EVENT STRUCTURE IN TURKISH SIGN LANGUAGE (TİD)

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EVENT STRUCTURE IN TURKISH SIGN LANGUAGE (TİD)

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Event Structure in Turkish Sign Language (TİD)

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DECLARATION OF ORIGINALITY

I, Aysemin Yaşar, certify that

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ABSTRACT

Event Structure in Turkish Sign Language (TİD)

This study investigates how telicity is realized in Turkish Sign Language (TİD), with a focus on the encoding of event structure through nonmanual markers, manual forms, and kinematic patterns. Data from 30 signers (15 Deaf of Deaf and 15 Deaf of Hearing) demonstrate that telicity marking in TİD involves an intricate interplay of continuous and discontinuous nonmanuals, manual forms, and movement dynamics. Continuous nonmanuals predominantly align with atelic events, while discontinuous nonmanuals are exclusive to telic ones. Iconic forms are primarily associated with atelic events. Phonological motion profiles provide another key cue, with atelic events exhibiting harmonic motion and telic events displaying non-harmonic motion. This distinction is observed through Pose Estimation, a cost-effective alternative to Motion Capture, which highlights distinct kinematic patterns. Age of acquisition (AoA) analysis further reveals that telicity encoding through nonmanuals is a resilient feature in TİD, with DoD signers displaying greater use of nonmanuals across both telic and atelic events. Collectively, these findings support the Event Visibility Hypothesis (EVH; Wilbur, 2003, 2008), illustrating that the underlying event structure is visible through both phonological and kinematic representations in TİD.

ÖZET

Türk İşaret Dili'nde (TİD) Olay Yapısı

Bu çalışma, Türk İşaret Dili'nde (TİD) telikliğin nasıl ifade edildiğini incelemekte ve olay yapısının manuel olmayan ifadeler, manuel biçimler ve kinematik örüntüler aracılığıyla nasıl kodlandığına odaklanmaktadır. Sağır ebeveynlere sahip 15 ve işiten ebeveynlere sahip 15 olmak üzere toplam 30 TİD kullanıcısından elde edilen veriler, TİD'de teliklik işaretlemesinin sürekli ve kesikli manuel olmayan ifadelerin, manuel biçimlerin ve hareket dinamiklerinin karmaşık bir etkileşimini içerdiğini göstermektedir. Sürekli manuel olmayan ifadeler ağırlıklı olarak telik olmayan (atelik) olaylarla örtüşürken, kesikli manuel olmayan ifadeler yalnızca telik olaylara özgüdür. İkonik biçimler çoğunlukla atelik olaylarla ilişkilidir. Fonolojik hareket profilleri de önemli bir ipucu sunar: Atelik olaylar harmonik hareketlerle, telik olaylar ise harmonik olmayan hareketlerle ayırt edilmektedir. Bu ayrım, Motion Capture adlı tekniğe düşük maliyetli bir alternatif olan Poz Tahmini (Pose Estimation) yöntemiyle gözlemlenmiş ve özgün kinematik örüntüler ortaya konmuştur. Edinim yaşı (AoA) analizleri ise, manuel olmayan ifadelerle yapılan teliklik kodlamasının TİD'de istikrarlı bir özellik olduğunu göstermiştir. Ancak bununla beraber, sağır ebeveynlere sahip TİD kullanıcılarının, hem telik hem de atelik olaylarda manuel olmayan ifadeleri daha yoğun kullandıkları görülmektedir. Bulgular, Wilbur'un (2003, 2008) Olay Görünürlüğü Hipotezi'ni (Event Visibility Hypothesis – EVH) destekler nitelikte olup, TİD'de örtük olay yapısının hem fonolojik hem de kinematik temsiller aracılığıyla görünür olduğunu ortaya koymaktadır.

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Dedicated to my family, for their constant love and support

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ABBREVIATIONS

SIGN LANGUAGES

ASL American Sign Language

TİD Turkish Sign Language

ÖGS Austrian Sign Language

HZJ Crotian Sign Language

LIS Italian Sign Language

NGT Sign Language of the Netherlands

TERMS RELATED TO LANGUAGE ACQUISITION

DoH Deaf of Hearing

DoD Deaf of Deaf

AoA Age of Acquisition

NON-MANUAL MARKERS

NMM Non-manual Marker

EVH Event Visibility Hypothesis

CHAPTER 1

INTRODUCTION

How do languages, whether sign or spoken, reveal the underlying structure of the events they describe? The notion of events has been a topic of interest to scholars across many domains, from linguistics, psychology, to cognitive science. Researchers have long been intrigued by how events are represented and how this connects to more general mechanisms of human cognition.

One key aspect of event structure is telicity, the property that distinguishes events with a natural endpoint (*telic*) from those without (*atelic*). It plays a central role in how languages express event structure. The study of telicity can be traced as far back as Aristotle's *Metaphysics*, where he observed that certain actions inherently involve a result or final state, while others do not, a distinction that laid the groundwork for later linguistic analyses of event structure (Parsons & Dowty, 1979; Chierchia & McConnell-Ginet, 1990). The term telicity itself is derived from Aristotle's concept of *telos*, meaning 'purpose' or 'goal', emphasizing the idea that some events are oriented toward a natural endpoint or culmination (Kuhn, 2017).

In sign languages, the study of telicity takes on a unique dimension, as meaning is conveyed not only through manual markers (articulated with hands) but also through nonmanual markers (head movements, mouth gestures, body movement, eyebrow movement, eye gaze etc.). In addition, as this thesis will demonstrate, kinematic movement patterns, such as the speed, acceleration, and deceleration of signs, also play a crucial role in marking telic and atelic distinctions. This interplay between manual markers, nonmanual elements, and kinematic movement dynamics distinguishes sign languages from spoken languages. Because

of their visual-spatial modality**,** sign languages offer a distinct perspective on issues like the encoding of telicity and event representation, uncovering features that spoken languages may not reflect (Strickland et al., 2015).

Previous studies have shown that in several sign languages, including American Sign Language (ASL), Austrian Sign Language (ÖGS), and Croatian Sign Language (HZJ), telicity is frequently marked through changes in morpho-phonological features, such as handshape, orientation, setting, or movement that culminates in contact. These features are phonologically realized through rapid motion followed by an abrupt stop, visually signalling the endpoint of a telic event (Wilbur, 2003, 2008; Schalber, 2004, 2006; Malaia & Wilbur, 2012; Malaia, Milković, & Wilbur, 2013; Krebs et al., 2021). These studies demonstrate that visual-kinematic properties systematically differentiate telic from atelic predicates. In addition to these phonological cues, nonmanual markers have also been shown to contribute to telicity distinctions, particularly in ÖGS, where specific mouth gestures align with event type (Schalber, 2004, 2006). Together, these findings provide cross-linguistic support for the Event Visibility Hypothesis (EVH) (Wilbur, 2003, 2008), which argues that the phonological form of predicate signs directly reflects their underlying event structure.

As will be explored in this thesis, the combination of manual, nonmanual, and kinematic resources offers a complex, multi-layered system for encoding telicity, as reflected in Turkish Sign Language (TİD). This makes sign languages particularly valuable for investigating how languages make event structure visible and how abstract temporal concepts are mapped onto the phonological form of predicates.

Although TİD has received growing scholarly attention in areas such as word order, negation, tense marking, classifier constructions, and aspectual marking (Zeshan, 2003; Kubuş, 2008; Gökgöz, 2011; Karabüklü, 2016, among others), systematic investigation into how telicity and event boundaries are encoded, particularly through the interaction of manual, nonmanual, and kinematic channels, remains limited. In particular, little attention has been given to how these channels operate in coordination to convey telicity in actual signing.

Moreover, TİD offers a particularly valuable opportunity for investigating event visibility in a cross-linguistic context. Given its historical development and relative typological distinctiveness (Zeshan, 2003), TİD serves as an important source for expanding typological studies of how sign languages encode event structure. Whether the patterns observed in languages like ASL and ÖGS extend to TİD, or whether TİD presents unique strategies for marking telicity, remains an open question.

This study aims to address this gap by providing a systematic and multi-layered investigation of how telicity is encoded across manual forms, nonmanual markers, and kinematic movement patterns in TİD. In doing so, it seeks to contribute not only to the description of TİD but also to broader typological and theoretical discussions about event visibility in sign languages.

To address the underexplored question of how telicity is encoded through the coordination of manual, nonmanual, and kinematic cues in TİD, this study adopts a novel, multi-faceted approach that integrates qualitative linguistic analysis with quantitative motion tracking**.** This combination allows for a deeper understanding of how event structure is encoded in both the form and movement of signs, and how these components work together to mark telicity.

A detailed qualitative analysis forms the foundation of this investigation, identifying distinct patterns in manual and nonmanual markers associated with telic and atelic events. Building on these qualitative insights, a quantitative layer is then added by examining kinematic patterns and phonological motion profiles of TİD event predicates. This enables an analysis of how movement features such as velocity and acceleration**,** signal event boundaries.

The technical core of this approach is the use of Pose Estimation**,** a computer vision technique that automatically extracts and tracks joint coordinates from video data. Unlike traditional motion capture, Pose Estimation offers a non-invasive**,** cost-effective**,** and flexible solution for analysing naturalistic sign language data. By applying this tool to TİD predicate signs, the analysis seeks to shed light on how event types are differentiated through motion dynamics. This technique makes it possible to analyze motion dynamics in detail, revealing how kinematic parameters contribute to event visibility in TİD. In doing so, the study brings a novel computational dimension to the morphophonological analysis of sign languages.

In addition to examining how telicity is encoded in TİD, this study also explores the potential impact of Age of Acquisition (AoA) on telicity marking in TİD. Prior research in sign language acquisition has consistently shown that early exposure to a natural language is crucial for the full development of linguistic competence and cognitive abilities (Mayberry & Kluender, 2018; Lillo-Martin & Henner, 2020; Humphries et al., 2016, 2019). In TİD, previous studies have documented AoA effects particularly in morphosyntactic and pragmatic domains, such as classifier constructions and reference tracking (Karadöller et al., 2017, 2021, 2022; Sevgi & Gökgöz, 2023; Kayabaşı & Gökgöz, 2023; Keleş et al., 2023).

However, little is known about how AoA might influence morphophonological features, particularly nonmanual markers involved in event structure.

To explore this dimension, the study compares productions from Deaf of Deaf (DoD) signers, who typically acquire TİD from birth, and Deaf of Hearing (DoH) signers, who are often first exposed to the language later in life. This comparison allows for a closer look at whether and how timing of language exposure may influence the distribution, and/or frequency of features involved in telicity marking, especially in relation to nonmanual markers. By integrating AoA as a factor in the analysis, the study offers additional insight into how early exposure may influence the morphophonological realization of event structure in TİD.

Overall, investigating telicity in TİD helps us better understand how language faculty works across modalities, while also providing important insights into the unique ways sign languages exploit the visual modality to represent event structure. More broadly, in-depth study of sign languages is crucial for gaining thorough understanding of the human language faculty, offering perspectives that spoken languages alone cannot fully reveal (Strickland et al., 2015).

The paper is organized as follows: Chapter 2 reviews previous studies on event structure visibility in sign languages, focusing on telicity, the Event Visibility Hypothesis (Wilbur, 2003, 2008), the nonmanual marking of telicity in Austrian Sign Language (ÖGS) (Schalber, 2004, 2006; Schalber & Grose, 2006), and kinematic studies employing motion capture techniques across three sign languages (Malaia & Wilbur, 2012b; Malaia, Milković, & Wilbur, 2013; Krebs et al., 2021). It also provides an overview of aspectual markers identified in TİD to date (Zeshan, 2003; Kubuş & Rathmann, 2009; Dikyuva, 2011; Karabüklü, 2016). Chapter 3 outlines the motivations of this research and its contributions to the existing literature on event

structure visibility. Chapter 4 details the methodology, including participant profiles, data collection processes, and analysis with ELAN and Pose Estimation. Chapter 5 presents the findings, while Chapter 6 provides an interpretation of the results. Finally, Chapter 7 concludes by reflecting on the findings and offering suggestions for future research.

CHAPTER 2

A BRIEF OVERVIEW OF TELICITY AND EVENT VISIBILITY

2.1 Sub-events, event types and telicity

Telicity constitutes a foundational element in the analysis of event structure. Essentially, it categorizes events into two distinct types: telic and atelic. Telic events are characterized by having an inherent endpoint or goal, signifying their completion or accomplishment once that endpoint is reached (1a). In contrast, atelic events lack an inherent endpoint and are perceived as ongoing or continuous. They have the potential to continue indefinitely, unless terminated by external factors (1b).

1) a. Jake built a house. (telic)

   b. Jake is swimming in the pool. (atelic)

In the relevant literature, definitions of telicity have been articulated in various ways, either based on aspect (the completion of the event/perfective), temporal structure (the status of an event as 'closed' or 'open'), or as an inherent feature of the verb itself. This study, following Wilbur (2003, 2008) and Schalber (2004, 2006), adopts Pustejovsky's (1991, 1995) model of Event Structure to define telicity. This model provides a systematic subevent analysis, classifying event types based on their internal structure.

Event structure analyses traditionally categorize events into four fundamental types, as proposed by Vendler (1967): States, Activities, Achievements, and Accomplishments (See Table 1). Among these, States and Activities are atelic, lacking semantic endpoints. A State describes a static situation without a notable change, while an Activity involves the same dynamic, continuous action. Conversely, the telic types of an Achievement and an Accomplishment possess a

distinct endpoint. Specifically, an Achievement is considered as a change of state where an alternation occurs from an initial state to a final (resultant) state. Similarly, an Accomplishment describes an activity that culminates in a final, distinct state.

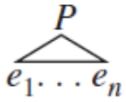
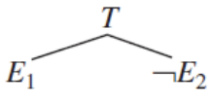
Table 1. Examples of Each Event Type

Event Type	Example
His hair is curly.	State
The child played with her toys.	Activity
Marlin died.	Achievement
Eve is giving me the paper.	Accomplishment

In developing the Event Visibility Hypothesis (EVH), Wilbur (2003, 2008) draws on Pustejovsky's (1991, 1995) framework of event structure, which includes the concepts of states, processes, and transitions, as well as their associated argument structures. Pustejovsky's (1991, 1995) subevent analysis classifies event types based on their internal structure. According to this analysis, events are categorized into stative and dynamic (sub-)events. Atelic events, such as States and Processes, exhibit a homogeneous structure that can be divided into identical intervals at any point in time, denoted as State (S) or Process (P). On the other hand, telic events, namely Achievements and Accomplishments, are referred to as Transitions (T). These telic events have a heterogeneous internal structure, consisting of non-identical subevents that culminate in a natural endpoint. Specifically, achievements involve a transition from one state (S1) to a distinct state (S2), while accomplishments entail a transition from a process (P) to a state (S). The reason they are considered heterogeneous structures is that, since they involve some kind of transition, they cannot be divided into identical intervals and will show a change as they proceed from an initial state to a final state.

Based on this foundation, Pustejovsky (1991, 1995) formally defines the relevant notions and gives their structural representations as in Table 2.

Table 2. Representation of Three Event Types and Their Structures

State (S)	Process (P)	Transition (T)
"a single event, which is evaluated relative to no other event":	"a sequence of events identifying the same semantic expression":	"an event identifying a semantic expression, which is evaluated relative to its opposition":
		
		(where E is a variable for any event type)

Note: Table is taken from (Pustejovsky , 1991,1995)

2.2 Event visibility hypothesis

My analysis of event structure is based on the framework of the Event Visibility Hypothesis (EVH), as proposed by Wilbur (2003, 2008). EVH posits that the event structure is visible in the phonological realization of the predicate sign. In other words, there is a correspondence between the semantic elements of events and their overt morphophonological representations. Wilbur argues that the structure of predicate signs is compositional, with components derived from universally accessible principles of physics and spatial geometry (Wilbur, 2003, 2008). Within the EVH framework, Wilbur (2003, 2008) further asserts that certain morphemes, based on these principles, serve to mark event structure in complex predicates. Given their foundation in universally accessible resources, she hypothesizes that these morphemes will be present across all sign languages. I will summarize her model in the following sub-sections.

2.2.1 Phonological structure

In the phonological aspect of the mapping, Wilbur (2003, 2008) adopts the Prosodic Model of American Sign Language (ASL) proposed by Brentari (1998), which introduces a distinction between Prosodic Features (PF) and Inherent Features (IF). Prosodic Features refer to the features that undergo changes during the formation of a sign, while Inherent Features are the ones that remain constant or persist throughout the sign. This distinction highlights the dynamic aspects of sign formation and the potential of prosodic features in conveying meaning and grammatical distinctions. Under the Prosodic Model of sign languages, syllables are analyzed as consisting of two-timing slots, namely x_1 and x_2. These timing slots are associated with relevant phonological features that are prevalent during the sign formation.

