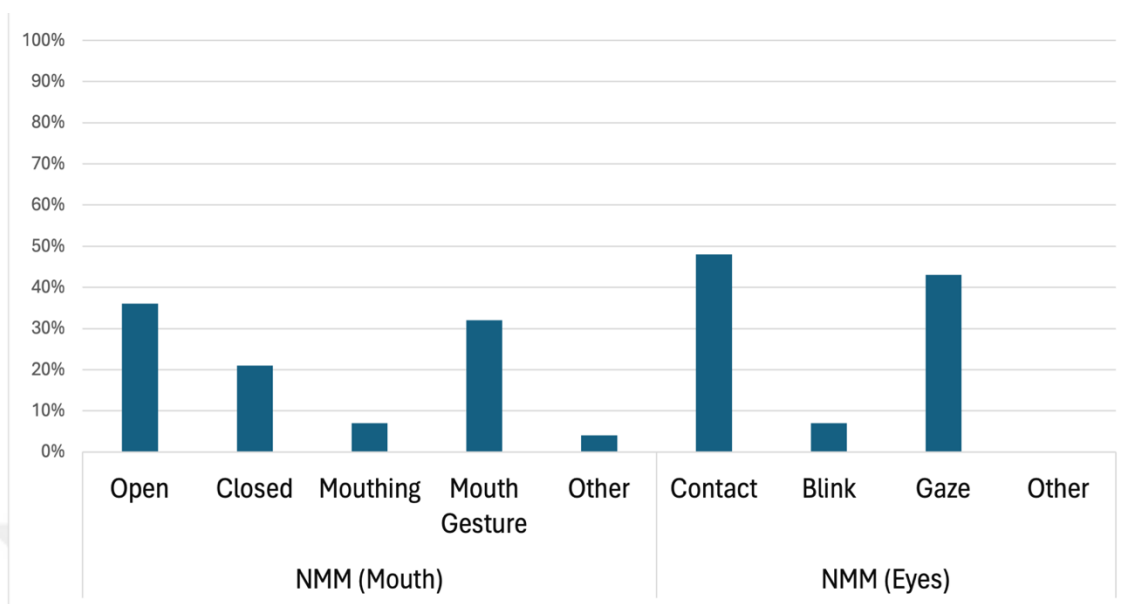


Figure 24. Morpho-phonological distributions (space, strength, movement and palm orientation)

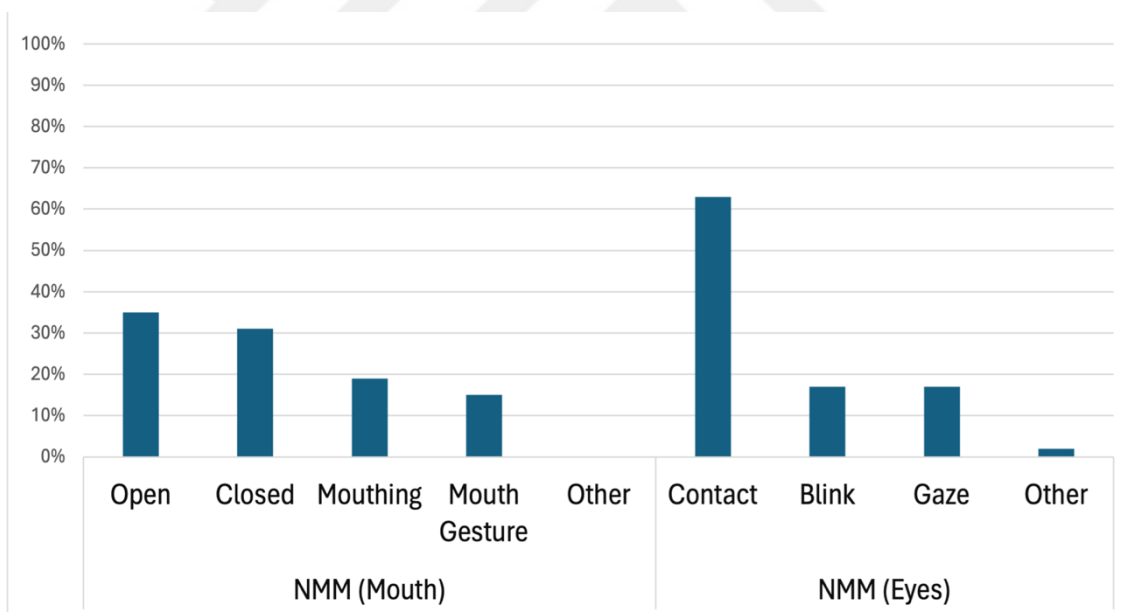
(a) Locatives



(b) Pronouns



(c) Demonstratives



(d) Clitics

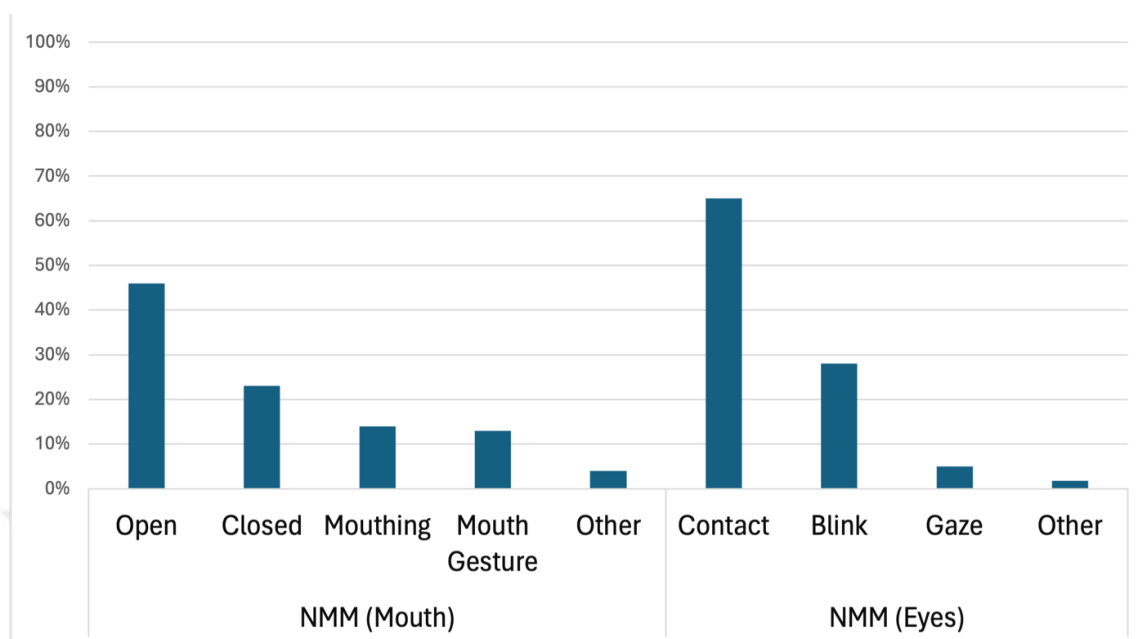


Figure 25. Morpho-phonological distributions (NMMs)

As shown in Figure 24a, Locative pointing signs tend to appear predominantly on the left side of the horizontal plane (62%), with fewer instances in the center (22%) and right (16%). On the vertical axis, they are most commonly articulated up (60%) or down (27%), while the mid space is used in only 13% of the cases. All Locatives are phonologically strong. Additionally, straight movement is the most common pattern (89%), followed by arched movement (9%) and rare instances of no movement (2%). The palm orientation is most frequently downward (49%), though slightly rotated (22%), pronated (16%), and vertical (13%) orientations are also observed.

In terms of NMMs (Figure 25a), mouth configurations are mostly open (49%), followed by closed (22%). Mouthing and mouth gestures appear at 9% and

20%, respectively. Eye behavior is primarily marked by gaze (51%), followed by contact with the addressee (36%), while blink occurs in 13% of the instances.

Figure 24b shows that Pronouns are most often located at the center of the horizontal space (43%), with notable use of left (36%) and right (21%) as well. On the vertical axis, mid space dominates (91%), while up (4%) and down (5%) occur infrequently. Phonological strength is predominantly strong (82%), with weak forms appearing in 18% of the data. Pronouns also show a more varied movement pattern: 68% are straight, 7% are arched, while 20% exhibit no movement and 5% fall under other. Palm orientation is most often vertical (36%) or slightly rotated (29%), followed by pronated (11%), downward (23%), and other (2%).

As we see in Figure 25b, for Pronouns, mouth configuration is largely open (36%) or closed (21%), with mouth gestures (32%) and mouthing (7%) also present. Eye behavior includes contact (48%) and gaze (43%), while blink is less frequent (7%) and other appears in 2% of cases.

According to Figure 24c, Demonstratives primarily appear in left space (57%), followed by right (29%), while center is used the least (14%). On the vertical axis, they overwhelmingly appear in the mid zone (96%). All Demonstratives are phonologically strong. Their movement is mostly straight (84%), with some arched paths (11%) and very few none (3%) or other (3%). Palm orientation is split between slightly rotated (32%) and vertical (32%), though pronated (13%), downward (19%), and other (4%) are also present.

Figure 25c shows that for Demonstratives mouth patterns include open (35%), closed (31%), mouthing (19%), and mouth gestures (15%). Contact is the dominant eye behavior (63%), with blink (17%), gaze (17%), and other (2%) appearing less frequently.

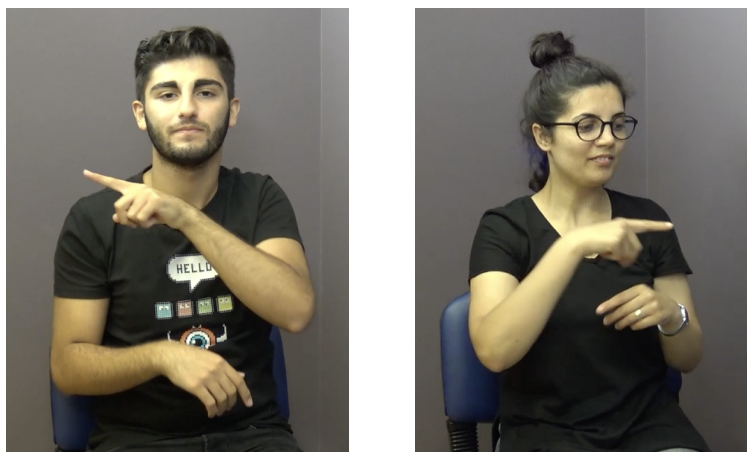
Lastly, as Figure 24d illustrates, Clitics overwhelmingly occupy the center of H-space (91%) and the mid zone of V-space (98%). Other horizontal and vertical locations are used less than 5% of the time. All Clitics are marked as weak in phonological strength. Movement is absent in 92% of the cases, with minimal presence of straight (6%) or other (2%) trajectories. Palm orientation is typically slightly rotated (73%), while vertical (18%), downward (6%), pronated (1%), and other (2%) values are also found.

