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ICONICITY IN GRAMMAR:
TYPOLOGICAL PATTERNS IN SIGN LANGUAGE CLASSIFIERS

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Acknowledgments

Ten years ago, when I walked unannounced into the office of the linguistics teaching assistants at Boğaziçi University and asked what it would take a young and lost copywriter and graphic designer who works in architecture to get a graduate degree in linguistics, I did not know the first thing about the field, let alone how much I would come to love it and this far. I would like to express my gratitude to the friends, family members and mentors who have been with me physically and mentally throughout this decade of learning.

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Abstract

Sign languages employ iconic strategies in their morphology in expressing spatial relations. These strategies, while iconic, are incorporated into the grammatical system and follow certain linguistic rules. One environment where we see an extensive use of iconic morphology is the instrumental classifier predicate. The three sign languages studied in this dissertation, American Sign Language (ASL), Hong Kong Sign Language (HKSL) and Turkish Sign Language (TiD), although unrelated, use the same two iconic morphological strategies as their main means to encode instrumental classifier predicates: (i) Handling iconicity, where the linguistic articulator hand represents the body part hand, and (ii) Object iconicity, where the linguistic articulator hand represents some physical property of an object other than the body part hand. While these two strategies are available to the morphologies of all three sign languages, they use them in different quantities and in different ways. I argue that these differences are a result of typological differences among the three languages.

The main purposes of this dissertation are to describe the environments in which these two strategies are observed and to offer an explanation to why one type of iconic strategy is more strongly associated with certain environments than the other. I do this by investigating a controlled set of experiments with the help of analytical tools from Information Theory, psychology, and statistics. My findings show that, with respect to classifier predicates, HKSL and TiD behave more similarly to one another than ASL does to either language. I call the former two languages 'Iconic Agreement' languages, and ASL a 'Grammatical Agreement' language. Iconic Agreement languages are typically highly sensitive to the perceptually salient

components of an event in choosing the suitable iconic type for its description. In these languages, Handling and Object strategies have a more diffuse distribution than Grammatical Agreement languages such as ASL, where the two strategies have a more clearly defined set of grammatical duties than the ones in Iconic Agreement languages. These grammatical duties include marking agency (Handling iconicity) and unaccusativity (Object iconicity). Iconic Agreement languages, on the other hand, follow a series of filters in determining the morphological strategy in the classifier predicate. These filters include lexical conventionalization, typicality, and event semantics. Moreover, my findings show that while the tendencies point to a typological distinction, in the two proposed language types we can still see the effects of the other, albeit at a lesser degree. This has implications for the interlacing status of the gestural modality with the language faculty. This dissertation offers ways in which this stochastic nature of the two types of grammar can be exploited to offer insightful explanations to the forces that shape them.

1 Visual Iconicity in Linguistic Space

Sign languages have been at the center of much debate concerning their extensive use of iconicity in the linguistic signal. Language researchers went from completely rejecting sign languages as natural or full-fledged languages to inventing and leveraging empirical tests to prove that sign languages do follow linguistic rules systematically in the same manner as spoken languages do. Perhaps languages in the two different modalities (signed or spoken) do not always follow the same set of rules or they may display different morphological actualizations of the same cognitive rules that apply to both the signed and the spoken varieties of language. One such morphological building block of sign languages is the vast use of visual iconicity in the many components of their grammar. Iconicity can best be described as a non-arbitrary connection between a linguistic form and its meaning – a connection that is usually anchored outside of the linguistic system: analogies drawn from the nature and the physical world into the fabric of language production. Linguistic research on sign languages, in its infancy, had to leave iconicity in the dark. A premature acknowledgment of the role that the visual iconicity plays in language formation would impede research and jeopardize the linguistic status of sign languages. The misconception about iconicity in human language dates to the Saussurean view about 'Arbitrariness of the Sign' (1916). Since then, the tables have turned in favor of research on iconicity in sign languages. Recent lines of research take iconicity as an inherent property of human language that transcends the boundaries of spoken and signed languages and consider it a central ingredient of the many accounts proposed for understanding the intricacies of human language (see Perniss et al., 2010; Gibson et al. 2019).

This inclusive attitude toward iconicity has pushed the limits of linguistic research in favor of abandoning the old *black-or-white* understanding of the systematic tools of interpersonal communication. It has also toned down the widely accepted high thresholds that are enforced on the level of required arbitrariness in linguistic signal to be considered a language. The advances in theoretical, computational, and psycho-linguistic research have helped to navigate the academic focus to providing explanations to abstract concepts found in the building blocks of *Language* in a more effective manner.

In this dissertation, I study a highly iconic environment, instrumental constructions, in three unrelated sign languages with the aim of finding explanations to why and how signers make certain morphological decisions in building iconic constructions. I also address the question why these decisions show a great deal of variation. My findings show that the linguistic form is shaped by multiple intertwined factors that lie not only internal to the linguistic system but also elsewhere, that is, external to the grammar. Internal factors include various relations between the predicate and its arguments. External factors include the effects of lexical conventionalization and the perceptually salient properties of an event. The linguistic signal should be maximally distinctive and come at a minimal cost.

I show that perceptual salience can explain variation and argue that it is an overarching factor that straddles the factors that are internal to the linguistic system and the ones that lie externally. Perceptual salience regulates the distribution of morphological resources. It leverages iconicity as a cost-effective way of encoding information at all levels of linguistic compositionality; and therefore, iconicity plays a tremendous role in how sign languages are shaped. This dissertation takes a holistic approach to the phenomenon known as Language and seeks flexible answers to the stochastic behaviors of signers without overgeneralizing. In the final part of the dissertation, I tie my findings together in a predictive computational model to explain and replicate the typological variations found in the naturalistic data that I collected using a set of controlled experiments.

1.0 Introduction

Three genealogically unrelated sign languages are targeted in this dissertation. American Sign Language (ASL) is historically related to the Old French Sign Language, a language that was first noticed by the philanthropic educator Abbé Charles-Michel de l'Épée and later brought to North America by Laurent Clerc (Lane, 1984). Hong Kong Sign Language (HKSL) is related to Chinese Sign Language; however, the two languages are now mutually unintelligible (Sze et al., 2013). Turkish Sign Language (TiD) allegedly dates back to Seraglio Sign Language, a language of prestige used at the Ottoman Sultan's court (Miles, 2000). The main purpose of choosing three very distinct sign languages lies in the nature of the methodologies used in this dissertation. For model building that aims to be predictive and to build a typology, data samples from various unrelated sources are a necessity.

Instrumental constructions in sign languages, the focus of this dissertation, typically use what we call a classifier to encode certain grammatical relations in physical space. The term classifier was borrowed from studies conducted on spoken language nominal morphology (Allan, 1977) and has since become a popular umbrella term to refer to many different types of morphological formats. Some previous studies conducted on sign languages (see for instance Mandel, 1977 and DeMatteo, 1977) considered the constructions that we now call classifiers as pantomimic. According to these accounts, classifier constructions were nothing more than a visual depiction of an event in the physical world, almost like a snapshot. However, Supalla's seminal works since the 1980s (Supalla 1982, 1986), which were on ASL verbs of motion and verbs of location, showed that classifier predicates are sophisticated constructions with systematic subatomic structures and restricted distributions across the language with certain boundaries. The following pictures in Figure 1 depict what a classifier looks like in the three sign languages studied here:

FIGURE 1 Still frame from a stimulus vignette.

'Man tightening a screw with a screwdriver'. Sample responses from (b) American Sign Language, (c) Hong Kong Sign Language and (d) Turkish Sign Language depicting a classifier construction to the same prompt.

In the pictures in Figure 1 above, each signer is seen linguistically encoding the instrumental event 'tighten screw with a screwdriver' using a classifier construction in their respective sign languages. The 'instrumental' in instrumental event comes from the use of a screwdriver in carrying out the task of tightening a screw. If the task were to be carried out with bare hands, it would not be considered an instrumental event. At first sight it seems like signers are merely mimicking what they see in the video prompt (leftmost frame). The left (non-dominant) hand of the signers expresses the handling of the box where the screw is attached, and the right (dominant) hand encodes the activity of tightening a screw. However, a closer investigation reveals that the handshapes used are different across the three languages. The ASL signer (middle-left) uses a handshape where the index and middle fingers are crossed, making reference to the long and thin screwdriver moving in a swirl motion. The HKSL signer (middle-right) makes reference to the handling of the screwdriver. Finally, the TiD (*Türk İşaret Dili* – Turkish Sign Language) signer on the rightmost frame uses a single extended index finger. Moreover, the three handshapes can be put into two groups: (i) those that represent the screwdriver (ASL and TiD), called 'Object' iconicity in the literature, and (ii) those that represent the *handling* of the screwdriver (HKSL), called 'Handling' iconicity in the literature. A special type of Object iconicity, namely *Instrument*, is also discussed in the sign language classifier literature (Boyes-Braem, 1981; Supalla, 1986; Liddell & Johnson, 1989; Schick, 1990; Liddell, 2003; Brentari et al., 2012; Meir, 2001 among others). Instrument iconicity reflects not only the iconic representation of the tool but also how it is used (Padden et al. 2013). In that regard, Instrument iconicity is phonologically more complex than Object iconicity, because it also reflects the action associated with the tool. For instance, the sign for the noun TOOTHBRUSH in ASL has an extended index finger, which represents the physical properties of the toothbrush, as its handshape; and a right and left movement along the mouth that encodes its function for brushing teeth. In this dissertation, I do not make a distinction between Object and Instrument iconicities in the noun or the classifier forms. If a handshape reflects a physical property of the item or tool under investigation, I refer to its iconicity type as Object, regardless of whether it has a movement specified in the lexicon. Therefore, this dissertation is mostly concerned with the type of iconicity in the handshape, and not necessarily in the movement. We shall see in the following sections that this dichotomy between the two types of handshapes, Handling and Object, have a crosslinguistic morphosyntactic function. While signer responses resemble the video prompt for the most part, it is in these details, such as handshape type, that Language demarcates the boundaries of iconicity, entering the domain of morphology.

Spoken language and sign language classifiers are similar in that both types of language use morphological strategies to group certain nouns together with respect to some shared feature that they have. In the example above we have seen that the classifier for screwdriver in TiD is an extended index finger. The same form of classifier is used for other long and thin objects such as a pencil. Technically, classifiers are grammatically compatible with any one of the nouns that share a feature with the rest of the group. According to the World Atlas of Language Structures (Gil, 2013; WALS), spoken classifier languages are mostly concentrated in East and Southeast Asia, with some hotbeds also in West Africa, the Pacific Northwest, Mesoamerica, and the Amazon basin. Spoken language classifiers are typically used with numerals in the nominal domain. For instance, in Japanese, small and round objects are marked with the classifier 個 'ko' while thin and long objects are marked with 枚 'mai'. These classifiers typically come between a numeral and a noun and serve as a grammatical hub situated before the noun where the functional markers are hosted.

One big difference between spoken language classifiers and sign language classifiers lies in their grammatical neighborhood. Spoken language classifiers are typically used in the nominal domain (i.e., in the noun phrase or the determiner phrase[1]) whereas sign language classifiers, although still classifying nouns, are incorporated into the verbal complex. Another difference in the two environments is that classifier systems are present only in a restricted subset of spoken languages whereas there is only one signed language around the world which reportedly lacks a classifier system (Nyst – Adamorobe SL). Classifier systems are reported in a wide range of sign languages (Engberg-Pedersen, 1993 – Danish Sign Language; Kyle & Woll, 1983 – British Sign Language; Mathur & Rathmann, 2010 – German Sign Language; Pizzuto, 1987 – Italian Sign Language; Supalla, 1982 – American Sign Language; Wallin, 1994 – Swedish Sign Language; Tang, 2003 – Hong Kong Sign Language; Zeshan, 2003 – Turkish Sign Language). Sign languages use classifiers in multiple ways: from marking object localizations in space to more complex forms involving multiple discourse participants. This dissertation focuses on one use of classifiers, that of the predicate of an instrumental utterance, which is a classic example of a complex classifier predicate.

Sign language linguistics lie in a semi-secluded location within the field of linguistics and oftentimes the field is mistakenly seen as only tangentially relating to the dominant subfield of spoken language linguistics. Despite the misconceptions and stigma around sign languages as well as the limited availability of research over many years, research on sign languages has

1 This is not to say that verbal classifiers do not exist in spoken languages. Innu, an Algonquian language, has morphemes attach to the verb that categorize an argument in terms of shape or substance (see Drapeau & Brétière, 2011)

provided key concepts in understanding the human linguistic capabilities and cognitive processes that were previously unknown to researchers. Some of these concepts broaden the limits of the levels of linguistic representation and complexity, which were once deemed to have reached their limits. This has in part been possible thanks to the intersecting studies between sign language linguistics, psychology and gesture studies. Sign languages, despite their stand-alone positioning from spoken languages, serve the same communicative purposes and functions as spoken languages and enrich the ways linguistic complexity may manifest at the interdependent levels of compositional representation. Within the context of instrumental classifier predicates, we can talk about complexity at the phonological, morphological, semantic and syntactic levels.

I take the space in this chapter to elaborate on these levels of complexity with a focus on classifier constructions. I will first present the literature on the semantics of instrumentals, then an overview of how morphology interacts with phonology in sign language classifier constructions. I will then briefly talk about iconicity in Language and how spatial relations are encoded iconically in sign languages through the use of classifier predicates. By the end of this chapter, I will have shown to the reader that while sign languages are home to domain-specific structures, they do nonetheless follow the same abstract concepts that spoken languages do, regarding argument and event structure, thematic roles and representation at the morphemic level.

1.1 The Semantics and Syntax of Instrumentals

The first question to answer is what an instrument and an instrumental utterance are. Some scholars define an instrument as a "causal intermediary" (Talmy 1976, Croft 1991, Rissmann & Rawlins 2017). In other words, an instrument is seen as an intermediate step in a causal chain between an initiator and a direct object. The intermediary is therefore a tool that carries the burden of executing a task which facilitates the role of the agent. While the agent is in charge of utilizing the tool, it is the tool that ensures the successful execution of the task with the agent's maneuvering. In fact, in certain cases the task would not be accomplished without the use of a designated intermediary. Imagine being a tailor and not having a pair of shears to cut fabric or being a plumber and having to use your hands to tighten nuts on a pipe without a wrench. In both cases, the agents, the tailor and the plumber, would not be able to carry out their task successfully without the designated tool, if at all

Other researchers break the instrumental event into two subparts. They describe the instrument as the acted upon entity of the first part of a causal chain and the cause of its second part, the resulting state of the patient (Koenig & Davis, 2006). In other words, the agent, by way of handling a tool, manipulates it to alter a patient. The tool assumes shared agency with the agent. Fillmore (1968) attributes instrumenthood to the causal involvement of an inanimate force or an object on the action or the state identified by the verb. In all of these definitions, the overarching theme that is highlighted as the property of the instrument is its intermediary nature between an agent and a patient. This nature can further be organized by factors that correspond to the type of agent and the type of instrumental event. An agent's intentional control over an instrumental event is one such factor. Another factor is the nature of the instrument as an intermediary in a given environment enabled by the verb. The agent's involvement with the instrument and the instrument's involvement with the patient form what is referred to as the causal chain in semantics and it forms the basis of many discussions in this dissertation.

An instrument noun is a frozen form used to refer to a particular tool in the lexicon. When it is used to express the tool used in the linguistic encoding of an instrumental event, it assumes the thematic role of instrument. The instrument thematic role is an umbrella term used for a number of grammatical relations. Schlesinger (1995) proposes a three-way split in the instrument thematic role: (i) intermediary, (ii) enabling and (iii) ancillary. In this study, I focus on the first sub-role specifically: the intermediary. Another term for the intermediary is causally intermediate or direct instrument. I interpret direct causality as a semantic notion that captures the relationship between an instrument and the end state of the patient. The following sentences from English exemplify varying degrees of causality:

(1)

a. Jackie cut the wood **with a saw**. – *direct causality/intermediary*

b. Kat ate ice-cream **with a spoon**. – *indirect causality/enabling*

c. Adam climbed the parapet **with a chair**. – *ancillary*

Instrument-subject alternation (Fillmore, 1968) is a syntactic test used (Marantz, 1984; Ono, 1992; Schutze, 1995; Koenig et al., 2008) to show the different semantic natures of the examples above:

(2)

a. **The saw** cut the wood. – *direct causality*

b. #**The spoon** ate the ice-cream. – *indirect causality/enabling*

c. #**The chair** climbed the parapet. – *ancillary*

The examples above show that the direct causality displayed by an instrument enables it to be positioned in the subject position in English, even though the instrument is not anthropomorphized. The only salient interpretations of the sentences in (2)b and (2)c would be when the spoon and the chair were anthropomorphized. This distinction captured by the English data above is important in this study. Sign languages display differential marking in the classifier predicate when expressing an instrumental event with direct causality. Signers may use Handling or Object iconicity in the classifier predicate to express the instrumental event. The main theoretical goal of this dissertation is to account for the distribution of these two strategies.

Perhaps, this morphological distinction in sign languages is a reflection of the lack of consensus on the argument status of instruments in the literature. The instrument thematic role in spoken languages is sometimes considered to be encoded as an adjunct in the syntax. This brings with it some false assumptions that instruments are optional. The status of instrumentals as an argument vs. an adjunct is a controversial topic that is not agreed upon. Dowty (1989) considers them syntactically optional. Carlson and Tanenhaus (1988) take instruments as adjuncts because instruments do not participate in valency changing operations in the English language. Koenig et al. (2003) argues that the argument vs. adjunct status of an instrument constituent depends on whether or not the verb requires an instrument. Schütze (1995), Van Valin & Lapolla (1997) treat instruments as arguments or quasi-arguments, and they locate instruments in a different position than other event participants such as location and time. Some generativist linguists such as Pylkkänen (2002) consider the instrument constituent to be located in a "high" applicative projection in the syntax; therefore, not necessarily an adjunct position. In my dissertation, I take a neutral stance to the argument- vs. adjunct-hood of the type of instrumentals that I study, and present evidence that instruments, especially in sign languages, are likely more argument-like than the generativist framework presupposes.

Moreover, according to Fillmore (1968)'s Thematic Hierarchy of roles (Agent > Instrument > Theme/Patient), if the sentence has multiple arguments, the highest ranked one will become its subject. While very intuitive and attractive, Thematic Hierarchy has been highly scrutinized over the years. It does account for some argument realizations; however, it has very low coverage for explaining a large number of phenomena – and it is not clear how precise or how general the roles should be in order for Thematic Hierarchy to have explanatory power. Prominence and salience-based accounts have been put forth to explain where Thematic Hierarchy falls short (Bresnan & Kanerva, 1992). Structural prominence among the semantic interactions of a verb's arguments is likely to be linguistically encoded; and a hierarchy of salience is also likely to affect the grammatical processes that reflect the topicality of arguments relative to one another. Moreover, sign language grammars exploit the iconic affordances available to the visual modality to effectively encode event structure. A theory that builds on how iconicity shapes the grammar of sign languages is put forth in Wilbur (2008): EVENT VISIBILITY HYPOTHESIS. According to Wilbur's hypothesis, certain components of the structure of an event is encoded in the phonology of certain signed verbs. Aksionsart is one piece of information that is effectively visible in sign language grammars. In this dissertation, I study the interactions of perceptual salience and two types of transparent iconicity (Handling and Object) and argue in favor of a mechanism where the two forces come together to shape the form of classifier predicates.

In the following few sections, I zoom out and present some general concepts around the components that make a language. Sometimes these components are taken for granted and their applicability to sign languages is indisputably accepted. I provide an overview of linguistic compositionality and discuss key concepts that relate to classifier predicates and instrumental constructions. At the end of the chapter, I tie them all together in a section dedicated to sign language classifier predicates, specifically the instrumental kind.

1.2 Morphological Complexity and Its Interactions with the Phonology

Classifier predicates are composed of three main components discussed in sign language phonology literature: (i) a HANDSHAPE (i.e., the classifier), (ii) a MOVEMENT (i.e., the verbal core that also serves as the phonological nucleus, i.e., the 'vowel') and (iii) a PLACE OF ARTICULATION that encodes the classified object's relative position to other event participants (see Brentari, 1998; Sandler, 2006). The following images in Figure 2 below from TiD show the classifier construction part of the two different responses to the same experiment stimulus:

FIGURE 2 The phonological components of a classifier predicate.