Table 3. Prosodic Features Defined in Brentari's Prosodic Model of SL Phonology (1998)

Prosodic Features
Hand aperture change
Hand orientation change
Setting Change
Path/Change of Location

In Brentari's Prosodic Model, the timing slots x_1 and x_2 correspond to the beginning and end of a sign, respectively. These timing slots represent specific points in time during the production of a sign. The features and movements associated with the sign unfold sequentially over time from the x_1 position to the x_2 position. By examining the phonological features and changes within these timing slots, Wilbur (2003, 2008) states that the phonological specification of the timing slots in predicate

signs is influenced by the underlying event structure, which suggests a direct relationship between the event structure and the phonological form of the sign.

Accordingly, Wilbur (2003, 2008) argues that telic signs occur in a more complex syllabic structure to expone a bi-morphemic structure compared to atelic signs which occur in a simpler syllable to expone monomorphemic morphology. More specifically, a telic sign involves a dynamic change between the two-timing slots and hence exhibit a contrast between x_1 and x_2. This contrast involves changes in prosodic features, such as a shift in handshape**,** a change in orientation**,** setting change or change of location which entails contact. On the other hand, an atelic sign shows no change in its prosodic features throughout the sign, resulting in a simpler syllable structure. Their movement is uniform across both timing slots, resulting in a motion with no marked endpoint.

In summary, Wilbur (2003, 2008) argues that this phonological encoding of event structure is not incidental but systematically built into the grammar of sign languages. The movement dynamics of the sign—whether there is a contrastive shift or consistent motion—mirror the underlying semantic structure**.**

2.2.2 Proposed morphemes in EVH for telicity marking

Wilbur (2003, 2008) proposes several morphemes involved in marking event structure in sign languages, among which the End-State, Extent, and Path morphemes are particularly relevant to this study.

2.2.2.1 End-State morpheme

The End-State morpheme marks telic predicates by signalling the presence of a specific endpoint or natural culmination. It occurs in the heterogeneous transition

Accomplishments and Achievements, which involve two subevents and culminate in a distinct Final State in the second timing slot (x_2). Phonologically, the End-State morpheme is realized as a rapid movement that stops abruptly, with prosodic changes in features like handshape, orientation, setting, or contact location (Table 3).

2.2.2.2 Extent and Path morphemes

Wilbur introduces two additional morphemes, namely Extent and Path, within her framework. The inclusion of the morphemes Extent and Path in predicate signs reflects the semantic distinction between changes that occur over time (Extent) and changes that occur over location (Path). In the case of non-spatial predicates, the presence of movement within the sign represents Extent, which corresponds to the elapsed time of an event (Wilbur 2008). Thus, the presence of movement in a sign signifies a non-punctual event, conveying the notion of duration or temporal extent. Conversely, the absence of movement indicates a punctual event, signifying that the event occurs at a single point in time.

On the other hand, in spatial predicates like CL (classifier) predicates, the morpheme Path is used to depict movement in physical space, representing the trajectory or path of the event. In other words, the Path morpheme serves as a marker for spatial movement within predicates, representing and conveying spatial aspects of the event being described. Wilbur (2003, 2008) further notes that spatial changes inherently involve the passage of time, linking these two dimensions.

According to Wilbur, in the absence of any explicit lexical specification, the default interpretation of predicates in sign language is temporal (Extent) rather than spatial (Path). This means that the movement or changes depicted in the sign are

understood to represent the passage of time or the duration of an event. However, if a spatial interpretation is desired, it must be lexically specified within the sign.

When combined with the End-State morpheme, the Extent and Path morphemes mark telic events that unfold over time or space and culminate in a natural endpoint. Without these morphemes, the End-State denotes punctual telic events that lack temporal duration. Additionally, Extent and Path can appear with atelic predicates, marking processes with temporal duration but no inherent endpoint.

2.2.2.3 Initial-State morpheme

The Initial State morpheme, proposed by Wilbur, serves as a linguistic indicator of the initial state and is phonologically realized as a rapid acceleration from a stop (Wilbur 2008). This morpheme is particularly employed when emphasizing the initial state and can effectively highlight the transition from the initial state to the end-state in transition events.

2.2.2.4 Adverbial modifiers

According to Wilbur, adverbial modification is applicable to each of the identified event morphemes and their combinations. One such adverbial morpheme is "Extra," which modifies predicates incorporating the morphemes Extent or Path. She defines this morpheme as "an adverbial morpheme meaning ‘extra, more (of)’. Its phonological form is a simultaneous affix consisting of Brentari’s shape feature [arc].." (Wilbur, 2008, e.g., p. 235).

The second adverbial morpheme is USET, which stands for 'Unchanged State in Elapsing Time' and is represented phonologically by a 'trilled movement [TM]' (Wilbur 2008). The presence of USET allows for an interpretation of time passing

without any change in the state or process being described, hence is used with atelic event predicates.

2.3 Event visibility in sign languages

Previous research has explored event visibility across several sign languages, including ASL (Wilbur, 2003, 2008; Malaia & Wilbur, 2012), Croatian Sign Language (HZJ) (Malaia, Milković & Wilbur, 2013), Austrian Sign Language (ÖGS) (Schalber, 2004, 2006; Schalber & Grose, 2006; Krebs et al., 2021), Italian Sign Language (LIS), Sign Language of the Netherlands (NGT), and TİD (Strickland et al., 2015). These studies have identified systematic correspondences between phonological form and event type, particularly in the marking of telicity through prosodic features and kinematic movement patterns.

Methodologically, they include both qualitative analyses, such as the examination of manual forms (e.g., changes in handshape, orientation, movement) and nonmanual markers (e.g., mouth gestures), and quantitative approaches, including motion capture techniques used to identify kinematic patterns that distinguish telic from atelic events. Together, these studies offer a cross-linguistic foundation for understanding how sign languages encode event structure through visible and measurable phonological cues.

2.3.1 Manual marking of telicity in sign languages

Wilbur (2003, 2008) observed that in ASL, telicity can be directly observed in the phonological form of signs**.** Specifically, telic verbs typically exhibit a rapid deceleration followed by a clear stop**,** often realized through a change in hand orientation, a movement to contact**,** or a shift in handshape that signals

the culmination of the event**.** This observation led her to formulate the Event Visibility Hypothesis (Wilbur, 2003, 2008), proposing that the underlying event structure is visible through the phonological forms of predicates.

Building on EVH, Schalber (2004, 2006) investigated ÖGS and found comparable patterns. In ÖGS, telic signs frequently exhibit sudden stops, rapid deceleration, or a change in hand orientation or handshape near the end of the sign's articulation. These features function as phonological markers that signal the endpoint of an event. In contrast, atelic predicates lack these rapid stops, displaying smoother and more continuous movement. Schalber's findings reinforce the predictions of the EVH.

Strickland et al. (2015) extended this research with a cross-linguistic perception study, testing whether non-signers could detect telicity purely from the visual form of signed verbs in LIS, NGT, and TİD. Participants viewed videos of verbs varying in telicity and chose between written telic and atelic verb pairs. Despite having no prior knowledge of sign languages, non-signers were able to accurately infer telicity by relying on the phonological and kinematic features of the signs. Strickland et al. (2015) states that this finding supports EVH, indicating a universal mapping between telicity and the phonological form of signs, even in historically unrelated sign languages.

Overall, these findings suggest that the internal structure of events is systematically encoded through specific phonological features in sign languages. As a result, events can be distinguished by observing differences in phonological and kinematic patterns**,** such as changes in handshape, orientation, movement deceleration, and endpoint marking. These visual cues indicate whether an event has a natural endpoint, thereby aligning the form of the sign with its semantic content**.**

The fact that even non-signers can accurately interpret these cues, as demonstrated by Strickland et al. (2015), further supports the EVH. Taken together, this line of research provides evidence that the visual-kinematic properties of signs systematically reflect underlying event structure, and that this mapping may be cross-linguistically universal.

2.3.2 Nonmanual marking of telicity in sign languages

In sign languages, nonmanual markers (NMs) refer to facial expressions, head movements, body posture, and especially mouth gestures that accompany signs. They can function independently or in conjunction with manual signs to convey grammatical information, modify meaning, or express prosodic structure. They are integral to the grammar of sign languages and have various functions such as differentiating sentence types and marking negation (Wilbur, 2000; Zeshan, 2003; Pfau & Quer, 2010; Gökgöz, 2013; Benitez-Quiroz et al., 2014; Karabüklü, 2024; Karabüklü & Gürer, 2024).

Expanding on this grammatical role, Schalber (2004, 2006) investigated how nonmanuals contribute specifically to the encoding of event structure in Austrian Sign Language (ÖGS). Focusing on mouth nonmanuals, her analysis revealed two distinct types based on their configuration and movement: *Continuous mouth position* (P-mouth) NMs, which involve stable configurations such as pursed lips or sustained exhaling, and *discontinuous mouth movement* (T-mouth) NMs, characterized by dynamic changes, such as opening and closing the jaw or abrupt exhaling.

Schalber's analysis shows that P-mouth NMs typically occur with atelic predicates, as seen in example (2b), where the NM *ph* indicates continuous exhaling.

These markers often extend across multiple signs within a clause, modifying the dynamic process of the event. In contrast, T-mouth NMs are associated with telic events, as illustrated in (2a), where the NM *pf* signals abrupt exhaling. The timing of T-mouth NMs often aligns with manual changes, such as shifts in hand orientation or movement to contact, marking a transition in the event structure.

2) Examples taken from (Schalber, 2004, pp. 225-226)

Figure 1. Example of t-mouth nonmanual marker reprinted from (Schalber, 2004, p. 225)

pf

a. KATHARINA IX AMERIKA FLIEGEN:[direction]

Katharina ix USA fly:[direction]

'Katharina flew to the USA.'

Figure 2. Example of p-mouth nonmanual marker reprinted from (Schalber, 2004, p. 225)

ph

b. FRAU IX FLUGZEUG FLIEGEN:[tracing]

woman ix plane go-by-plane:[tracing]

'The woman is going by plane.'

Figure 3. Example of p-mouth nonmanual marker used together with a telic event reprinted from (Schalber, 2004, p. 226)

pursed lips

c. FRAU IX BLUME GIESSEN:[supination]

'Woman waters a plant'

Importantly, while T-mouth NMs emphasize the endpoint of an event, telic predicates may also include P-mouth NMs, but in those cases, the nonmanuals do not highlight the endpoint (2c). Instead, they focus on other qualities of the event, such as manner or intensity.

Further expanding on this, Schalber and Grose (2008) argue that these nonmanuals operate at different syntactic and phonological levels: T-NMs mark transitions between subevents (e.g., Process → State), while P-NMs have wider syntactic scope and modify entire verbal predicates. Their analysis views nonmanuals as meaningful grammatical elements that reflect the internal structure of events in a sentence.

In sum, research on ÖGS supports the Event Visibility Hypothesis (EVH) by demonstrating that mouth nonmanuals reflect internal event structure in systematic ways, with distinct functions based on the nature of the events being described.

2.4 Kinematic studies of event structure

Quantitative research on event visibility has identified kinematic parameters that are crucial for distinguishing between telic and atelic events in sign languages. Malaia and Wilbur (2012b) conducted a motion capture study in ASL, analyzing 40 target signs (24 telic, 16 atelic) produced by six deaf native signers across four syntactic conditions: in isolation, within a carrier phrase, and in sentence-medial and sentence-final positions. The study focused on five kinematic variables: sign duration, peak velocity, time to peak velocity, deceleration slope, and instantaneous deceleration. The results revealed that telic signs consistently exhibited higher peak velocity, greater deceleration, shorter duration, and steeper deceleration slopes compared to atelic signs.

However, some of these variables, especially peak velocity and duration, varied depending on the sign's position in the sentence**,** likely due to prosodic effects such as phrase-final lengthening**,** which tends to stretch sign duration and reduce velocity. For instance, signs in final positions were, on average, 15–20% longer in duration**,** and peak velocity showed a measurable drop, diminishing its reliability as a consistent cue for telicity across contexts. In contrast, deceleration slope and instantaneous deceleration remained stable across all syntactic contexts**,** establishing them as consistent phonological cues for telicity independent of sentence position.

Extending this work cross-linguistically, Malaia, Milković, and Wilbur (2013) explored verb kinematics in HZJ, confirming that telic-perfective verbs exhibited significantly higher peak velocities and steeper decelerations than their atelic-imperfective counterparts.

Unlike ASL, where some kinematic variables such as peak velocity and duration were sensitive to prosodic positioning, HZJ shows no such variation. In HZJ, key markers of telicity, such as peak velocity and deceleration, remain consistent regardless of where the verb appears in the sentence. These findings support Wilbur's Event Visibility Hypothesis (EVH), which posits that visual motion cues systematically encode event structure in sign languages.

Additionally, HZJ employs a productive morphological system: many verbs have two distinct forms that directly correspond to telic and atelic interpretations. This contrasts with ASL, where differences between telic and atelic events are typically signalled through phonological features of movement, such as deceleration, rather than through changes in verb form.

Krebs et al. (2021) further investigated kinematic parameters in ÖGS using motion capture. The study involved a native ÖGS signer who produced 20 verbs, 10 telic and 10 atelic, chosen using standard tests like the "almost" and conjunction tests to identify event types. All signs were performed in isolation to avoid prosodic effects. The motion capture data revealed that telic signs exhibit significantly sharper deceleration, faster acceleration, and higher jerk (rate of change of acceleration), with reduced overall duration compared to atelic signs. In line with findings from ASL (Malaia & Wilbur, 2012b) and HZJ (Malaia et al., 2013), the ÖGS data confirm that telicity is encoded in the phonological motion profile of signs**,** reinforcing the Event Visibility Hypothesis (EVH)**.**

In summary, these motion capture studies reveal distinct kinematic parameters, such as deceleration and peak velocity, that differentiate telic and atelic events. These findings provide support for the EVH, pointing to a cross-linguistic pattern in how sign languages visually encode event structure.

2.5 Event visibility in TİD

2.5.1 Cross-linguistic study of event visibility

To date, the only study that directly addresses event visibility and telicity marking in TİD is Strickland et al. (2015), which is a cross-linguistic analysis that included data from three sign languages: LIS, NGT, and TİD. This study explored whether non-signers could intuitively distinguish between telic and atelic events based solely on the visual form of signed verbs. Their findings provided additional evidence for the EVH, showing that even non-signers, with no prior exposure to sign language, could consistently and accurately map event semantics to the visual forms of the signs.

A key finding was that telic signs were visually marked by rapid deceleration and an abrupt stop, creating a perceptually salient boundary, features that were recognized across all three languages, including TİD. This suggests that TİD shares common strategies with other sign languages in visually encoding event structure.

Despite these promising findings, the specific ways in which telicity is marked in TİD, through manual forms, including prosodic features, and nonmanual cues, have yet to be systematically examined. This gap highlights the need for further research into how both manual and nonmanual markers contribute to the visibility of event structure in TİD.

2.5.2 Nonmanual markers

Previous research on TİD has revealed that nonmanual markers (NMMs), particularly mouth gestures, are used to encode aspectual distinctions, especially those related to viewpoint aspect (Kubuş & Rathmann, 2009; Dikyuva, 2011; Karabüklü, 2016). Viewpoint aspect concerns how a speaker presents the internal

temporal structure of an event, whether as completed, ongoing, or just beginning, focusing on their perspective of the event.

Karabüklü (2016) offers an overview of these markers in TİD. One of the most detailed analyses of nonmanual aspectual marking in TİD comes from Dikyuva (2011), who identifies three distinct mouth gestures that correspond to different types of viewpoint aspect. The first, 'bn'**,** involves a tongue protrusion gesture and is used to signal completive or perfective aspect. Kubuş and Rathmann (2009) interpret this same marker, referred to as 'pt' in their study, as expressing past and telic meaning, supported by its compatibility with past-tense adverbials. The second gesture, 'ee', is produced by positioning the tongue between the teeth and is interpreted as marking inceptive aspect**,** indicating the onset or initiation of an event. The third, 'lele', is characterized by an up-and-down tongue movement and is associated with continuative or imperfective aspect, suggesting that the event is ongoing**,** habitual**,** or repeated in nature.

Karabüklü (2016) builds on Dikyuva's analysis and highlights the particular importance of the nonmanual marker 'bn' in expressing perfective aspect in TİD. While following Dikyuva in treating 'bn' as a perfective/completive marker, she emphasizes that its behaviour, especially when it co-occurs with the manual aspectual marker BİT ('finish'), suggests that it operates at a different level of the grammar. Specifically, 'bn' contributes to outer aspect, shaping how the signer frames the event as complete, while BİT encodes inner aspect, marking whether the event itself has reached its endpoint.