As shown in Figure 25d, mouth configurations for Clitics are most commonly open (46%) or closed (23%), with mouthing (14%) and mouth gestures (13%) also represented. Eye behavior includes high rates of contact (65%) and blink (28%), while gaze (5%) and other (2%) are rare.

Below are instances of pointing signs, each directed at a different area within the signing space. The slightest vertical deviation in the V-Space was annotated as Up or Down in this tier (see Figure 20b). However, individual variation among participants was observed: some signers produced all signs relatively higher, others made use of a broader signing space, while some utilized a more restricted area throughout their narration. Annotations were made bearing this variance in mind.

For instance, in Figure 26a, the male signer consistently produced signs above torso level, exceeding the shoulder line, with the index fingertip directed upward in all of his pointing productions. In contrast, the signer pointing to the left articulated her signs below shoulder level. Thus, although the rightward pointing sign may appear to utilize V-Space when observed in isolation, it is interpreted in the context of the signer's overall production and therefore annotated as occurring within H-Space only.

(a) H-Space Use



(b) H- and V-Space Use



(c) No Use of H- or V-Space

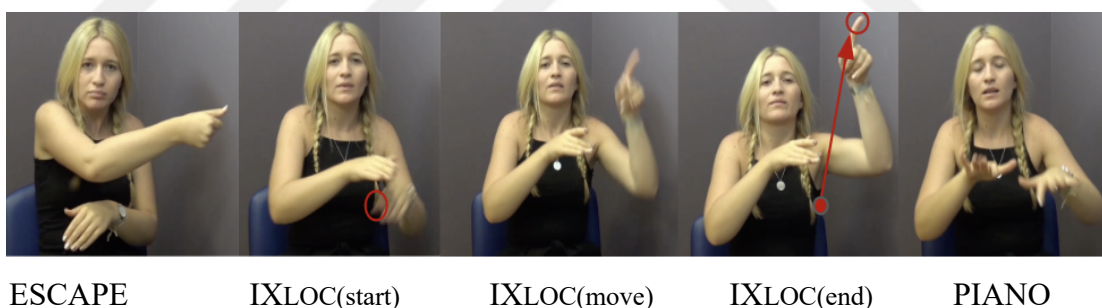


Figure 26. Space use of pointing signs

In Figure 26b, as the pointing sign covers substantial distances on the vertical dimension, there is a clear use of V-Space. Generally, pointing signs with V-Space use do not follow a straight vertical line but rather move slightly to the right or left as they go up or down. Thus, when V-Space is used, H-Space may also be utilized.

In Figure 26c, the pointing sign is held right across the signer's torso. There is no movement, therefore this type of pointing signs are annotated as Mid for the V-Space and Center for the H-Space, that is no use of H- or V-space.

Notably, for Locatives if Horizontal Space is Center (36%), Vertical Space is never Mid (12%). Conversely, when the V-Space was set to Mid, indicating no vertical movement, the H-Space was specified as either Right or Left, ensuring that one of these spatial dimensions is always specified. In Figure 27, there is a Locative pointing sign using both the V and H-Space, as Up and Left, displaying a straight movement trajectory. The palm of the signer is facing downward.



‘(The mouse) escaped. The piano is over there.’

Figure 27. Locative pointing sign

As I mentioned above, for Pronouns and Demonstratives, spatial distributions overlapped in their preference for H-Space over V-Space. However, subtle differences emerged: Demonstratives were more frequently positioned in the Left (57%) and Right (29%) on the H-Space, whereas Pronouns tended to appear in the Center 30% more frequently. As Pronouns can get assimilated into the Verb Phrase

(Gökgöz, 2020), their reduced use of space can be partly explained by assimilation. In contrast, the Demonstrative group excludes Demonstrative pointing signs that underwent assimilation. As the weak Demonstrative signs are highly frequent in our data, we have decided to categorize them under a different group named “Clitics”. Therefore, if we had decided to create a group for weak Pronouns too, this would account for all the 30% more frequency of Center difference for Pronouns.

In Figure 28, there is a Pronoun which uses the H-Space by covering a certain distance to the right while in Figure 29, the pointing sign is directed left on the H-Space with approximately the same amount of distance travelled by the Pronoun. Therefore, we argue that Space Use (H-Space and V-Space) is not a sufficiently discriminative morpho-phonological parameter for distinguishing between Pronouns and Demonstratives. Both the Demonstrative and the Pronoun follow straight movement trajectories; moreover, they are influenced by the preceding sign, resulting in a pronated palm orientation in both cases.



RUB

IXPRO(start)

IXPRO(end)

FOAM

Preceding Context: The mouse has a bar of soap and is rubbing it on the cat's mouth. The pointing pronoun refers to the cat.

'The mouse is rubbing, and the cat is foaming at the mouth.'

Figure 28. Pronominal pointing sign

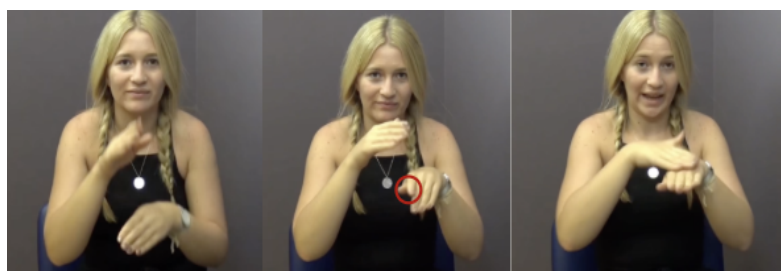


CAT IXDEM(start) IXDEM(end) MOUSE
 ‘(That) cat and that mouse (are sitting comfortably.)’

Figure 29. Demonstrative pointing sign

For Clitics, H- and V-Space are consistently specified as Center and Mid. The categorization of this class as distinct from Demonstratives emerges from the frequent occurrence of pointing signs that exhibit a substantial lack of syllabicity, that is, they show no movement from one location to another. Most often, they appear solely as a slight index-fingertip lift at the beginning of a lexical item. These signs do not cover any significant distance along the horizontal or vertical plane and typically consist of brief pointing acts, many of which are nearly imperceptible at normal viewing speed. Their identification is only possible by reviewing the narration data at half speed.

In contrast, some instances of Clitics may appear to involve movement across space. However, this generally results from their occurrence during transitional phases between lexical signs; they are not directed toward any specific location and thus lack inherent articulatory movement of their own (see Figure 30).



CAT

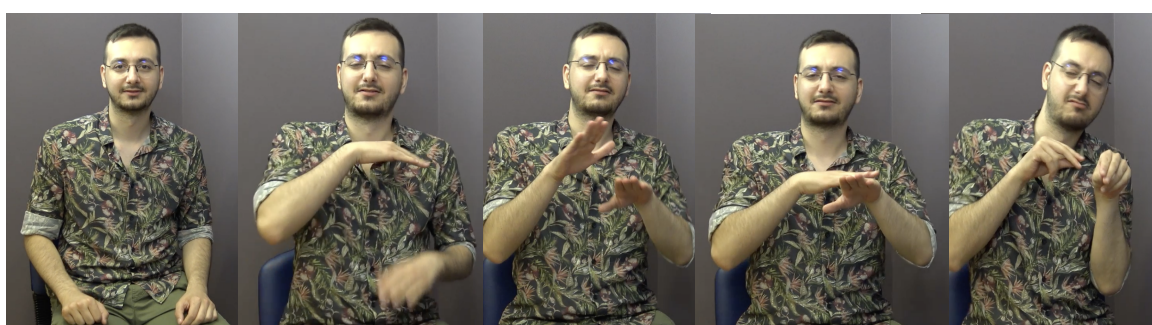
IXCLT(start-end)

CAT

‘That cat’

Figure 30. Clitic pointing sign

While in Figure 30, the pointing sign seems to blend into the onset of the nondominant hand of the lexical sign for ‘CAT’, yielding a progressive assimilation instance, in some cases, it is possible to observe a regressive handshape assimilation on the pointing sign. For instance, in Figure 31, the signer starts his narration from a neutral position, where both hands rest on his lap in the first frame. In the second frame, there is a movement of the whole hand in the center before moving onto the articulation of ‘CAT’. This occurrence is considered as a form of Weak Demonstrative pointing sign due to its getting assimilated by the handshape of the following sign and thus categorized as Clitic in our data.



Neutral Position

IXCLT

CAT(start)

CAT(end)

SLEEP

‘That cat is sleeping.’

Figure 31. Handshape assimilation

Clitics displayed various types of syllabicity loss, realized through distinct phonological patterns. The first and most frequent type of weak form occurred during *transitional phases* between lexical signs as we saw an example under assimilation in Figure 30 above. Another example comes in Figure 32. These signs were not directed toward any identifiable locus in space and lacked a discrete movement configuration. They were typically produced as a lift of the index fingertip appearing during transition from one sign to another. I argue that these forms exhibit a loss of syllabicity and therefore should be classified as phonologically weak.

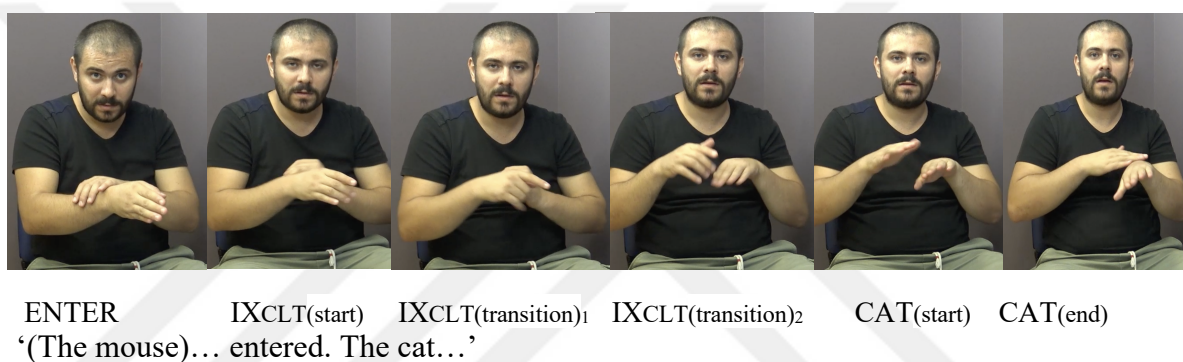


Figure 32. Transition phase weak pointing

A second subtype of Weak pointing signs involved extremely *restricted spatial use*. Although these signs sometimes displayed a slight upward movement in front of the signer’s torso, the movement was so minimal that it was barely perceptible at normal signing speed. Crucially, they did not appear to explicitly engage the horizontal or vertical signing space. These pointing signs typically occurred immediately before a noun phrase, with the nominal construction beginning at the same Place of Articulation (PoA) where the pointing sign ended. These instances were different from a weak pointing occurring during a transition phase in that they had a separate movement timing slot directly targeted at the PoA of the

following unit. Due to their minimal and spatially constrained articulation, these signs were also categorized as phonologically weak (Figure 33).