[L] Handling classifier [R] Object classifier; both signs mean 'putting fan [on the table]'.

The signs PUT.DOWN.FAN[2] in Figure 2 above have three main components: (i) a single, top down, big *movement* in the elbow, (ii) two *locations* in space for the start and the end of the

2 The glossing conventions for sign language examples throughout the dissertation are as follows. Individual signs are glossed using English words. The period notation '.' (e.g., put.down.fan) that separates English glosses encode polymorphemic signs where the meanings indicated before and after the period make up a single phonological word. Sometimes a caret '^' is used between English glosses (e.g., pick^up), this notation is used when the two-word English gloss corresponds to a single monomorphemic sign in the sign language, such as phrasal verbs in English.

movement, and (iii) a certain *handshape* that classifies the noun fan. Both signs encode the same event and have the exact same form except for the difference in the handshape[3].

Morphemes and syllables reside at separate levels of linguistic representation. A syllable can be defined as a small sound or sign unit belonging to a limited number of phonotactically legal combinations in the grammar of a language (See Brentari, 1998; Clements et al., 1983; Deaton et al., 1990; Perlmutter, 1991). Spoken syllables typically host a single vowel which acts as the nucleus and carries the consonants attached to it. The phonological syllable does not bear meaning. Morphemes, on the other hand, are the smallest phonological units that do have a meaning. In other words, they are the building blocks of the semantics of a language (see Anderson, 2019 for a detailed overview of the notion of morpheme). Morphemes come together to form complex meanings. A morpheme can have one or more syllables, and sometimes it may be in the form of a consonant, which means it requires a host nucleus from the stem that it attaches to. The extent of a syllable is determined by how much dependent phonological material its nucleus can carry with respect to the specific phonological limitations of a language. For instance, we know that English words can start with a cluster of two or sometimes three consonants such as the words *STeep* [sti:p] (CCV:C) and *STReet* [stri:t] (CCCV:C). However, Turkish does not allow onset consonant clusters (*CCV, *CCVC, *CCVCC), while coda consonant clusters are allowed with certain restrictions that obey the sonority hierarchy (CVCC, VCC). Sign languages, as is the case with all human languages,

3 The difference in handshape will be elaborated on later in the chapter when I present classifier constructions.

respect certain rules in structuring their syllables and distributing their meaning bearing units, i.e., morphemes, across linguistic signals.

Sign languages use the gestural modality as the articulatory system to transmit information and the visual modality as the perceptual system to receive it. Spoken languages, on the other hand, use different channels to transmit (vocal modality) and to receive (auditory modality) information. These most fundamental differences between the two prevalent modes of human language create a dichotomy of systems that serve the same purpose of communication but with discernible particularities in their subcomponents (for a detailed account of the articulatory and perceptual systems of sign and speech differ see Meier, 2002).

The differences in the natures of the two modalities are manifested in how the atomic units of meaning as well as syllables are formed across modalities. Brentari (1998), argues that MOVEMENT is the locus of sonority in a sign syllable and therefore the syllable nucleus. Movement is visually the most salient part of a sign. Since sign languages, contra spoken languages, have multiple articulators with multiple sets of joints at different levels of the anatomy; multiple co-temporal movements happening at different joints is a possibility. Most signed classifier constructions are monosyllabic but polymorphemic. In other words, while they have one main movement and smaller movements nested co-temporally under the main movement, consonantal segments are exploited to add co-temporal meaning units attached to the nucleus.

Complexity at the morphological level can be measured in terms of how semantically-loaded a linguistic form is. Sign languages differ from spoken languages in one very important aspect: spoken languages tend to stack meanings horizontally while sign languages allow for heavier vertical stacking (see Aronoff et al., 2005). This is known as sequential (horizontal) vs. simultaneous (vertical) morphology. It has consequences for both how the morphology is structured and how it interacts with the phonology and semantics. In other words, while a single signed morpheme is likely to be monosyllabic but polymorphemic, a single spoken morpheme tends to span at least one and oftentimes multiple syllable nuclei. The following schemata in Figure 3 and the Turkish sentence in (3) below illustrate this distinction.

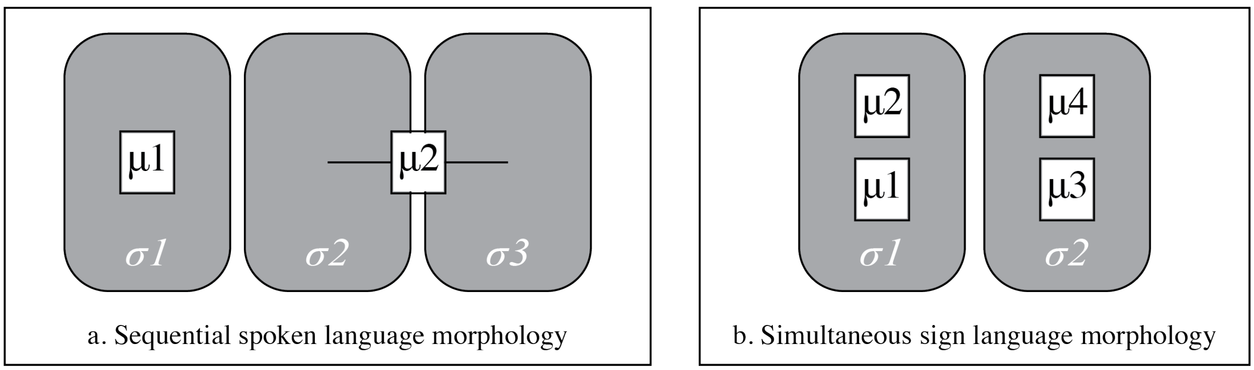


FIGURE 3 Distribution of morphemes (μ) across syllables (σ) in the two modalities.

(3) Sequential morphology – *horizontal stacking (Turkish)*

Bakan-ın	*özel*	*istek-ler-i*	*yerine^getir-il-me-meli*
minister-GEN	private	request-PL-POSS	grant-PASS-NEG-DEON

'The minister's private requests should not be granted.'

The schema on the left draws an impressionistic illustration of how syllables and morphemes are likely to be distributed with respect to one another in some spoken languages. One morpheme or less is available per one spoken syllable. In other words, the overall morpheme-to-syllable ratio in spoken languages is likely to be less than 1. The Turkish sentence above has 4 phonological words with morpheme-to-syllable ratios of 0.66, 0.5, 0.75, 0.44. The sentence has 10 morphological units (i.e., morphemes) expressed using 18 phonological units (i.e., syllables). The sentence-wide morpheme-to-syllable ratio is 0.55. This pattern of morphological sequentiality in spoken languages is of course not without exception. We see varying degrees of limited simultaneity especially in tone languages, Semitic languages[4], which have templatic morphologies, and also in small pockets of the morphologies of other spoken languages where contractions between two morphemes can occur[5]. However, the general trend points toward a sequential morphology for spoken languages[6] as depicted in Figure 3.

The schema on the right in Figure 3 above shows the sign language tendency to be structured simultaneously in the morphology. If we take syllables as atomic units in time, sign

4 A templatic morphology allows for presets of vowel bundles to vertically come between and separate a two- or three-consonant long verbal root for derivational and inflectional purposes (McCarthy, 1981). For instance, the abstract Arabic root ktb 'read' vertically merges with the templatic morpheme /CiCaC/ in a cogwheel manner and gives the noun kitab 'book'; or it merges with /Ca:CiC/ and gives ka:tib 'clerk'. The same two templatic morphemes can merge with the root htb 'address' and give hitab 'courtesy' and hatip 'preacher' respectively. Notice that, while templatic morphology does work vertically, it operates over multiple syllables, which is inherently different than the kind of simultaneity we find in sign languages with respect to the distribution of morphemes over syllables.

5 Such as the optional English /is/+/not/ > /isn't/ or the mandatory Turkish [i]-deletion in /gir/ 'enter' + /di/ PST + /im/ 1PS > [gir.dim]; /gir-di-m/ 'I entered'

6 Other forms of simultaneity can be found in the oral modality. Speakers may choose to emphasize, for instance, that a movie was looong by lengthening a vowel. This has an iconic flavor, and it does not necessarily add an extra morpheme to the utterance.

languages tend to stack one or more morphemes per syllable, making the overall morpheme-to-syllable ratio greater than 1. This is an affordance made available to sign languages by the visuo-spatial modality, which can use more than one articulator simultaneously (two manual and several non-manual articulators). It is, however, not just the number of articulators but also the iconic quality of the modality that is available to the subatomic parts of their phonology that allow for more simultaneous articulation of meanings in sign language morphologies. The example in Figure 4 below from Brentari (2019) shows how morphemes can be stacked on top of each other within a single time unit:

FIGURE 4 Polymorphemic classifier predicate in American Sign Language.

TWO-PEOPLE-HUNCHED–GO-FORWARD–CAREFULLY (Gloss and image obtained from Brentari, 2019).

According to Brentari, the ASL sign in the above picture has at least three morphemes in a single syllable. But in reality, there may be as many as seven morphemes stacked in a single time unit. These seven morphemes are (i) /TWO/ indicated with the use of two hands, (ii) /HUMAN/ indicated with the use of the index finger classifier, (iii) /HUNCHED/ indicated by the bent property of the index fingers, (iv) /GO/ indicated by the movement of the hands, (v) /FORWARD/ because the movement of the hands is oriented away from the signer, (vi) /CAREFULLY/ indicated in the nonmanual markers (the facial expression with pursed lips and squinted eyes), and lastly (vii) /SIDE-BY-SIDE/ indicated by the relative position of the hands. While all these meaning units can be inferred from the picture above, and the sign is most certainly polymorphemic, we cannot be sure how much of those units are linguistic and how much are gestural. Another problem with claiming that the sign has that many morphemes is with context. The signer would not be able to produce this sign in isolation. Classifiers are anaphoric and that means that they require overt antecedent nouns to license them. Can we then count /HUMAN/, i.e., the antecedent of the extended index finger classifier, as a morpheme? Or are anaphoric elements just a copy of their antecedents with no new information to offer and serve a functional purpose in the grammar such as linking the verb to its arguments?

Van der Hulst & Van der Kooij (2005) argue that the phonology and morphology of classifier predicates are conflated. This is a controversial statement but not one without an empirical basis. Sign languages undoubtedly have separate phonological and morphological systems, but it would be false to claim that these two independent components of linguistic representation do not extensively interact. We said that movement is the nucleus of a signed syllable (Brentari, 1998). Signers may alter the movement at the phonological level to fine grain the meaning it contributes to the whole. For instance, a sign can start with a straight path movement and change to an S-movement in order to convey the unsteady, wobbly movement of an entity, such as a drunk person. Similar subatomic adjustments can be made to other phonological components such as handshape, location and hand orientation with the consequence of new added meanings. This is not to say that sign languages have an unlimited arsenal of simultaneous morphology, nor is it to say that they lack monomorphemic-polysyllabic forms (for a discussion on crosslinguistic variation in simultaneous morphology see Brentari et al., 2020). Typical environments where we see constructions that express multiple meaning components while retaining their monosyllabic nature are classifier constructions and agreement verbs. The sentence in Figure 5 below is a question with a single agreement verb from Turkish Sign Language:

(4) Simultaneous morphology – *vertical stacking* (*TiD – Turkish Sign Language*)

FIGURE 5 Simultaneous morphology in Turkish Sign Language.

_________Q

$_{a}$CHEAT^ON$_{b}$

'Did [a] cheat on [b]?'

The question is composed of a single phonological word which has one movement: therefore, a single syllable. The starting and ending loci of the movement mark the agent, i.e., the cheater, in point [a], and the patient in point [b]. The movement itself encodes the semantic alignment of the act of cheating between two individuals. This is already three morphemes in one syllable. The suprasegmental question marker, another morpheme, annotated as ' __Q' consists of BROW RAISE and HEAD FORWARD, two nonmanual markers in TiD in the face and the head that are co-articulated with the single syllable in the manual articulator. This gives us a morpheme-to-syllable ratio of 4.0. The same sentence in Turkish, would be articulated as *'O ona ihanet etti mi?'* '3SG 3SG-DAT cheat do-PST-3SG QM', 8 morphemes distributed over 9 syllables in 5 words (morpheme-to-syllable ratio is 0.88). Brentari (2019) translates this interplay between the phonology and morphology of linguistic systems into a typology, where the number of syllables per word and the number of morphemes per word create a 2 by 2 grid. The following grid in Table 1 is an adaptation of her typology.

	Monosyllabic words	**Polysyllabic words**
Monomorphemic words	I *Hmong*	II *English*
Morpheme #	1 #noj#	1 #character#
Syllable #	1 .noj.	3 .cha.rac.ter.
m2s ratio	**1.0**	**0.33**
translation	‘eat’	‘character’
Polymorphemic words	IV *Turkish Sign Language*	III *Hopi*
Morpheme #	5 #a-give-money-b-Q#	3 #pakiw-maqto-ni#
Syllable #	1 .give.	5 .pa.kiw.maq.to.ni.
m2s ratio	**5.0**	**0.67**
translation	‘Did [a] give money to [b]?’	‘will go fish-hunting’

TABLE 1 Typological membership with respect to morpheme to syllable ratios. Table adapted from Brentari (2019).

According to this typology, the language-wide morpheme-to-syllable ratio in languages like Hmong, a Southeast Asian language, will be very close to 1.0. In such languages (quadrant I), one syllable maps neatly to one morpheme. In monomorphemic-polysyllabic languages like English (quadrant II) we expect the language-wide ratio to be lower than or equal to 0.5, because typically one morpheme spans multiple syllables. Languages such as the Native American language Hopi (quadrant III) should have a more erratic behavior but never a ratio greater than 1.0, as these languages are highly polysynthetic, i.e., the words are composed of multiple morphemes, and the. morphemes typically span multiple syllables. Interestingly, what we never find in quadrant IV is spoken languages. While polymorphemic-monosyllabic words do exist in spoken languages, they are not the majority of words that make up a spoken language morphology. Examples to this would include stem modification such as the d-t alternation in English verbs and their past tense forms (e.g., send~sent) or vocalic apophony (ablaut), again in English verbs (e.g., sing~sang~sung). Leaving these exceptions aside, the number of meaning components a syllable nucleus can carry in spoken languages is very limited. On the other hand, in sign languages polymorphemic-monosyllabic signs seem to be the rule, not the exception. The syllable nucleus in sign languages is highly capable of carrying multiple morphemes, some of which may be in the form of stem modification and without having to rely heavily on concatenation.

Classifier constructions might be morphologically as simple as a locative expression or an existential construction, or they might be more complex as is the case with the instrumental predicates that I study in this dissertation. The sentence in (5) below from my ASL data has a monosyllabic predicate that houses at least three morphemes:

(5) Simultaneous morphology in a classifier predicate in ASL – *vertical stacking*

domH: CUT.WITH.SCISSORS

nonDomH: HOLD(.HAIR)

FIGURE 6 ASL example of simultaneous morphology in an instrumental predicate.

In the same syllable, the ASL signer is encoding the meanings /SCISSORS/, /CUT/ and /HOLD.HAIR/. The handshape encodes scissors as the tool being used, the movement of the hand and the movement of the index and middle fingers encode the task of cutting hair. His non-dominant hand indicates that the hairdresser is holding the client's hair. In all signer responses that I received, such as this one, the classifier predicate hosts multiple morphemes in a single time unit. The multiple meanings partially arise from the participation of multiple articulators and their subcomponents, but sometimes, an articulator's specification may change mid-sign, such as the type of handshape, which means that a single sign syllable can carry even more semantic content than I previously presented.

In this section, I presented some notions around levels of phonological and morphological complexity as they pertain to a specific type of construction that we see in pretty much all documented sign languages to date: classifier predicates. I presented the linguistic concepts morpheme and syllable, and how classifier predicates behave with respect to these two atomic units that we find in the phonology and the morphology of all languages, spoken and signed alike. Before moving on to a discussion on the syntactic complexity of classifier predicates, I would like to elaborate on some notions that came up until this point.

In what follows, I briefly present studies on iconicity and gesture, and examine how the two concepts are intertwined with the lexicon and the morphosyntax of sign languages. We will see that classifier predicates belong to a component of the lexicon named the 'spatial lexicon' and that the morphophonological peculiarities of this class are an extension of the affordances made available to sign languages by the iconic nature of the visuo-gestural modality that they use. I will discuss these affordances with the context provided by making comparisons between linguistic arbitrariness, iconicity and gesture. I will then discuss how these paralinguistic concepts play an important role in the shaping of the linguistic components of sign languages including the lexicon. I will focus on their role in the intersectional environment of classifier predicates and later shift the focus to the syntax of classifier predicates. Finally, I will present a subset of the environments that use classifier predicates: instrumental constructions, the focus of this dissertation.

1.3 Iconicity in Language

Iconicity has been a controversial topic since Saussure (1916), who claimed that the linguistic signal needs to be arbitrary ("Arbitrariness of the Sign"). In other words, according to Saussure and Structuralists, there exists no (and later on, should not exist any) logical or intrinsic relationship between the signifier (the linguistic form) and the signified (the concept). This misinformed and overgeneralized induction had very serious consequences for the status of sign languages and sign language research for many years to come. Sign languages were claimed to be a series of manual gestures lacking structured complexity at any level of linguistic representation. It was not until William Stokoe (1960) and Tervoort (1959)'s influential works on American Sign Language that the view on sign languages had started to change.

The misconception about iconicity brings with it the assumption that being iconic and being linguistic are mutually exclusive notions. Sign languages are iconic, and they are natural human languages. We see iconicity one way or another in all layers of linguistic organization. What one must emphasize here is that despite the prevalence of iconicity in sign languages, they are linguistic systems with systematic organization in all aspects of their grammar. As Brentari (2019) puts it: 'the arbitrariness is in the organization of the system, not in the source'. In sign languages, we see an interwoven system of iconically-motivated representations and a structured set of linguistic rules from non-arbitrary sources. Signs may be iconic; however, the iconic flavor of signs is reorganized by the components at all levels of the grammar. Therefore, iconically motivated structures cannot be claimed to be unsystematic.

1.3.1 Iconicity in Signed and Spoken Languages

> Iconicity is a resemblance between a linguistic item's form and its meaning. Note that resemblance is a human-defined, interactional property based on our ability to create conceptual mappings (Gentner & Markman 1997). We feel that two things resemble each other when we can establish a structure-preserving mapping between our image of one and our image of the other. To be more precise, then, in linguistic iconicity there is a structure-preserving mapping between the phonetic form (sound sequence, handshape or movement, temporal pattern) and some mental image associated with the referent.
>
> -Taub, 2001

Taub (2001)'s definition of linguistic iconicity above is on par with first-order resemblance, a structure-preserving, direct mapping between two entities. However, there is no academic consensus on the definition of iconicity. Downing and Stiebels (2012) note the *plasticity* of the notion of iconicity. Some authors equate iconicity with non-arbitrariness, while some others consider only transparent cases as iconic. According to Ramat (1995) iconicity is a relation of similarity and he does not consider transparent forms as iconic. A clear definition of iconicity is not required in order to support the discussions in this dissertation. Iconicity is a venue and a strategy that many signers resort to when they are faced with a situation where they need to make a linguistic decision depending on the salient properties of the event that they are describing. The data presented in this dissertation is no exception.

Resemblance, transparency, and non-arbitrariness are fluid matters. A straightforward example of first-order resemblance can be made between two pairs of scissors with the exact same shape, color, sharpness and make – two identical scissors, made possible by mass production, although they are two separate objects in the physical world. We can resort to the properties on the stereotypical object *scissors* and compare the same object to the (most probably) universal gesture for scissors, where the index and middle fingers are spread and move with a motion of opening and closing together that mimics how the two blades of the scissors operate. There are two important things to be pointed out here. The handshape of the gesture (or of the sign for that matter) represent the object itself – the existence and shape of an object such as scissors. The movement of the fingers, on the other hand, represent the function of the scissors – the opening and closing of its two blades that allow the scissors to cut through paper, or hair, or whatever object they are cutting. The manual gesture serves a communicative purpose rather than a function of cutting hair. Sign languages take this communicative purpose step further and add a linguistic function to this iconic manual form after incorporating it into the lexicon through a series of linguistic processes, filters and alterations. What's important here is the division of labor the two phonological parameters, handshape and movement, employ to reflect the two salient properties of the object scissors in the linguistic articulators. With a typical pair of scissors used in a typical way, such as 'to cut paper using scissors', we expect the morphophonology of a classifier predicate to reflect the full breadth of the properties of scissors made available to the grammar by the iconic engine.