According to Karabüklü (2016), though 'bn' and BİT can appear together, their co-occurrence is not redundant, rather, they carry different grammatical roles. While BİT denotes that the event is completed, 'bn' highlights how that completion is perceived or presented.

In addition to these studies focusing on aspectual distinctions, Coşkun (2020) offers a preliminary yet significant contribution to the understanding of nonmanual markers in TİD by examining mouth gestures from the perspective of event visibility. Coşkun investigates the relationship between mouth gestures and the visibility of event structures. The study identifies a systematic correlation between the use of continuous and discontinuous mouth gestures and the phonological forms of predicate signs in TİD, indicating that these nonmanual markers play a role in marking the event structure. This finding aligns with Schalber's (2004, 2006) observations on the relationship between mouth gestures and predicate signs in ÖGS, where adverbial mouth gestures reflect the telicity of predicate signs. However, it is important to note that Coşkun's study solely focuses on mouth gestures, without addressing other types of nonmanuals or their potential interaction.

The following table summarizes the key nonmanual and manual aspectual markers identified in TİD, highlighting their functions, phonological forms, and their roles within the aspectual structure based on previous research.

Table 4. Nonmanual and Manual Aspectual Markers in Turkish Sign Language (TİD)

Marker	Type	Function	Phonological Form	Layer in Aspectual Structure
‘bn’	Nonmanual	Perfective / Completive (Viewpoint Aspect)	Tongue protrusion	Outer
‘lele’	Nonmanual	Imperfective / Continuative (Viewpoint Aspect)	Tongue movement (up and down)	Outer
‘ee’	Nonmanual	Inceptive (Viewpoint Aspect)	Tongue between teeth	Outer
BİT ‘finish’	Manual	Event Completion (Viewpoint Aspect)	Lexical sign for ‘finish’	Inner

2.5.3 Manual aspectual markers

Earlier research has identified several manual aspectual markers in TİD. Karabüklü (2016) outlines these markers, starting with those discussed by Zeshan (2003), who was among the first to examine tense and aspect encoding in the language. Zeshan notes that manual markers such as TAMAM ('done, complete, ready') and BİTTİ ('finished') occur at the end of sentences to express a completive aspect. Karabüklü’s analysis of the TİDBİL database (TÜBİTAK #111K314) identifies additional markers, including BİT ('finish'), SON ('end'), TAMAM ('done, complete, ready'), HAZIR ('ready'), and MÜSAİT ('available, ready').

She also states that Dikyuva (2011) identifies markers like HER ZAMAN (‘everyday/always’), interpreted as contributing to habitual aspect, and SON (‘end’). These markers are used to convey aspectual information and describe the internal

temporal structure of events, often signaling whether an event is completed, ongoing, repeated, or habitual (Table 5).

Table 5. Previously Reported Manual Aspectual Markers in TİD

Manual Aspectual Markers in TİD	Function
TAMAM	'done, complete, ready'
BİTTİ	'finished'
BİT	'finish'
SON	'end'
HAZIR	'ready'
MÜSAİT	'available, ready'
HER ZAMAN	'everyday, always'

2.5.4 Internal modification of the signs

Internal modification refers to changes made within the structure of a sign, achieved by changing the movement path or adjusting the movement itself. In TİD, this strategy is used to express aspectual distinctions**,** especially those related to viewpoint aspect—how the event is temporally framed by the signer.

Karabüklü (2016) discusses internal modification in the context of earlier observations by Zeshan (2002, 2003)**,** Kubuş (2008)**,** and Gökgöz (2009)**,** who observe that a single, accented movement, that is, a sharply defined, non-repetitive motion, conveys a perfective aspect, indicating that the event is viewed as complete or bounded. Conversely, lengthened or repetitive movements are associated with imperfective aspect**,** presenting the event as ongoing, habitual, or unbounded. She further adds that Zeshan (2002, 2003) notes a modified, single-accented hand movement in the verb's base form can signal a completive meaning.

Meanwhile, Kubuş (2008) highlights that shorter, repetitive movements tend to express incompletive aspect, framing the event as still in progress.

These movement patterns are interpreted as components of 'Viewpoint Aspect and show how the form of a sign can be internally adjusted to reflect different temporal perspectives on an event.

2.6 Age of acquisition (AoA) effects

The study of Age of Acquisition (AoA) effects has played a crucial role in comprehending how early exposure to language shapes language development, for both visual-spatial (sign languages) and auditory (spoken languages) modalities**.** Research in this area consistently shows that the timing of language exposure has lasting consequences not only for linguistic competence but also for broader cognitive development, even when language input is introduced later in the developmental trajectory (Mayberry, 2007; Mayberry & Kluender, 2018).

In the context of sign languages, only about 5–10% of deaf children are born into deaf families who can provide natural sign language input from birth (Mitchell & Karchmer, 2004; Woll, 2013). The overwhelming majority, 90–95%**,** are born into hearing families, where early input from a natural language is often delayed and not readily accessible (Humphries et al., 2017). As a result, many deaf children only begin to encounter consistent and accessible sign language input upon entering deaf schools, typically around the age of 7, particularly in Turkey (Sari, 2006; İlkbaşaran, 2015).

Even then, the instruction in Turkish Sign Language (TİD), and thus the language input that deaf children receive, is often limited, as many teachers in Türkiye have only rudimentary knowledge of TİD and predominantly rely on oralist

methods, placing greater emphasis on teaching Turkish (Ministry of National Education, 2020; Keleş, 2023).

Importantly, even though the modalities differ, sign languages are just as complex as spoken languages in terms of grammar and developmental trajectory. When deaf children receive early input from a natural sign language, their developmental milestones closely parallel those observed in hearing children acquiring a spoken language (Bellugi, 1988; Newport & Meier, 1985; Lillo-Martin, 1999). The importance of the Critical Period Hypothesis (CPH) holds true across modalities, which proposes that there is a sensitive window early in life during which full, native-like language acquisition is possible (Lenneberg, 1967; Johnson & Newport, 1989; Mayberry & Kluender, 2018).

For deaf children born into hearing families, where accessible linguistic input is often delayed, missing this critical period has significant consequences. Research shows that delayed exposure to a first language leads to enduring differences that cannot be fully compensated for by later exposure (Johnson & Newport, 1989, Lenneberg, 1967; Johnson & Newport, 1989; Mayberry & Kluender, 2018). Deaf individuals who acquire sign language later tend to display reduced proficiency in various linguistic domains, including morphology, syntax, and phonological processing, when compared to native signers (Newport, 1990; Boudreault & Mayberry, 2006; Emmorey & Corina, 1990).

Complex morphosyntactic structures, such as classifier constructions, and inflectional morphology, are particularly vulnerable to late acquisition and often remain less developed, even after years of exposure (Mayberry & Eichen, 1991; Mayberry et al., 2018). A growing body of research has shown that these effects persist into adulthood (Mayberry, 2007; Mayberry, 1993; Mayberry et al., 2011;

Mayberry & Eichen, 1991; Mayberry et al., 2002; Morford & Hänel-Faulhaber, 2011; Newport, 1990), highlighting that consistent language input during adolescence cannot fully overcome the initial period of language deprivation (Mayberry & Kluender, 2018; Lillo-Martin & Henner, 2020). Beyond linguistic outcomes, language deprivation has also been linked to broader cognitive delays, including impairments in Theory of Mind and social cognition (Schick et al., 1990, 2006).

These findings have been further supported by recent research on TİD. Studies such as those by Karadöller et al. (2017, 2021, 2022), Sevgi and Gökgöz (2023), and Kayabaşı and Gökgöz (2023) have shown that TİD signers with late exposure often display differences in morphosyntactic production, particularly in the use of classifier constructions. For example, Karadöller et al. (2017, 2021, 2022) demonstrated that late-exposed signers tend to use morphologically simpler strategies when describing spatial relationships. Rather than employing complex locative classifiers, they more frequently rely on relational lexical items such as "in," "under," or "on."

Importantly, these studies highlight that the amount of exposure alone is not enough to fully compensate for early language deprivation. Karadöller et al. (2021) found that even when late-exposed child and adult signers had the same length of exposure (about 2 years), adult signers still used significantly fewer classifier constructions. This suggests that it is the timing of exposure during early childhood, and not merely the duration of exposure, that plays a critical role in the acquisition and full use of such complex morphosyntactic structures.

Similarly, Coşkun (2020) investigated the effects of AoA on mouth gestures in TİD. The study focused on how telicity of predicate signs is reflected in adverbial

mouth gestures and revealed that the linguistic realization of these mouth gestures differs between early and late learners of TİD. Early learners were found to produce the expected mouth gestures corresponding to the event structure of predicate signs more frequently compared to late learners. In contrast, late learners showed a reduced tendency to perform these systematic mouth gesture-event structure correlations. Coşkun's findings align with previous research emphasizing that early exposure significantly contributes to mastering the full range of linguistic markers, including nonmanuals, in TİD.

Kayabaşı & Gökgöz (2023) also found that while native and late learners of TİD do not differ dramatically in some alternation preferences, such as causative-inchoative structures, late learners tend to produce fewer multi-predicate and complex constructions. Similarly, Sevgi & Gökgöz (2023) investigated the effects of AoA on the relationship between argument structure and classifier type in TİD. They found that regardless of AoA, signers consistently used similar patterns to encode argument structure within classifier constructions, indicating that this mapping is robust to late exposure.

However, AoA did affect argument expression as native and early-learner signers were more likely to drop the agent argument, while late learners tended to express it overtly. Sevgi & Gökgöz suggest that this difference might be linked to perspective-taking abilities, with native signers better coordinating character perspective and argument omission, while late learners tend to include the agent explicitly, even when redundant.

Nonetheless, not all domains appear equally affected. In TİD, some areas seem more resilient than others. Keleş, Atmaca, and Gökgöz (2023) found that late signers could perform near-natively in reference tracking tasks, suggesting that

narrative structures might be less sensitive to AoA effects than morphosyntactic structures.

Collectively, these findings highlight the importance of providing deaf children with early, accessible, and consistent exposure to a natural language during the critical period. Early input is necessary to support the full development of both linguistic competence and cognitive abilities. The results also show that Age of Acquisition (AoA) effects are particularly evident in complex areas of grammar, such as morphosyntax.

CHAPTER 3

CURRENT STUDY

As I cited above, the representation of event structure in sign languages has been a significant area of research in linguistics, often framed within Wilbur's (2003, 2008) Event Visibility Hypothesis (EVH). Studies on sign languages such as ASL, HZJ, LIS, NGT, and ÖGS have demonstrated that both manual and nonmanual markers contribute to encoding telicity. While previous research on TİD has primarily focused on tense and viewpoint aspect, documenting aspectual markers—including both manual and nonmanual markers, as well as sign internal modifications—no comprehensive study has specifically addressed telicity marking and its visibility through phonology in this language. Only Strickland et al. (2015) have included TİD in their work, highlighting the universal accessibility of event visibility in sign languages, even to non-signers. However, their study did not explore the specific mechanisms by which telicity is marked in TİD. Consequently, key aspects of event visibility in TİD, particularly the interaction between manual and nonmanual markers, remain underexplored.

This study addresses the gap in research on telicity marking in TİD by adopting a multidimensional approach that combines qualitative and quantitative analyses. It examines how telic and atelic events are morpho-phonologically expressed, focusing on manual markers, nonmanual markers, and kinematic motion profiles. Within this scope, 1239 atelic predicates and 699 telic predicates have been annotated, along with 1685 nonmanual markers identified across these predicates, using data from both Deaf of Deaf (DoD) and Deaf of Hearing (DoH) signers of TİD. Furthermore, the study introduces Pose Estimation as a novel, cost-effective

tool for quantitative analysis, offering new insights into the movement dynamics of telic and atelic verb signs. By integrating these methods, this research aims to deepen our understanding of event visibility in TİD and contribute to typological studies by providing data on telicity marking and revealing cross-linguistic patterns.

Guided by three research questions, the study explores: 1) how manual and nonmanual markers represent underlying event structure in TİD and whether distinct patterns emerge across different event types; 2) whether calculable kinematic profiles systematically differentiate event types; and 3) whether age of acquisition (AoA) affects telicity marking in TİD. While AoA effects in TİD have been documented in morphosyntax and pragmatics (Kayabaşı & Gökgöz, 2023; Sevgi & Gökgöz, 2023; Keleş et al., 2022, 2023), their impact on morphophonology, particularly as expressed via nonmanuals, remains underexplored.

All in all, the current research builds on the EVH by providing evidence from TİD and introduces pose estimation as a novel tool for quantitative analyses in sign language research. Through this multifaceted approach, it aims to offer a comprehensive account of telicity marking in TİD.

CHAPTER 4

METHODOLOGY

This chapter outlines the methodology used to investigate how telicity is marked in Turkish Sign Language (TİD) through manual, nonmanual, and kinematic features. It describes the participant profiles, data collection procedures, and the multi-layered analytical approach applied to examine the phonological representation of telic and atelic predicates across different age-of-acquisition groups.

The study focused on two types of telic predicates and two types of atelic predicates. Telic predicates, characterized by an inherent endpoint or culmination, were classified as Achievements and Accomplishments. In contrast, atelic predicates, which lack a natural endpoint, were categorized as States and Activities.

4.1 Participant profiles

A total of 30 TİD signers participated in this study. Participants were divided into two groups based on their Age of Acquisition (AoA) profile. The first group consisted of fifteen Deaf of Deaf (DoD) signers (Mean-age = 29), who were exposed to TİD from birth through direct familial interaction with parents, siblings, or other close relatives. The second group comprised fifteen Deaf of Hearing (DoH) signers (Mean-age = 37), who acquired TİD later in childhood, typically around eight years of age, primarily through formal education in deaf schools.

Participants were recruited for the study and data collection took place at the Sign Lab at Boğaziçi University, İstanbul, Türkiye. Although participants originated from various regions of Türkiye, all were residing in Istanbul at the time of data collection.

Prior to participation, individuals completed an informed consent form and a background questionnaire. The questionnaire collected information regarding language history**,** AoA**,** daily language use**,** and educational background**.** The participants indicated that TİD was their primary mode of communication in daily life.

This AoA-based participant division allowed the study not only to examine general patterns of telicity marking but also to explore whether early language exposure influences the realization of phonological features associated with event structure.

4.2 Data collection

Visual stimuli were used to elicit productions of predicates corresponding to the four event types: States, Activities, Achievements, and Accomplishments. Stimuli consisted of a mixture of still images and animated GIFs that depicted simple events designed to evoke target event structures without enforcing specific lexical choices. A total of six visual stimuli were created for each event type, resulting in 24 stimuli items overall.

An example stimulus intended to elicit the achievement predicate ‘FALL’ is provided below. While the figure presented here consists of still images, the stimulus shown to participants was in the form of an animated GIF. Participants were instructed to describe what they saw in each stimulus to a deaf consultant seated across from them, simulating a conversational interaction. The deaf consultant was unaware of the specific stimuli, as the items were randomized.

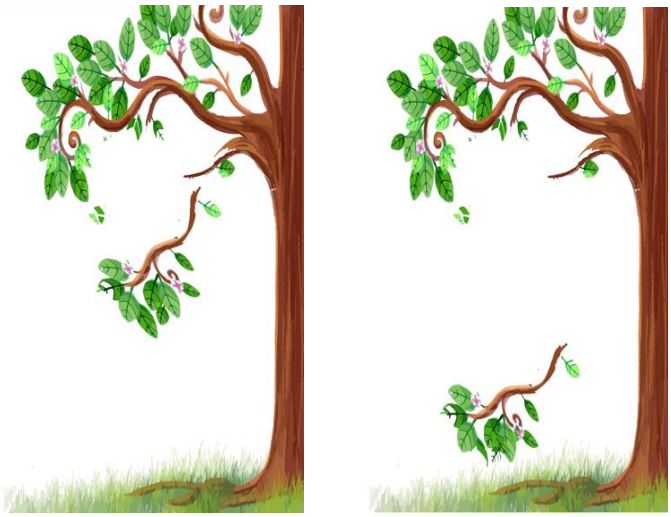


Figure 4. Example stimulus to elicit the telic achievement predicate ‘FALL’

To illustrate, when the stimulus depicting a tree branch falling appeared on the screen, the signer was expected to produce the predicate sign ‘FALL’ in a sentence.

The signers' responses were recorded using two cameras: one captured the participant's frontal view, while the other recorded the computer screen displaying the stimuli.