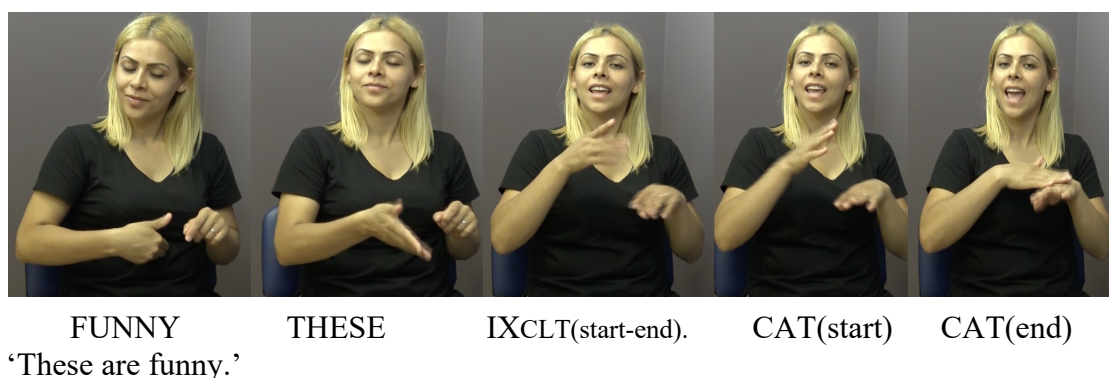


Figure 33. Undirected use of weak pointing

A third subtype involved *assimilation into the following linguistic unit*. In such cases, the index finger was no longer distinctly selected, and the pointing sign merged with the handshape of the following sign. What remained was a minimal, often indistinct, movement, rendering the pointing sign virtually unrecognizable as an independent phonological unit. Even though movement technically occurred, the lack of handshape distinction led to a loss of phonological strength (Figure 34, see also Figure 31).



‘(The cat)... is running. The mouse...’

Figure 34. Assimilation of weak pointing

Finally, a small number of pointing signs were found to occur with a lexical item at the same time. In these instances, the lexical sign occurred on one hand and the pointing sign occurred on the other hand and they were articulated co-temporally, thus within the same timing slot. While these signs were more clearly articulated, often employing H-space and targeting a specific locus, their temporal overlap with another sign suggests a form of coalescence.



IXCLT(start-end)^MAN

CAT

Figure 35. Coalescence of weak pointing

In Figure 35, a pointing sign co-occurring with the lexical sign for ‘MAN’ is observed. In these cases, the pointing sign appears to undergo syllabicity loss due to its integration into the prosodic structure of the surrounding material. Thus, coalescence is treated here as a distinct instance of phonological weakening.

5.3.2 Morpho-phonological distributions out of Pose Estimation

While our initial analysis in ELAN provided valuable insights into the morpho-phonological distributions of pointing signs, it was constrained by the reliance on impressionistic observation, limiting the precision in capturing subtle spatial changes. To enhance accuracy, we integrated Pose Estimation, enabling the precise calculation of Euclidean distances along the horizontal and vertical axes. The code

was designed to measure the straight-line distances between the start and end points of each pointing sign on x and y coordinates.

The data in the preceding section has shown that Demonstratives and Pronouns share similar spatial features and differ solely in their syntactic properties. Initial impressionistic observations also suggested that Locatives were consistently specified either for the V-Space or the H-Space. In contrast, Clitics had limited spatial use. The quantitative ranges yielded by Pose Estimation suggested a striking alignment with the classes identified impressionistically through manual annotations. This alignment supports our morpho-phonological analysis of H and V-Space for pointing signs in TĪD.

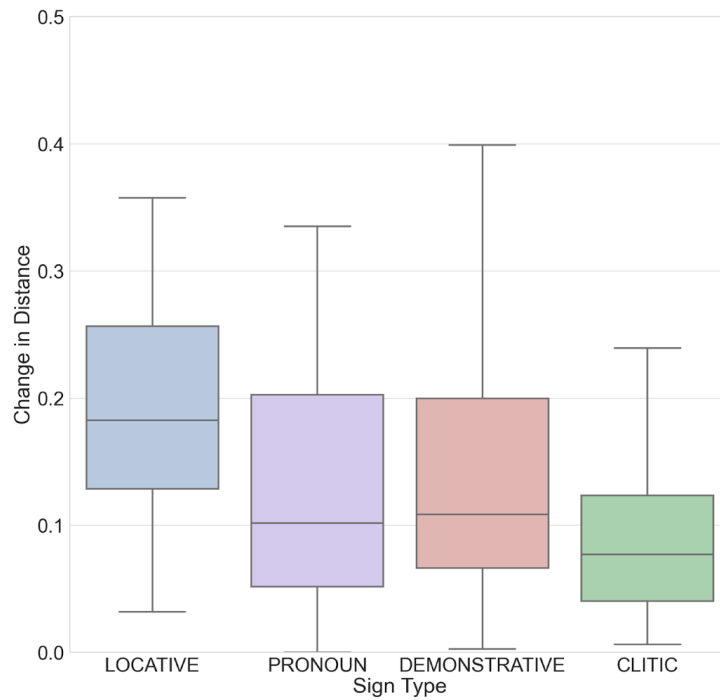


Figure 36. The mean distance change of grammatical categories

In Figure 36, the results show that Locatives are articulated with the greatest normalized distance change ($M=0,214$), followed by Pronouns ($M=0,166$), and then Demonstratives ($M=0,172$). Clitics are articulated with the least distance change

($M=0,105$). Notably, there is a striking overlap between the Demonstratives and Pronouns, with both categories covering approximately the same distances.

5.3.3 Preliminary discussion of morpho-phonological distributions of pointing signs

The percentages yielded from ELAN annotations indicate that Locatives, in contrast to all other categories, show a notably higher frequency of Up and Down values in the vertical space parameter. This expansive use of V-Space is supported by Pose Estimation data, which reveal a greater average distance for Locatives compared to all other categories. Together, the qualitative and quantitative analyses indicate that Locatives engage a broader range of the signing space.

In contrast, ELAN annotations show that Pronouns and Demonstratives predominantly operate along the horizontal axis. Pose Estimation further confirms that these categories exhibit a more restricted range of motion when compared to Locatives. This restricted spatial use is most pronounced in Clitics, which show the highest percentages for Center in H-Space and Mid in V-Space. Pose Estimation similarly reveals that Clitics cover the least average distance, confirming their significantly reduced spatial profile.

Overall, patterns of space use across pointing signs are distinctive enough to support the division into two main types of pointing: Locatives and Nominals. Locative pointing signs utilize a much broader space, often reaching the peripheries of the signing space, whereas nominal pointing signs, namely Demonstratives, Pronouns, and Clitics occupy a more confined range along the horizontal axis. Since the establishment and use of loci can be achieved within H-Space and the H-Space is usually sufficient for setting referential contrast (due to being divided into at least two potentially referential areas, i.e., ipsilateral and contralateral side), the spatial use

of nominals remains largely confined to this dimension. Clitics, as assimilated and phonologically weakened forms of Demonstratives, exhibit minimal spatial use. Thus, a gradual reduction in space utilization from Locatives to Clitics is observed, suggesting a correlation between reduced space use, increased grammatical functionality, and loss of lexical content, a point to which we will return in the grammaticalization discussion.

The phonological parameters of movement and strength emerge as direct consequences of space use, they are closely intertwined and cannot be considered in isolation. Specifically, the minimal spatial use observed in Clitics is further supported by the annotations as ‘weak’ for the strength and ‘none’ for the movement parameters. Clitics undergo phonological reduction, losing syllabicity and becoming assimilated into adjacent signs, and thus do not display the movement or strength patterns characteristic of more prominent forms.

All other categories generally maintain strong phonological forms, with the exception of Pronouns, which sometimes surfaced as a reduced form. Roughly three in ten Pronouns are annotated as Weak in ELAN, indicating occasional loss of syllabicity. According to the same annotations, Pronouns more frequently occupy the Center in H-Space compared to Locatives and Demonstratives, both of which show a stronger preference for Leftward spatial placement. This tendency toward staying in the Center is likely connected to the elevated rate of ‘none’ for the movement parameter found in the Pronoun group.

However, Pose Estimation data do not support a distinctive pattern between Pronouns and Demonstratives in terms of overall spatial articulation. Although the distance range of Pronouns tend to begin slightly closer to the signer’s center, both categories utilize similar widths of signing space (see again Figure 36). In this

respect, the subtle percentage differences observed in ELAN regarding H-Space, strength and movement do not produce quantitatively distinctive results in the Pose Estimation analysis.

The results coming from cross-linguistic studies (de Vos, 2015; Pfau, 2011; Zimmer & Patschke, 1990) on the movement parameter suggested that Locatives would pattern more frequently with either an arc-shaped or a tracing movement. Initially, we hypothesized that Locatives would predominantly follow an arched movement trajectory in TID too, as such movements were assumed to enhance the articulation of locational information by reflecting the intentional placement of the fingertip within a specific spatial area. However, the data revealed a different pattern: arched movements occurred slightly more frequently with Pronouns and Demonstratives, which seems to be due to referential purposes to mark contrast between distinct referents. This movement typically involved a shift from the ipsilateral to the contralateral side (or vice versa) across the horizontal plane (H-space). While Pfau (2011) observed in German Sign Language (DGS) that arc-shaped movements are associated with distal adverbials and that repetitive forward movements emerged with demonstratives, the patterns found in TID differ: repetition was not characteristic of any pointing class, and arc-shaped trajectories were not consistently linked to locative expressions, but rather emerged primarily in referent-establishing contexts. Similarly, the tracing movement proposed by Zimmer & Patschke (1990) for ASL Locatives was not a characteristic trait of a locative pointing sign in TID, but rather emerged with classifier constructions. Overall, all pointing signs most frequently patterned with straight movement trajectories, while nominal categories showed a slight tendency toward arched movements, and highly reduced forms typically showed no movement at all.

Palm orientation also revealed distinct patterns across categories. A slightly rotated orientation where the hand is positioned close to vertical but tilted slightly with a lax posture, was most frequent among Clitics. Additionally, Pronouns showed a higher tendency toward slightly rotated palm orientation compared to Demonstratives, likely due to the inclusion of cliticized forms within the Pronoun group (a possible distinction which we did not draw in this thesis). Overall, nominal pointing signs favored either a vertical or a slightly rotated orientation configuration.

On the other hand, Locatives show a striking number of instances with downward orientation, which may be related to the locational content of these pointing signs. As Senghas & Coppola (2010) have noted for NSL, there is a general tendency for downward orientation to mark locational content, while vertical orientation aligns more with referential functions. This proposal was further supported by cross-linguistic studies that gave an analysis of palm orientation (de Vos, 2015; Marsaja, 2008; Pfau 2011). This pattern appears to hold in our TID data as well, suggesting a general cross-linguistic tendency. However, we avoid strictly defining a Locative pointing sign by downward orientation, as the results of this study reveal a non-negligible number of Locatives articulated with other orientation types, as well. It seems that the phonological parameter of orientation is particularly susceptible to influence from surrounding signs, and that hand orientation can become assimilated into adjacent articulations for ease of articulation.