How would the language react if I changed one of these two salient properties of scissors? Consider what would happen in a language feeding so much from iconicity had I used the same object to stir tea? The salient, two-pronged blades would still be expressed in the classifier predicate, but the motion would be replaced with that of stirring. On the flip side, what if the scissors were not fully intact and had one broken blade? How would the user of that language express the act of cutting a piece of paper with this broken pair of scissors? She may encode the blade that's intact in the handshape and keep the movement the same.

Iconicity is not a property we find exclusively in gesture and sign languages. Although sign languages allow more iconicity than spoken languages (Taub, 2001; Mandel, 1977), we see that spoken languages, although to a limited extent, also make use of some auditory iconicity (see Perlman et al. 2018; Hinton et al., 1994; Haiman, 1985). We see onomatopoeic words in spoken languages, mimicking sounds found in the nature or, more broadly speaking, in the physical world. Examples of this include the linguistic encoding of the sounds that animals make in a variety of spoken languages: "meow" and "moo" in English for instance, which are first-order resemblances of animal sounds from the vocal source domain. The iconicity in these forms is so strong that many of the world's spoken languages will use an approximation along the lines of these forms to refer to the sounds that cows and cats make, although the forms will differ [mö:] for 'moo' and [mi.jav] for 'meow' in Turkish; but 'woof' is [hav].

We also see less transparent cases of arguable iconicity at the subatomic level of the English phonology, for instance. Sound symbolism is a common phenomenon which occurs with certain sound segments that have a loose association with certain meanings. Computational linguistics models (see Elman et al., 1996) are able to capture and classify phenomena such as sound symbolism. For instance, English words ending in the sequence *-rl* are loosely associated with the abstract meaning of circularity. Therefore, the semantically rather distant forms such as "swirl", "twirl", "curl" and "whirl" create an association with the phonological form in speakers' conceptual space because of the one abstract semantic meaning that is shared across all these *-rl* words. Moreover, when English speakers are presented with nonce words such as "flurl", they associate it with a meaning containing some sort of circularity. While this is not at all an example of first-order resemblance, it shows that iconicity is just as legitimate a formative force in spoken language grammars as full arbitrariness is.

Sound symbolism and onomatopoeia are not the only two venues where we see iconicity. The famous Latin phrase *veni, vidi, vici* 'I came, I saw, I conquered', popularly attributed to Julius Caesar, is according to Peirce (1932) a *diagrammatic* example of iconicity found in spoken languages, where its coordinated linguistic subparts reflect more or less an abstract relation among concepts or elements of discourse, in this case, the temporal order in which the events unfolded. While the morphosyntactic structures of spoken languages can easily reflect the structure of sequential events, it seems that sign languages may be at an advantage when it comes to encoding simultaneous events where the morphosyntax is also highly simultaneous. Consider the English sentence "He was reading a book while sipping coffee", where all constituents must come sequentially. The same event can be expressed with simultaneous, vertically-stacking morphology in virtually any sign language that I am aware of. One hand would express the book, the eye gaze at that hand would encode reading the book and the other hand would encode the act of drinking coffee, all in one or two time slots or syllables. Instrumental classifier predicates are no different. Recall the examples given in the previous section where I presented morphological simultaneity in the context of classifier predicates. We saw four, sometimes five morphemes stacked on top of each other as the single syllabic nucleus, the movement, is responsible for holding them together in a single unit. Looking at such examples, one cannot help but cease to wonder why at first sight sign languages were regarded as a series of unstructured hand gestures. However, sign languages are not entirely composed of iconic depictions of simultaneous events as such and these iconic depictions do obey certain linguistic restrictions, and, describing and identifying them is one of the purposes of this dissertation.

Researchers such as Newmeyer (1992) and Haspelmath (2008) argue that the proportion of iconicity in spoken languages is not very small. Newmeyer studies iconicity and generative grammar and argues that grammatical structure is an iconic reflection of conceptual structure, and that iconicity does not go against the foundations of generative grammar. Some languages make a head-complement order distinction with extensional and intensional verbs and their direct objects. Napoli et al. (2017) find show that in Brazilian Sign Language the relative order of the verb and the object depend on whether or not the sentence presupposes the existence of the verb's object (SOV if it does, SVO if it does not). A cake does not exist before someone bakes it, and it has to exist before someone eats it. This simple fact about the physical world that we live in is reflected in languages as a word order asymmetry between extensional and intensional verbs. Intensional verbs such as 'bake' take their complement to the right, extensional ones such as 'eat' take their complement to the left; reflecting the manifestation of events as they occur in the physical world. Schouwstra & Swart (2014) show in a gesture production study that objects of intensional verbs tend to follow the verbal gesture, while the objects of extensional verbs precede the verbal gesture.

Perniss et al. (2010) attribute the abundance of iconic representations in sign languages to the greater extent of compatibility between the nature of the visual modality and the contents of what we talk about. Sign languages use two manual articulators in front of the body and much of what we talk about the world is visually perceived and spatially arranged. Therefore, sign languages have a great predisposition to being highly iconic.

1.3.2 Iconicity in the Sign Language Lexicons and Gesture

The interactions between iconicity and sign language lexicons have been the focus of much research (see Johnston & Schembri, 1999; Supalla 1982, 1986; Liddell, 2003; Cormier et al., 2012; Berent & Goldin-Meadow, 2015, among others). Most of those studies converge around the general observation that sign language lexicons have very close ties with iconicity in their organization and that certain signs are more predisposed than others to using iconic and modifiable strategies in depicting certain events. In a recent unpublished study, where we use computational vector space models, we found that phonological similarity is an indicator of semantic similarity in the lexicons of American Sign Language and British Sign Language, although, crucially, different phonological systems utilize iconic material in different ways. The iconic affordances of the visual modality are overlooked no more, and this study stands by this current trend in sign language linguistics.

As a natural consequence of these views, Brentari (1998, 2019), following Itô and Mester (1995) likens the lexical organization of ASL to that of Japanese, where they compartmentalize the Japanese lexicon into three classes: Yamoto (native), Sino-Japanese and Foreign. Brentari divides the ASL lexicon into three groups: “foreign”, “native 1” and “native 2”:

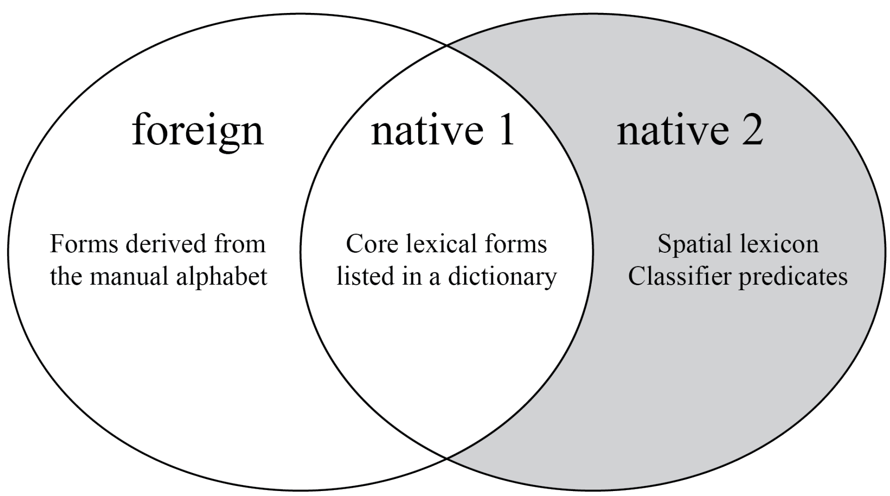


FIGURE 7 The three components of a sign language lexicon

Figure adapted from Brentari, 2019; cf. Brentari and Padden, 2001)

The foreign lexicon consists of signs that are derived from the manual alphabet and therefore has a connection to spoken English (or sometimes less transparently to spoken French due to ASL's shared history with French Sign Language). These signs, while they are frozen forms, do not always display a patterned behavior with the signs in the Native 1 group. Native 1 consists of frozen core lexical entries that can be best described as dictionary forms. Native 2 is home to classifier predicates. Classifier predicates belong to a special part of the lexicon referred to as the spatial lexicon (Brentari & Padden, 2001). We see them used most extensively in the linguistic description of situations that take place in the physical world, such as the organization of objects in physical space. Native 2 and to a certain degree Native 1 are the two compartments of a sign language's lexicon where this dissertation focuses on. These two components of the lexicon are where we see the formational effect of iconicity the most.

These transparent iconic constructions, classifier predicates, are sometimes referred to as 'depicting constructions' or 'polycomponential verbs'. They resemble the manual reenactment of an event that takes place in the physical world. Classifier predicates in ASL belong to the spatial lexicon, one of the two native components of the ASL lexicon. As an extension of ASL, we can expect other sign language lexicons to behave in a similar manner (Johnston & Schembri, 1999). This is a consequence of the highly complex nature of classifier predicates and the iconic affordances of the visual modality. The handshape in a classifier predicate can be considered the most linguistically salient component followed by the movement of the hands as a second. But what does it mean to be linguistically salient if these parameters are already a part of the phonology? The subcomponents of the movement combined with those of handshape such as hand orientation, and the manner of movement, iconically reflect the parts of an event in the physical world; therefore, they can be argued to have a gestural flavor (Liddell, 2003), they are not without linguistic meaning, nonetheless. They can be so iconic that earlier studies on sign languages considered these constructions merely as visual imageries, almost like a snapshot, and with no linguistic compositionality (DeMatteo, 1977; Mandel, 1977). Some of the studies might have painted a picture of classifier predicates where they look like a series of pantomimes; however, that is certainly not the case – these constructions have systematic forms across signers as well as certain linguistic restrictions that regulate them. As described in the previous section with the broken scissors example, while they do have standard forms across signers, modifying these forms to reflect the properties of an event or an object is easily and readily available to signers. The availability of this elasticity in the morphology stems from the iconic affordances of the visual modality.

Independent of the contents of my experiments or their design, we can easily test whether signers are merely mimicking what they see in the stimuli or whether the grammar is filtering and processing the information that they see before they output the linguistic utterance. A simple statistical analysis between the durations of my experiment stimuli and the durations of signer responses reveals that the two measures are not strongly correlated. The graph in Figure 8 shows exactly that:

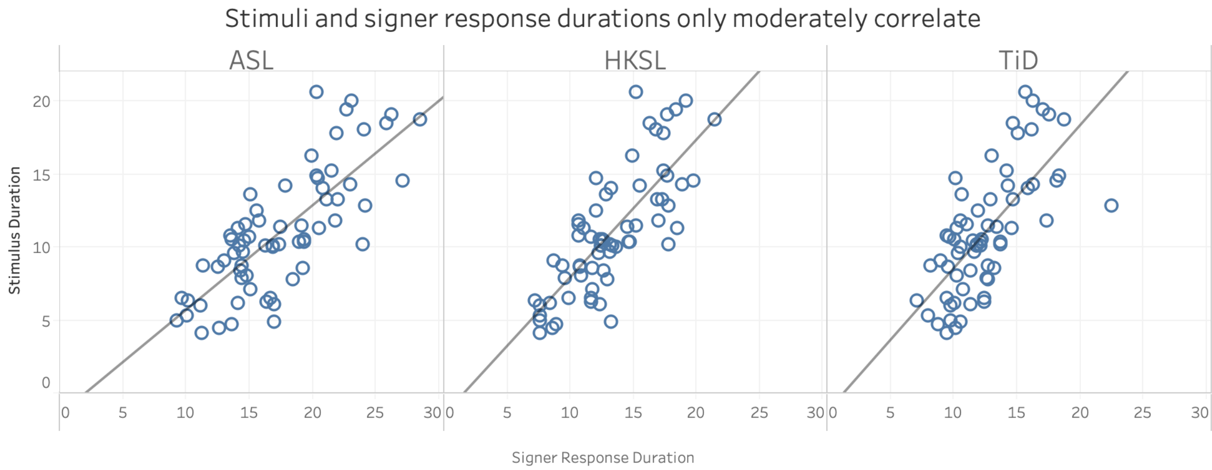


FIGURE 8 Moderate correlation between individual stimuli and response durations.

X-axis shows mean production duration, y-axis shows stimuli durations. Moderate positive correlation (Pearson's r: ASL: 0.45, HKSL: 0.56, TiD: 0.46).

The graphs show moderate positive correlation (Pearson's r: ASL: 0.45, HKSL: 0.56, TiD: 0.46) between the durations of stimuli and signer responses. This can be taken as secondary evidence that signers first digest the prompt, and the influx of information is processed by the grammar before they spell out their linguistic production instead of straight out mimicking what they see. Had their responses been completely pantomimic, we would expect to find a strong correlation between the two measures. The steady increase that we see in duration is attributable to the different types of stimuli presented to participants:

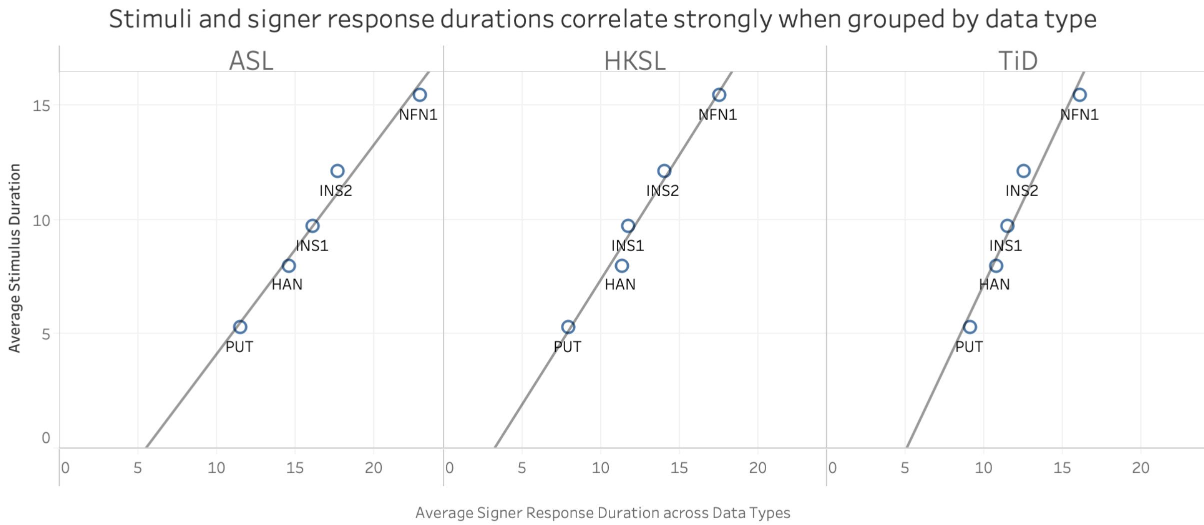


FIGURE 9 Strong correlation between grouped stimuli and response durations.

X-axis shows mean production duration, y-axis shows stimuli durations. The steady increase in duration results from the increased information content per stimulus (Pearson's r: ASL: 0.99, HKSL: 0.99, TiD: 0.97 $p<0.001$).

The 'PUT' condition is where a person is seen putting down an object on the table – this is the extent of complexity in the event. From 'PUT' to 'NFN' in the graph above we see a steady increase in the complexity of the event where the prompt starts to involve multiple participants and multiple activities[7]. The 'HAN' condition is where a person carries out an action using bare hands, such as hammering a stick to the ground using the fist. The 'INS' condition has a bit more complex information structure in that the person now uses an instrument to carry out a task, such as hammering a nail using a hammer. The 'ATY' condition adds another layer of complexity by using an atypical instrument that successfully carries out

7 A more detailed explanation of these conditions will be presented in the next chapter.

the same action, hammering a nail using a book. In the 'NFN' condition the agent uses an atypical object that fails to carry out the task, such as trying to hammer a nail using a wooden spatula. There is a steady increase in event complexity form the 'PUT' condition to the 'NFN' condition. As the stimuli increase in the amount of information they pack, so does the duration of signer responses. This provides further support to the many claims that descriptions of events using classifier constructions are indeed linguistic in nature. The correlations between the durations of the individual signer responses and the corresponding stimuli are weak. Only when we group signer responses by data type are we able to find a strong correlation between the average durations of signer responses and stimuli. This observation is in line with the works of other researchers who do not deny a relation but draw a line between language and gesture (see for instance Tomasello, 2008; Emmorey et al., 2011). Linguists now believe that certain parts of classifier constructions are composed of modules that are governed by linguistic rules while certain other parts do mimic some components of the event and are, therefore, gestural.

Morphemes need to be productive, discrete and their meanings isolable (Brentari, 2019). While this is the case for linguistic unit, we cannot say the exact same thing for gestures. Gestures do not contribute to the core meaning of a linguistic utterance although they may occur simultaneously with speech or sign (i.e., co-speech/co-sign gestures or gesticulation, see Goldin-Meadow, 2003; Kendon, 1980). First of all, they do not interact with the linguistic elements they co-occur with in the same way that morphemes interact with one another and with other units at different levels of the linguistic hierarchy. A gesture does not have an effect on the phonological form of a word, and it also does not alter the syntax of a sentence. Certain gestures may systematically occur with certain linguistic elements or in the seams in between, but they do not combine with an entire paradigm of linguistic units, at least not at a sub-phrasal level, which makes them paralinguistic. Secondly, they do not interact with other gestures to form more complex gestures as morphemes would combine.

Iconicity and gesture are two important parts of the explanations provided in this dissertation, and therefore require close attention. Most of what is salient in an event is encoded using an iconic property of that event. In the chapters that follow, I argue that PERCEPTUAL SALIENCE is the one overarching factor that underlies the decisions made among iconic strategies. Salience is defined as the state of being prominent – when some property of an entity makes it stand out from its neighbors in the same environment. Neuroscience studies show that a certain part of the brain called the Salience Network is responsible for modulating the switch between the default mode network and the central executive network in the presence of salient stimuli (see Menon & Toga, 2015). The presence of salient stimuli triggers the brain to switch to a network where attention and complex problem-solving skills are activated. In other words, in the event that something atypical or out-of-the-ordinary happens or if the stimulus has a component that stands out from the rest, the brain deactivates the "auto-pilot" and lets the central executive network take over, which makes more informed decisions than the default mode network.

The spatial lexicon can also borrow from the core lexicon and make alterations to the frozen form in order to convey a meaning difference or highlight certain information. These are obligatory modifications required by event salience. For instance, signers of Turkish Sign Language may modify the noun KNIFE and use two fingers rather than only one, which is the phonological specification in the noun's frozen form. This is a necessary and effective modification made to the noun in order to indicate that the knife in question has a wider blade than that of a regular knife. This wider property of the object is salient in a way and needs to be encoded in the linguistic utterance. Duncan (2005) has observed that Taiwanese signers make small, context-dependent modifications to the form of the classifier used for animals in order to reflect a certain property of the event that they are describing. Duncan argues that while these modifications are rooted in gesture, the selected fingers for the classifier handshape are morphophonological. It is safe to say that the two components of the sign, gesture and morphophonology, are not mutually exclusive and may be interacting extensively at the levels of phonology, morphology and even syntax. Perniss et al. (2017) have found that signers tend to make alterations to frozen forms during storytelling and in child-directed signing. Perniss has shown that these modifications are found especially in iconic signs, and we know from the many studies on classifier predicates that they are highly iconic signs. Therefore, appropriate modifications to classifier constructions that are motivated by iconic properties are an integral part of sign language grammars. Moreover, iconic constructions that start out in the spatial lexicon may become conventionalized over time and this is one of the ways a sign language expands its vocabulary (Wilcox & Occhino, 2016; Occhino, 2017). I would like to raise the question here; can we really talk about a 'frozen' lexicon if the forms of the signs in it are so easily changed? Or are we talking about moldable bundles of salient features that each have a form in the lexicon and can flexibly be substituted to mark certain divergences from the standard?