4.3 Data analysis

The elicited data from both DoD and DoH were analyzed using two distinct methods, combining qualitative annotation and quantitative kinematic analysis. First, the data were manually annotated and examined using the free software program ELAN. Second, the recorded data from participants were processed and analyzed through Pose Estimation, a novel computer vision technique utilizing OpenCV and MediaPipe libraries, in order to capture and compare phonological motion profiles across different event types.

4.3.1 Data annotation with ELAN

A comprehensive set of annotation tiers was developed in ELAN to capture the multidimensional aspects of telicity marking. Each tier targeted distinct elements that contribute to the representation of event structure in TİD, including manual predicate forms, nonmanual markers, and accompanying aspectual markers. The tiers that were central to the data analysis are detailed below.

4.3.1.1 Targeted predicate

This tier was used to mark whether the signer produced the specific predicate intended for elicitation.

4.3.1.2 Analyses

In this tier, the produced targeted predicate was categorized based on its event type. Each sign was annotated as one of four possible values: *'Telic, Achievement', 'Telic, Accomplishment', 'Atelic, Activity',* or *'Atelic, State.'*

4.3.1.3 Nonmanual-1

In this tier, the presence of any nonmanual markers accompanying the targeted predicate was identified, followed by annotation of their presence or absence by assigning one of two values: *'Yes'* or *'No.'*

4.3.1.4 Nonmanual-2

If the value in the Nonmanual-1 tier was marked as 'Yes,' indicating the presence of a nonmanual marker, this tier specified whether the nonmanual marker was '*Continuous*' or '*Discontinuous.*' The definitions of 'continuous' and 'discontinuous'

forms were adopted from Schalber's (2004, 2006) study, where these terms were used to categorize mouth gestures. In the present study, this categorization was extended to encompass all nonmanual markers, rather than limiting it to mouth gestures alone. Continuous nonmanuals are characterized by their stable, consistent form throughout the duration of the sign, exhibiting no changes during the articulation of the sign. Conversely, discontinuous nonmanuals are marked by a sudden and distinct change during the sign's production.

4.3.1.5 Combination/Single NM-marker

In this tier, if the Nonmanual-1 tier was marked as "Yes," it was determined whether the signer used a single nonmanual marker or a combination of nonmanual markers with the targeted predicate. This tier offered two possible values: *'Single NM-marker'* or *'Combination of NM-markers,'* where the latter indicated the use of two or more nonmanual markers simultaneously.

4.3.1.6 Type of NM-marker

This tier specified the exact type of nonmanual marker used when nonmanual markers were identified as accompanying the predicate. Seven distinct values were used to categorize the specific nonmanual marker observed: *'Eye Aperture,' 'Eyebrow Movements,' 'Cheeks,' 'Nose,' 'Head Movements,' 'Body Movements,'* and *'Mouth Gesture.'* These values allowed for a detailed annotation of nonmanual markers, especially when multiple markers were used simultaneously.

- Eye Aperture: Refers to changes in the configuration of the eyes, such as 'eyes squinted,' 'continuous eye blinks,' 'eyes wide open,' or transitions between these states.

- Eyebrow Movements: Captures changes observed in eyebrow positioning, including 'raised brows,' 'furrowed brows,' or transitions like 'neutral to furrowed brows at the end.'
- Cheeks: Involves changes in cheek configuration, such as 'puffed cheeks,' 'cheeks inward,' **o**r shifts like 'neutral to puffed cheeks at the end.'
- Nose: Records any changes related to the nose, specifically when the nose becomes 'wrinkled.'
- Head Movements: Includes variations in head positioning or motion, such as 'head tilt,' 'ongoing head nods,' 'side-to-side shakes,' or combinations thereof.
- Body Movements: Documents any significant body movements, including actions like 'single shoulder tilt,' 'body going back and forth,' or similar gestures.
- Mouth Gestures: Encompasses changes in the mouth's configuration, including 'lips rounded,' 'lips pushed forward,' 'protruding tongue,' 'mouth open,' 'mouth closed,' 'lips stretched,' as well as 'Lele' (tongue up-and-down) and 'pf' (abrupt exhaling).

To accurately capture instances where multiple nonmanual markers occurred simultaneously, a total of six 'Type of NM-marker' tiers were used, ensuring comprehensive annotation of each marker when combined.

4.3.1.7 Combination pattern

This tier was used to manually note the specific combination pattern of nonmanual markers when multiple markers were employed, following their specification in the

'Type of NM-marker' tiers. For instance, a combination could be annotated as *'Mouth Gesture + Eye Aperture + Head Movement,'* reflecting the exact nonmanuals accompanying the targeted predicate.

4.3.1.8 Aspectual marker

This tier was used to identify the presence of any aspectual markers following the targeted predicate, assigning one of two values: *'Yes'* or *'No.'*

4.3.1.9 Type of aspectual marker

In this tier, if aspectual markers were detected, their specific types were identified and manually labelled. The following aspectual markers were observed in the data: 'BİTTİ (finished),' 'BİT (finish),' 'HAZIR (ready),' 'SON_2 (end),' 'DEVAM (continue),' 'ÖYLECE_1 (as it is, without changing),' and 'ÖYLECE_2 (as it is, without changing).'

4.3.1.10 Predicate-Form

In this tier, the target predicate was annotated as exhibiting either an iconic or representative form, with one of two values selected: *'Iconic'* or *'Representative.'* Iconic forms involve using the human body to depict human and animal actions, while representative forms are reduced to hand movements that convey whole entities, body part classifiers, and lexical verbs.

4.3.2 Data analysis of ELAN annotations: Average nonmanual marker intensity

To explore the influence of Age of Acquisition (AoA) on event structure encoding, further analysis focused on nonmanual marker usage patterns among DoD and DoH

participants. To investigate this, calculations were conducted focusing on the nonmanual markers employed by both Deaf of Deaf (DoD) and Deaf of Hearing (DoH) signers. The steps taken to calculate the *average nonmanual marker intensity* for telic and atelic predicates across DoD and DoH signers are outlined below, serving as a key measure for analyzing age of acquisition effects.

First, the total number of targeted predicates produced by each signer was counted, distinguishing between those annotated as telic and atelic. Subsequently, the total number of nonmanual markers annotated for each group of predicates (telic and atelic) was counted. This provided the count of nonmanual markers accompanying telic and atelic predicates for each signer separately. These counts, along with the total number of predicates for each signer, were used to calculate the average nonmanual marker intensity. This was done separately for telic and atelic predicates for all participants. Following the individual calculations, the average rate of nonmanual marker usage was derived for both DoD (15) and DoH (15) groups across the two event types, resulting in the overall marker intensity for each group.

4.3.3 Pose estimation

One of the primary objectives of this study was to identify potential differences between telic and atelic event predicates in terms of their movement dynamics and phonological motion profiles. To explore these distinctions, a technique called Pose Estimation (Google Research, 2024) was implemented. Pose estimation is a method in computer vision that automatically detects and tracks key points on the human body (like joints, hands, or fingertips) in images or video. It offers a novel and cost-effective alternative to traditional motion capture methods, which require specialized equipment like sensors or motion-tracking suits.

While motion capture is highly effective for precise motion analysis and calculation of certain values, it is not always practical due to its high cost, potential discomfort for signers, and limitations when working with larger participant groups. Pose estimation, on the other hand, offers a more accessible and efficient way to analyze larger datasets in a shorter time, making it a practical and economical tool for sign language research.

For these reasons, Pose Estimation has been increasingly adopted in sign language recognition and analysis**,** offering a practical methodological tool for extracting motion-based features that are relevant for linguistic investigation. Its implementation in this study provides a novel approach for examining the dynamic properties of event predicates in TİD.

4.3.3.1 Data processing

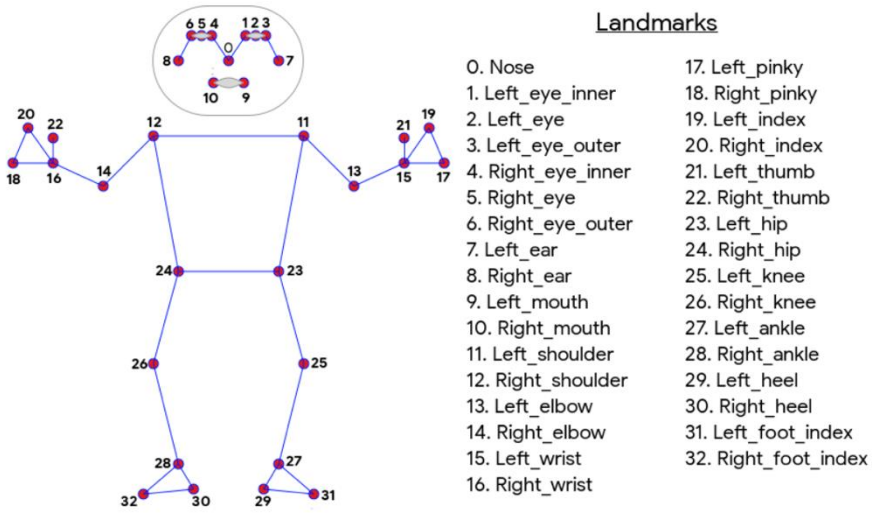


Figure 5. Key landmarks for human pose estimation, from pose landmarker model (reprinted from Google Research, 2025)

To identify the phonological motion profiles of telic and atelic events, two software tools were used: OpenCV (OpenCV, 2024) and Mediapipe (Google Research, 2024). OpenCV, which is an open-source computer vision library, was employed to process the video recordings of the participants. Mediapipe is a framework developed by Google that can detect and track parts of the human body, in this case, the hands. It was used to extract specific points on the hand (called *landmarks*, such as fingertips and joints) that could be tracked over time.

For landmark selection, a calculated point representing the average position of the five fingertips and the wrist was tracked (see Figure 6). This created a central point that represented the general location of the hand. The rationale for choosing this particular reference point stems from both the challenges inherent in computer vision and the characteristics of the dataset. In some frames, certain landmarks may not appear consistently, and selecting a single fingertip, such as the index finger, could lead to issues where the reference point is not visible due to the movement of the signer. This lack of visibility would disrupt the continuity of the data. To mitigate this, an averaged reference point was used that remains trackable across most frames, ensuring a more reliable and consistent data flow throughout the analysis.

In cases where the hand moves completely out of the camera frame and the reference point becomes entirely invisible, a value of 0 is assigned. This approach was chosen to avoid applying smoothing or prediction-based techniques, such as moving average method, which are often used in motion tracking. These methods estimate missing or unclear data by averaging nearby values or predicting future positions based on previous frames. While this can create a more continuous-looking motion, it also introduces assumptions that may not reflect the actual recorded

behaviour. In this analysis, only clearly visible frames were used to ensure the data represents what was directly observed in the video.

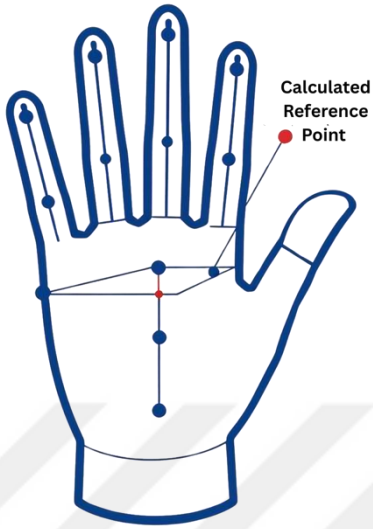


Figure 6. Tracked hand landmark as reference point for motion analysis

Once the reference point was established, its movement along the horizontal (x) and vertical (y) axes was initially tracked to compute its spatial positions in each frame. From these tracked positions, relevant derivative values of motion were calculated: how fast the hand moved on average (*average velocity*), how fast it moved at its peak (*peak velocity*), and how long each movement lasted (*duration*). These were calculated for a total of 386 signs (204 telic, 182 atelic).

Among all the calculated values, the focus was placed on average velocity. This decision was based on two primary considerations. First, peak velocity was not emphasized because certain signs may reach their peak velocity toward the end of the sign, at which point the hand may move out of the frame and become invisible, hindering reliable calculation. Second, duration measurements depend on the frame rate of the camera, which can vary between devices. Consequently, if other researchers were to try to replicate the calculations using different cameras,

inconsistencies could arise, as the code might not yield the same results. In contrast, average velocity provides a more stable and reproducible measure, making it more suitable for further analysis.

Following the calculation of average velocity for each sign, *unit function graphs*, which are simplified step-like graphs that mark whether certain values meet a condition (in this case, whether the hand's speed at a given moment exceeds the average), were generated. These graphs illustrate how often the peak movement values rise above the average velocity line during each sign. Box plot graphs were then created to visualize the distribution of velocity motion around a specific axis. Given the substantial presence of outliers (extremely high or low values) within the dataset, the median was used instead of the average, as it provides a more robust measure of central tendency and gives a more reliable picture of typical movement without being skewed by extremes. The results and interpretation of this data are discussed in the 'Results' section.

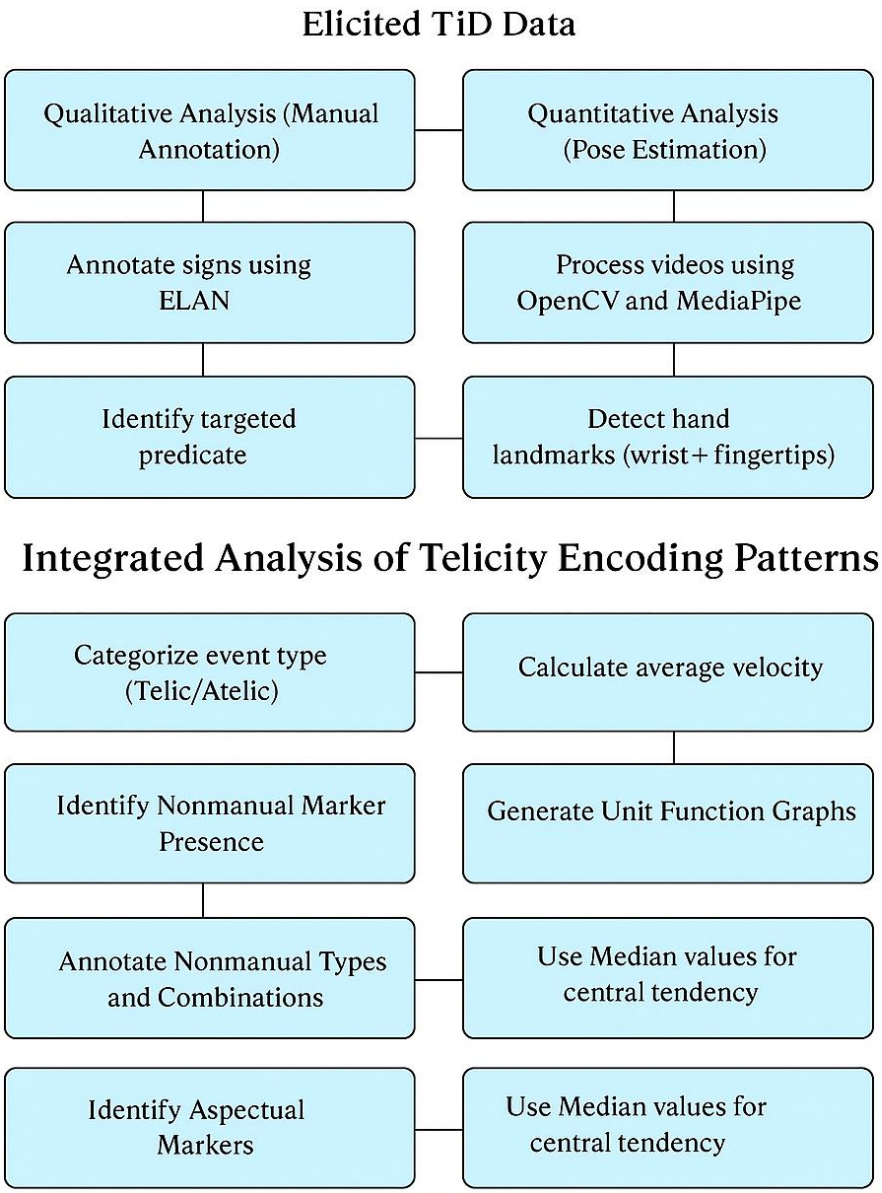


Figure 7. Combined insights into telicity marking

CHAPTER 5

RESULTS

5.1 Nonmanual marking of telicity in TİD

Previous studies (Wilbur, 2000; Zeshan, 2003; Pfau & Quer, 2010; Gökgöz, 2013; Benitez-Quiroz et al., 2014; Coşkun (2020); Karabüklü, 2024; Karabüklü & Gürer, 2024) have revealed that nonmanuals perform a variety of grammatical functions. This study also highlights their significance in expressing the underlying event structure in TİD, especially in relation to telicity. It is important to note that the present study examines nonmanual markers of telicity within the framework of "Situation Aspect," which centers on the inherent temporal properties of the event itself, independent of any subjective perspective or specific way of viewing the event.