As for NMMs, there is a striking proportion of eyegaze configurations co-occurring with Locative pointing signs. This may be attributed to the nature of locational input: Locatives do not simply operate at a functional level by modifying other linguistic units, they tend to carry greater content when compared to, for instance, a Clitic. This content-heavy function appears to trigger broader spatial

engagement, both manually, through vertical expansion in signing space, and non-manually, through the use of eyegaze to provide additional spatial information. On the other hand, the appearance of eyegaze in nominal categories can often be interpreted as a reflection of locus establishment or use, and notably, it emerges about 20% more frequently with Pronouns than with Demonstratives.

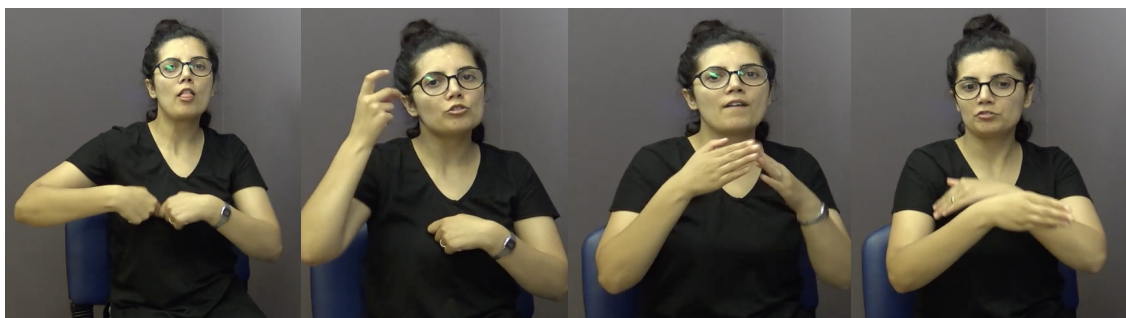
We have observed that even phonologically weak Pronouns often co-occur with eyegaze. Although these pronominal forms may not cover any measurable spatial ground due to their shortened articulation, the presence of eyegaze helps distinguish the pronoun from surrounding verbal signs. In this sense, it may be that a reduction in the duration of manual articulation is compensated for by the integration of a non-manual marker, such as eyegaze. As a result, referential information remains accessible to the addressee through the spatial anchoring provided by the gaze.

In Figure 37, we observe such a case: the referent MOUSE is assigned to spatial loci through a pointing sign performed during sustained eye contact. Subsequently, all actions attributed to the mouse; running, forgetting the rope, and entering the house, are signed while maintaining that eye contact (ec). In the final frame of the sign ENTER, a clear shift in gaze occurs as the signer directs her eyes toward a specific locus in signing space, which we interpret as a moment of discourse planning. The last action of the mouse, GO, is articulated with a re-established eye contact, sustaining the facial expression. Although the signer briefly adjusts her glasses with the non-dominant hand, an eyegaze remains clearly aligned with the pointing sign, IXPRO. Notably, this particular index does not occupy any specific region of H- or V-Space; it is simply paused for a moment at the center in front of the signer. We analyze this type of pronominal pointing as the ‘reduced

form’. Nevertheless, due to the accompanying facial expression change and eyegaze, there is a clear shift of reference, to the CAT. Following this index, a sequence of new verbs such as SEE and RUN is produced, each accompanied by facial expressions that are markedly distinct from the previous set. We therefore identify a reference shift, from the mouse to the cat, realized not through a Pronoun that engages the H-Space but through a phonologically weak form and thus, primarily through non-manual cues, particularly eyegaze.



ec
IXCLT MOUSE ESCAPE ROPE



ec
TIE FORGET HOUSE eg
ENTER



_____ec _____eg
 _____ec
 GO IXPRO SEE RUN

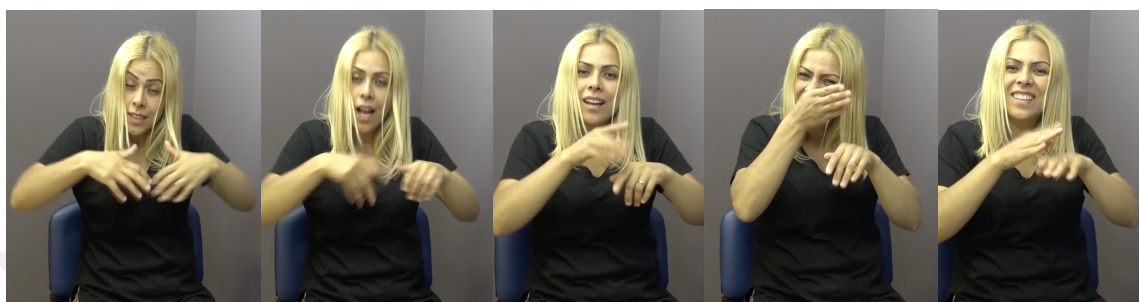
‘The mouse, while escaping, forgets about a rope tied around it. It enters the house and disappears. The cat sees the mouse and starts running.’

Figure 37. A phonologically weak pronominal pointing sign and reference shift through non-manuals

Regarding mouth configurations accompanying pointing signs, we observe a largely similar distribution of mouthing and mouth gestures across grammatical categories. However, Pronouns show a slightly higher co-occurrence with mouth gestures. We suggest that this may be due to the frequent proximity of pronominal signs to verbs which are often accompanied by verb-related facial gestures that express additional event-related information, such as manner (Liddell, 1980). These gestures may begin with or spread over the pronominal sign. As shown in Figure 33, an expression shift begins with the Pronoun: the signer moves from a neutral expression to a more animated, positive one, potentially indicating the cat’s excitement upon seeing the mouse.

Other configurations annotated under the Mouth tier did not exhibit clearly discriminative patterns. The distribution between Open and Closed mouth postures is relatively balanced across all categories. However, it is important to note that the Open mouth configuration appears to carry a functional difference depending on the

category. In Locatives, an open mouth may contribute to the expression of distality, while in Clitics, the same configuration often appears as part of a preparation phase onto a mouthing. Clitics tend to display an Open mouth configuration immediately before a mouthing, as signers prepare to mouth or articulate the first syllable of the lexical item corresponding to the noun sign.



_____open
_____fe
 RUN IXCLT(start) IXCLT(end) MOUSE CAT
 ‘(It) is running. The mouse... Correction: Cat’
 Figure 38. Error correction with a clitic pointing sign

Moreover, in our data, pointing signs co-occurring with an open mouth often coincide with narrative-level errors. Signers occasionally confused the two referents, cat and mouse, and expressed this confusion through a Clitic pointing sign accompanied by an open mouth (open) and followed by a face expression (fe) (see Figure 38). In such cases, the pointing did not align precisely with the start of a mouthing sequence. Additionally, in some cases, it remained unclear whether a mouthing followed at all, due to visual obstruction caused by the hand partially covering the mouth area (see again Figure 38). Consequently, we annotated these instances as Open mouth rather than mouthing.

5.4 Age of acquisition effects

This study also investigated potential differences in the use of pointing signs between late and early signers. The data included video recordings from both groups, and the pointing signs were analyzed using the same methodology, with any possible variation examined in detail.

Although slight differences were observed in overall pointing frequency and in the distribution of specific grammatical categories, the patterns remained largely similar across the two groups. Native signers produced an average of 45 pointing signs out of 408 total signs, accounting for approximately 11% of the narration. Late signers, in comparison, produced an average of 30 pointing signs out of 335 signs, corresponding to about 9% of their narration. In terms of grammatical category distribution, native signers produced pointing signs consisting of 7.66% Locatives, 14.96% Pronouns, 57.30% Demonstratives, and 20.07% Clitics. While late signers' pointing signs included 8.02% Locatives, 16.41% Pronouns, 48.47% Demonstratives, and 24.05% Clitics. The slight differences in pointing frequency and categorical distribution between the groups proved to be statistically insignificant.

Given this, we turned our attention to the articulatory properties of pointing signs across groups. Upon a comparison of Pose Estimation calculations for the two groups, we observed that Demonstrative pointing signs were typically signed using a narrower range along the Horizontal Plane by late signers compared to early signers. Demonstratives normally function to establish loci in the signing space by extending toward contralateral or ipsilateral areas; however, this movement appeared notably more restricted among late signers. This observation led us to hypothesize that the use of spatial mechanisms, such as locus establishment, may differ between native and late signers.

Initially, loci were not annotated, as our primary objective was to analyze the main grammatical categories of pointing signs. However, following this observation, a new annotation tier was introduced to identify each locus established by the signers. Since our dataset consisted entirely of narrations describing non-present referents, where signers depicted scenes from videos without any physically present entities, locus establishment was a frequent and crucial grammatical mechanism, particularly realized through demonstratives. In Figure 39, we observe that native signers use loci-bearing demonstratives 84% of the time, whereas the frequency for late signers is 62%.

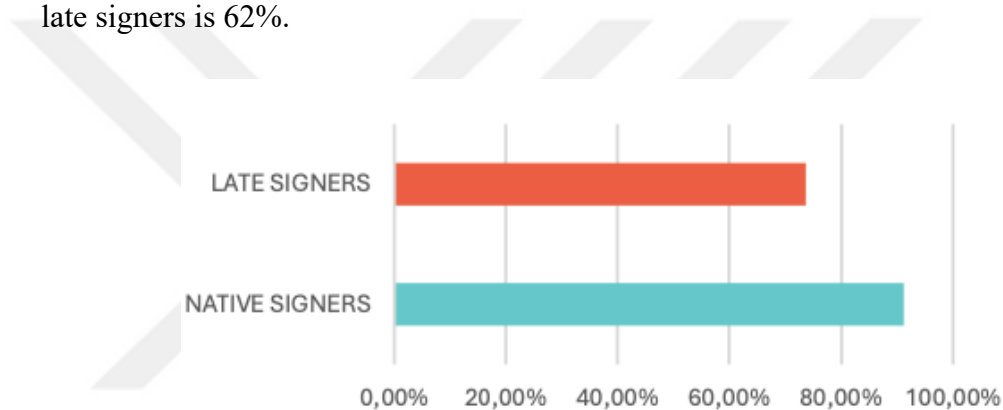


Figure 39. Percentages of loci use in late and native signers

To further probe spatial articulation patterns, we have analyzed the Pose Estimation-generated graphs illustrating the mean distance change for each grammatical category among late signers and native signers (see Figure 40a-b). A multiple linear regression model was then employed on R to compare normalized distance values between late and native signers.