Brentari (2019:39) discusses the two pressures on a phonological system: the Pressures of Efficiency and the Affordances of Iconicity. Efficiency is common in both signed and spoken languages and defines how the building blocks of a phonological system are organized in order to maximize the information conveyed while at the same time allowing ease of production and ease of perception. Iconicity is an affordance available to all languages to exploit – vocal or gestural, but sign languages make a greater use of it[8]. This is thanks to the greater range of available correspondences that can be made between forms and their meanings in the visual modality[9]. Gibson et al. (2019) discuss the importance of having a balance between complexity and efficiency as two forces that shape language. Perry et al. (2015) and Laing (2014) suggest that non-arbitrariness may play an important role in early language acquisition.

Classifier predicates are considered to have a partial gestural component (Emmorey & Herzig, 2003; Liddell, 2003). Gestures and discrete linguistic elements in sign languages can be intertwined, which is an affordance made available by the iconic component of sign languages. Classifier predicates are one environment where we see the extensive effect of iconicity and how flexible, although systematic, sign language morphologies can be. The following excerpt from Brentari (2019) addresses the linguistic status of classifier constructions in sign languages:

8 See Grote and Linz, 2003 where they address iconicity in sign languages.

9 According to Brentar i& Coppola (2016) transparent iconicity is crucial at the early stages of the emergence of a sign language. Earlier forms of sign languages and homesign systems depend heavily on transparent mapping between the physical world and linguistic form, however, over time transparency is lost to some extent.

> “
> Many researchers are now arguing that there are some parts of a verb’s structure that are linguistic and some parts that are gestural (Brentari, 2011; Lillo-Martin & Meier, 2011 and 2011). For example, in classifier predicates there is no dispute that many properties of handshapes are morphological, but for movement there is likely a linguistically “light” verb such as BE-AT or MOVE, which is expressed by some movement features. These are coupled with a gestural layer to show a special arrangement of the object(s) in a particular location or specific loci at the beginning and end of the path movement. The evidence that the movements of classifier forms function as predicates is that they can function as the only predicate in a sentence; however, some of the content of the predicate itself maybe gestural […] I believe it makes more sense to appeal to the gestural nature of these forms and call them “hybrids”, which include properties that are linguistic and properties that are gestural. Some researchers have continued to think of these nonproductive meaningful forms as morphemic.
>
> - Brentari, 2019

Four points are especially crucial from the excerpt above: (i) the handshape in a classifier construction is morphological, therefore linguistic. There is no doubt that the classifier portion of these predicates, that is the handshape, or certain phonological parts that make it a discrete unit, are “frozen” forms in the lexicon. Certain handshapes belonging to the core lexicon can be subjected to alterations in a variety of ways, therefore calling them frozen forms may be misleading. I prefer the term “elastic” – they are indeed composed of a bundle of phonological and semantic features, some of which may be altered. Remember the knife example from TiD presented earlier: (a) extended index finger is the quotation form of KNIFE, and (b) extended and unspread index and middle fingers can refer to a knife with a wide blade. Second, (ii) the classifier (i.e., handshape) merges with some sort of a movement which is expressed using a semantically ‘light’ verb that denotes movement or location. Brentari calls those verbs BE-AT and MOVE. Note that we use the term ‘light verb’ independent of all the connotations that its use in the generativist syntactic framework brings. BE-AT and MOVE are the two quintessential light verbs that denote relations between entities in space. An entity might be stationary at a location (that is, existential or locative: an unaccusative construction) or it might be moving in space. It might be moving on its own (unergative: an intransitive construction) or someone might be moving it (agentive: transitive). Languages like English tend to have manner information encoded in their verbs of motion in addition to the motion information itself. An entity might be swimming (self-controlled movement in a body of water) or it might be floating (involuntarily stationary on the surface of water). Sign languages tend to use classifier constructions to express meanings relating to movements in space[10] and information such as manner and path can be encoded gesturally, which brings us to the third crucial point: (iii) the spatial arrangement of entities in the physical world are reflected in the linguistic form. This takes us back to the discussion on iconicity in the previous section. Spatial relations between entities are oftentimes directly imported from their actual arrangement in the physical world, therefore they are iconic. The pictures in Figure 10 below are an example from Hong Kong Sign Language where the signer is locating event participants in the signing space:

10 This is not to say frozen and conventionalized forms such as swim, walk or run do not exist in sign language lexicons.

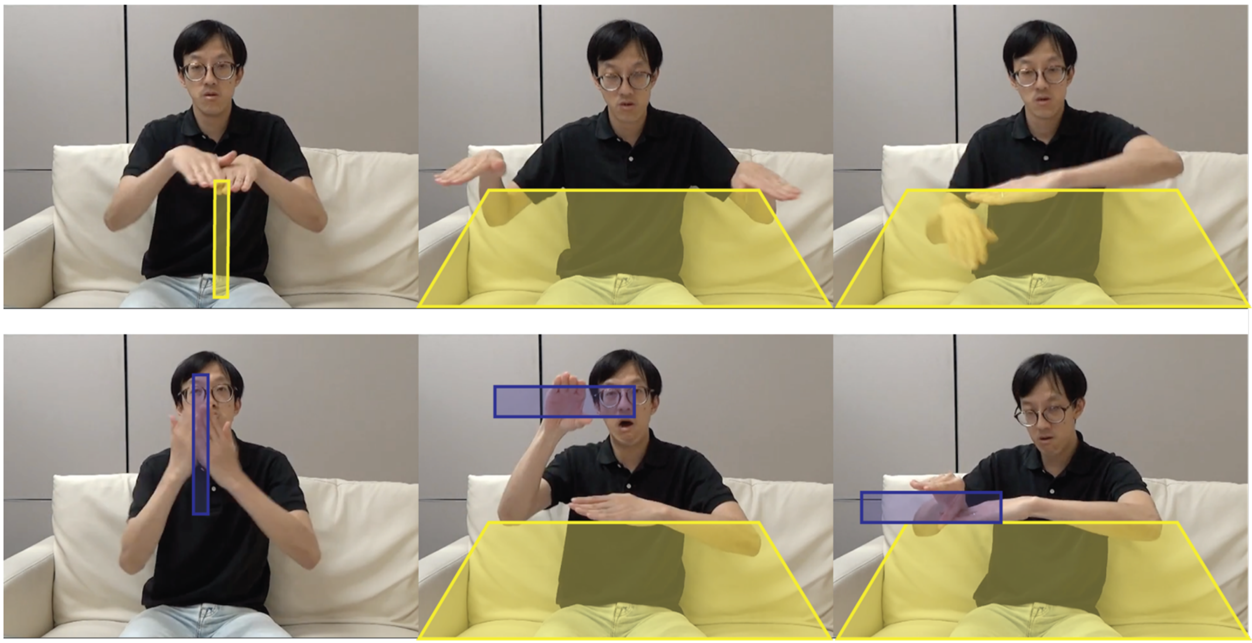


FIGURE 10 HKSL signer setting up the arrangement of event participants.

The HKSL signer in the image above first signs TABLE (top left-and top-middle frames), then indicates where the table is located (top-right frame). He then signs BOOK (bottom-left frame), indicates that it is THICK (bottom-middle) and then expresses its location in the final frame. The spatial configuration of the linguistic elements exactly reflects that of the event participants in the experiment prompt. Only the signs in the top-right and the bottom-right frames are predicates. They are classifier predicates of the locative type, Brentari's BE-AT kind. The others are either nouns or modifiers. The fourth and final point is that (iv) these predicates can function as the sole predicate in the utterance. Their function as a verb is on a par with any other verb that may not have the elastic, iconic properties that these predicates have; therefore, they are linguistically autonomous units. Brentari calls classifier predicates 'hybrids' between a morpheme and gesture. The reason lies in the fact that in addition to their linguistic components, their gestural components are not arbitrary either. They are mapped directly from the physical world into the signing topography and provide information on the trajectory, orientation, speed and location of entities.

Iconicity and gesture are two important aspects of the data studied in this dissertation as they are linguistic descriptions of instrumental events that take place in the physical world. Padden et al. (2013) found that iconicity channels properties from the act of 'manipulation' in creating the lexicon for tools in ASL, Central Taurus Sign Language (CTSL) and Japanese Sign Language (JSL), whereas other subclasses of the vocabulary exploit different forms of iconicity. They call this systematic division "patterned iconicity". According to Brentari (2019), the iconic affordances of the visual modality are the raw material that needs to be shaped by the phonology in a systematic way. Wilbur (2008), in her Event Visibility Hypothesis, argues that movement can iconically express event structure and Aksionsart. She argues that event structure and aspectual information are transparently reflected in the phonology of verbs. These researchers stress the importance of leaving aside the assumptions on iconicity rooted in the Saussurean ideology. Brentari argues that iconicity and phonology do not contradict each other. Indeed, she says they cannot because iconicity is in the source of the phonology, while what's arbitrary lies in the organization of the linguistic system.

The presence of iconicity and its close relation to the gestural component of communication do not mean that a structured study with a data-driven approach cannot be conducted. Moreover, this dissertation is not seeking an answer to the question about their linguistic vs. gestural status. What it does seek instead is to explain why classifier constructions look the way they do, by breaking them down into their components and studying how they interact with different parts of the grammar as well as with factors external to the grammar. In the following section, I elaborate more on the spatial lexicon with an emphasis on instrumental constructions, the focus of this dissertation.

1.4 Encoding Spatial Relations Through Iconicity

One part of the sign language lexicon that we saw in the previous sections is called the Spatial Lexicon (Figure 7**Error! Reference source not found.** *native 2)*. This component is attested in all sign language lexicons studied to this day (but see Nyst (2004) for a discussion on how Adamorobe Sign Language might lack classifiers) and considering the iconic and simultaneous affordances of the visual modality discussed in the previous section, we expect all sign languages to have a part of their lexicon dedicated to expressing spatial relations with iconic strategies. In this section, I elaborate on the linguistic components of classifier predicates.

1.4.1 Classifier Predicates Elaborated

The spatial lexicon is composed of polymorphemic (Supalla, 1986) or semantically multi-componential signs (Slobin et al., 2003) that are structured around a nucleus, i.e., the movement component. A polymorphemic sign typically encodes an event in the physical world, which involves one or more participants, or it might encode a signer's mental representation of the same event. Three things are important here: (i) spatial signs are generally polymorphemic, (ii) the multiple morphemes phonologically depend on the movement of the hand(s) which (iii) mimics the movement of a physical entity. These spatial forms are generally called "classifier predicates", "depicting constructions" and sometimes "poly-componential verbs" (Morgan & Woll, 2007). Each of these nomenclatures reflect different aspects of their structure. They are classifier predicates because the shape of the hand is a classifier that encodes a nominal linguistic element that is anaphoric and referential. The classifier is considered to be in agreement with an antecedent noun that is presented previously in the discourse; therefore, bound by it. They are depicting constructions because they iconically transfer meaning from the physical world and depict an event by use of hands. They are sometimes referred to as poly-componential because they seem to have their own logistics and an environment separate from the rest of the language with regards to their phonology, morphology and syntax. Perhaps, it is best to retain all three names to be used when there is a need to highlight a different aspect. In this dissertation, I will be referring to them as "classifier[11] predicates" for the most part.

The images in Figure 11 below show a sequence of three classifier predicates describing the same task of flattening a chunk of dough with spatula. In the first two and the final two frames, the signer uses a Handling classifier. In the middle two frames we see him use a Whole

11 The term 'classifier' has been heavily stigmatized in sign language research because spoken language literature on classifiers (see Allan, 1977; Craig, 1986), that is, the source of borrowing of the term classifier, may not be adequate in reflecting the phenomenon we see in sign languages (see Emmorey, 2003). However, that is beyond the scope of this dissertation.

Entity (Object) classifier. This is a rare strategy where an event is described in the complex Handling-Object-Handling 'sandwich' classifier format. In what follows I give a description of the components that make up a classifier predicate and discuss their status and relevance in my dissertation.

FIGURE 11 Classifier construction example from Turkish Sign Language.
The signer describing a scene where a piece of dough is being flattened with a spatula.

The two main components of a classifier predicate are the movement and the handshape. The handshape is considered the most salient semantic part of the classifier predicate and it is morphemic. In other words, the handshape encodes a meaning that maps to a form that is present in the lexicon. The movement part of the classifier predicate is a light verb that accounts solely for the movement component of the predicate's entire denotation. These are usually verbs with very little semantic content such as MOVE or BE-AT-LOCATION, hence 'light'. Davidson (2015) argues that the semantics of this [handshape+movement] morphological complex is further enriched by iconic borrowings from the environment, where hand orientation may reflect how objects are arranged in physical space, and the manner and path of the movement may mimic what one might see in the physical world.

The handshape and the movement components of these spatial forms have been classified into different typologies with respect to different criteria such as morphological, syntactic or semantic. In this dissertation, I follow a partially modified version of Brentari (2019)'s classification for the handshape (classifier) and movement (verb head) components, which are adapted and modified from Engberg-Pedersen (1993)'s classification for handshapes[12], and Supalla (1982) and Wallin (1992)'s classification for movements:

A. HANDSHAPE MORPHEMES[13]

i. **<u>Handling Classifiers (H-CL)</u>** – HS refers to how an object would be handled (= hand as hand)

ii. **<u>Object Classifiers (O-CL</u>**) – HS refers to an object or some part of it (= hand as object)

  a. Whole entity + Instrumental classifiers – first-order resemblance of an object
  b. (Semantic classifiers) – no transparent iconicity
  c. (Tracing & SASS classifiers) – the movement of the hand refers to the size or shape of an object and not to its movement in space. The movement may trace the outline of the object.

---

12 For other classifications see Supalla (1986) and Sutton-Spence & Woll (1999)

13 Other (sub)categories of classifiers that are not presented in this dissertation exist in the literature, for instance Contact classifiers that encode cases where an agent is touching an object but not handling it. An example to that would be the classifier for typewriters, keyboards, computers, where the handshape with internal movement of the fingers represent hitting the keys.

iii. **<u>Body Part Classifiers (BP-CL)</u>** – HS refers to a part of the body (human or animal)

This classification of handshape morphemes focuses on the distinction between the scales of representation (Cormier et al., 2012). Handling classifiers (i), like the name suggests, is a real-world scale of representation that focuses on the handling or manual manipulation of an object. The hand refers to the hand of a human or sometimes that of an animal that is capable of grasping a solid object. While the hand may take a different shape depending on the object that is being handled, it crucially always represents the hand itself. In Figure 12 on the left, we see the handling classifier for the object 'fan' in Turkish Sign Language:

FIGURE 12 Iconic forms for the noun/verb FAN in Turkish Sign Language. Handling (left) and Object (right).

Object classifiers, on the other hand, may have a smaller scale of representation than Handling classifiers. In the example above on the right, we see the iconic representation of the object 'fan' again, but this time it *has hand-as-object* iconicity. The size difference between a hand

and a hand fan is not great. But, for instance, a table may also be represented with the palm of a hand, which is smaller in scale by multitudes than the real-world object 'table'. Object classifiers represent a physical property of an object. The archetype of the category Object classifiers is the kind "Whole entity". Whole entity classifiers are transparent representations of objects, i.e., they have first-order resemblance to the objects they encode, such as the quality of having a flat surface (e.g., a book) or having two a double pronged body (e.g., scissors).

Instrumental classifiers are sometimes considered a separate type from whole entity and a subtype of Object, but purely on functional grounds. For now, I group instrumental classifiers and whole entity classifiers together. Semantic classifiers behave like whole entity, but unlike whole entity they do not always display first-order resemblance to the objects they represent. The ASL classifier for vehicles  for instance, although has no resemblance to the vehicles it represents, is still considered a subtype of Object classifiers. The upright being classifier  while having a first-order resemblance to its referent, is considered a semantic classifier as well. An odd member of the group Object classifiers is the category *Tracing*. Tracing classifiers have a path movement that carries meaning related to the object they classify, unlike Object and Handling classifiers, which do not have an internal path movement in their phonological specification. The movement traces the size or shape of an object rendering Tracing classifiers phonologically incompatible with the kind of classifier predicate constructions that are central to this dissertation. Tracing classifiers, more commonly called SASS *(Size and Shape Specifiers),* are descriptive, that is, they depict the appearance of an object rather than describing an event that the object has been a part of. The handshape may be neutral, reflecting the physical boundaries or the smooth surface of an object, or it may be more specific like a pointing sign with an extended index finger or thumb when the movement traces the shape of the object. In my data, we do see Tracing classifiers, but they are modifiers to an object noun; therefore, not a part of the targeted classifier predicate in the same utterance.

According to some researchers (iii) Body part classifiers constitute their own category, some others point out reasons why they lie in a gray area. From the perspective of scale of representation, Body part classifiers, such as the *legs* classifier in ASL  and in many other sign languages, are akin to Object classifiers. Human or animal legs are much larger than what two fingers can possibly represent. Similarly, Handling classifiers represent the hand, i.e., a body part, suggesting that we could group Handling classifiers under Body part classifiers. However, there are syntactic and semantic reasons why Body part classifiers should constitute their own category from a linguistic point of view.

All of the classifier types listed above, with the exception of Tracing classifiers, can combine with a movement morpheme, which produces a classifier predicate:

B. MOVEMENT VERBS

i. **<u>Motion/Active Verbs</u>** – movement of the hand/arm refers to the movement of the object by some agent or the object's inherent movement

ii. **<u>Position/Contact Verbs</u>** – movement of the hand/arm has an existential meaning and does not denote movement in physical space

iii. **<u>(Extension/Stative/Surface Verbs)</u>** – similar to Tracing classifiers and Position/Contact verbs above, the movement denotes spatial arrangement or size/shape of an object, and not movement in physical space

Movements can be considered underspecified bundles of semantic features that equal light verbal morphemes whose meanings are enriched when combined with a handshape morpheme. The majority of the predicates that I study in my data fall under the Motion/Active category of verbs described in (i). This category consists of morphemes where the movement of the hand or the arm represents how an object would move in physical space. The movement may be caused by an internal or an external force (e.g., "The pencil is moving from point A to point B" or "[Some agent] is moving the pencil from point A to point B"). It might be moving on its own or some agent or another external force such as wind or magnetic force might be causing the movement.

The movement in the second category, Position/Contact verbs, does not reflect the movement of an object in the physical world. The denotation of the movement form is *existential* or *locative* (e.g., "There is a pencil on the table" or "The pencil is on the table."). In this regard, in this highly iconic environment where morphemes have a direct mapping of meaning from physical objects and events, one might consider the movement in this group to be an epenthetical insertion as a result of the nature of the visual modality. The third kind of movement that we find in the spatial lexicon, (iii) Extension/Stative/Surface verbs, is similar to the movement we find in Tracing classifiers, in the sense that the movement does not reflect the movement of an object in the physical world. With this kind of movement, signers can represent the spatial arrangement of multiple objects in space, therefore this kind of movement has an existential/arrangement function. For instance, a slalom of flags distributed in a ski course can be expressed using a zig-zag path movement. This kind of movement can also represent the size and shape of an object with the use of a tracing movement.

1.4.2 Classifier Predicates at the Syntax-Semantics Interface

In the previous section, I presented the morphological classifications of the two main components that make up a classifier predicate: the handshape (classifier) and the movement. In this section, I present studies investigating the use of these classifier types in sentence formation.

Benedicto and Brentari (2004) have found that the morphological distinction between Handling and Whole Entity (Object) classifiers has a syntactic correlate in ASL that marks the divide between different types of verbs with respect to valency and argument type. They found that Handling classifiers are used to encode agentive (transitive) events and Whole Entity classifiers encode unaccusative (intransitive) events.

FIGURE 13 Handling vs. Whole Entity classifiers in American Sign Language. Marking the universal agentive/unaccusative distinction (from Brentari et al., 2016a).