5.1.1 The distribution of continuous – discontinuous nonmanuals by event types

Schalber (2004, 2006) previously proposed that mouth gestures in Austrian Sign Language (ÖGS) are sensitive to event structure. Similarly, Coşkun (2020) focused on the relationship between mouth gestures and event visibility in Turkish Sign Language (TİD), identifying a systematic correlation between adverbial mouth gestures and the telicity of predicate signs.

While Schalber and Coşkun's studies specifically focus on mouth gestures as markers of event structure, the present study extends this line of inquiry by examining a broader range of NM types in TİD. This study reveals that the distribution of two types of nonmanuals in TİD—continuous and discontinuous, each

with distinct morpho-phonological properties—is linked to event structure (Figure 8), offering insights into the marking of telicity in TİD.

As we mentioned earlier, continuous nonmanuals are characterized by their stable, consistent form throughout the articulation of the sign, exhibiting no changes during the duration of the sign. The results displayed in Figure 8 indicate that, while continuous nonmanuals appear in both event types, they are predominantly associated with atelic events as in example (3). In contrast, discontinuous nonmanuals, marked by a sudden and distinct change during the sign's production, are exclusively linked to telic events as in (4).

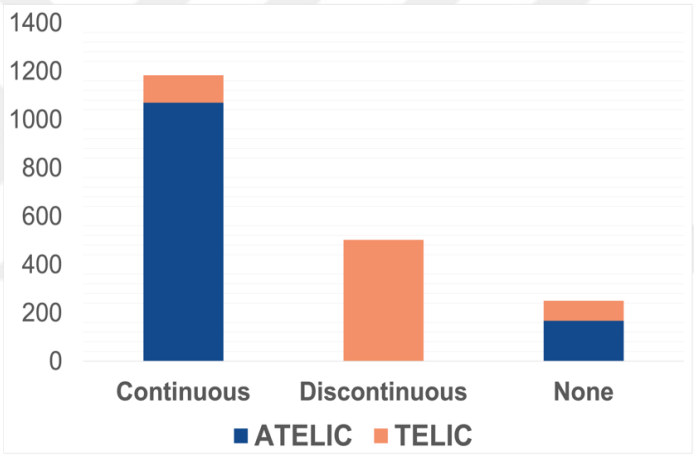


Figure 8. Distribution of nonmanuals by event types

However, as seen in Figure 8, nonmanuals are not always obligatory in TİD, as predicates can be produced without them[1]. Nonetheless, signers frequently accompany predicate signs with one or more nonmanual markers. This suggests that nonmanuals, even when optional, are preferred to reinforce event structure.

[1] Of course, there might be subtle nonmanual cues present in the None category in Figure 5 that are not detectable to the human eye. One could look into these with Pose Estimation face models, which we leave to a future study.

3) **‘WALK’ (ATELIC):** continuous mouth gesture, lips pushed forward

----------CAT---------- ----------WALK----------

- ‘The cat is walking.’

Figure 9. Continuous mouth gesture

4) **‘FALL’ (TELIC):** combination of discontinuous eye aperture, mouth gesture, cheeks, eyebrow, head movement

----------GOAT---------- -STAND (ON THE CLIFF)- -------FALL DOWN------

‘The goat stands on the cliff, then falls down’.

Figure 10. Combination of discontinuous nonmanuals

While these observations suggest a strong link between nonmanuals and event structure, a statistical analysis was conducted to formally evaluate this relationship. A chi-square test of independence was conducted to examine the relationship between nonmanual types (continuous, discontinuous, none) and event types (atelic,

telic). The results revealed a statistically significant association, $\chi^2(2, n = 1935) = 1248.28$, $p < .001$, indicating that the distribution of nonmanuals differed depending on the event type. The effect size, measured by Cramér's V, was 0.80, suggesting a very strong relationship between the two variables.

A standardized residuals analysis (see Figure 11 for a visualization of standardized residuals highlighting these associations) indicated that continuous nonmanuals were significantly overrepresented in atelic events (residual = 11.40, $p < .001$) and underrepresented in telic events (residual = -15.16, $p < .001$). Conversely, discontinuous nonmanuals were exclusively observed with telic events, showing a strong positive residual (residual = 23.81, $p < .001$) and a strong negative residual for atelic events (residual = -17.91, $p < .001$), confirming their absence in atelic contexts.

No significant deviations were found for the "None" category of nonmanuals. These findings provide robust statistical support for the hypothesis that continuous nonmanuals are associated with atelic events, while discontinuous nonmanuals are linked exclusively to telic events.

Standardized residuals heatmap illustrating the relationship between nonmanual types (continuous, discontinuous, none) and event types (atelic vs. telic) in TİD. Positive residuals (red) indicate that the observed frequency is significantly higher than expected, while negative residuals (blue) indicate that the observed frequency is significantly lower than expected. Asterisks denote the level of statistical significance ($p < .05$, $*p < .01$, $**p < .001$). The residuals demonstrate that continuous nonmanuals are predominantly associated with atelic events, whereas discontinuous nonmanuals are exclusively linked to telic events. The "None" category shows no significant deviations from expected frequencies.

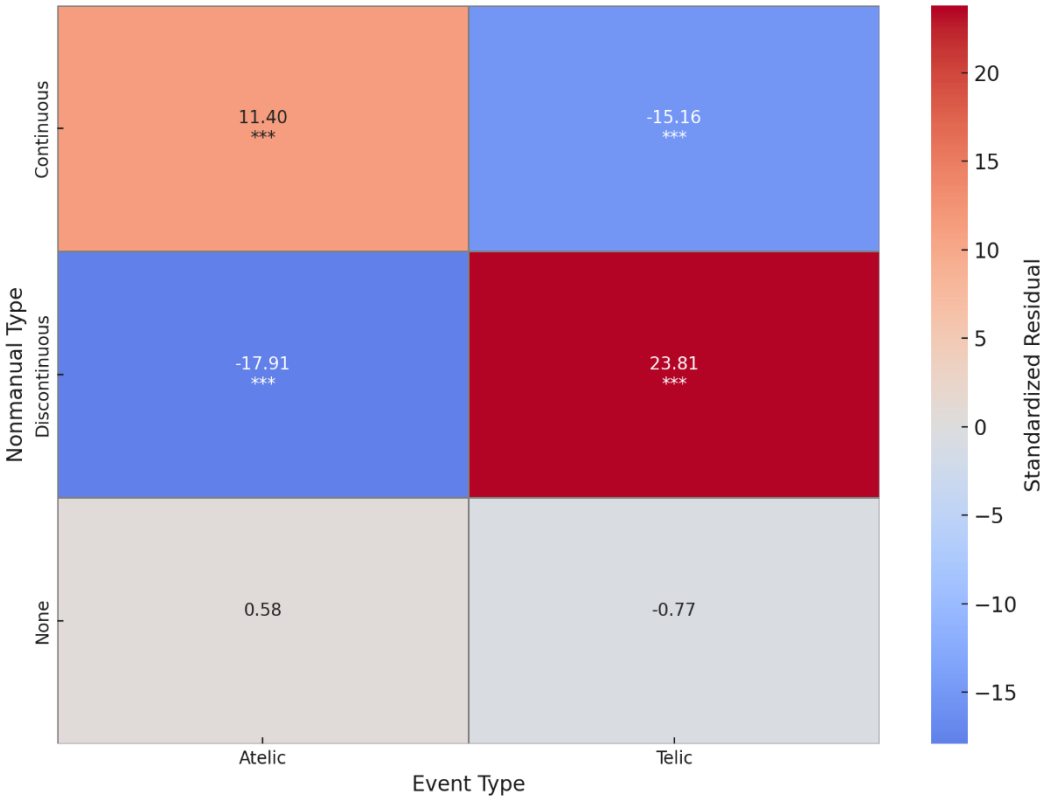


Figure 11. Standardized residuals with significance for nonmanuals by event type

5.1.1.1 Preliminary discussion

The findings indicate that continuous nonmanual markers, which remain consistent throughout a sign, are present across both telic and atelic predicates but predominantly accompany atelic events. This distribution suggests that continuous nonmanuals function as markers of processuality**,** emphasizing the ongoing, durative, and unbounded nature of activities and states. Their stability across the articulation of the predicate aligns with the semantic structure of atelic events, which lack a built-in endpoint.

In contrast, discontinuous nonmanual markers, characterized by abrupt changes during the production of the sign, were found exclusively with telic events. This **s**harp shift mirrors the event boundary inherent to telic predicates,

providing a visual-phonological cue for the culmination of an event. The abrupt transition highlights the change of state encoded within the predicate, thus serving as an indicator of event boundedness.

Overall, the distinct distribution of continuous and discontinuous nonmanuals supports the hypothesis that TİD signers differentiate telic and atelic events not only through manual phonological features but also through systematic nonmanual strategies. These results align with earlier findings from ÖGS (Schalber, 2004, 2006) and further reinforce the proposal that nonmanual markers contribute to the expression of situation aspect in TİD.

5.1.2 Preference for layering of nonmanuals

The data further reveal a consistent tendency among signers to combine multiple nonmanual markers simultaneously (5), rather than relying on a single marker (6). In most instances, signers frequently co-produce at least two nonmanuals simultaneously, instead of using them individually, as illustrated in Figure 12.

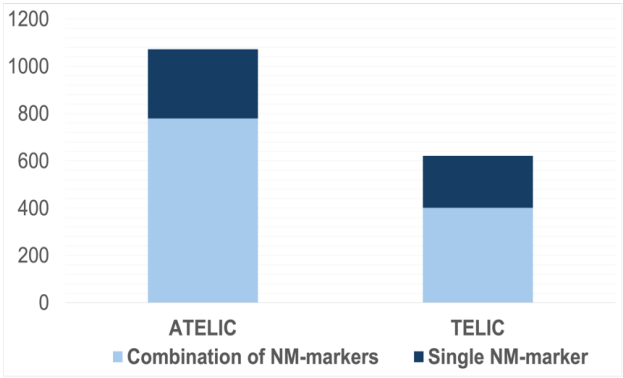


Figure 12. Preference for layering

5) **‘**SWEAT’ (ATELIC): combination of continuous eye aperture, eyebrow, mouth gesture, body movement

----------SUN---------- ----------VERY HOT----------

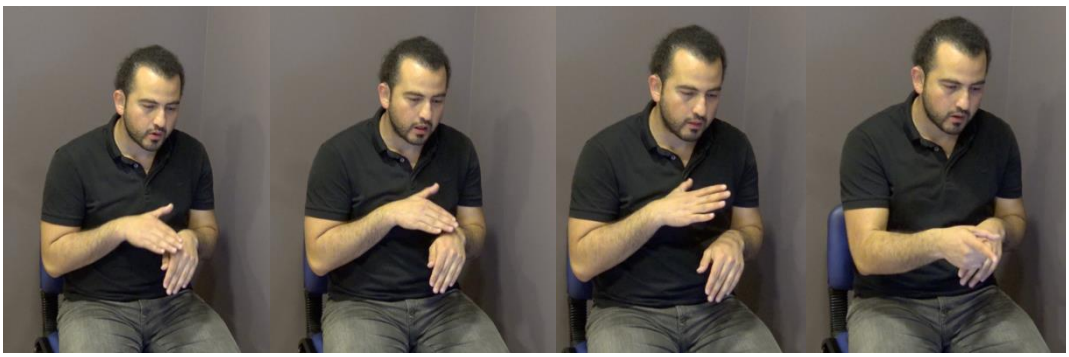
‘The sun. It is very hot.’

----------SWEAT----------

‘(He) is sweating.’

Figure 13. Combination of continuous nonmanuals

6) ‘SIT’ (ATELIC): single nonmanual marker, continuous puffed cheeks

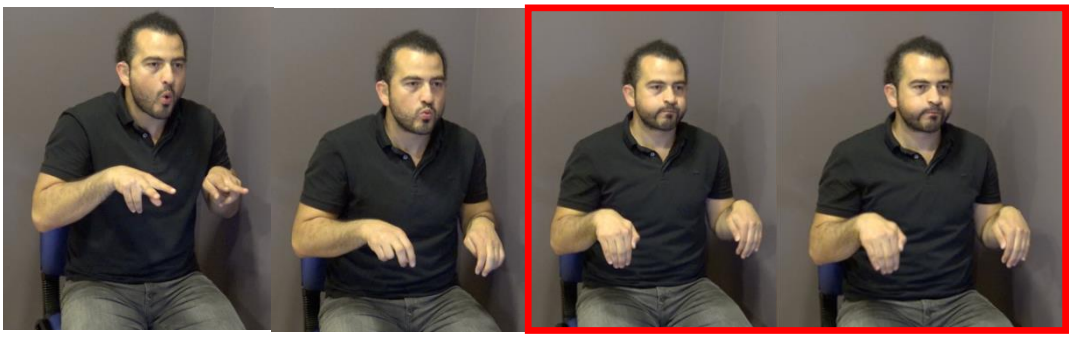


----------CAT---------- ----------THERE IS----------

‘There is a cat.’

-------WHITE------- ----------CAT---------- --THERE--

‘A white cat.’



----------SIT---------- ----------SIT:CL----------

‘(It) is sitting.’

Figure 14. Single nonmanual marker

To statistically evaluate the observed preference for combining nonmanual markers, binomial tests were conducted separately for atelic and telic events (see Figure 15). In both cases, combinations were significantly more frequent than single-marker use. For atelic events, the preference for combinations was statistically significant, $p < .001$. A similar preference was observed for telic events, $p < .001$. These results confirm that signers favour using multiple nonmanuals simultaneously, regardless of event type.

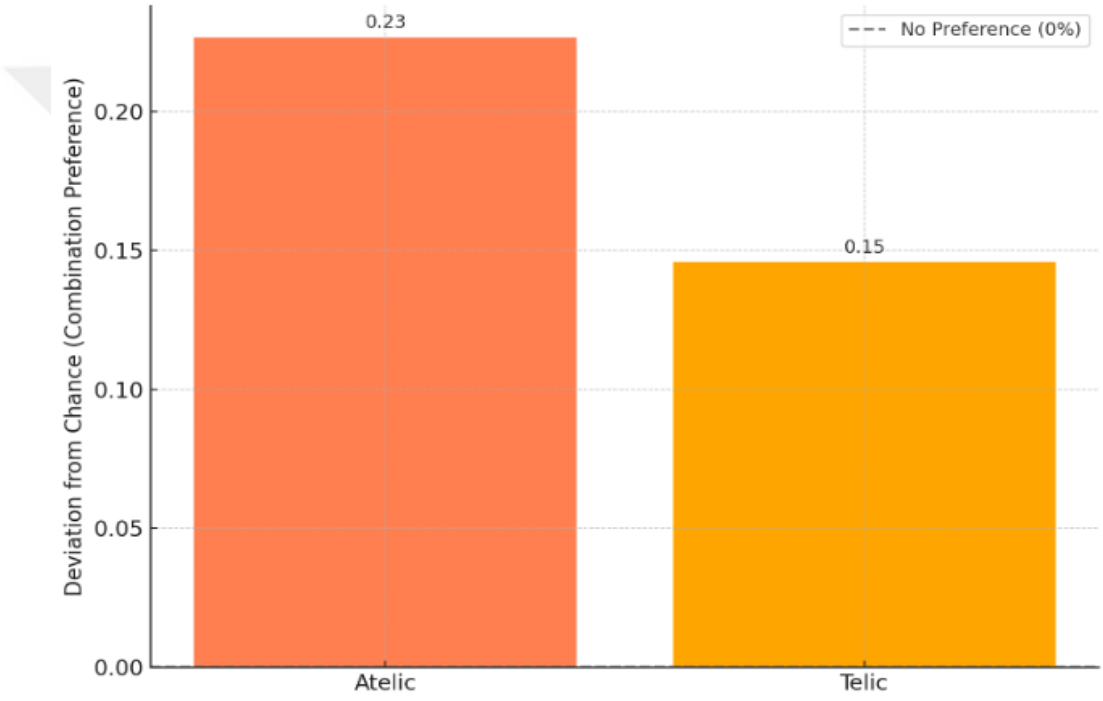


Figure 15. Deviation from chance-level preference for combination NMs

Deviation from chance-level preference (50%) for combination nonmanual markers across atelic and telic events in TİD. Positive deviations indicate a higher-than-expected frequency of combinations. Binomial tests confirmed that the preference for combinations was statistically significant for both event types ($p < .001$).