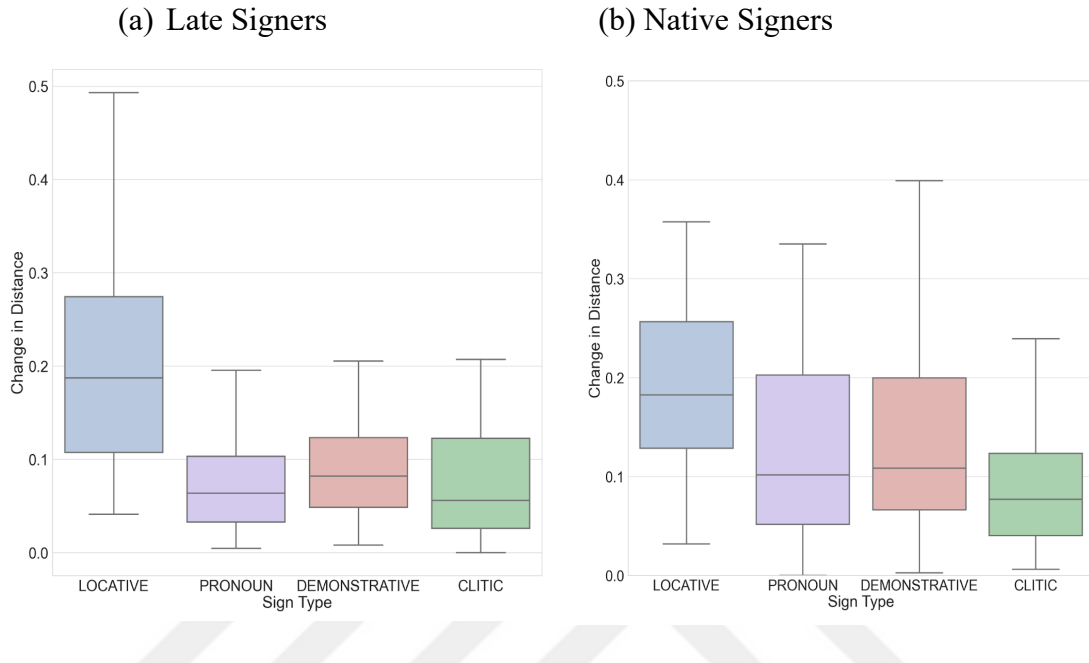


Figure 40. Comparison of the mean distance change of grammatical pointing categories for late and native signers

The regression analysis assessed the relationship between the grammatical categories of pointing signs (dependent variable) and signer groups (independent variable). A significant interaction between group and grammatical category would suggest that the mean distance change for a specific grammatical category varies according to the signer group, indicating a meaningful dependency.

The analysis demonstrated that both age of acquisition (early vs. late) and grammatical category (Locative, Pronoun, Demonstrative, Clitic) significantly affected the Euclidean distance between the start and endpoint of a pointing sign. These findings provide strong evidence that the grammatical categories of pointing signs are characterized by distinct and meaningful spatial properties.

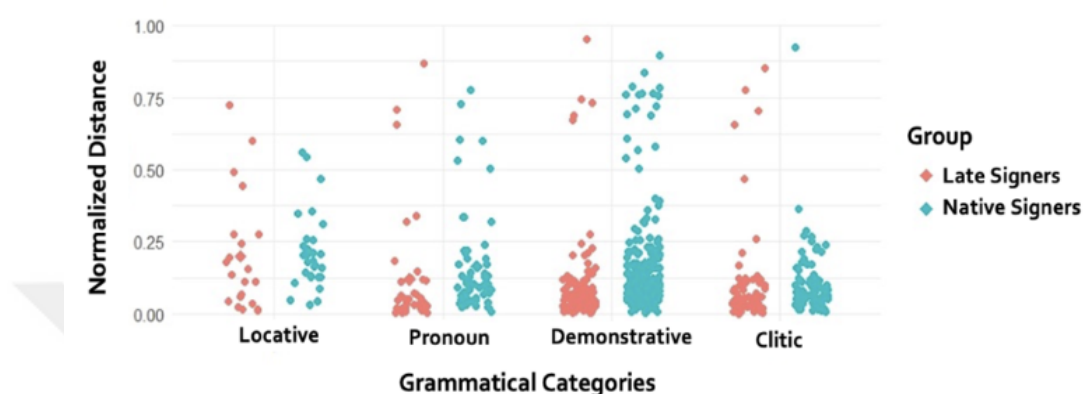


Figure 41. Normalized distances of pointing categories for late and early signers

Additionally, an interaction between group and grammatical category was observed for Demonstratives. The difference in mean Euclidean distance between the two groups for Demonstratives is statistically significant ($p=0.0002$). Specifically, the distance for late signers within Demonstratives is smaller than that for native signers, with an estimated difference of -0.0758 (Figure 41). The reduced distance values for Demonstratives, coupled with a lower frequency of loci use among late signers, suggest that late signers utilize space less extensively for this abstract referential category.

5.5 Prosodic distributions

Pointing signs, like all other linguistic units, conform to the prosodic structure of the language. This section presents an analysis of how pointing signs interact with the prosody of TlD. While prosodic research on TlD remains scarce, our analysis offers

a preliminary exploration of the prosodic behavior of pointing signs, rather than a comprehensive account of the language's overall prosodic architecture.

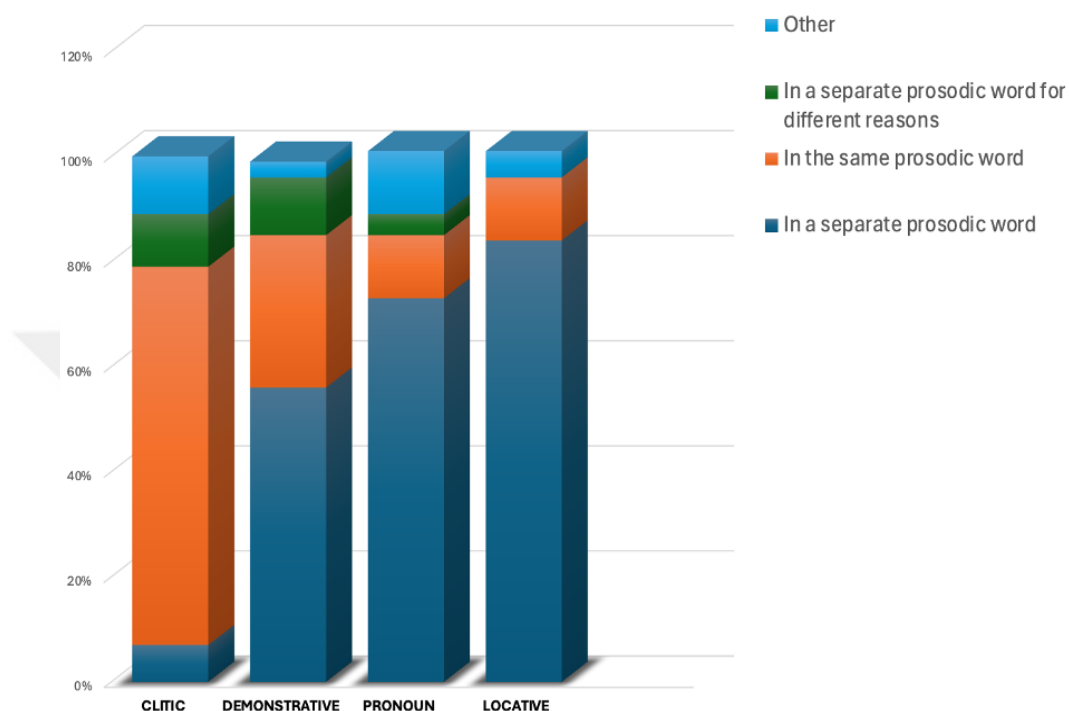


Figure 42. The distribution of prosodic behaviors of pointing signs

Figure 42 presents the distribution of prosodic structures across four grammatical categories of pointing signs: Clitic, Demonstrative, Pronoun, and Locative. Each class is segmented into four structural patterns based on prosodic behavior: (i) In a separate prosodic word, (ii) In the same prosodic word, (iii) In a separate prosodic word for different reasons, and (iv) Other. As shown in the figure, each category demonstrates a different pattern of prosodic integration.

The proportion of pointing signs annotated as occurring in a separate prosodic word is highest in the Locative and Pronoun groups, followed by Demonstratives and Clitics. In contrast, the proportion of pointing signs annotated as occurring in the

same prosodic word with an adjacent element is highest in Clitics, and gradually decreases across Demonstratives, Pronouns and Locatives. This pattern reveals a reverse distributional tendency between these two prosodic groupings across the grammatical categories, which will be discussed in further detail in the following section. Finally, and notably, the category *In a separate prosodic word for different reasons* appears in all grammatical classes except for Locatives.

Based on these findings, it becomes evident that pointing signs can display two main prosodic patterns. In some cases, the pointing sign is articulated forming a separate prosodic unit; in others, it shows no independence and is prosodically integrated with an adjacent sign. One of the primary non-manual markers through which this distinction can be observed is the mouth configuration: the mouth may either adopt a distinct shape simultaneously with the pointing sign, or remain largely continuous with the preceding or following linguistic material. As Brentari and Crossley (2002) propose for ASL, changes in lower face tension (LFT) serve as a primary cue for identifying prosodic words. Given the potential for cross-linguistic variation, however, we carefully considered additional cues in the TID data alongside mouth configuration to identify prosodic boundaries.

In addition to the mouth, other non-manual markers such as eyegaze and blink may also serve as important cues for prosodic boundaries. Our observations indicate that the presence of an eyegaze or a blink during a pointing sign enhances its prosodic prominence, resulting in a clearer separation from adjacent signs. These non-manual cues contribute to the pointing sign being articulated as an independent unit. Furthermore, the position and movement of the head or body might additionally serve as prosodic indicators: when an autonomous head movement occurs with the

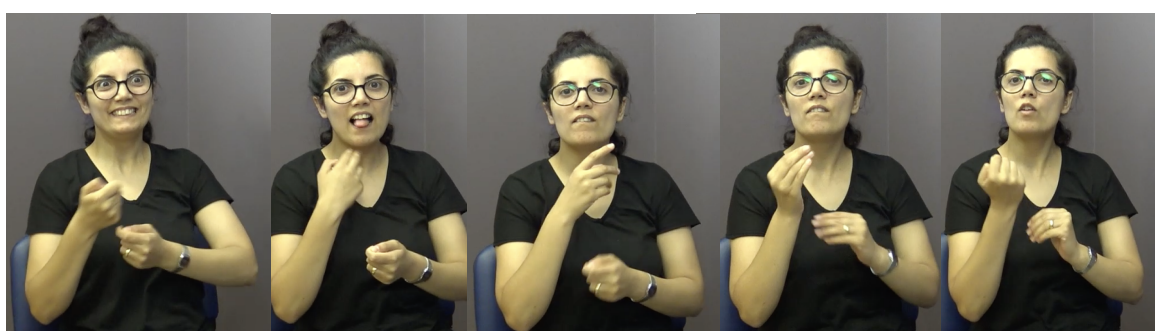
pointing sign, the sign is articulated more independently, creating a clear prosodic boundary between it and neighboring linguistic material.

In some cases, a pointing sign is accompanied by simultaneous changes in Lower Face Tension (LFT), eye configuration, and head/body posture. However, it is also possible to observe only one of these cues marking prosodic boundaries. In Figure 43, the pointing sign, IXDEM, can be seen appearing prosodically independent from the surrounding lexical items. In contrast, Figure 44 shows the pointing sign, IXCLT, that appears prosodically integrated into the following item, MOUSE, displaying no noticeable contrastive features compared to this adjacent sign.



CAT IXDEM ILLNESS THERE-IS
(PW) (PW) (PW) (PW)
'The cat is ill.'