The image on the left describes an unaccusative event: 'there is [a lollipop] upside-down'. The one on the right described an agentive one: '[someone] put a lollipop upside-down'. The difference is in the handshape and the movement. The handshape in the unaccusative predicate (left) resembles an upside-down lollipop: the extended index finger mimics the stick and the fist the candy; the entire hand represents the lollipop upside down. The handshape on the right denotes the hand of the person who places a lollipop upside-down; the hand represents the hand, and the joint configuration represents the handling of the lollipop. As for movement, the one on the left that brought the signer's hand to its current location bears no meaning – it is merely an epenthetical that is required to move the hand in space from one location to another. It is the stationary whole entity classifier that bears the meaning of existentiality. On the other hand, in the image on the right, the top-down movement of the hand represents the agent's hand movement that is seen in the stimuli.

This finding meant that the classifier type determines its argument structure. This had one big implication for the spatial lexicon: it follows linguistic regulations in the most fundamental way. A reproducible strategy is adopted across the ASL morphology in distinguishing a most foundational semantic difference. In later studies, similar transitive-intransitive splits in the spatial lexicons of various sign languages were reported (see Glück & Pfau, 1998 – German Sign Language (DGS); Zwitserlood, 2003 – Sign Language of the Netherlands (NGT); Benedicto et al., 2007 – Argentinian Sign Language and Catalan Sign Language; Pavlič, 2016 – Slovenian Sign Language) and the same pattern was observed in homesign systems as well (Rissman et al., 2020). There is something about the act of *handling* that makes it a universal indicator for agency. Agents (or *doers* of an action) have a universally distinguished position in the linguistic systems of the world. If an agent is present and salient, the most prominent position in a sentence is reserved for the agent information (Li & Thompson, 1976; Givón, 1979; Givón, 1992). In many languages, this prominent syntactic position also happens to be the one used for topics.

Turkish Sign Language researchers claim that the language does not follow the pattern (Gökgöz and Sevgi, 2020) observed by Benedicto and Brentari. Kimmelman et al. (2019) argue against Benedicto and Brentari's claim that argument structure follows from classifier type, at least in RSL. He (2020) finds a similar pattern in Hong Kong Sign Language, Beijing Sign Language and Tianjin Sign Language, and argues that the mapping between iconic type and grammatical marking may be language specific. In my data, although the entirety of the prompts described is composed of agentive events, signers from all three sign languages studied use object classifiers in more cases than we can attribute to chance. In my data, 27% of all ASL responses given to agentive situations have an Object classifier. In HKSL, it is almost half of the data (42%) and in TiD the proportion of object classifier use is 37%. How can we then explain these high proportions of Object iconicity use?

1.4.3 Linguistic Encoding of Instrumental Events using Classifier Predicates

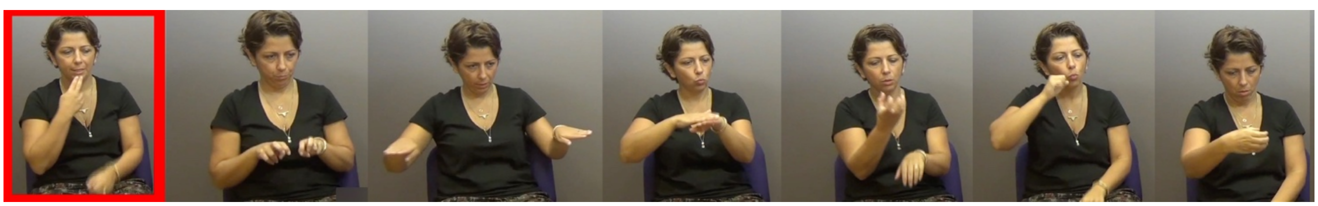
Sign languages encode instrumental events using classifier constructions, where certain types of iconicity are prevalent. The two main types of iconicity I find in my data are hand-as-hand and hand-as-object (Padden et al., 2013), which I refer to here as Handling and Object iconicities respectively. Recall from Section 1.4.2 that Handling iconicity captures the shape of the hand during the handling or manipulation of an object. Object iconicity, on the other hand, captures the shape of the object that the signer expresses. These two types of handshape iconicity are what form the iconic basis for the morphology of two classifier types that we find in sign languages: Handling classifiers (H-CLs) and Object classifiers (O-CL). This iconic encoding of events taking place in space is one of the many affordances made available by the visual modality (see Klima & Bellugi, 1979; Taub, 2001; Emmorey & Lane, 2013, among others).

The existence of these two morphological options to linguistically express an event enables sign languages to effectively mark certain salient properties of that event. The employment of this morphological distinction as a linguistic strategy is also found in the encoding of instrumental events. While the agentive nature of an instrumental utterance requires the use of a Handling classifier (Benedicto & Brentari, 2004), certain factors such as

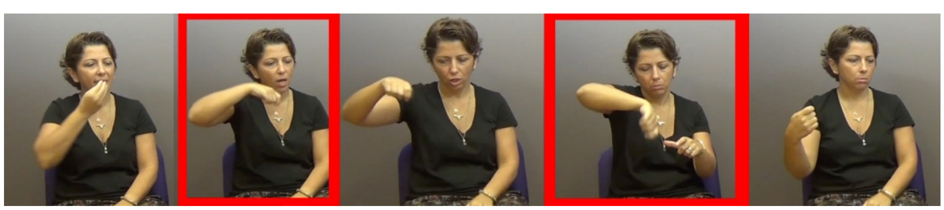
ICONIC HANDSHAPE PREFERENCE, INSTRUMENT SENSITIVITY (Brentari et al., 2016a) and INSTRUMENT TYPICALITY (Brentari et al. 2016b) were shown to encourage the use of an object classifier in the predicate. The use of Object iconicity over Handling iconicity could be argued. to foreground the object (the instrument) information and to demote the agent information. The following is an example from Turkish Sign Language that shows the kind of instrumental constructions that I study:

(6) [CS[14] **WOMAN** SIT TABLE // ON CUP CUP ON-TABLE // **FOOD^SPOON-H** GRAB-H] / **[IU[15] STIR-H]** / [TAKE.OUT-H]

There's a woman sitting behind the table. On the table is a cup. The cup is on the table. She grabs a spoon, stirs [the cup] / and takes [the spoon] out.



WOMAN SIT TABLE // ON CUP CUP ON^TABLE//



FOOD^SPOON-H GRAB-H // STIR-H // TAKE.OUT

FIGURE 14 Turkish Sign Language instrumental classifier construction.

14 CS: Context Setting. This will be explained in the next chapter.

15 IU: Instrumental Utterance. This will be explained in the next chapter.

The image sequence in Figure 14 highlights the three constituents that I study closely in the dissertation. They are the agent (i.e., WOMAN), the instrument (i.e., FOOD^SPOON-H) and the classifier predicate (i.e., STIR-H). This is a prototypical example of the data that I study. The agent noun WOMAN is not iconic in its phonological form, and even if it were, it does not interact with the iconicity that we find in the classifier predicate, STIR-H. The instrument noun FOOD^SPOON-H, on the other hand, is iconic and its iconicity may match the iconicity found in the classifier predicate. In this case, they both have Handling iconicity, i.e., how a spoon would be handled. However, this is not to say that the only iconic component of the lexical noun SPOON lies in its handshape; transparent iconicity is also present in the phonological place of articulation of the sign, that is the mouth, and the movement of the hand in the noun, which reflects the movement of how one would spoon food. The lexical specification for Handling in the noun form can be detached from the other phonological components of the sign and be used in the classifier predicate. Without the location parameter of the sign, the sentence's information content would be incomplete.

Studies have claimed that sign language lexicons have a predisposition to use either Handling or Object iconicity in the handshape parameter of handheld instrument nouns (Padden et al., 2013). However, Santiago-Batista's dissertation on a wide range of sign languages shows that there is no statistically significant preference for Handling or Object iconicity in instrument nouns in any of the five sign languages that she studies. My dissertation data are in line with Santiago-Batista's findings. No language strictly prefers Handling iconicity or Object iconicity - in the noun forms or in the verb forms. Variation, although gradient, is prevalent across individual nouns, and apart from a few highly conventionalized signs there is no consensus among signers on a certain iconicity. No language or no signer has a strong preference for one type of iconicity over another for the majority of nouns.

This stochastic behavior of the nouns and their correlates in classifier predicates requires analyses at different levels than the level of the entire lexicon. I use mathematical methods and concepts from Information Theory, computational linguistics and psycholinguistics in order to account for the variations we see in the distributions of these two prevalent iconic strategies. In Chapter 4, I propose an account that heavily relies on Perceptual Salience to as a factor that explains the variation in the Object and Handling uses that we see in the data I present in this dissertation. In psychology and neuroscience Perceptual Salience is the phenomenon that when some property of a signal stands out from the other signals within its contexts, it requires attention. Salience have been used extensively in psycholinguistics research, although mostly in comprehension studies. In this dissertation, the focus is on production responses.

In this dissertation, I use Shannon's entropy as a metric to find uncertainty in the data in order to make quantifiable generalizations about my observations. Perceptual Salience and entropy will be elaborated further in Chapter 4. In the following chapter, I elaborate on the studies that influenced this dissertation heavily and discuss how their methods and influential findings can be reconciled to build a more comprehensive account for sign language classifiers. The findings are brought together in a predictive statistical model which will be the topic of Chapter 5

2 Previous Literature on Iconicity in Classifier Predicates and the Current Data

In this chapter, I briefly go over the details of the three articles that motivated this dissertation and influenced its methods. Benedicto & Brentari (2004) paved the way to many papers on the relation of iconicity to the syntax and argument structure of classifier predicates of sign languages all around the world. Padden et al. (2013) studied the lexicon and found patterns in iconic tendencies of certain nouns. Brentari et al. (2016a) was a comprehensive paper that addressed the issues and loose ends that arose after the influx of research following the 2004 Benedicto & Brentari paper. This dissertation borrows concepts heavily from Brentari et al. (2016a) and remolds them into new findings with the help of a more comprehensive methodology.

I start with AGENCY, the hypothesis put forth in Benedicto & Brentari (2004) which claims that the argument structure of classifier predicates and the type of iconicity found in the classifier are linked. Then I move on to Brentari et al. (2016a) and present their findings and methodology which partially builds on research by Padden et al. (2013). This part of the chapter is concerned with ICONIC HANDSHAPE PREFERENCE and INSTRUMENT SENSITIVITY. Finally, I finish the chapter with a brief discussion of a research that we started on INSTRUMENT TYPICALITY Brentari et al., 2016b) as an extension of the Brentari et al. (2016a) paper. In Chapter 4, I re-analyze each factor using new methodologies, which are partially presented in Chapter 3 and in Chapter 4 where necessary.

2.1 Agency

The AGENT, if present, is the most privileged thematic role encoded in a linguistic utterance. It also happens to be the most salient participant of an event. This privilege is reflected in the morphosyntax. Nominative-accusative case-aligned languages tend to fill the arguably most prominent argument position of the sentence, i.e., the Subject (or the spec, TP position), with the agent information. Agents (or Proto-Agents; see Dowty, 1991) can undergo a special morphosyntactic valency-changing operation (widely known as passivization) in many languages. In languages where English-like passivization is not available, there are other ways to mitigate the importance of the agent in a sentence or omit it altogether. Duranti (2007) calls this rich network of linguistic qualities and processes around the agent 'the inevitability of agency'. The verb is more likely to display morphological agreement with an agent than with a patient. The breadth of studies conducted on Agency[1] range from studies on full-fledged languages to ones on homesign systems and gesture studies (see Glück & Pfau, 1998 – German Sign Language (DGS); Zwitserlood, 2003 – Sign Language of the Netherlands (NGT); Benedicto et al., 2007 – Argentinian Sign Language and Catalan Sign Language; Pavlič, 2016

1 Sometimes referred to as 'Agentivity'.

– Slovenian Sign Language; Rissman et al., 2020 – Nicaraguan homesigners). While Agency is undoubtedly a linguistic universal there are pragmatic differences in the distribution of agentive language across languages. Fausey et al. (2010) show that Japanese speakers are less likely to use agentive language than English speakers in describing accidental events. They have also shown that English speakers are better at remembering the agents of accidental events than Japanese speakers, in line with their findings on agentive language use.

Agency is the basic notion that separates events that involve an intentional and animate (typically a human) doer from those that do not involve one. I take Agentive as a semantic subgroup of transitive verbs. Transitive is used in this dissertation in the sense that the verb has (at least) 2 arguments: an internal and an external one. Agentive verbs, following this, fill their external argument position in the syntax with the Agent thematic role, and the internal argument with either the Patient or Theme role. Instrumental events found in this dissertation have an extra constituent, the Instrument. Some languages mark the distinction between agentive vs. non-agentive in their morphosyntax. The well-known distinction between unaccusative-intransitive and agentive-transitive events is a simple and straightforward way to describe this phenomenon.

In the generative syntax and semantics literature[2], the Patient theta role is assigned to the complement position of the head of a Verb Phrase, i.e., the V^0 *(V-head)*, which is referred to as the internal argument. The Agent theta role is assigned to the specifier position of a vP (the "little" vP, or *voice*P) and it is referred to as the external argument. While transitive

2 See generative grammar literature and earlier for the treatment of theta-roles and syntactic argumenthood (Gruber 1965, Fillmore 1968, Chomsky 1981, Carnie 2006).

sentences have both the specifier of the vP and the complement of the V^0 as the two positions available for two DPs (Determiner Phrases containing a Noun Phrase) to fill, intransitive sentences have only either one of these positions available. Specifically speaking, unaccusatives (a subtype of intransitive) only have the internal argument position available to be filled with a semantically suitable candidate, that is typically a Theme or a Patient. Unergatives, likewise, only have one slot, but a different one than unaccusatives: for the external argument. The following figure shows the different syntactic schemata for unaccusatives, unergatives and transitives:

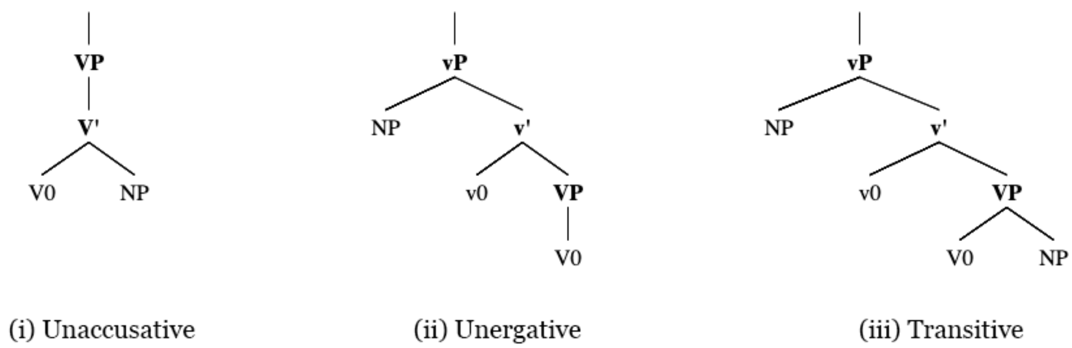


FIGURE 15 Syntactic tree schemata for (in)transitives.

(i) Unaccusatives, (ii) Unergatives and (iii) Transitives. Head directionality may differ between languages, but the hierarchies are the same.

Consider the following pairs from spoken English and Italian (data adapted from Burzio, 1986):

(7)

a. Jack read the book. -transitive, *agentive*

b. The book fell. -intransitive, *unaccusative*

(8)

a. Giancarla	**ha**	mangiato	la mela.	-transitive, *agentive*
GIANCARLA	HAS	EAT.PART^MASC	THE APPLE	

Giancarla has eaten the apple'

b. Giancarla	**è**	arrivata.	-intransitive, *unaccusative*
GIANCARLA	IS	ARRIVE.PART^FEM	

'Giancarla has arrived'

While this grammatical dichotomy between an unaccusative and a transitive is not readily visible in the English morphosyntax (7)a-b, Italian displays a differential auxiliary selection. The auxiliary *avere* 'to have' and the auxiliary *essere* 'to be' are found in the linguistic encodings of transitives (8)a and unaccusatives (8)b respectively. We also see that the verb *arrivata* in (8)b agrees in gender and number with the subject *Giancarla* just the way an adjective following the auxiliary *essere* would. We don't see this morphological agreement in (8)a. This dichotomy is argued to be the consequence of the thematic nature of the DP in the subject position. While in (7)a and (8)a *Jack* and *Giancarla* are the doers (i.e. the Agents) of their respective actions, *reading* and *eating*; in (7)a-b and (8)b *the book* and *Giancarla* are the undergoers (i.e. the Patients) of *falling* and *arriving*.

Studies on the argument structure of classifier predicates in the ASL morphosyntax reveal a behavior similar to what we see in the Italian auxiliary split. Kegl (1990) noticed that certain verbs in ASL vary in their handshape type depending on transitivity. Likewise, Benedicto & Brentari (2004) demonstrated a partitioning in the functions of three classifier types in encoding grammatical relations in the predicate with respect to its valency and argument type. They observe that Handling classifiers are used as a morphological strategy to encode agentive-transitive events, and that Object (also called Whole Entity) classifiers encode unaccusative-intransitive events such as BE-LOCATED-AT and MOVE-ON-ITS-OWN while Body Part classifiers encode unergative-intransitive events such as RUN and SWIM. Consider the following transitive and unaccusative examples (data and images from Benedicto & Brentari, 2004):

FIGURE 16 The Agentive/Non-Agentive Distinction in American Sign Language. Picture obtained from Brentari et al. (2016a).

(9)

unaccusative:	*agentive:*
a. There's a lollipop upside down.	b. (Somebody) put the lollipop upside down.

The two examples above show the distinction between the morphological encodings of agentive and non-agentive events in ASL. In (9)a the signer uses an Object-Classifier (O-CL) to represent an unaccusative event, a still image where a lollipop is seen standing upside down on a table. Conversely, when the signer was presented with a video of a person putting a lollipop upside down on the table, he used a Handling-Classifier (H-CL). Benedicto and Brentari support this claim further with their observation that agentive adverbials in ASL are used grammatically only with transitive-agentive classifier constructions that have Handling iconicity or with unergatives that have a Body Part classifier. Following Benedicto and Brentari's study, many researchers conducted studies on the valency and argument structure of classifier predicates in different sign languages around the world and found similar results (De Lint, 2018 for Sign Language of the Netherlands; Benedicto et al., 2007 Catalan SL and Argentinian SL; Kimmelman, 2020; Kimmelman et al., 2019 for Russian SL, German SL, Kata Kalok and Sign Language of the Netherlands, Rissman et al., 2020 for homesign systems).

In my dissertation, I take Benedicto and Brentari's observation on how ASL classifiers behave with Agency as my null hypothesis since all of the events studied here, including and especially instrumental events that use the hand to manipulate the instrument, are agentive.

Following the results from studies on other sign languages, one might expect such instrumental events to be coded exclusively with Handling-iconicity in the predicate:

Hypothesis 0 Agency

> Since all instrumental events are inherently agentive, we expect to find Handling classifiers in all signer responses in all the data from the three sign languages.