5.1.2.1 Preliminary discussion

The preference for combining multiple nonmanual markers, even when their use is not obligatory (as shown in Figure 2), suggests that signers strategically utilize layering as a means of reinforcing event structure. Rather than relying on a single nonmanual cue, signers frequently opt to use two or more markers simultaneously, enhancing the phonological salience of telicity marking.

In sum, the findings show that nonmanual markers in TİD are not used randomly but are systematically layered to reinforce distinctions in event structure. Building on these observations, the next section explores whether age of acquisition influences how signers employ these nonmanual strategies.

5.1.3 Age of acquisition effects in TİD: Quantity of nonmanual markers in telicity marking

The study also investigates the effects of age of acquisition (AoA) on nonmanual markers in TİD, comparing the expression of event structure through these markers between 15 Deaf of Deaf (DoD) and 15 Deaf of Hearing (DoH) signers. As discussed in the previous section, a significant cue for expressing telicity in TİD lies in the distribution of continuous and discontinuous nonmanual markers. The analysis reveals that there are no significant differences between DoD and DoH signers regarding the distribution of these nonmanuals across various event types, indicating that both groups employ them in a similar manner (Figure 16 and Figure 17). Specifically, discontinuous nonmanuals are found to be exclusive to telic events, while continuous nonmanuals are primarily associated with atelic signs in both groups.

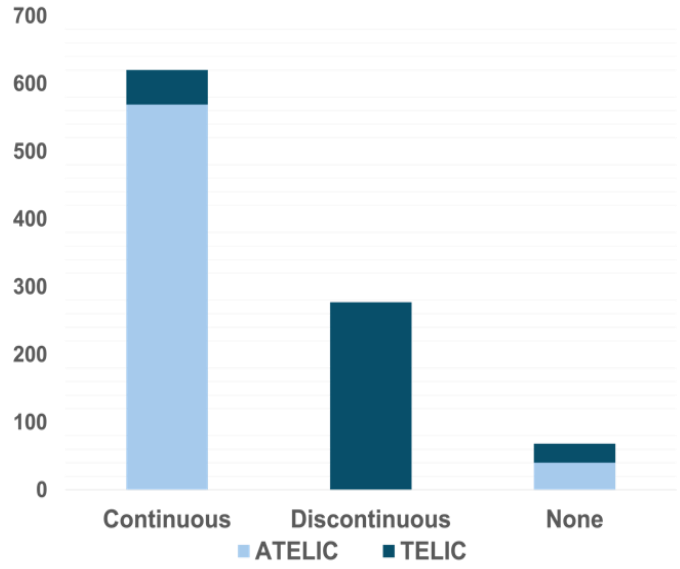


Figure 16. Distribution of nonmanuals by event types – Deaf of Deaf signers

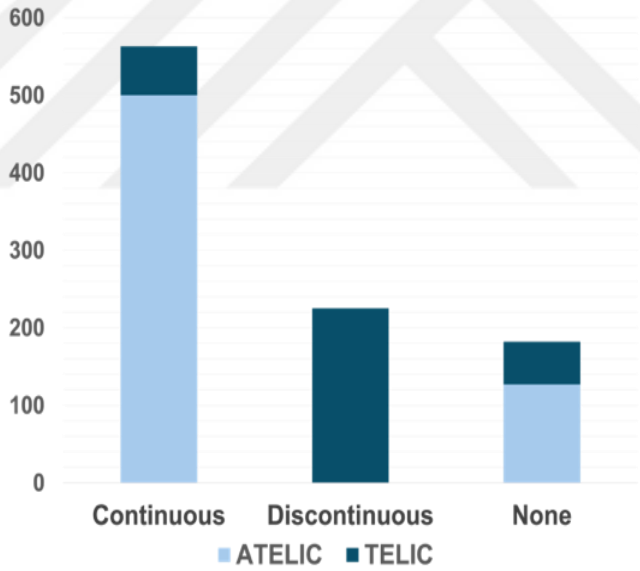


Figure 17. Distribution of nonmanuals by event types – Deaf of Hearing signers

Nonetheless, the current study reveals that the quantity of nonmanual markers used to express events is sensitive to AoA as we will see next.

5.1.3.1 The quantity issue

To investigate the effect of Age of Acquisition (AoA) on the use of nonmanual markers in telicity marking, I first calculated the average nonmanual marker intensity for telic and atelic predicates among Deaf of Deaf (DoD) and Deaf of Hearing (DoH) signers. This involved counting the total number of targeted predicates produced by each signer, distinguishing between telic and atelic types, and then counting the nonmanual markers accompanying each group of predicates. I then calculated the average marker intensity for each signer and derived the overall average marker intensity separately for the DoD and DoH groups.

Following this calculation, a two-way ANOVA was conducted with signer type (DoD vs. DoH) and event type (telic vs. atelic) as factors. The analysis revealed a significant main effect of signer type ($p < .05$), with DoD signers producing a higher quantity of nonmanual markers across both event types (Figure 18). No significant interaction was found between signer type and event type, and event type alone did not significantly influence marker quantity. These findings indicate that the observed differences in nonmanual marker quantity are attributable to AoA, rather than to the semantic properties of the event types themselves.

Coşkun (2020) found a similar AoA effect specifically for mouth gestures, where early learners (DoD signers) produced mouth gestures corresponding to the event structure of predicate signs more frequently than late learners (DoH signers), while the present study extends this observation to a broader range of nonmanual markers.

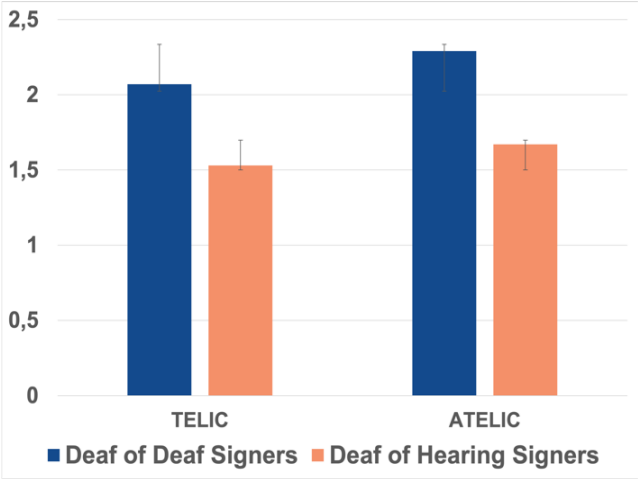


Figure 18. Average nonmanual marker intensity

5.1.3.2 Preliminary discussion

While morphosyntactic and pragmatic domains in TİD have been increasingly studied (Kayabaşı & Gökgöz 2023, Sevgi & Gökgöz 2023, Keleş et al. 2022, 2023), our understanding of AoA effects on morphophonological features**,** particularly as expressed by nonmanual markers**,** remained limited**.** By investigating the use of nonmanual markers in relation to telicity, this study provides new insight into how morphophonological structures may be shaped by AoA effects.

The absence of distributional differences between DoD and DoH signers suggests that the morphophonological encoding of telicity through nonmanual markers is a resilient feature of TİD, unaffected by the age at which the language was acquired. In TİD, the consistent use of continuous and discontinuous nonmanuals to mark atelic and telic events, respectively, appears to reflect a system that is robust across different acquisition profiles.

However, the significant difference in the quantity of nonmanual markers between groups points to an effect of AoA on the usage of nonmanual markers. The higher frequency of nonmanuals among DoD signers may indicate enhanced

articulatory control and greater sensitivity to nonmanual layering, likely fostered by earlier and more continuous exposure to TİD. By contrast, DoH signers, while employing the morphophonological mapping, exhibited less frequent use of layered nonmanuals. This finding aligns with broader critical period research, which has emphasized that the complexity of linguistic production are deeply shaped by early linguistic experience (Mayberry & Kluender, 2018; Lillo-Martin & Henner, 2020; Humphries et al., 2016).

In sum, while the inherent morphophonological system for encoding telicity in TİD appears resilient to AoA effects, the frequency of nonmanual layering seem more sensitive to early exposure. These findings reinforce the view that early and accessible exposure to a natural language, regardless of modality, is critical for the full development of a language's grammar**.**

5.2 Distribution of predicate forms by event types

Another significant cue for telicity marking comes from the distributional evidence of predicate forms in relation to event types, highlighting a correlation between manual forms and event telicity. Remarkably, a great majority of the iconic forms in the data are observed with atelic events (Figure 19) (i.e. *human body* for human and animal actions (7) vs. more representational use reduced to hands, such as whole entity (8), body part classifiers and lexical verbs).

This indicates that the nature of atelic events is more conducive to the occurrence of these forms. This can be attributed to the characteristic involvement of animate participants in atelic activities, often engaging in tangible actions. Additionally, atelic events provide a suitable context for expressing the manner of

movement (as seen in verbs like RUN, SWIM, DANCE). These findings suggest that the type of event influences the form of predicates in TİD.

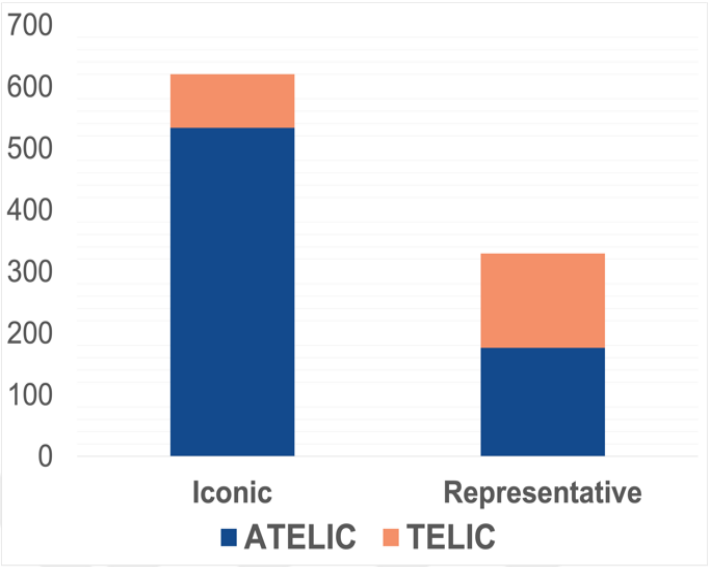


Figure 19. Distribution of predicate forms by event types

7) 'DANCE' (ATELIC): Iconic form

----------MAN---------- ----------WALK----------

'A man is walking.'

----------DANCE----------

‘He is dancing.’

Figure 20. Iconic predicate form of ‘Dance’

8) ‘COLLAPSE’ (TELIC): Representative form

----------HOUSE---------- ----------HOUSES----------

‘There are houses.’

----------COLLAPSE----------

‘(They) collapse.’

Figure 21. Representative predicate form of ‘Collapse’

To formally assess the relationship between predicate form and event telicity, a chi-square test of independence was conducted. The results revealed a statistically significant association, $\chi^2(1, N = 949) = 118.24$, $p < .001$, with a moderate to strong effect size (Cramér’s V = 0.35).

Iconic forms occurred predominantly with atelic events, while representative forms were more evenly distributed, showing a relative increase in frequency with telic events.

Standardized residuals (see Figure 22) confirmed that iconic forms were significantly overrepresented in atelic contexts, while representative forms were overrepresented in telic events.

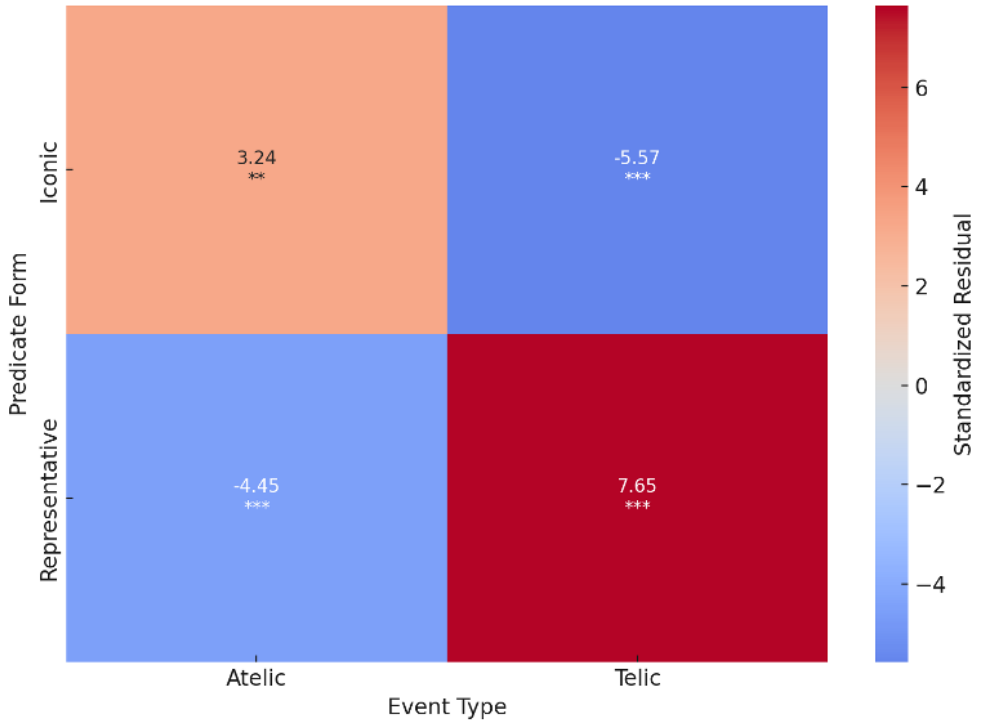


Figure 22. Standardized residuals: Predicate form by event type

Standardized residuals heatmap illustrating the relationship between predicate forms (iconic vs. representative) and event types (atelic vs. telic) in TİD. Positive residuals (red) indicate greater-than-expected frequencies, while negative residuals (blue) indicate lower-than-expected frequencies. Asterisks denote statistical significance ($p < .05$, $*p < .01$, $**p < .001$).

5.2.1 Age of acquisition (AoA) effects on predicate forms

To examine whether Age of Acquisition (AoA) has an impact on the distribution of predicate forms by event types, the data were analyzed separately for Deaf of Deaf (DoD) and Deaf of Hearing (DoH) signers. As shown in Figures 23 and 24, both groups display a similar pattern, with iconic forms predominantly occurring with atelic events, while representative forms are more evenly distributed between telic and atelic events.

The analysis revealed no significant differences between DoD and DoH signers regarding the distribution of predicate forms. This indicates that the mapping between manual forms and event types in TİD is a stable feature, unaffected by the age at which the language was acquired.

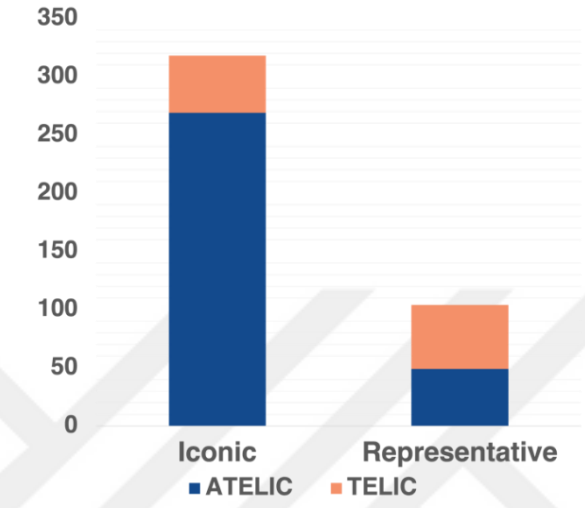


Figure 23. Distribution of predicate forms by event types – Deaf of Deaf signers

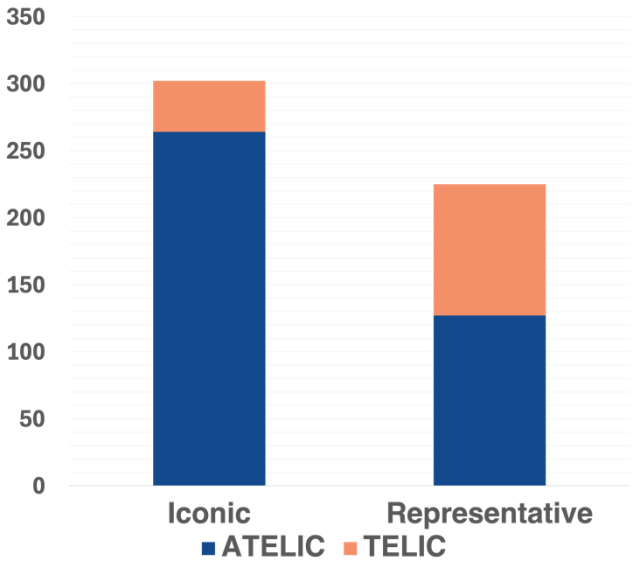


Figure 24. Distribution of predicate forms by event types – Deaf of Hearing signers

5.2.2 Preliminary discussion

A majority of the iconic forms observed in the data were associated with atelic events, suggesting that the nature of atelic predicates is particularly conducive to iconic representation. Several structural and semantic properties of atelic events likely contribute to this tendency.