Figure 43. In a separate PW



PULL NOT-HAPPENING IXCLT MOUSE STRONG
(PW) (PW) (PW) (PW)
'(The cat) is trying to pull (the carpet). It can't be pulled. The mouse is strong.'

Figure 44. In the same PW

Building on this, our annotations distinguish between pointing signs that form a PW independently and those that form a PW jointly with an adjacent host. Cases with observable prosodic breaks, evident through changes in non-manual markers (NMMs), such as LFT, eye configuration, or head/body tilt, are annotated as *In a separate prosodic word*. In contrast, pointing constructions lacking such prosodic separation are annotated as forming the same prosodic word with either the preceding or following sign.

Occasionally, pointing signs surfaced during discourse-level phenomena, such as discourse planning, pauses, or corrections, introducing prosodic breaks not reflective of typical category behavior. These were grouped under *In a separate prosodic word for different reasons*, as they carry metalinguistic weight not directly attributable to prosodic structure.

Prosodic cues are crucial for clarifying which constituent a pointing sign is syntactically grouped with. In our dataset, pointing signs frequently appear between two lexical items, such as nouns or verbs; however, prosodic evidence often indicates alignment with only one of them. For instance, when a pointing sign occurs between two nominals, changes in non-manual markers, such as lower face tension (LFT), eye configuration, and head or body tilt, frequently signal a prosodic boundary. These cues allow us to determine whether the pointing sign functions as pre-nominal or post-nominal, rather than assuming attachment based solely on linear order.

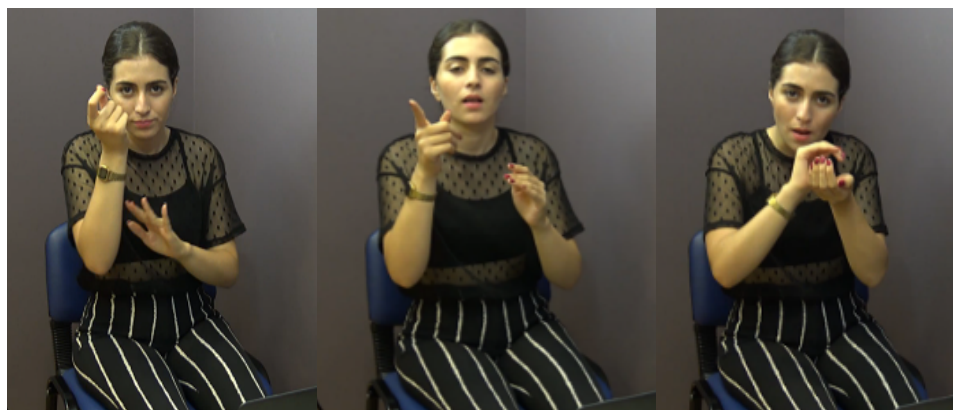


[NP	CAT	]	/fare	/
(PW		)	[NP	IXDEM
			MOUSE	]
			(PW	)

‘ Cat, the mouse...’

Figure 45. Demonstrative between two nominals

One such instance involves two nominal phrases with an index sign positioned between them (see Figure 45). In this example, the noun CAT is produced first, followed by a demonstrative pointing sign, and then the noun MOUSE. A clear prosodic break can be observed after the articulation of CAT, as indicated by a shift in LFT, marking the pointing sign as being in separate prosodic unit from the CAT. In contrast, the mouthing accompanying MOUSE, that is /fare/ actually starts with the pointing sign, IXDEM, and continues over the MOUSE without detectable prosodic disruption, suggesting that ‘MOUSE’ forms a single Prosodic Word (PW) with the pointing sign. These findings are consistent with earlier observations by Gökgöz (2020), who reported that demonstrative pointing signs in TİD tend to form a single PW with their host noun.



ESCAPE

IXPRO

WASH

(PW

)

(PW

)

(PW

)

‘(The mouse) escaped, it (the cat) washed its claws.’

Figure 46. Pronoun between two verbs

In Figure 46, the pointing sign situated between two verbs is accompanied by distinct head configuration compared to those of the surrounding verbs. The head is tilted back, and LFT changes dramatically when the point is initiated, creating a prosodic break that separates the pronoun from the preceding element ESCAPE. Although the LFT stays the same through the articulation of the pointing sign and the following lexical item WASH, the shift in head/body orientation is enough to create a contrast, which we assume to be a prosodic break between IXPRO and WASH. Thus, the pronoun forms a Prosodic Word (PW) independently, without attaching to any other lexical unit¹¹.

¹¹ Consistent with Gökgöz (2023), I have also identified Pronouns that cliticize to Verbal hosts to form a PW. The cliticization of pronouns seem to be less discriminative than that of Demonstratives, though. Therefore, I will leave further categorization within pronouns to a future study.



FALL IXCLT(start) IXCLT(end) CAT_{host}
(PW) (PW)
‘(The cat) has fallen on its head. That cat’

Figure 47. Clitic in a PW

Figure 47 illustrates that lower-face non-manual markers (LFT) shift significantly from a mouth gesture accompanying the verb ‘FALL’ to the onset of a pointing sign, which emerges during a transition phase. LFT and head/body orientation remain clearly constant throughout the articulation of the assimilated pointing sign and its noun host. Although there is the beginning of a facial expression associated with the lexical item ‘CAT’, this expression is not present during the articulation of the pointing sign itself. Our annotations did not include a specific value to capture facial expressions reflected primarily through eye configurations. Future research could expand on this by developing a more fine-grained coding system for upper face movements, particularly subtle changes around the eyes, to better account for their functions as prosodic cues. For now, we suggest that the

pointing sign, IXCLT, and the noun host, CAT, form a single prosodic unit in Figure 47, separate from the one created by the verb, FALL.



CAT PULL IXLOC(start) IXLOC(end) PIANO-FALL
(PW) (PW) (PW) (PW)
‘The cat is pulling (the carpet). That piano over there is falling.’

Figure 48. Locative as a PW

In Figure 48, the Locative pointing sign appears to constitute an independent Prosodic Word. This is evidenced by a sudden shift in eyegaze at the onset of the pointing sign and a blink occurring in its final frame, both of which serve to clearly distinguish this sign from the surrounding lexical items. The preceding verb ‘PULL’ is produced with a slight leftward head tilt and a distinct lower face non-manual marker, i.e., a slim protruded tongue. As the Locative is articulated, there is a sharp transition in lower face tension from this tongue gesture to a slightly open mouth, which continues throughout the duration of the pointing. Simultaneously, the head tilts subtly backward during pointing, reinforcing the separation. Following the pointing sign, the subsequent sign ‘PIANO-FALL’ introduces another shift in lower face configuration, transitioning from the open mouth posture back to a different mouth gesture, i.e., continuous puffing, co-articulated with the falling motion. This transition is further marked by a re-established eye contact following the blink, and the head tilts slightly to the right.

Taken together, this example demonstrates the co-occurrence of all three prosodic boundary cues identified for T1D, namely, changes in Lower Face Tension (LFT), eye configuration, and head/body orientation, each aligning to mark the Locative pointing sign as an independent prosodic unit.

5.5.1 Preliminary discussion of prosodic behavior of pointing signs

The analysis reveals that pointing signs in T1D show systematic variation in how they are integrated into the prosodic structure of the language. Across all grammatical categories, pointing signs were annotated either as forming a separate prosodic word, forming the same prosodic word with an adjacent host, or appearing separately due to discourse-level phenomena.

Locatives most consistently form separate prosodic words, indicating their strong prosodic independence, clearly distinguished from surrounding material. They are frequently associated with multiple prosodic boundary cues, such as shifts in lower face tension (LFT), changes in eye configuration, and autonomous head or body movements.

Pronouns also predominantly form separate prosodic words, although not as uniformly as Locatives. In many cases, Pronouns are prosodically separated from surrounding verbal phrases through clear shifts in non-manual markers. However, unlike Locatives, a small portion of Pronouns may attach prosodically to adjacent verbs, reflecting variability in their phonological realization.

Demonstratives show a more balanced distribution between independent and dependent prosodic structures. While a substantial portion of Demonstratives forms separate prosodic words, a significant portion integrates with adjacent nouns into a shared prosodic unit. In particular, pre-nominal Demonstratives often show prosodic

integration with their host nouns, whereas post-nominal Demonstratives are more likely to be separated, accompanied by increased prosodic salience such as stronger facial marking or body shifts.

Clitics, in contrast, overwhelmingly form prosodic words with adjacent nouns. They rarely exhibit prosodic independence, and in most cases, the pointing sign appears fully integrated with the lexical host, without introducing any prosodic boundaries.

The category *In a separate prosodic word for different reasons* was observed across Pronouns, Demonstratives, and Clitics, but notably absent among Locatives. These instances typically involve pointing signs produced during discourse planning, corrections, or hesitations, contexts where a signer momentarily pauses or searches for references. The absence of such cases for Locatives likely highlights their distinct grammatical function: Locatives are not produced to establish referents in discourse but instead specify spatial relations for already introduced entities. Consequently, they are less likely to surface during stages of referent establishment or to coincide with errors and corrections in referent selection.

Overall, the prosodic distributions align closely with the grammatical distinctions proposed for pointing signs in T1D. The strong tendency for Locatives to appear as independent prosodic units, and for Clitics to prosodically integrate fully with their lexical hosts, supports the proposed categorical differences. Non-manual markers, particularly shifts in lower face tension (LFT), eye configuration, and head/body orientation, emerge as reliable indicators of prosodic boundaries and offer crucial cues for interpreting the linguistic structuring of pointing signs in T1D.

CHAPTER 6

DISCUSSION & CONCLUSIONS

6.1 Summary

This study examined the grammatical multifunctionality of pointing signs in TİD. First, the pointing signs were identified within narrations provided by the signers and annotated in ELAN. Subsequently, various tiers were designed based on current literature and observational insights to capture syntactic and morpho-phonological features that play a key role in differentiating grammatical functions. The tiers included annotations for syntactic position, space use (H and V-Space), strength, movement, palm orientation and non-manual markers. Specific combinations of these parameters were found to indicate distinct grammatical categories.

Chi-square tests were conducted across syntactic and morpho-phonological parameters to identify which features most significantly distinguished the four grammatical categories of pointing signs. The analysis revealed that Movement ($\chi^2 = 483.68, p < 10^{-98}$), V-Space ($\chi^2 = 394.98, p < 10^{-82}$), and Position ($\chi^2 = 369.82, p < 10^{-69}$) were the most significant features, exhibiting the highest chi-square values and indicating their primary role in creating category distinctions. These parameters were followed by Strength ($\chi^2 = 269.08, p < 10^{-58}$) and Palm Orientation ($\chi^2 = 260.99, p < 10^{-49}$), which also contributed significantly to the distinctions, though to a lesser extent. H-Space ($\chi^2 = 196.29, p < 10^{-39}$) showed a moderate level of significance, while non-manual features such as NMM (Mouth) ($\chi^2 = 97.01, p < 10^{-15}$) and NMM (Eyes) ($\chi^2 = 59.85, p < 10^{-9}$) played a more limited role in distinguishing the categories, though their differences were still statistically significant. These results suggest that, while non-manual features contribute to category differences, the

movement-related and spatial features along with syntactic position have a far stronger influence on categorization.