Despite the expectation from the hypothesis AGENCY that we should see Handling iconicity across the board in agentive responses, we see varying degrees of non-Handling strategies including Object classifier use as well as other strategies in the three languages studied including ASL. In other words, the hypothesis AGENCY does not empirically hold in the data that I present in this dissertation. The bar plots in Figure 17 show participants' average Handling iconicity use in the classifier predicate per language:

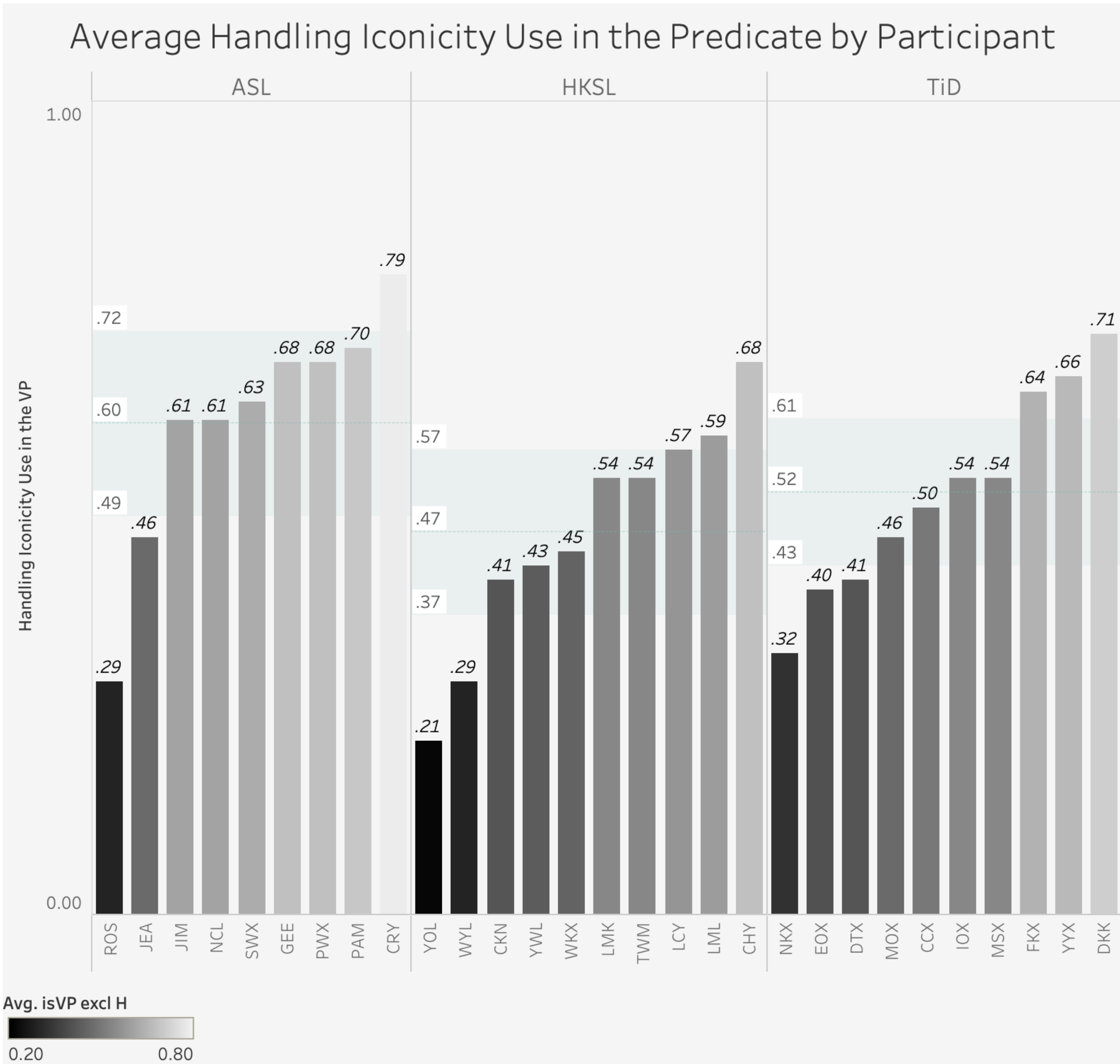


FIGURE 17 Average Handling iconicity use in the predicate by participant.

Lighter gray means more Handling use per participant response.

While certain participants prefer Handling iconicity to other strategies (lighter taller bars; CRY in ASL 79%, CHY in HKSL 68%, DKK in TiD 71% of their responses), with some other signers Handling iconicity is not the leading strategy (the darker shorter bars).

Conducting a simple chi-square test shows that we can safely reject the applicability of the null hypothesis AGENCY in this dataset, and that agentive events are not necessarily encoded using Handling iconicity (p<at least 3.97e-5 in all three languages). In other words, there is no one-to-one, exclusive mapping between Handling iconicity and agentive-transitive utterances. It would be too strong a claim. This behavior was also observed in Kimmelman's works cited earlier in the previous chapter.

Studies on this divergence from Brentari and Benedicto's 2004 generalization have been conducted and found possible explanations to why Object iconicity, a type of iconicity we typically see in unaccusatives in ASL according to the two researchers, would occur in transitive-agentive structures. Brentari et al. (2016) follow a Greenbergian (1966) universals approach to put sign languages into typological groups with respect to the iconicity found in their instrument classifier predicates and instrument nouns. They identify two factors that they argue form this typological membership: ICONIC HANDSHAPE PREFERENCE and INSTRUMENT SENSITIVITY. The following sections are concerned with these factors.

2.2 Iconic Handshape Preference

Aronoff et al. (2009) and Padden et al. (2013) has shown that sign languages can be categorized with respect to the preferred iconicity in their instrument vocabulary. They found that American, Danish, Swedish and Al-Sayyid Bedouin Sign Languages display prevalent Object iconicity in the lexical form of their instrument nouns. Other sign languages such as British, Japanese, Israeli and New Zealand Sign Languages have Handling iconicity in instrument nouns for the most part. Brentari and colleagues (2016a) build on these observations and assume a relationship between the lexical instrument noun and the classifier predicate where the handshape associated with that noun is expressed. In other words, they draw an association between the core lexicon (Native 1; Brentari and Padden, 2001) of a sign language and how a non-core (Native 2) lexical item, a classifier construction, takes its form in linguistic production in a different grammatical environment. In this section, I provide a review of their proposal and propose modifications to it.

2.2.1 Brentari and colleagues (2016): ICONIC HANDSHAPE PREFERENCE

Brentari and colleagues studied 41 objects in their noun naming task in ASL, BSL, LIS and HKSL. Their findings confirm the observations made by Aronoff, Padden and their colleagues. In their results, some sign languages do indeed have a predisposition to using Handling iconicity in the form of the noun, while some others have one for Object iconicity. According to them, ASL and LIS are Object-preference languages in the noun domain, while BSL and HKSL are Handling-preference. Their study has contributed the important generalization that nominal iconicity plays a crucial role on morphological patterns in classifier predicates. This observation brought with it two generalizations and an important consequence for Benedicto & Brentari (2004). Their data showed that if a language leaned heavily on Handling iconicity in the form of lexical instrument nouns, such as HKSL and BSL, then that language is likely to use Handling iconicity in the production of an instrumental classifier predicate. Likewise, languages that heavily lean on Object iconicity in the form of the lexical instrument nouns, such as ASL and LIS, would use this iconicity preference in the instrumental classifier predicate, which would result in a tendency for higher Object iconicity use in the classifier verbal domain. This meant that AGENCY, as presented by Benedicto and Brentari in 2004, is a factor that, under the right circumstances, can be overridden by another factor such as ICONIC HANDSHAPE PREFERENCE if the language has a structural sensitivity to match iconicities in the nominal and verbal domains:

Hypothesis 1 Iconic Handshape Preference

> The predominant iconic preference of instrument nouns found in a sign language's lexicon will be reflected in the type of iconicity found in that language's instrumental classifier predicates.

In this dissertation, there are 16 objects and bare hands that I target. 8 of the 16 objects are items that have a designated instrumental function, and that function is the same across cultures. For instance, HAMMER is used to hammer a nail in the United States, and also in Turkey and in Hong Kong. The remaining 8 objects are items that do not typically have an instrumental function. For instance, BOOK is the theme of the action *reading* but it is not an instrument with a designated function. However, it can be used as an instrument; for instance, it can replace a hammer if it is heavy enough with a strong spine that is able to hammer a nail. The following table shows the Target Object paradigm in this experiment:

(A) Instruments	(B) Non-Instruments	
Hand fan	*Book*	
Hammer	*Cardboard*	
Knife	*Coin*	
Pliers	*Cutting board*	**(C) Hands**
Screwdriver	*Hook*	
Shovel	*Mug*	
Spatula	*Pitcher*	
Teaspoon	*Cooking pot*	

TABLE 2 Target objects in this study.

It is not possible to indicate the lexical iconicity of each object for each language because of the range of variability within and across signers.

Each object in (A) has a designated instrumental use with an intermediary function, and that use is its typical function. We use a hand fan to create an airflow, a knife to cut or slice organic matter and a screwdriver to tighten a screw. Objects in (B), on the other hand, are not tools. Pitchers hold liquid, cutting board provides a sturdy ground for chopping vegetables and meat, and we use coins to pay our expenses. They are not intermediaries in the strictest sense that the way the objects in (A) are. All of the 16 target objects fit the hands; therefore, object size is controlled for. Finally, we have bare hands, whereby the 8 unique functions of the objects in (A) can be carried out without their designated instruments. I will go into more detail about what these instrumental functions (basically the verb heads) are in the next chapter.

All three corresponding lexicons of the sign languages under investigation here have the morphological strategies available to them to encode these objects nominally. There are two main iconic strategies that the corresponding lexemes can utilize: Handling and Object. Some of the items are more likely to have one iconicity in their noun form than the other, while for some others the line is not clear. Additionally, the preferred type of iconicity for the same object may not be the same in different languages. For instance, TEASPOON in ASL has a tendency to use Object iconicity. The same noun in TiD and HKSL uses Handling iconicity. Therefore, the iconic type in the form of each of these nouns is not indicated in Table 2. In their object naming task, Brentari et al. (2016a) find a single iconicity per object in around 95% of the production responses they collected. They exclude the portions of the data (around 5%) from their analysis, where both Handling and Object iconicities were provided as an answer to name an object.

In my data, however, single iconicity is the exception. Only 1 out of the 16 target objects studied, the noun BOOK (and only in ASL invariably) depicts a single iconicity in the noun form. Rest of the objects have different levels of variation in their iconic form. Unlike Brentari and colleagues, in this dissertation I do not exclude these datapoints – I use their distribution to make informed generalizations about how conventionalization, iconic consistency and frequency affect the type of iconicity found in the classifier predicate. The graph in Figure 18 breaks down the distribution of iconicity in the nouns in this study. The left half is composed of the 8 instrument objects and the right half the other 8, non-instrument objects. A total of 2,375 target object nouns (ASL: 863; HKSL: 952; TiD: 560) went into the below probability distributions of iconicity. That is the total number of mentions of the target object noun. Each noun was annotated for the type of iconicity it displays. Most common types were Handling and Object; the rest were SASS-Trace and two non-iconic strategies: fingerspelled nouns and non-iconic lexical nouns.

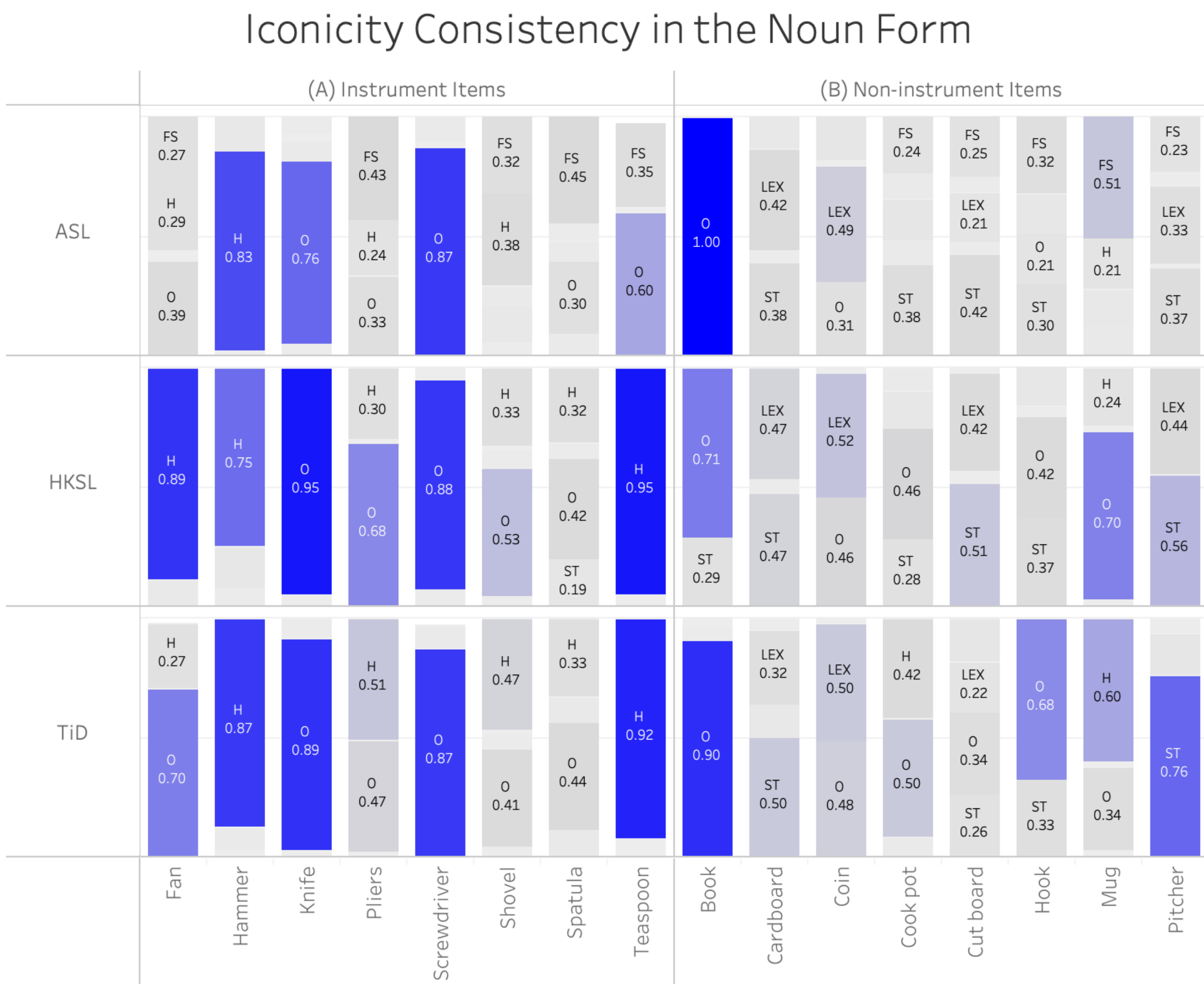


FIGURE 18 Iconic consistency in the noun form.

How consistent signer responses were in the iconicity found in the nominal references made to target objects. Bright blue means consistently one iconicity over the other; gray colors indicate inconsistency. (*Labels* H: Handling, O: Object, ST: SASS-Trace, Lex: Non-iconic, H2O: Shift, FS: Fingerspelled).

Nouns such as BOOK in ASL and TiD, SCREWDRIVER in all three sign languages and KNIFE in HKSL and TiD depict strong Object iconicity. TEASPOON in HKSL and TiD, HAMMER in HKSL and TiD and FAN in HKSL are strong Handling-preference nouns. Everything else falls in between or in some cases follows a non-iconic strategy. Moreover, the type of nominal iconicity is not consistent across sign languages. While the noun TEASPOON uses Handling in HKSL and TiD, it is expressed using Object iconicity most of the time in the ASL data.

While some of these nouns very consistently display either Object iconicity or Handling iconicity within a single language, some others have a much less strong consensus such as PITCHER, CUTTING BOARD and COOKING POT; where, for each object, we see a combination of Object, Handling, non-iconic, fingerspelled or SASS strategies produced as the primary nominal reference to the object by signers. This is in line with Santiago-Batista's M.A. thesis on the iconicity preference of instrument nouns in five sign languages: BSL, New Zealand Sign Language (NZSL), Spanish Sign Language (LSE), Catalan Sign Language (LSC), and HKSL. Her results show no significant difference between the use of one pattern over the other within any of the 5 sign language lexicons she analyzes.

2.2.2 Proposal: Lexical Conventionalization

What is special about this stochastic distribution in my dataset? First of all, the noun data were not collected separately from the instrumental data, as it was the case in Brentari and colleagues' 2016 study where they had a separate item naming task. In the current dissertation, the nouns were extracted from production responses given to experimental stimuli; therefore, my noun collection methodology has the quality of being in a sentential context than a targeted noun elicitation task, where the linguistic recall of signers may have been biased by the specialized format of the experiment. This is not to say that in my lab experiment, the linguistic recall of signers is not biased by other factors. Secondly, my methodology gives us a clear distinction between nouns that are truly conventionalized and without much room for variation in iconic type; and those that are not conventionalized where signers resort to active iconic strategies to create nominal forms to refer to them.

I propose that if ICONIC HANDSHAPE PREFERENCE is indeed a factor that affects the form of the classifier predicate, we should see its effect most pronounced in highly conventionalized iconic strategies, with TEASPOON in HKSL and TiD for instance. I stress the necessity of separating highly conventionalized nouns from those that are not. This methodology and analysis divert from the generalization made in Brentari and colleagues' work in one main aspect. Instead of taking languages as a whole that have either a Handling tendency or an Object tendency, I show that all sign languages have varying degrees of the two types of iconicity in their nominal lexicon and that it is the level of lexical conventionalization of individual nouns that plays a role in determining the form of the classifier predicate. This observed quality of the lexicons calls for a by-object analysis of the experiment data.

In Chapter 4, I will describe how I study my data with respect to ICONIC HANDSHAPE PREFERENCE and present more in-depth observations. However, we will see that ICONIC HANDSHAPE PREFERENCE cannot be the only factor at play in determining the iconicity of the classifier predicate. If that were the case, we would see a one-to-one mapping between the object noun and the classifier predicate. However, that is not the case. An intricate web of factors is responsible for this. These interactions were also observed by Brentari and colleagues. In the following section, I present the second factor that they studied, INSTRUMENT SENSITIVITY, and show how my data behave with respect to this factor.

2.3 Instrument Sensitivity

In 2016, Brentari and colleagues proposed the notion of INSTRUMENT SENSITIVITY to account for the considerable amount of Object iconicity they observe in their data obtained from four different sign languages. According to this notion, if a language makes a morphological distinction between the grammatical environment where a noun bears the thematic role instrument in a sentence versus the environment where it does not, then it is considered an instrument sensitive language. In this section I will go over the details of the findings in Brentari et al. (2016a) on INSTRUMENT SENSITIVITY and propose an alternative explanation to this phenomenon.

2.3.1 Brentari and colleagues (2016): INSTRUMENT SENSITIVITY

Consider the English sentences below that help to conceptualize the different thematic roles the item 'paring knife' can assume in different grammatical contexts:

(10)	Timothy cut the apple in half with a **paring knife**.	*instrument*
(11)	Timothy put the **paring knife** on the table.	*theme*

The morphological marking of INSTRUMENT SENSITIVITY in such languages, in their account, is achieved through the use of Object iconicity in the classifier predicate when the object in question is used as an instrument versus the use of Handling iconicity when the object has a different thematic role such as theme. Brentari and colleagues' data show that while HKSL and LIS are instrument sensitive languages, BSL and ASL are not. However, languages show different levels of sensitivity to this factor and therefore Handling iconicity is still a viable option in encoding instrumental events. They come to this typological categorization of languages by comparing instrumental (agentive) verbs against non-instrumental agentive verbs. They put their findings in a feature-based representation with respect to ICONIC HANDSHAPE PREFERENCE and INSTRUMENT SENSITIVITY, and propose the quadrant in Table 3 below to describe a typological membership that sign languages are likely adhere to in their instrumental classifier constructions:

	Handling preference	**Object preference**
instrument sensitive	HKSL	LIS
instrument insensitive	BSL	ASL

TABLE 3 Typological membership of sign language instrumentals.

Adapted from Brentari et al. (2016).

According to this typology, HKSL instrument objects lexicon is mostly composed of nouns with Handling iconicity. That is the same for the BSL lexicon. ASL and LIS, on the other hand, have instrument nouns composed of Object iconicity for the most part. While HKSL and LIS are instrument sensitive languages, BSL and ASL are not. LIS is an Object iconicity-preference language in the classifier department, and BSL prefers Handling across the board. However, it does not account for how strongly these factors are associated with the languages. DOES INSTRUMENT INSENSITIVITY mean more to the ASL classifier predicates than lexical Object-preference does? What does it mean for HKSL to be a Handling preference language and an instrument sensitive one at the same time?

In my data, the core group in the dataset is composed of 8 vignettes where an agent carries out an instrumental task using the designated tool for that event. Table 4 shows the functions of the 8 instrument objects studied in this dissertation:

Instrument Objects	
item	**function**
Hand fan	put out flame
Hammer	hammer nail into wall
Knife	cut tomato
Pliers	remove nail
Screwdriver	tighten screw
Shovel	shovel dirt
Spatula	flatten dough
Teaspoon	stir tea

TABLE 4 Functions of the 8 instrument objects in the core group.