First, atelic events are typically durative and unbounded, lacking a clearly defined endpoint. This temporal openness creates space for the expression of manner, allowing signers to depict how an action unfolds over time. In sign languages, previous research has shown that meaning is often encoded through iconic forms, where the visual representation of the sign resembles the movement or quality of the action itself (e.g., Supalla, 1986; Engberg-Pedersen, 1993; Emmorey, 2002; Liddell, 2003; Talmy, 2006; Perniss, 2007). Verbs like RUN, SWIM, and DANCE clearly show how the sign's form matches the movement of the action.

Second, atelic events frequently involve animate agents engaged in bodily actions. This animacy factor might promote the use of full-body iconic representation articulators, such as the use of torso, head, and arms, in addition to the hands. The broader use of the body enhances opportunities for iconic mapping, making the visual resemblance between the action and the sign more intuitive.

In contrast, many telic predicates appear more semantically lexicalized. Signs such as HIT, BREAK, and FINISH are typically realized through conventionalized and compact manual forms, with fewer opportunities for elaborate iconic depiction. One possible explanation for this pattern comes from what is known in the spoken language literature as Manner/Result Complementarity (Levin & Rappaport Hovav, 1991, 2006 2010; Levin, 2011). This principle suggests that individual verb roots tend to encode either the manner in which an action is carried out (e.g., *run, scratch*)

or the result it produces (e.g., *break*, *open*), but generally not both simultaneously. In this view, manner and result are in complementary distribution within the lexical semantics of individual verbs: if a verb specifies how an action is done, it tends not to specify what result it causes, and vice versa.

While this hypothesis has been formulated based on spoken languages, it may offer a useful lens for interpreting sign form in TİD as well. Applied cautiously to the current context, it is possible that telic predicates in TİD often lexicalize a result state**,** leaving less room for fine-grained expression of manner through form. As a result, these verbs may be realized in more fixed and representative forms. Atelic predicates**,** by contrast, may be more likely to highlight how an action is performed, since there is no specific endpoint to encode, and therefore may be more compatible with gradient, mimetic, and richly iconic representations. This perspective is consistent with the observation that iconic forms in TİD were more frequently associated with atelic events.

Taken together, these findings suggest that the structural properties of events, particularly durativity, animacy, and manner richness, shape the extent to which iconic strategies are employed in predicate formation in TİD. While the applicability of Manner/Result Complementarity to sign languages requires further investigation, it may help illuminate why certain event types lend themselves more naturally to iconic form than others.

Building on these observations about predicate form, the next section examines how kinematic properties further differentiate event types in TİD.

5.3 Movement dynamics analysis

One other important cue for telicity marking in TİD arises from the distinct phonological motion profiles that differentiate telic and atelic events. In our impressionistic observations, we noted that atelic signs are often produced with repetitive motion patterns, whereas telic signs are typically executed in a single instance.

Analysis of the velocity graphs of telic and atelic signs visually revealed that these graphs also illustrate this distinction in motion. Atelic signs typically exhibited harmonic motion, marked by multiple peaks above the average velocity line, suggesting rhythmic repetition and sustained action. This type of motion fits well with the semantics of atelic events, which are durative and lack a clear endpoint.

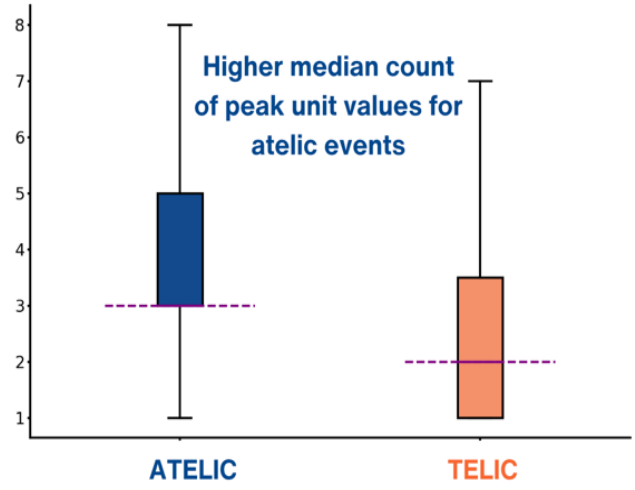


Figure 25. Peak unit values

To further validate this finding with a mathematical insight, the average velocity for each sign was calculated, and the frequency of peak unit values forming above the average velocity line was subsequently measured for each group. The results revealed a higher median count of peak unit values for atelic events (Figure 25), indicating a harmonic motion pattern that fluctuates around the average velocity

line (Figure 26). In contrast, telic events displayed more non-harmonic motion profiles, with typically one or two peaks above the average velocity line (Figure 27). These findings appear to validate our initial observations and confirm that these two event types possess distinct morpho-phonological motion profiles.

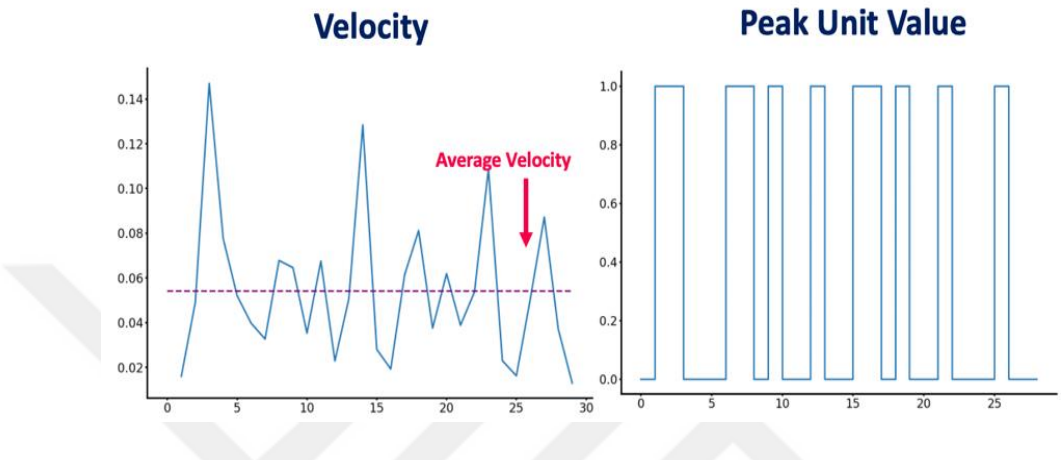


Figure 26. Velocity and peak unit value graphs of 'EAT' (ATELIC)

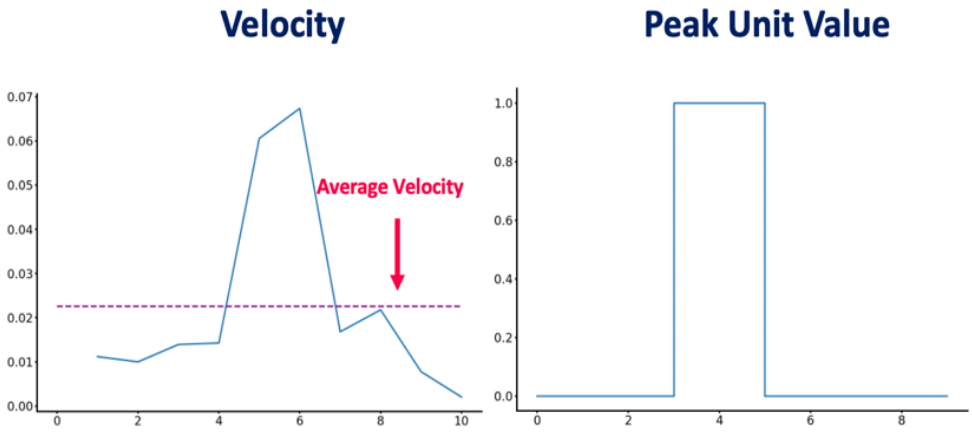


Figure 27. Velocity and peak unit value graphs of 'DISCOVER' (TELIC)

5.3.1 Preliminary discussion

Alongside nonmanual markers and manual predicate forms, the movement dynamics of events also serve as an important cue for telicity in TİD. The analysis of motion profiles through Pose Estimation revealed clear distinctions between telic and atelic events. Atelic predicates exhibited harmonic movement patterns**,** characterized by multiple rhythmic peaks above the average velocity line, reflecting the continuous and durative unfolding of action over time. In contrast, telic predicates displayed non-harmonic and less repetitive motion profiles**,** marked by fewer and more isolated peaks, corresponding to the bounded nature of telic events.

These findings suggest that the underlying event structure is systematically mirrored in the phonological motion patterns of TİD event predicates. The continuous and durative nature of atelic events is reflected in their harmonic and repetitive motion patterns, whereas the inherent endpoint of telic events corresponds to non-harmonic, less repetitive movement.

Importantly, these results are consistent with previous findings in ASL, HZJ, and ÖGS, where kinematic differences between event types have also been documented. However, the present study contributes methodologically by employing Pose Estimation, a cost-effective alternative to traditional motion capture systems, demonstrating that kinematic distinctions in signs can also be captured using accessible computer vision technologies.

5.4 Manual aspectual markers in TİD

While the primary aim of this study has been to investigate the representation of underlying event structure in event predicates, the data also revealed the use of various aspectual markers alongside these predicates. These markers offer additional

insight into how signers encode the internal temporal structure of events in TİD. Some of the observed markers align with previous findings in the literature, while others, to the best of our knowledge, have not been documented in earlier research.

All aspectual markers observed in the data, including new ones identified in this study, are listed in Table 6, which shows their distribution across atelic, telic, or both types of event predicates. The last four markers are new observations made in this study.

Table 6. Manual Aspectual Markers and Their Distribution Across Telic and Atelic Predicates

Aspectual Markers	Function	After Telic Achievement	After Telic Accomplishment	After Atelic Activity	After Atelic State
BİTTİ	'finished'	Yes	Yes	No	No
BİT	'finish'	Yes	Yes	Yes	No
HAZIR	'ready'	No	Yes	Yes	No
SON_2	'end'	No	Yes	Yes	Yes
DEVAM	'continue'	No	No	Yes	No
ÖYLECE_1	'as it is'	No	No	Yes	Yes
ÖYLECE_2	'as it is'	No	No	Yes	No

The table shows that BİTTİ ('finished') is exclusively used with telic events, being compatible with the completion of events with a natural endpoint (9).

9) After telic achievement ‘COLLAPSE’ – Completion

----------HOUSE---------- ----------HOUSES----------

‘There are houses.’

----------COLLAPSE---------- ----------FINISHED----------

‘(They) collapse. BİTTİ (‘finished’).’

Figure 28. Manual aspectual marker BİTTİ (‘finished’)

In contrast, BİT (‘finish’) is used with both telic and atelic events, indicating its compatibility with both the completion and termination of events (10&11).

10) After telic accomplishment ‘CLIMB & FALL DOWN’ - Completion

----------MOUNTAIN---------- ----------CLIMB----------

‘(There is a) mountain. (The goat) is climbing.’

---------- REACH SUMMIT ---------- ---------- REACH SUMMIT ----------

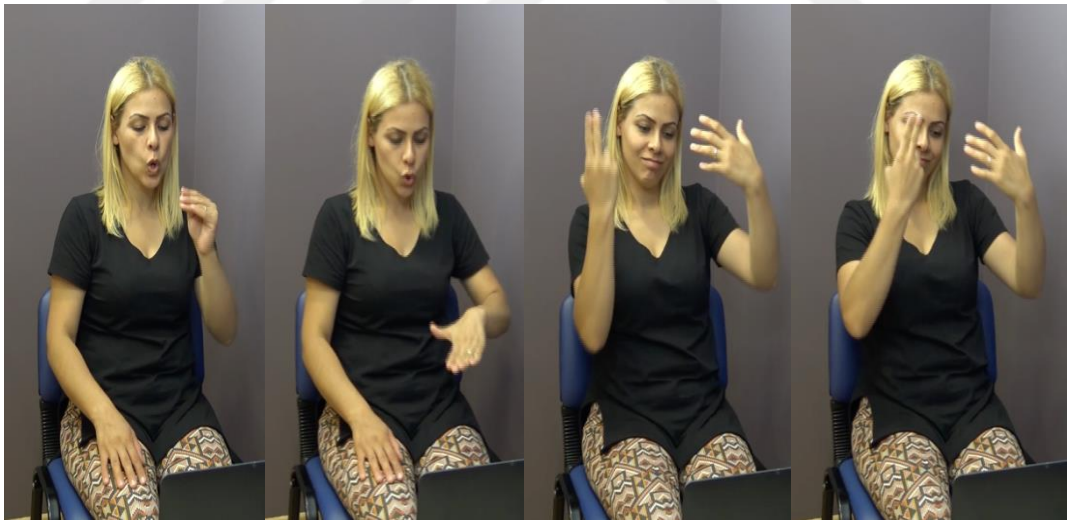
‘(The goat) has reached the summit.’

----------FINISHED----------

BİT (‘FINISHED’).

Figure 29. Manual aspectual marker BİT (‘finished’) after telic event

11) After atelic activity ‘PAINT’ – Termination



---------- LITTLE KID ---------- ---------- PAINT ----------

‘A little kid is painting.’

----------FINISHED----------

BİT (‘FINISHED’).

Figure 30. Manual aspectual marker BİT (‘finished’) after atelic event

HAZIR (‘ready’) and SON_2 (‘end’) both appear with telic accomplishments, but their usage patterns differ with atelic events. HAZIR (‘ready’) (12) appears to be compatible with atelic activities, suggesting that it is more suited for events that have a process-based structure. On the other hand, SON_2 (‘end’) (13) can occur after both atelic states and activities.

12) After atelic activity ‘PAINT’ – Termination

---------- LITTLE KID ---------- ---------- PAINT ----------

‘A little kid is painting.’

----------READY----------

HAZIR (‘READY’).

Figure 31. Manual aspectual marker HAZIR (‘ready’)

13) After telic accomplishment ‘WIN THE RACE’ – Completion

---------- HORSE ---------- ---------- RUN ----------

‘The horse is running.’

---------- FLAG---------- ---------- PASS----------

(The horse) passed the flag.’

----------END----------

END (‘SON_2’).

Figure 32. Manual aspectual marker SON_2 (‘end’)

DEVAM (‘continue’) is exclusively used with atelic activities, showing its compatibility with events that are durative and ongoing in nature (14). Its absence with atelic states suggests that it is compatible with dynamic events, highlighting the distinction between dynamic and static aspects within atelic events.

14) After atelic activity ‘WALK’ – Termination

----------CAT---------- ----------WALK:CL----------

‘A cat is walking.’

---------- CONTINUE----------

CONTINUE (‘DEVAM’).

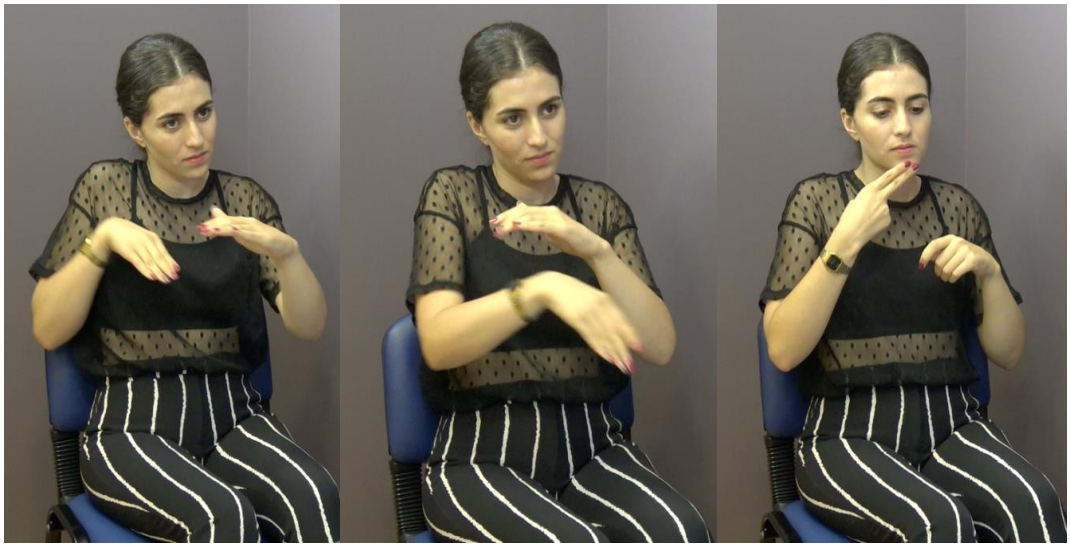
Figure 33. Manual aspectual marker DEVAM (‘continue’)

Lastly, both ÖYLECE_1 (‘as it is, without changing’)(15) and ÖYLECE_2 (‘as it is, without changing’) (16) appear to be exclusive to atelic events, indicating that they are compatible with events that are continuous in nature and remain unchanged over time. However, ÖYLECE_2 (‘as it is, without changing’) does not occur after atelic states, showing the same distribution as DEVAM (‘continue’), meaning that it is more compatible with events that are process-based and lack an endpoint. It should be noted that ÖYLECE_2 occurred only once in the entire dataset, suggesting that further research is needed to better understand its usage. The phonological forms of these manual aspectual markers are provided in Table 7 below.