Syntactically, Locatives appeared in all positions except simultaneous NP co-occurrence, while Pronouns were restricted to preceding, following or simultaneously with VPs and never with NPs. Demonstratives occurred around and simultaneously with NPs but never with VPs, a pattern shared with Clitics. These distinctions reinforce syntactic independence as a key factor in category delineation (Figure 49).

Looking ahead, future studies should refine our understanding of Demonstrative syntax, particularly in pre- versus post-nominal positions. The limited semantic scope of the present data calls for complementary tasks, such as grammaticality judgment tests, to investigate familiarity and uniqueness in Demonstrative use.

Morpho-phonologically, Locatives are distinguished through maximal V-Space

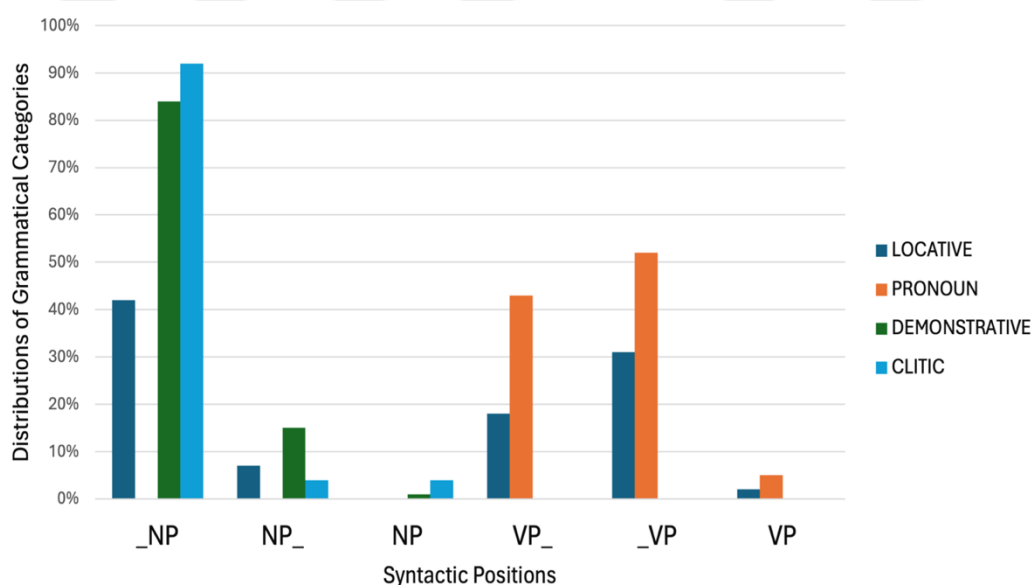


Figure 49. Syntactic distributions of all pointing categories

¹² Locatives might be considered multi-morphemic constructions, as they distinctively activate the vertical signing space (V-Space) in their phonological realization, potentially triggered by an additional morpheme operating on the vertical plane. A similar pattern can be observed in Turkish,

was limited (13%), in contrast with the other categories, which predominantly utilized Mid space. While Locatives, Pronouns, and Demonstratives all employed H-Space, Clitics showed minimal spatial engagement in both H- and V-Space. Similarly, Locatives and Demonstratives were consistently Strong, whereas Pronouns varied and Clitics were uniformly Weak. Movement patterns also differentiated the categories: Clitics lacked Arched movement entirely and often exhibited no movement, while Nominals and Locatives occasionally included Arched or Straight movement, with nominals having a slight tendency for arched configuration over locative pointing. Though the numerical distributions for Palm Orientation were similar, downward orientation was most prevalent among Locatives, and Nominals most frequently patterned with vertical or slightly rotated handshapes (Figure 50).

where the locative form *burada* is morpho-phonologically more complex than the demonstrative *bu*, suggesting a parallel layering of spatial and morphological structure in both modalities.

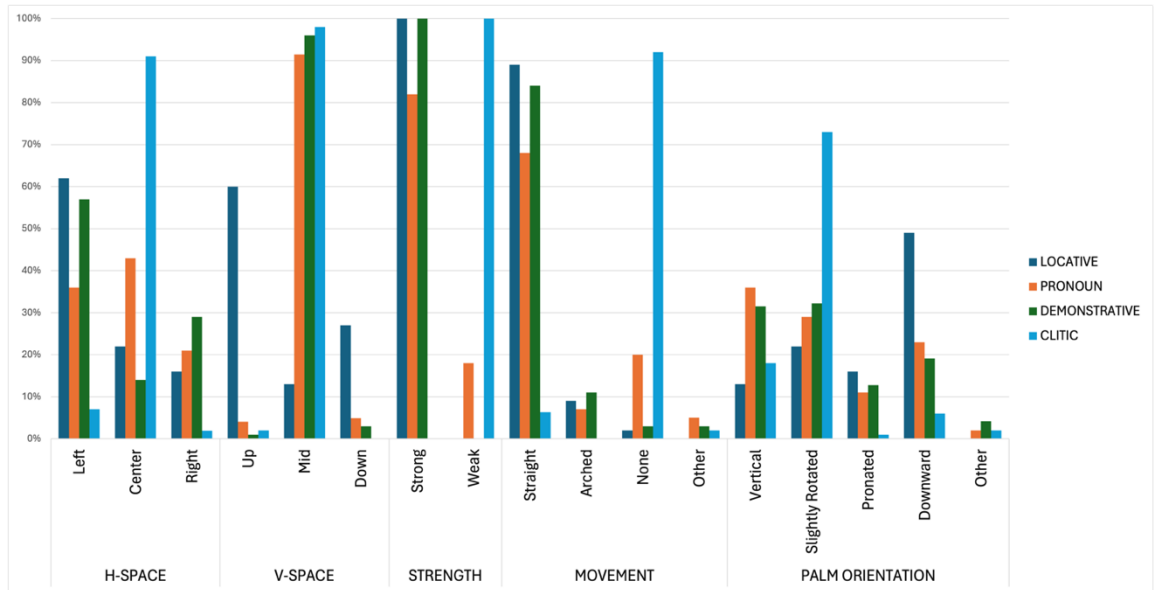


Figure 50. Morpho-phonological distributions of all pointing categories

To validate spatial findings, distance changes along x and y axes were calculated using Pose Estimation for each pointing sign. Locatives showed the greatest distance range, followed by Pronouns and Demonstratives, with Clitics again exhibiting the least. These data confirm that spatial engagement, therefore strength and movement parameters play a central role in grammatical differentiation.

The analysis of morpho-phonological properties of pointing signs through Pose Estimation is vital for advancing linguistic research with the help of practical applications such as machine learning. Moreover, by training computer vision algorithms to link these properties with the accurate grammatical categories, we can pave the way for more sophisticated sign language translation technologies using artificial intelligence, a breakthrough that could transform accessibility for the Deaf community. Thus, this research not only bridges theoretical insights with methodological innovation, but it also points toward a future where technology and linguistic theory converge to enhance inclusive communication.

On the other hand, non-manual features do not play as significant a role in distinguishing classes, as also proved by the statistical test. Mouth configurations were evenly distributed, showing little categorical significance. In contrast, eye behavior revealed interesting patterns. Eyegaze accompanied over half of Locative signs, with its frequency decreasing steadily across Pronouns, Demonstratives, and Clitics. This suggests that gaze serves as an additional spatial cue, particularly in Locative constructions. The relatively high co-occurrence of eyegaze with Pronouns reflects their reliance on previously established referential loci, whereas Demonstratives and Clitics exhibited diminishing use of spatial anchoring mechanisms. Increased percentages of Contact and Blink with Demonstrative and Clitics mirrored this decline. This pattern suggests that the need to use spatial anchoring mechanisms, such as directing gaze toward loci in the signing space, decreases as we move toward more grammaticalized categories like Clitics.

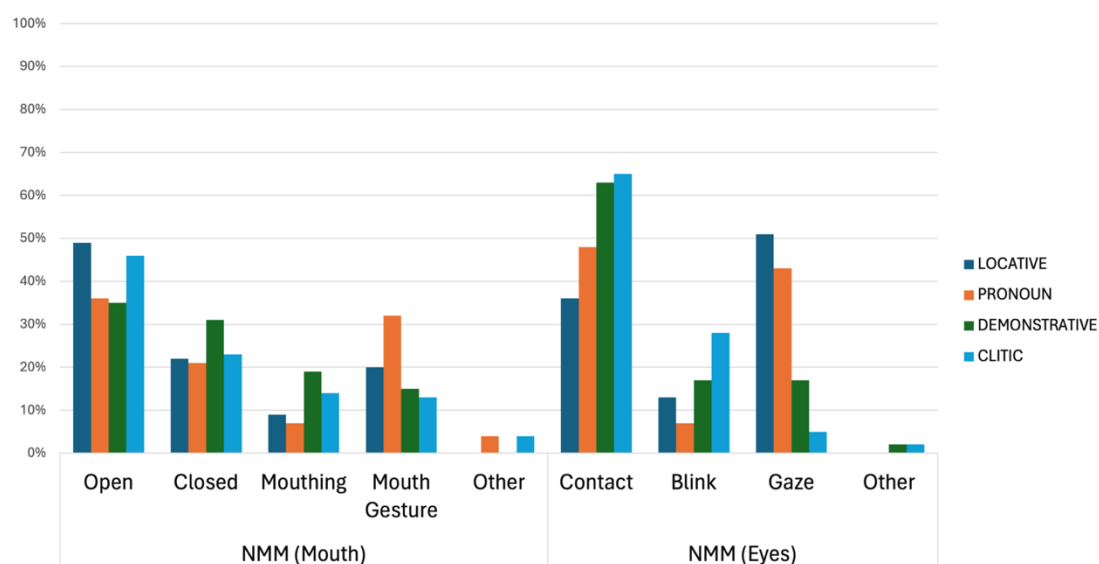


Figure 51. Morpho-phonological distributions of all pointing categories (Non-manuals)

A typology of Clitics was proposed, identifying four formal reduction strategies: Transition, Undirected, Assimilation, and Coalescence. The cliticization patterns observed in the dataset reveal four distinct types of formal reduction: Transition, Undirected, Assimilation, and Coalescence.¹³ Each type reflects a specific mode of phonological loss, ranging from loss of movement and spatial engagement to handshape assimilation and temporal overlap. Transition clitics emerge during the transition phases between lexical signs, while Undirected forms display slight hold of index finger near the torso. Assimilation involves the merging of handshapes with following signs, and Coalescence occurs when the articulation of a pointing sign temporally overlaps with another sign. Together, these types illustrate the gradual phonological erosion that accompanies grammaticalization in TID pointing signs into Clitics.