Each of the 8 items in Table 4 above is also seen in a separate vignette where it is merely being put down on a table (the 'PUT' dataset which corresponds to the 8 items in the typical non-instrumental subset in the main dataset). This isolated portion of the dataset forms the basis for comparing instrumentals against non-instrumentals. The results are in line with Brentari and colleagues, albeit not as clear-cut for ASL. Consider the following graph.

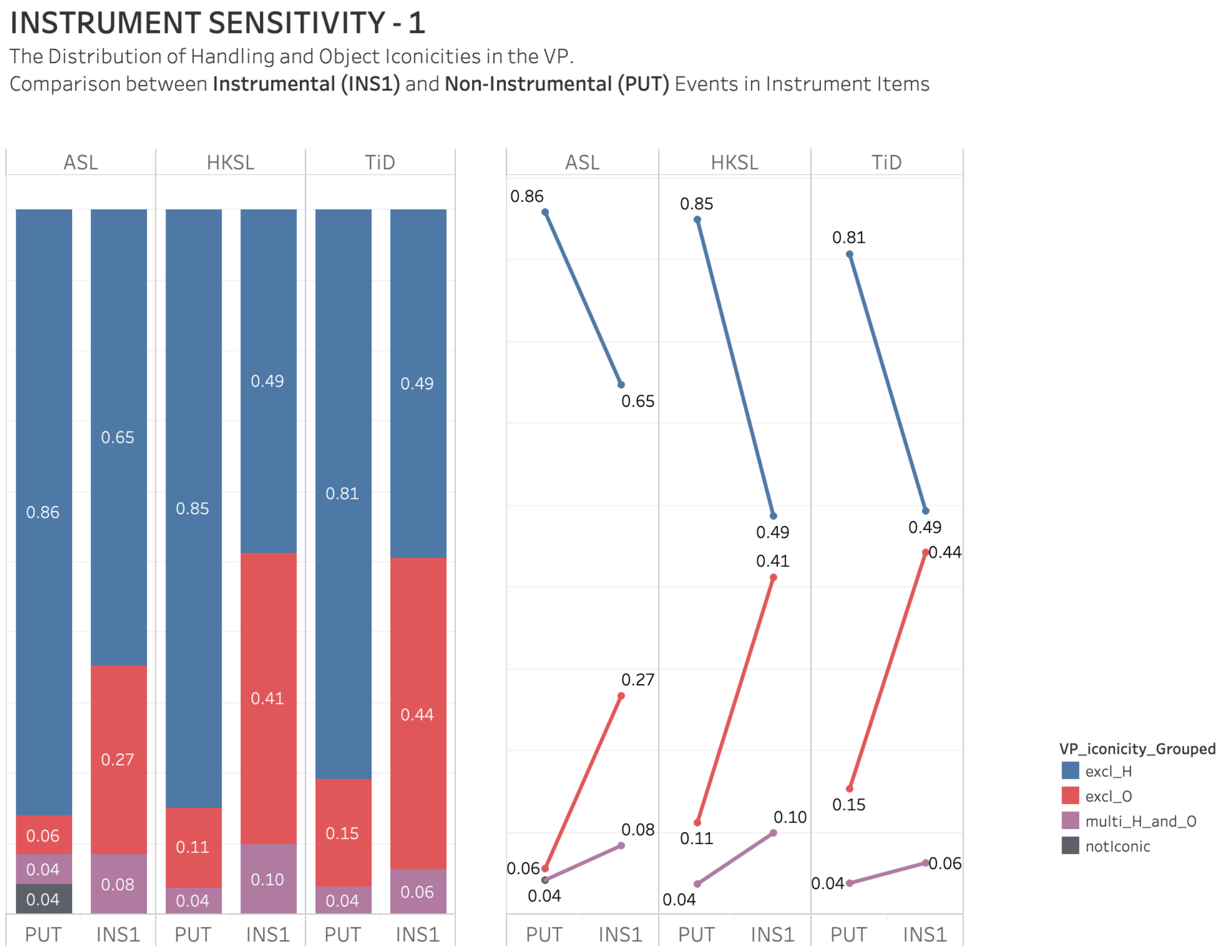


FIGURE 19 Instrument Sensitivity.

The pane on the left with bars shows the distribution of the probability mass across different iconicity types in the predicate. The pane on the right shows how strongly these distributions change as we change the condition on the target object from 'used as an instrument' to 'used as the theme of putting down'. The direction of change as predicted by INSTRUMENT SENSITIVITY should be O↗H↘ from PUT to INS1. Blue bars and lines show exclusively Handling iconicity in the predicate, red encodes exclusively Object iconicity and purple is for cases where both iconicities are present in the predicate. ASL has a 4% distribution in this portion of the data where signers did not produce an iconic VP. (Total N = 464). Each vertical column adds up to 1.00.

The graph above shows a clear-cut case of when an object is used instrumentally; the predicate in the sentence is indeed more likely to display Object iconicity. The results are in line with Brentari and colleagues' observation of the same nature. However, ASL also seems to pattern alike with HKSL and TiD and conform to the INSTRUMENT SENSITIVITY factor, albeit at a smaller magnitude than the other two languages. The right pane shows how steeply the iconicity preference changes to Object when signers are given an instrumental event. ASL Handling preference (blue) drops from 86% in the non-instrumental condition ('PUT' bars) to 65% in the instrumental condition ('INS1' bars) and object preference (red) increases by 21% from the non-instrumental to the instrumental condition. The change is more pronounced in HKSL and TiD. In HKSL, the use of Handling iconicity drops 36 points from 85% to 49% and Object use increases by 30 points (from 11% to 41%). In TiD, Handling use drops 32 points (from 81% to 49%) and Object iconicity adds 29 points to its probability mass (15% to 44%), making up almost half of the instrumental data. We also see a small but steady increase in the use of multiple iconicities (Handling and Object; purple) as we go from non-instrumental to instrumental events. In fact, in HKSL VPs with multiple iconicities make up 10% of the instrumental dataset.

The results above confirm Brentari and colleagues' finding that HKSL is indeed instrument sensitive and add Turkish Sign Language as an instrument sensitive language to the picture. However, the increase in Object use, and the decrease in Handling use between the 'PUT' and 'INS1' environments in ASL are also statistically significant ($p<0.005$). It may be that INSTRUMENT SENSITIVITY is a factor found in all sign languages with its strength varying across languages. This will be elaborated further in Chapter 4.

An important note here is that the target objects used in my data, or the participants for that matter are not identical to the items used in Brentari and colleague's experiments and their participants. This could mean a combination of the following three things: (i) if replacing the items in the experiment changes the results dramatically (to the extent that the effect becomes statistically significant), what we are looking at cannot be a generalizable effect of the grammar favoring Object iconicity in instrumental events, (ii) there may be variation in the production behavior of individual signers in the population, or (iii) INSTRUMENT SENSITIVITY may actually be capturing a phenomenon but the direction of the effect may be in reverse.

My data show that Handling is the majority strategy in the non-instrumental ('PUT') condition, whereas Object is not the main strategy in the instrumental ('INS') condition. In other words, the blue and the red lines in the right pane never cross in any of the three sign languages, which would have indicated a strong shift from Handling to Object as the main strategy. If INSTRUMENT SENSITIVITY were the positive factor that alters the elsewhere[3] form in these languages, we would likely see the probability distribution of Object iconicity surpassing that of Handling iconicity. However, this is not the case.

2.3.2 Proposal: Turning INSTRUMENT SENSITIVITY on Its Head

If we turn the question on its head and look at the data from a different perspective, we can argue that while certain verbs (e.g., PUT) have a strong universal semantic tendency to encode

3 Note that I use the term 'elsewhere' independent of the theoretical baggage it brings with. I do not claim that there is an 'elsewhere' or a 'base' form in classifier predicates, nor do I believe that is the case for any linguistic phenomenon.

a marked relationship between the agent and the theme/patient arguments, i.e., the agent handling the theme/patient (therefore, we see prevalent Handling iconicity in the predicates of the 'PUT' condition), certain others (i.e., the instrumental paradigm, 'INS1' in this dataset) do not have a strong predisposition to highlight the instrument. I argue that it is this lack of a strong predisposition in instrumental constructions that allows other factors to determine the iconicity of the predicate.

When the handling of a tool becomes semantically less salient by way of the fact that the tool now assumes partial agency, aside from the human doer of the action, the robust requirement on expressing the iconically-salient aspect of 'handling the object' ceases to exist. In fact, the non-instrumental verbs that Brentari and colleagues studied (e.g., EAT, HOLD, PUT-ON) require the handling of the direct object (i.e., EAT-**FRUIT**, HOLD-**BOOK**, PUT-ON-**CLOTHING**), just as it is the case with the semantically light verb PUT that I use in my experiments. Could it be that the 'PUT' condition represents a group of marked environments where the theme/patient argument is being handled and one that therefore requires Handling iconicity? What happens when the object assumes partial agency in the event or becomes a key player in the successful undertaking of a task such as an instrumental one? It becomes a salient discourse participant that can optionally be foregrounded. In certain languages, this optionality allows the ICONIC HANDSHAPE PREFERENCE of the object under investigation to surface in the classifier predicate. According to this hypothesis and if there were no other factor involved, because not all of the target objects in the three sign languages in this dissertation have Object iconicity in their noun form, we see a significant but limited increase in Object use when we make a comparison between the non-instrumental ('PUT') condition and the instrumental ('INS1') condition. Had the ICONIC HANDSHAPE PREFERENCE of all nouns studied in this dissertation were Handling, we would see no variation in classifier iconicity between the instrumental and non-instrumental conditions. We will see later in Chapter 4 that while this is a close approximation of what is likely happening, there are other factors that directly influence classifier decision. This interplay between multiple factors forms the basis of my discussions. This network does not say that sign languages do not fall into a typological membership. They indeed do, but the criteria for the formation of the typology have a different quality and levels of gradience. The typology is composed of a ranking of multiple factors.

Sign languages manifest linguistic phenomena in different forms, just like spoken languages do. Iconic handshape preference needs to be studied at the object-level. As for INSTRUMENT SENSITIVITY, it is a factor that requires a different treatment than previous studies. INSTRUMENT SENSITIVITY is likely not a factor in the strictest sense but more of an environment that allows the ICONIC HANDSHAPE PREFERENCE of a noun to surface in the classifier predicate, or it is one of the environments that allows other factors to determine the iconicity of the classifier predicate depending on what components is (or what components are) salient in the described event. Before turning to methodologies in Chapter 3, let me conclude this chapter by briefly presenting another work that likely affects decision process of the iconic form of the classifier predicate.

2.4 Instrument Typicality

In a pilot study in Brentari et al. (2016b) we observed that in TiD, ASL, LIS and HKSL, one of the environments where Object iconicity use in the classifier predicate increases is when an object is used outside of its typical use to carry out an instrumental task. For instance, the typical use of a book is reading it. However, one can use it for the purposes of an instrumental task such as hammering a nail. While the experiments were not as comprehensive and datasets not completely balanced, we found certain increases in Object iconicity use in the classifier predicate:

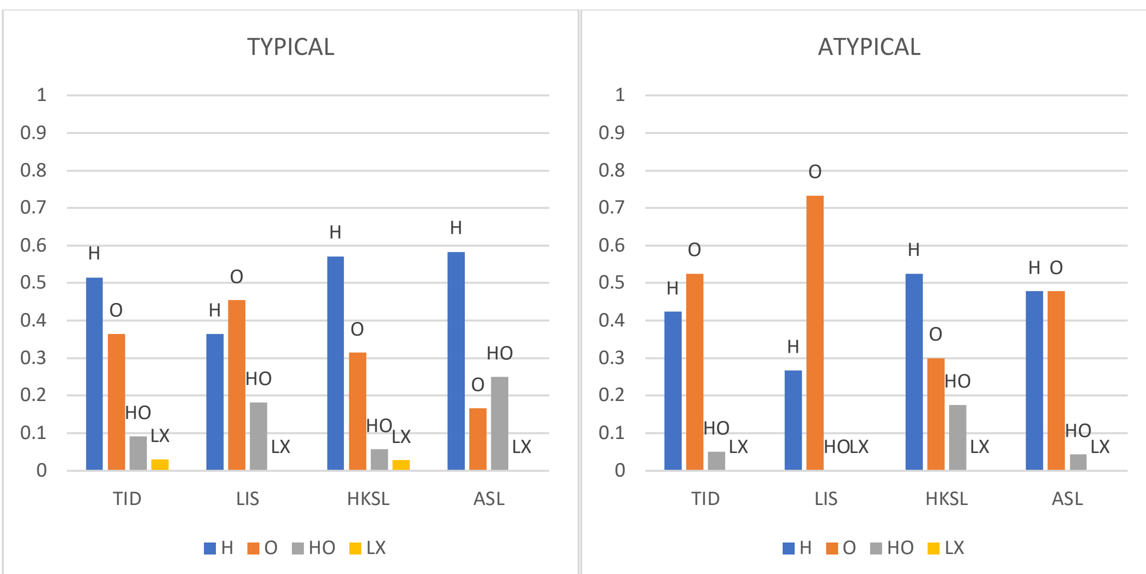


FIGURE 20 Instrument Typicality.

[L] Distribution of iconicity in the typical instrumental condition, such as stir tea with teaspoon. [R] Distribution of iconicity in the atypical instrumental condition, such as stir tea with scissors. Graphs taken from Brentari et al. (2016b).

Although our sample size was considerably small (3 TiD signers, 1 ASL signer, 1 LIS signer and 2 HKSL signers), we contributed the generalization that, iconicity decision in the classifier predicate is also affected by the choice of instrument. However, there was one major caveat in our methodology. We designed the experiment by varying only the object used in the same instrumental task and not by keeping the object constant while modifying the instrumental action. For instance, we drew comparisons between using a teaspoon to stir tea vs. using scissors to stir tea but not between using teaspoon to stir tea vs. using teaspoon to cut cheese, for instance. The lack of covering conditions on both sides was a major flaw in the experiment design because it disregards the importance of the iconic preference of the object noun in the lexicon. In other words, the variation (or the increase, really) that we see in the atypical condition is very likely to be because we prompted by the use of more lexical Object-preference nouns (e.g., SCISSORS) in the atypical condition than in the typical condition. In this dissertation, I remedied this methodological gap. The new results show a similar but less pronounced effect of INSTRUMENT TYPICALITY which will be discussed in the Chapter 4.

3 Methodology

In this chapter, I present my experiment design and methodologies that aim to elicit production data with as limited gradience as possible to answer the research questions put forth in Chapter 2. I will also build on the descriptive statistics to develop some observations about why previous explanations fall short of accounting for the current data. First, I present where the data were collected and the profile of participants that partook in the experiments, then I describe the data annotation steps and the characteristics of the sets of stimuli. Finally, I present some descriptive statistics of the datasets before investigating my hypothesis in Chapter 4.

3.1 Participants

The datasets are composed of 1,856 responses given to production stimuli that I collected from a total of 29 adult signers. The first portion of the dataset was collected in Spring 2019 from 10 Hong Kong signers at the Centre for Sign Linguistics and Deaf Studies at the Chinese University in Hong Kong (CUHK), with the help of the center's director, Professor Gladys Tang. The second portion was collected from 10 Turkish signers in Summer 2019 at Boğaziçi University Sign Language Linguistics Laboratory in Istanbul, with the help of Professors Meltem Kelepir and Kadir Gökgöz. The third portion was collected from 9 American signers in Fall 2019 at the University of Chicago through Professor Diane Brentari's Sign Language

Linguistics Laboratory. This project is part of a larger NSF project to Diane Brentari Susan, Goldin-Meadow and Marie Coppola "Two-verb predicates in sign languages: Typological Variation and Emergence" (BCS 1918545).

All participants are self-reported native signers of their respective sign languages and are aged between 23-55. The ASL cohort consists of 5 female and 4 male signers, the HKSL cohort has 4 male and 6 female signers, and the TiD cohort consists of 5 female and 5 male signers. All signers reported that they have good vision, with or without the help of glasses or contact lenses. This study did not require its deaf participants to be native in the strictest sense that we define in linguistics. The fact that they use their respective sign language as their main means of communication since childhood is where the line was drawn. The dissertation does not seek to test the grammaticality of production responses. It seeks an answer to how certain linguistic patterns emerge and in what contexts they are used.

3.2 Stimuli Design and Data Collection

The experiment has 64 stimuli that comprise short vignettes (2-10 seconds long) where someone is seen carrying out an action. The majority of these vignettes depicts instrumental events; others depict different types of non-instrumental but agentive events. Instrumental events are strictly of the intermediary type[19], where the instrument used has a direct effect on

19 For a more detailed explanation see Chapter 1.

the post hoc form of the patient, its location or condition. For instance, when someone uses a knife to cut a tomato in half, the tomato is not in the same form as it used to be before the cutting event took place. The knife plays the important and direct role of precisely breaking the tomato into two pieces.

3.2.1 Target Objects

Each experiment stimulus has an item that we target (referred to as Target Object throughout the dissertation). The target object is presented to the participants in the thematic role of an instrument (intermediary) for the most part, and sometimes as having a different role such as patient, theme or location depending on the type of the event. I use the term Target Object as an umbrella term to refer to the object that we focus on, regardless of its thematic role in the sentence. Target objects in this study were presented in the previous chapter and they are repeated in Table 5 below.

(A) Instruments	(B) Non-Instruments	
Hand fan	Book	
Hammer	Cardboard	
Knife	Coin	
Pliers	Cutting board	**(C) Hands**
Screwdriver	Hook	
Shovel	Mug	
Spatula	Pitcher	
Teaspoon	Cooking pot	

TABLE 5 Target objects in this study[20].

In each stimulus, the agent (the doer of the action) is clearly visible with their full upper body in the frame. The two sequences of images in Figure 21 and Figure 22 are examples of the two stimulus types:

20 Codes for [A] instrument items: Hand fan (FA); Hammer (HM); Knife (KN); Pliers (PL); Screwdriver (SD); Shovel (GS); Spatula (SP); Teaspoon (TS);

Codes for [B] non-instrument items: Book (BO); Cardboard (CD); Coin (CO) Cutting board (CB); Hook (HK); Mug (MG); Pitcher (CF); Cooking pot (PO);

Hands [C] (HN, ~HI)

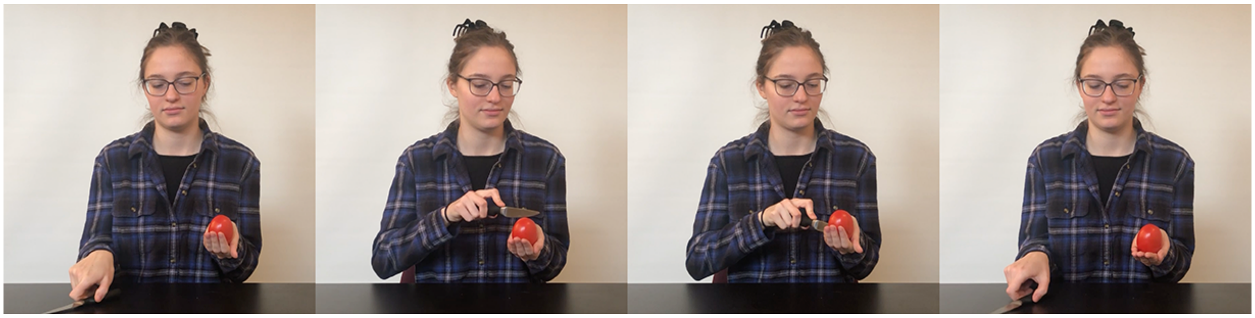


FIGURE 21 Sample instrumental stimulus.

Woman cutting tomato in half using a knife.

The image sequence above is an example of an instrumental stimulus. In this example, a woman (the agent) is seen sitting down behind a black surface (the ground) and holding a tomato (the patient). She picks up a knife (the instrument, which is the target object of this stimulus) and cuts the tomato in half using the knife that she picked up, which constitutes the instrumental action. She then puts down the knife on the table. All instrumental stimuli carried out by human agents are structured like this, where a patient held in the non-dominant hand undergoes an operation with the use of an instrument. This stimulus is 12 seconds long. The average video length for instrumental stimuli is 9.7 seconds.

FIGURE 22 Sample non-instrumental stimulus.
Woman putting a knife on the table.