15) After atelic state ‘LIE DOWN’ – Termination

---------- TENT ---------- ---------- SLEEPER BAG ----------

‘(There is a) tent and a sleeping bag.’



---------- INSIDE THE SLEEPING BAG ---------- ---------- GIRL ----------

‘(There is a) girl inside the sleeping bag.’

---------- LIE DOWN ---------- ---------- AS IT IS ----------

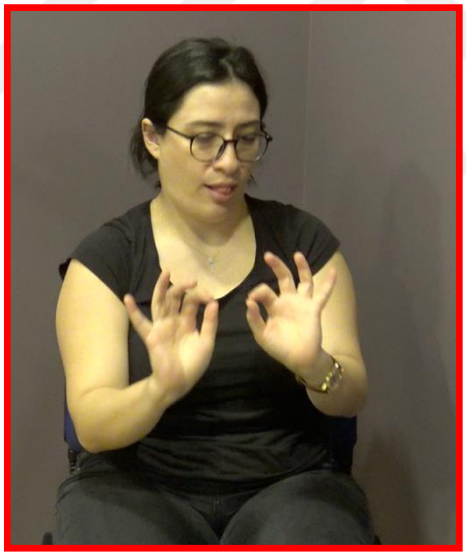
‘(She is) lying down. AS IT IS (‘ÖYLECE_1’).’

Figure 34. Manual aspectual marker ÖYLECE_1 (‘as it is’)

16) After atelic state ‘BURN’ – Termination

---------- CANDLE ---------- ---------- BURN ----------

‘The candle is burning.’

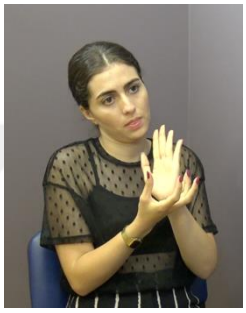
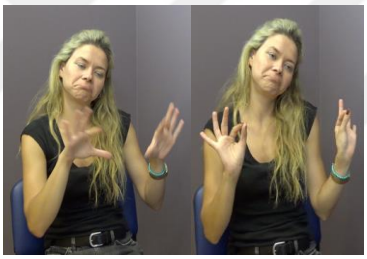


----------AS IT IS ----------

‘AS IT IS(‘ÖYLECE_2).’

Figure 35. Manual aspectual marker ÖYLECE_2 (‘as it is’)

Table 7. Phonological Forms of Aspectual Markers

Aspectual Markers	Phonological Forms	Aspectual Markers	Phonological Forms
BİTTİ (‘finished’)		DEVAM (‘continue’)	
BİT (‘finish’)		ÖYLECE_1 (‘as it is, without changing’)	
HAZIR (‘ready’)		ÖYLECE_2 (‘as it is, without changing’)	
SON_2 (‘end’)			

Overall, when comparing Deaf of Deaf (DoD) and Deaf of Hearing (DoH) signers, BİT is the most frequently used aspectual marker for telic events, while DEVAM is the most common marker for atelic events in both groups.

Interestingly, signers can also use two aspectual markers sequentially, as seen in the following example (17), where the signer first uses the aspectual marker HAZIR and then BİT after the atelic predicate "WRITE" to indicate the event's termination.

17) After atelic activity ‘WRITE’ – Termination

---------- WRITE ----------

‘(He) wrote (the letter)’.

---------- READY ---------- ---------- FINISHED ----------

‘HAZIR (‘ready’). BİT (‘finished’).

Figure 36. Sequential use of two manual aspectual markers HAZIR (‘ready’) and BİT (‘finished’)

5.4.1 Preliminary discussion

This study provides preliminary insights into the use of manual aspectual markers alongside event predicates in TİD. The findings suggest that signers often use these markers to add grammatical information about the internal temporal structure of events. Their distribution varies according to event type: some markers appear more frequently with continuous, process-oriented atelic events, while others tend to accompany telic events that involve a natural endpoint. A few markers show compatibility with both event types, suggesting a degree of flexibility in aspectual marking strategies in TİD.

When comparing Deaf of Deaf (DoD) and Deaf of Hearing (DoH) signers, BİT emerged as the most frequently used aspectual marker following telic events, while DEVAM was the most commonly observed marker with atelic activities across both groups. This pattern suggests that despite differences in age of acquisition, there may be shared tendencies in the use of aspectual markers in TİD.

Additionally, the data show occasional instances where two aspectual markers are used sequentially to elaborate event progression, which highlight the potential for layered aspectual expression through manual forms.

These findings contribute to ongoing discussions about the encoding of event structure in sign languages and highlight areas for future research on the interaction between aspect and event representation.

CHAPTER 6

DISCUSSION

This study set out to investigate how telicity is represented in Turkish Sign Language (TİD) across multiple articulatory domains, guided by three central research questions: (i) how manual and nonmanual markers represent underlying event structure and whether distinct patterns emerge across event types; (ii) whether kinematic profiles systematically differentiate event types; and (iii) whether Age of Acquisition (AoA) influences the marking of telicity in TİD. In exploring these questions, the study aimed to offer a comprehensive view of how event structure is made visible in TİD, drawing connections to broader theoretical debates in the field of sign language linguistics.

The findings reveal that TİD uses a multi-faceted system to mark telicity, involving the coordination of manual forms, nonmanual markers, and kinematic motion profiles. Each of these elements systematically appear to contribute to distinguishing between telic and atelic event types.

First, both manual forms and nonmanual markers play roles in expressing distinctions between telic and atelic events, indicating a systematic pattern linked to the underlying event structure of predicate signs. Continuous nonmanual markers, characterized by stable form and configurations, were found to appear in both event types but were particularly dominant with atelic predicates. This observation is consistent with findings from Austrian Sign Language (ÖGS), where continuous nonmanuals were similarly associated with durative, unbounded event types (Schalber, 2004, 2006; Schalber & Grose, 2006). In TİD, continuous nonmanuals appear to emphasize the ongoing and process-oriented nature of atelic events,

visually reinforcing the lack of an inherent endpoint. In contrast, discontinuous nonmanual markers, defined by abrupt changes in their configurations, were found exclusively with telic predicates. The use of discontinuous nonmanuals with telic predicates seem to visually highlight the semantic boundary of an event, again in line with Schalber's (2004) findings in ÖGS. These parallels suggest that the relationship between nonmanual patterns and event structure may extend beyond individual sign languages, supporting a cross-linguistic pattern.

Interestingly, even though nonmanuals were not obligatory for all predicates, TİD signers frequently layered multiple nonmanual markers simultaneously**.** Rather than relying on a single nonmanual marker, signers often combined mouth gestures, eyebrow movements, head movement and other articulators to strengthen the signal. The frequent co-occurrence of nonmanuals suggests that signers seem to work to reinforce the salience and transparency of event boundaries through visual redundancy.

Manual predicate forms further reflected distinctions tied to event type. Iconic predicate forms, those that use the human body to directly depict actions, such as running or swimming, were predominantly associated with atelic predicates. This association likely reflects structural and semantic properties of atelic events: their durative, unbounded temporal structure provides more opportunities for manner depiction through continuous, bodily forms. Activities like RUN, SWIM, and DANCE exemplified this trend, where the form of the sign mapped directly onto the dynamic properties of the action. In contrast, telic predicates were more often realized through representational forms (e.g., lexicalized verbs or classifiers on the hands) that encode goal-directed actions without necessarily depicting the manner of movement in a continuous way. This distribution suggests that the boundedness of

telic events encourages more conventionalized forms, possibly due to their focus on outcomes rather than processes.

The study also observed the use of various manual aspectual markers alongside event predicates. Markers like BİTTİ ("finished"), BİT ("finish"), and DEVAM ("continue") allowed signers to talk about the internal temporal structure of events. BİTTİ was strictly associated with telic events, compatible with clear event completion, while DEVAM appeared predominantly with atelic activities, highlighting their durative and ongoing nature. BİT showed flexibility, occurring after both telic and atelic predicates, suggesting a broader range. The occasional sequential use of two aspectual markers, for example, HAZIR ("ready") followed by BİT after an atelic predicate, points to the compositional potential of aspectual marking strategies in TİD. While this phenomenon was rare, it suggests that signers can layer temporal meanings when necessary to provide a more detailed event structure.

Kinematic analysis using Pose Estimation provided additional support for the distinction between telic and atelic events. Quantitative analysis of velocity profiles revealed that atelic predicates often exhibited harmonic, repetitive motion patterns**,** with multiple peaks above the average velocity line. This pattern reflects the continuous, durative nature of atelic events and is consistent with previous observations in ASL, ÖGS, and HZJ, where kinematic differences between event types were reported (Malaia & Wilbur, 2012; Malaia, Milković & Wilbur, 2013; Krebs et al., 2021). In contrast, telic events displayed non-harmonic, less repetitive motion**,** with one or two prominent peaks, aligning with their bounded, result-oriented nature. Importantly, the use of Pose Estimation in this study offers a novel methodological contribution, demonstrating that such distinctions can be captured

through more accessible tools compared to traditional motion capture techniques. Using Pose Estimation makes it easier to collect larger amounts of data and study signers in more natural settings, since it does not require intrusive equipment. Although it is less precise than traditional motion capture for tracking depth, it still captures the important two-dimensional movements needed for analyzing phonological patterns in sign languages. Its successful implementation here points toward the growing role of computer vision tools in the field of sign language linguistics.

In examining AoA effects, the study found that the basic patterns of telicity marking through manual and nonmanual elements remained consistent across signer groups. Both Deaf of Deaf (DoD) and Deaf of Hearing (DoH) signers used continuous and discontinuous nonmanuals in similar ways across different event types. These results suggest that the connection between event structure and phonological form is a resilient property of TİD, not easily affected by when a signer acquires the language. This stability may reflect deeper cognitive patterns in how humans represent events, as suggested by Strickland et al. (2015).

At the same time, differences did emerge in the quantity of nonmanual markers used. DoD signers produced a greater number of nonmanuals across both telic and atelic events. This suggests that while the morphophonological encoding of telicity remains consistent, the density of nonmanual markers may be more sensitive to early language exposure. It is possible that early exposure facilitates more refined articulatory control and greater sensitivity to layering strategies, where multiple articulators are used simultaneously for grammatical purposes.

These findings add an important perspective to Age of Acquisition (AoA) research, suggesting that morphophonological features, particularly the use of

nonmanual markers, can be shaped by early language experience, alongside previously documented effects in morphosyntax and pragmatics. Previous research on TİD, including studies by Karadöller et al. (2017, 2021, 2022), and Kayabaşı & Gökgöz (2023), has shown that late-exposed signers tend to use fewer complex morphosyntactic structures, particularly in areas such as classifier constructions. Similar trends have been reported for other sign languages, including ASL, where late learners often show challenges in acquiring and using complex morphosyntactic structures, such as inflectional morphology and classifier systems (Newport, 1990; Mayberry & Eichen, 1991; Boudreault & Mayberry, 2006). Together, these patterns across languages reinforce the idea that certain areas of grammar are particularly sensitive to the timing of first language exposure.

Beyond the specific findings on telicity marking, this thesis highlights the importance of early and accessible exposure to a natural language input for deaf children to support their full linguistic and cognitive development. Research across languages shows that early exposure is essential not just for morpho-syntax and phonology, but also for broader cognitive, academic, and social development (Humphries et al., 2016, 2019; Mayberry & Kluender, 2018). In Türkiye and elsewhere, many deaf children born to hearing families face delayed access to sign language, often not receiving consistent TİD input until school age (Sarı, 2006; İlkbaşaran, 2015). Even then, instruction quality can vary, with many deaf schools lacking fluent TİD instructions (Ministry of National Education, 2020; Keleş, 2023).

By examining how AoA shapes morphophonological features like nonmanual marking, this thesis not only expands our understanding of telicity marking in TİD but also supports the broader goal of creating accessible language environments for all deaf individuals.

Overall, the findings of this study support the central claims of the Event Visibility Hypothesis (Wilbur, 2003, 2008): that event structure is directly encoded in the phonological properties of predicate signs. In TİD, telicity emerges through a multi-layered integration of manual forms, nonmanual markers, and motion dynamics, making the internal structure of events visibly accessible to interlocutors. These findings show how underlying event structures are made visible through a variety of cues in the visual-spatial modality.

Beyond TİD, these findings contribute to broader typological and cross-linguistic studies. They show that TİD uses similar strategies for marking telicity as other sign languages. At the same time, they highlight the importance of looking at multiple cues, manual, nonmanual, and kinematic, when studying how languages represent events. Cross-modality studies in spoken languages can also benefit from this approach, by exploring how different channels work together to express telicity.

Table 8. Summary of Findings: Cues for Telicity in TİD

Feature	Telic Events	Atelic Events
Continuous Nonmanuals	Observed (less frequent)	Predominantly observed
Discontinuous Nonmanuals	Exclusive	Not observed
Iconic Forms	Observed (less frequent)	Predominantly observed
Motion Pattern	Non-harmonic motion	Harmonic motion
Aspectual Markers	BİTTİ (exclusive); others used with both types	DEVAM, ÖYLECE_1, ÖYLECE_2 (exclusive); others used with both types

CHAPTER 7

CONCLUSION & FUTURE WORK

This study demonstrates that telicity in TİD is a complex, multidimensional phenomenon marked by various cues, including nonmanuals, manual forms, and movement dynamics (measured using cost-effective Pose Estimation technology). Comprehensive accounts of telicity in other (sign) languages might also benefit from investigating multiple potential cues.

As a next step, further research could focus on examining individual predicates. While event predicates are categorized as telic or atelic in this study, each predicate has not yet been analyzed separately. It would be particularly valuable to investigate how a single predicate marks telicity through its own phonology, specifically through changes in its prosodic features. This would provide further insight into how predicates in TİD utilize phonological parameters to express event structure. Moreover, the experiment's stimuli comprised both static images and GIFs. This modality contrast may have shaped how signers marked events. Because the current study did not test for stimulus-type effects, future research could systematically compare signer responses to static images and GIFs.

Additionally, while this study explores manual aspectual markers as part of viewpoint aspect and analyzes their compatibility with telic and atelic events when accompanying predicates, the manual aspectual markers themselves warrant more detailed, fine-grained investigation. Future research could investigate which manual aspectual markers co-occur with specific predicates and analyze the complex structures they form. It would also be of interest to explore how these complex structures are acquired by deaf children.

Another area for future research could involve investigating whether nonmanual markers alone can provide clues about event structure, and whether nonsigners can match the telicity value of predicates based solely on these markers. A potential experiment could involve nonsigners watching signers produce event predicates with nonmanuals while hiding the hands (Personal communication with Prof. Diane Lillo-Martin). This would deepen our understanding of how nonmanuals contribute to expressing event structure. Furthermore, examining the threshold at which signers perceive a sign's telicity would also be an insightful topic for future exploration. For instance, investigating when a sign's movement clearly signals whether an event is telic or atelic could be done by showing sign frames to signers and asking them to identify the telicity value at each stage. Another potential direction for future work involves quantitatively analyzing nonmanual markers using pose estimation, which presents challenges due to the complexity of facial muscle movements and would require advanced facial recognition technology.

Finally, I would like to investigate the neural processing of telic and atelic verb predicates in TİD and compare these findings with those of American Sign Language (ASL). This comparative study could shed light on the relationship between movement dynamics of signs and their form-to-meaning mapping, offering insights into the neurocognitive mechanisms underlying event structure processing in sign languages and contributing to broader discussions of cross-linguistic and cross-modal patterns in language processing

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