Table 1. A Typology of Cliticization in TID

Type of Cliticization	Key Feature	Loss Type
Transition	Occurs between lexical signs	Movement + temporal independence
Undirected	Slight upward movement near torso	Weak engagement with space
Assimilation	Handshape merges with following sign	Handshape
Coalescence	Overlaps temporally with another sign	Temporal independence

For future research, it is important to note that some of the articulation of a Clitic pointing sign starts and ends at a distal location. Such instances occur when a

¹³ The process of cliticization in TID may be understood as a case of phonologically driven allomorphy, where the surface form of pointing signs is shaped by the phonological environment in which they occur. The different types of cliticization exhibit distinct phonological behavior tied to their position relative to surrounding signs. For instance, Coalescence involves temporal overlap with an adjacent sign and is only attested when the pointing sign is articulated with a one-handed lexical sign.

clitic attaches to a noun produced in a specific area within the signing space, often due to spatial reorganization. To improve the accuracy of the calculations, the reference landmark should be the noun articulated in the designated space, rather than the midpoint of the torso. Thus, future research could develop a formula that measures the mean distance change between the frame where the index finger becomes selected and the final coordinates of the index finger cliticized to the noun host.

Additionally, integrating angular calculations could provide further insights. We consistently observed that Clitic pointing signs exhibit minimal lifting of the index finger, resulting in a narrower angle between the index and middle fingers. This narrowing may indicate assimilation, as these signs blend with adjacent lexical items. The diminishing angle could serve as a potential marker of this phonological integration.

Alongside these morpho-phonological observations, this thesis has also looked into the role of Age of Acquisition (AoA) in shaping the grammatical use of pointing signs. Findings further indicated that AoA plays a role in spatial articulation. When compared to their native-signing peers it has been revealed that Demonstrative constructions of late signers are restricted in their spatial use. The reduced horizontal extent observed in the signing space suggests that delayed exposure may affect the development of abstract referential mapping (i.e., loci). This outcome is consistent with prior research (e.g., Mayberry & Eichen, 1991), which demonstrates that lack of accessible language input during critical period leads to lasting differences in grammatical processing.

Taken together, these findings underscore the importance of early exposure for the full development of spatial-grammatical structures in sign languages. Beyond

their theoretical implications, they point to the urgent need for policies that ensure Deaf children's immediate access to natural sign language environments during early developmental stages. Such access is essential for acquiring the full range of grammatical mechanisms that underlie language development, as demonstrated in this thesis.

6.2 Grammaticalization

The combined morpho-phonological, syntactic, and prosodic findings in this study provide supporting evidence that pointing signs in Turkish Sign Language (TİD) have undergone grammaticalization. The patterns align with cross-modal grammaticalization pathways proposed for both sign and spoken languages (Pfau & Steinbach, 2006; Senghas & Coppola, 2010).

Locative pointing signs, marked by broader space use, wider syntactic distribution and prosodic independence, are closer in use to an earlier grammatical stage in which pointing primarily served to indicate physical locations through spatial deixis.

The gradual reduction in space use, syntactic range and prosodic independence implies that there might be a grammaticalization path from locative uses of pointing to nominals. Demonstratives, modifying nouns within NPs, and Pronouns, serving as full referential expressions, signal an increasing abstraction from purely locative functions (Senghas & Coppola, 2010). While still occasionally forming independent prosodic words, the nominal categories also show instances of assimilation into adjacent signs, suggesting an intermediary stage of grammaticalization.

Clitics, with minimal spatial engagement, reduced phonological features, and complete prosodic and syntactic dependency on adjacent lexical hosts, appear as a highly grammaticalized form. Their loss of syllabicity reflects processes typical of grammaticalization in spoken languages. All three criteria defined by Heine and Kuteva (2002) for grammaticalization can be argued to have taken place. Firstly, Clitics might have undergone desemanticization, which is reflected in the loss of lexical meaning as these forms take on purely grammatical functions. Secondly, these forms might be decategorializing, as Clitics lose core properties associated with nominal pointing signs, including the ability to function independently as locus-bearing demonstrations. Thirdly, erosion (or 'phonetic reduction') is observed through the reduction of phonetic material, specifically the reduction in the use of space. Therefore, they seem to be in an intermediary stage from lexicality to affixhood.

Sandler (1999) proposes several Constraints relevant to the restructuring of Clitics in sign languages, including Monosyllabicity, Symmetry, Place, and the Selected Finger (SF) Constraint. Reflecting the articulatory affordances of the visual-gestural modality, these constraints shape how clitic forms are realized. In our data, the Clitic group and its four subtypes: Transition, Undirected, Assimilation, and Coalescence, reveal different phonological pathways toward the same outcome: the formation of a single prosodic word as the optimal structure. For Transition Phase Clitics and Coalescence, due to a loss of phonological movement and lack of a separate timing slot for articulation, these clitic signs obey the Monosyllabicity Constraint. On the other hand, the Undirected Clitics which are produced in the same PoA of the adjacent sign can be argued to obey the Place Constraint. Finally, Assimilation Clitics display a minimal movement, therefore a different PoA,

violating both Place and Monosyllabicity Constraint. However, they obey the Selected Finger Constraint, as the pointing sign assimilates into the handshape of the following lexical sign and is therefore unidentifiable as a separate unit.

Despite these varying phonological strategies, the system consistently optimizes toward the production of a single prosodic word. Each subtype seems to rank constraints differently, but the overarching goal remains the same: the formation of a unified, structurally minimal phonological output.

Another highly functional and potentially grammaticalized form of pointing emerged in our data. In these cases, two consecutive pronominal pointing signs were articulated in space, coordinated with an eyegaze shift from one referential locus to another. This swift movement across the signing space may function as an agreement auxiliary. We refer to these forms as agreement auxiliaries, as their primary role appears to be marking agreement between verbal subjects and objects (see the Appendix).

The findings of this study converge on the conclusion that pointing signs in T1D may have undergone multiple pathways of grammaticalization. Through different phonological mechanisms, pointing signs evolve from spatial deixis to nominal expressions, clitic forms, and to agreement auxiliaries. Although Pfau & Steinbach (2006) proposed a similar perspective, my argument diverges in suggesting that demonstrative pronouns do not necessarily precede personal pronouns. Instead, it appears that they may have evolved concurrently, each following a distinct trajectory from the main lineage. This branching results in the

development of personal pronouns into agreement auxiliaries, and demonstratives into weaker forms, i.e., clitics.

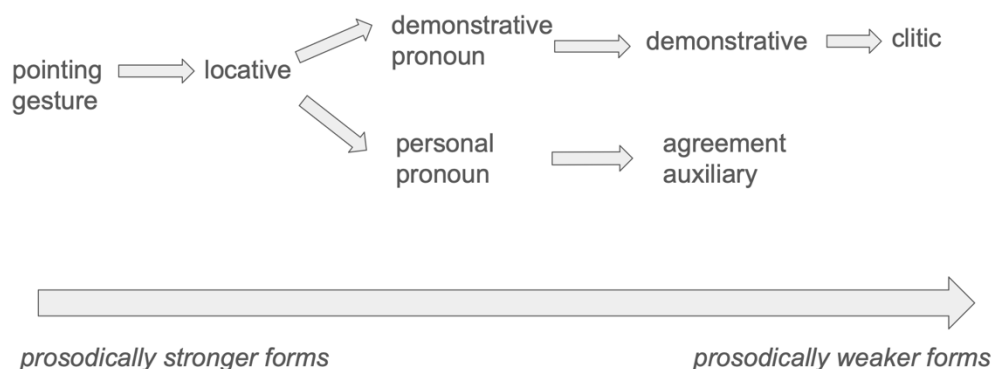


Figure 52. Possible grammaticalization pathway for T1D pointing signs

Overall, the findings from T1D support the idea that pointing signs move along a grammaticalization continuum from semantically rich, spatially anchored expressions toward highly reduced, abstract functional elements (Figure 52). This progression mirrors pathways observed in emerging as well as established sign languages (Steinbach & Pfau, 2013; Senghas & Coppola, 2010) and demonstrates that, while the visual-gestural modality offers unique mechanisms such as the incorporation of spatial structure, the underlying grammaticalization processes are fundamentally modality-independent. In other words, T1D provides further support that, languages, regardless of modality, reshape linguistic tools into more functional items over time by integrating them to the syntactic and prosodic system as well as optimizing their phonological shape.

Future research could provide more insight through a diachronic study on pointing signs in T1D, with a particular focus on the development of clitics, agreement auxiliaries and verbal agreement as the endpoints of grammaticalization.

Moreover, the synchronic status of these index signs can be further theoretically discussed within an optimality theory framework.

In conclusion, this thesis has been about getting to the point by unraveling the linguistic functions of pointing signs in Turkish Sign Language (TİD), developing a fine-grained understanding of a fundamental component of the grammar. By integrating distributional analyses with state-of-the-art computer vision techniques, the study demonstrates how subtle shifts in morpho-phonology, syntax and prosody shape grammatical classes.



APPENDIX

AGREEMENT AUXILIARY

In Figure 53, a highly complex referential system is articulated by the signer. There are three cats depicted in the video clip: two males and one female. The first male cat continuously kisses and circles around the female cat, who is seated on the couch. Meanwhile, another cat (the second male) notices the female. As the second male attempts to kiss her, the first male cat reappears and, with his eyes closed, mistakenly kisses the second male cat instead of the female.

In Figure 53, it is clearly visible that the first male cat is assigned to a locus on the ipsilateral side, with a head/body tilt accompanying the lexical sign 'MALE' and the numeral 'TWO', serving as a visible anchoring. Importantly, when introducing the second male cat, the signer uses the lexical sign for 'OTHER,' starting from the ipsilateral side and moving toward the contralateral side. Following this construction, the verbs associated with the second male cat, 'SEE' and 'HOLD^KISS' is articulated. In the eighteenth frame, the signer initially points incorrectly to the contralateral side using a demonstrative pointing sign with his non-dominant hand but immediately shifts back to the ipsilateral side. During correction, the movement direction of the lexical item 'OTHER' is reversed, beginning from the contralateral side and moving toward the ipsilateral area, where the locus for the first male cat had been established. This is immediately followed by the repetition of the lexical item 'MAN' but with a shift of dominance from the second hand back to the first hand which might be used to further indicate the shift of referential locus.

Crucially, the IXAUX includes a hold-movement-hold sequence, consisting of one syllable. It begins at the ipsilateral locus associated with the first male cat and

moves toward the contralateral locus associated with the second male cat. When we turn back to the video clip, we can observe that this pointing direction mirrors the actual direction of action occurring between the two cats. Based on our observation, we propose that this type of pointing, observed seven times across different participants, may function as a Subject-to-Object agreement auxiliary in TĪD.



CAT MALE TWO FEMALE



ONE TURN^AROUND MALE TURN^AROUND



FEMALE KISS TURN^AROUND KISS



TURN^AROUND



MALE



OTHER



SEE



HOLD^KISS



IXDEM



MALE



OTHER



MALE



IXAUX(start)



IXAUX(end)



KISS

‘There are two male, one female cat. The male cat is turning around the female cat. The male cat kisses the female. Then, he continues turning around her and kisses her again. He keeps turning, another male cat sees the female. This second male holds the girl and as he is about to kiss her, the first male kisses the second male cat.’

Figure 53. Agreement auxiliary pointing sign

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