The image sequence in Table 6 below exemplifies a non-instrumental stimulus. A woman (the agent) is seen sitting behind a black table (the ground) and holding up a knife (the theme, the target object of this sequence). She puts the knife down on the table (the non-instrumental action). This video is 5 seconds long. The average video length for non-instrumental stimuli is 5.26 seconds, over 4 seconds shorter on average than instrumental events.

3.2.2 Data Subsets

The entire dataset consists of eight subsets where different hypotheses are targeted. The diagram in Figure 23 below shows how the data are distributed across all subsets. Each subset differs minimally from the dataset in the middle and is composed of 8 experiment items. The colors code the different types of objects targeted in the experiment: [red] the 8 instrument items, [purple] the 8 non-instrument items and [green] bare hands; corresponding respectively to the groups (A), (B) and (C) in Table 5 above.

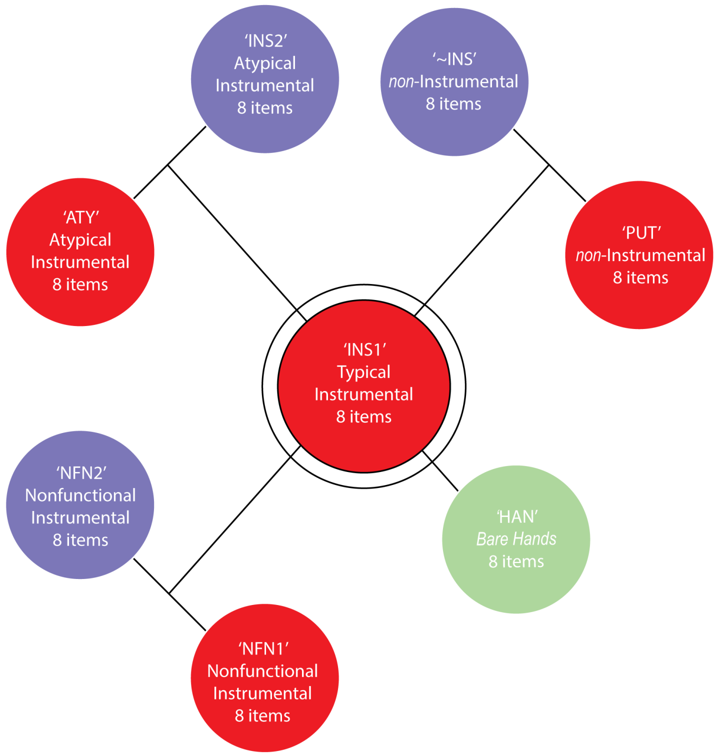


FIGURE 23 The distribution of data across groups.

The dataset consists of 64 items, where a human agent is seen acting on an inanimate patient with or without an instrument. The core of the main dataset is the TYPICAL INSTRUMENTAL group ('INS1'), located in the center of the diagram in Figure 23 above. Each of the seven other subsets in this dissertation shares at least one property with this core group. The core group is where we see instrumental events carried out with the typical, designated tool for the task, such as hammering a nail using a hammer or stirring tea with teaspoon. There are 8 such short vignettes in this group: eight different instrumental events carried out using eight different instruments (HAND FAN, HAMMER, KNIFE, PLIERS, SCREWDRIVER, SHOVEL, SPATULA and TEASPOON).

The 'HAN' dataset (green) consists of the same actions found in the core dataset but carried out with bare hands (e.g., hammer with a fist or stir tea with finger), in other words, bare hands are used as an instrument. From a semantic point of view, whether or not this subset is instrumental is not clear, as the agent does not use a tool external to their body to carry out the action. This will be discussed further in the Chapter 4.

The two NON-INSTRUMENTAL groups consist of 16 objects (the original 8 objects in the core group ('PUT) + 8 other objects ('~INS'), which are not typical instruments – BOOK, CARDBOARD, COIN, CUTTING BOARD, HOOK, MUG, PITCHER and COOKING POT) and depicts short non-instrumental events (e.g., putting a hammer on the table, reading a book). The two ATYPICAL INSTRUMENTAL subsets combine the same 16 objects (8 instrument ('ATY'), 8 non-instrument 'INS2') with an instrumental activity such as hammering a nail with a book and stirring tea with a screwdriver. These tools are not the designated instruments for those tasks, but they successfully accomplish the instrumental task. It is the combination of a task and the tool that makes the situation atypical.

The two NONFUNCTIONAL INSTRUMENTAL groups mix and match the same 16 objects with the 8 actions in the core instrumental group. Differently from the two ATYPICAL INSTRUMENTAL groups, in the NONFUNCTIONAL INSTRUMENTAL groups the instrument of choice does not successfully carry out the instrumental function: e.g., trying to stir tea with a book, trying to hammer a nail with a plastic hand fan. Note that the failure to complete the instrumental task successfully does not stem from the agent's incapability but from the instrument of choice's lack of a certain property that would allow it to carry out the task. The ATYPICAL INSTRUMENTAL and the NONFUNCTIONAL INSTRUMENTAL groups will be elaborated in the next chapter. Table 6 below is a summary of how the stimuli are distributed. The detailed contents of the stimuli and experiment paradigms will be elaborated later in the following sections.

Instrumental	48	**Non-Instrumental**	16
Typical	32	**Atypical**	32
Functional	48	**Non-functional**	16

TABLE 6 Stimuli subsets.

Distribution of stimuli by instrumentality, typicality and functionality. Each row adds up to 64.

Each stimulus was annotated for the following questions. The datapoints from the following annotations and sign by sign glosses and parts of speech tags of signer responses serve as the constants in the statistical explorations and computational model trained in the following chapters:

i. Whether or not it depicts an Instrumental event

ii. Whether or not it is a typical event

iii. Whether or not the Target Object is a tool designated for an instrumental task (e.g., HAMMER has a designated instrumental purpose, but BOOK does not)

iv. What the Target Object is (out of 17; eight instrument objects, eight other objects and bare hands)

v. Whether or not the Instrument and the Patient in the event have physical contact (e.g., a hammer needs to touch the nail, but a fan does not need to touch the surface that it's fanning)

vi. The verb type (there are multiple light V^0s – the core 'INS1' group forms the basis for the 8 instrumental verb types studied here)

vii. Whether or not the intended action is accomplished (Functional vs. Nonfunctional)

3.3 Data Collection

Each signer saw all 64 vignettes in an order that was uniquely randomized for themself prior to the data collection session, and they were simply asked to describe the event that they saw in their native language. Stimuli randomization for individual participants was achieved with a script that I wrote which ensures that no same target object or agent is seen consecutively in the presentation of the stimuli. For instance, if the agent was a woman W in stimulus S_0, the following stimulus S_1, had a different agent. Similarly, if the target object in stimulus S_0 was T, stimulus S_1 had a different target object. This was a necessary step to control for the newness of information and an attempt to discourage signers from omitting the agent and the target object arguments in their responses. Participants saw the vignettes on a laptop computer and were allowed to re-watch the vignette if they wanted. There was no time constraint. They were instructed to watch each vignette until the end and were asked to sign their responses looking at a camera that was positioned on a tripod facing their full upper body. Recordings took place in a private room where signers were by themselves, and each signer session took between 40 to 70 minutes to complete[21].

3.4 Data Processing and Annotation

Research assistants at the University of Chicago clipped each session recording on ELAN into individual signer responses corresponding to the stimuli, using Jonathan Keane's video clipping script fflipper. Then each response was glossed by a native signer and looks like the following example:

(12) WOMAN MUG-O GRAB.MUG-H TEASPOON-H GRAB.TEASPOON-H STIR-H PUT.DOWN

A woman grabs a mug and a teaspoon, stirs [the liquid in the mug] [with the teaspoon] and puts [them] down.

21 Signers actually saw 100 stimuli, results from 36 of which are not reported in this dissertation.

The example above is a TiD signer's response to the stimulus 'woman stirring tea with a teaspoon'. The signer lists the event participants and uses the iconic affordances available to the language to express the event. These iconic decisions are indicated on the glosses with a suffix separated by a hyphen. In this stimulus, the object we target is TEASPOON. The noun phrase TEASPOON-H has handling iconicity indicated with the -H marker, the signer produces the signs GRAB.TEASPOON-H and STIR-H using handling iconicity (indicated with the -H marker; Handling indicates the handling of the teaspoon). In this example, the iconicity decision is indicated for the other iconic constituents as well (MUG-O and GRAB.MUG-H).

We utilized phonological cues and semantic composition in signer responses to identify our target utterance and to determine its boundaries. Phonological cues we used to determine clause boundaries include eye contacts with the camera, sign breaks, the status of the non-dominant hand, pauses between clauses and final holds. Semantic components include modifiers and locative predicates. Typically, a signer, after optionally setting up the discourse participants in the signing space, would sign the utterance that we target. I call the first, optional part "Context Setting" (CS for short). The context setting typically expresses the participants in the event that receive a thematic role. The signer would typically start with a location or ground such as TABLE, and then express the agent and the consecutive thematic roles such as the patient and the instrument, and their locations relative to the ground and to each other.

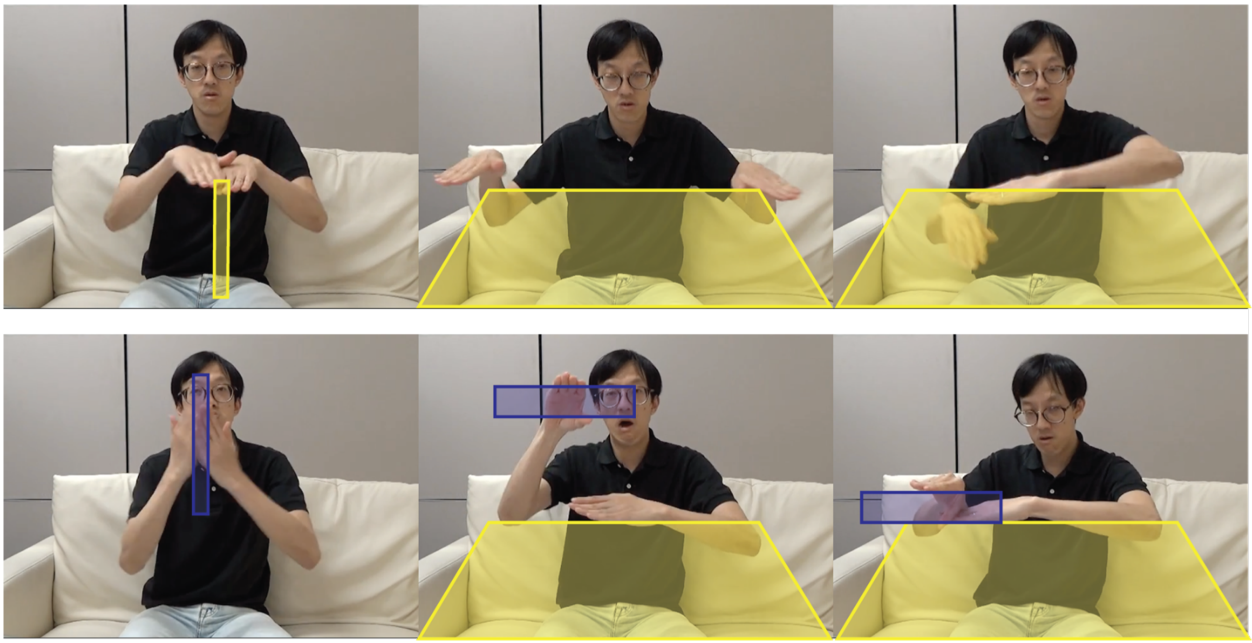


FIGURE 24 Signer response context Setting.

HKSL signer "TABLE TABLE-LOC BOOK-O BOOK-MOD-SASS BOOK-LOC-SASS"

The above sequence shows how one of the HKSL signers sets up the context. In each iteration, he first signs the noun and then locates that in space as one of the event participants. In this very example in Figure 24 above, we first see the noun TABLE (frames 1 & 2, top left and top middle), then its localization of the noun TABLE in space in frame 3 (top right) by use of a classifier in the non-dominant hand. Then the participant signs the noun for BOOK (frame 4, bottom left) and in the following frame (bottom middle) signs a modifier for the BOOK that shows its thickness before indicating its relative location to the table, again via the use of a classifier predicate (frame 6, bottom right). The signer after finishing setting up the event context, continues with the production of the rest of the utterance (not depicted above).

Following the context setting comes the Target Utterance (TU for short). The target utterance is where the signer encodes the gist of the event that they have seen in the stimulus. This is where, for instance, the action where the instrument is used (i.e., the VP) is expressed. The VP has the form of a classifier predicate in the majority of the data sets. The agent and the target object arguments might be expressed in the target utterance, and most of the time, regardless of the language we are looking at, they would precede the classifier predicate. The following is the full response from the same HKSL signer to the image sequence above and the square bracket notation shows how the signer response is organized into the Context Setting and the Target Utterance:

(12) [$_{\underline{CS}}$ TABLE TABLE-LOC BOOK-O BOOK-MOD-SASS BOOK-LOC-H WOOD BOX NAIL NAIL.ON.BOX] [$_{\underline{TU}}$ IX-I MAN-I GRAB.BOX.WITH.NAIL-H GRAB.BOOK-H BOOK-O BOOK-MOD-SASS GRAB.BOOK-H2O HAMMER-O]

There is a table and there is a book on the table. That man grabs the box with a nail attached, grabs the thick book and hammers [the nail with it].

The next step in annotation was to identify the thematic roles and parts of speech for each constituent (indicated as glosses below each sign):

(13)

[CS	TABLE	TABLE-LOC		
	ground	pred_loc		
	BOOK-O	BOOK-MOD-SASS	BOOK-LOC-SASS	
	TO_instr	TO_mod	pred_loc	
	WOOD	BOX	NAIL	NAIL.ON.BOX]
	patient_mod	patient	patient	pred_loc
[TU	IX-i	MAN-i	GRAB.BOX.WITH.NAIL-H	
	agent_ix	agent	pred_grab	
	GRAB.BOOK-H	BOOK-O	BOOK-MOD-SASS	
	pred_grab_TO	TO_instr	TO_mod	
	GRAB.BOOK-H2O	HAMMER-O	]	
	pred_grab_TO	pred_main		

The marker "-LOC" indicates that the sign is a classifier that indicates the location of the object in space, "-mod" indicates that the sign is a modifier. Markers -H, -O AND -H2O encode the handshape iconicity found in that sign: H for handling, O for object and H2O for when the handshape iconicity changes from handling to object in a single sign. Table 7 belowmaps the acronyms used in annotation to their full forms:

-H	Handling		**TO**	target object
-O	Object		**pred_loc**	locative predicate
-H2O	Handling to object shift		**-mod**	modifier
-O2H	Object to handling shift			
-SASS	Size and shape specifier			

TABLE 7 Acronyms used in data annotation.

After having identified each sign's thematic role or semantic function, we asked the following questions:

i. How many times was the Agent NP overtly expressed? (0 to *N*)
   a. Was the Agent expressed in the Target Utterance? (Yes or No)

ii. How many times was the Target Object expressed as a noun? (0 to *N*)
   a. Was the Target Object NP expressed in the Target Utterance? (Yes or No)
   b. For each Target Object NP, did it have Handling or Object iconicity or not? (Yes or No)

c. What was its type of iconicity? (Handling or Object or both?)

d. How many modifiers did the Target Object NP have? (0 to *N*)

iii. How many VPs were there in the Target Utterance? (0 to *N*)

a. For each VP, was it a classifier predicate? (Yes or No)

b. What was the type of iconicity in the VP(s)? (Simplex Handling or Object; H2O or O2H shift iconicity, or OH, HO or HOH complex serial verb)

iv. What was the string order of the signs and the order of sub-phrase level components in the signer response? (e.g. [agent patient *modifier1 modifier2* instrument predicate])

v. Were there any agentive cues in the production? (Such as *grab* in 'grab the object X')

vi. Was there a resultative VP?

a. What was the iconicity of the resultative?

As presented earlier in Chapter 1, classifier predicates are composed of three main components: (i) a handshape (i.e., the noun classifier), (ii) a movement (i.e. the verbal core and the phonological nucleus) and (iii) a location that encodes the classified object's relative position to other event participants. The following images from TiD show two different responses to the same stimulus item:

FIGURE 25 Components of the classifier predicate.

[L]: Handling classifier; [R]: Object classifier. Both signs mean 'putting fan [on the table]'.

The sign 'PUT.DOWN.FAN' has three main components: (i) a single, top down, big movement in the elbow, (ii) two locations in space for the start and the end of the movement, and (iii) a certain handshape that classifies the noun FAN. Both signs encode the same event and have the exact same form part except for the difference in the handshape. In deciding how many predicates the target utterance has, we looked at certain phonological and syntactic cues. If the predicates were separated by other signs, then they were considered separate. If they consisted of a sequence of Handling and Object forms without any phonological or syntactic break after each iteration, then we considered them a serial verb construction. These complex predicates have multiple movements, but the signs belong to a single prosodic unit. If the handshape changed from Handling to Object or vice versa within a single movement, we considered those complex H2O or O2H verbs (or shift iconicity). There are very few cases of shift iconicity in the data. The following two image sequences are an example of the Handling-Object-Handling verbal complex ('HOH' sandwich), and an example of the Handling-to-Object shift iconicity in the predicate (VP-H2O).

FIGURE 26 Handling-Object-Handling complex predicate.

'HOH sandwich'. TiD signer. "FLATTEN-H FLATTEN-O FLATTEN-H"

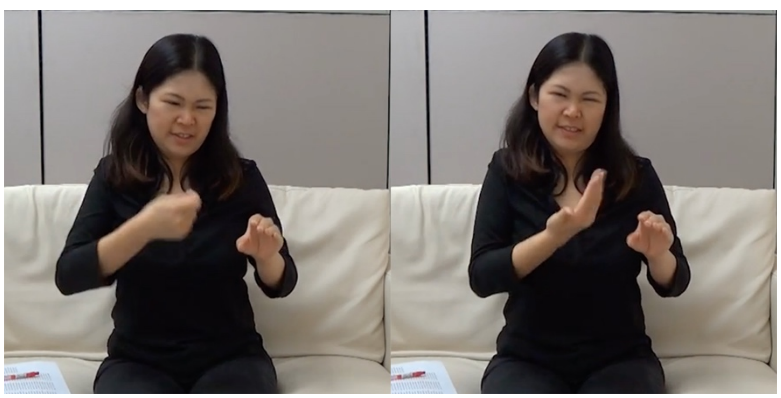


FIGURE 27 Handling-to-Object shift predicate.

HKSL signer. "PRY-H2O"

In the following section, I give a brief overview of data acquired from simple descriptive statistics.

3.5 Data Overview and Exploration

In this section, I give an overview of the structure of the data and how they are distributed across parameters. There are 13 questions asked per each signer response and the responses were glossed. We study a total of 24,128 data points. 64 responses were collected from each of the 29 signers in ASL (9), HKSL (10) and TiD (10) (13x64x29=24,128).

The graph in Figure 28 below shows the breakdown of signer responses in each language and the iconic strategies they have used in the classifier predicate(s) that I target in their responses. This graph does not include the bare hands condition.

Language Wide Predicate Strategies

	H_only	O_only	M	notIconic	noVP	Grand Total
ASL	0.645 (324)	0.251 (126)	0.050 (25)	0.022 (11)	0.032 (16)	**1.000 (502)**
HKSL	0.488 (273)	0.418 (234)	0.077 (43)		0.018 (10)	**1.000 (560)**
TiD	0.548 (305)	0.390 (217)	0.041 (23)		0.022 (12)	**1.000 (557)**

FIGURE 28 The distribution of morphological strategies across predicates.

Signers from all three languages employ predominantly iconic ways to express spatial-agentive relations in their response predicates. We found exclusively non-iconic predicates only in about 2% of the ASL responses, this is the number of such cases where no iconic predicate to complement the non-iconic one is present. Non-iconic predicates are non-existent in HKSL and in TiD. 3% of the responses in ASL, and 2% in HKSL and TiD responses each did not provide the predicate (the noVP cases). Iconic responses make up 94% of the ASL data, 98% of the HKSL data and 98% of the TiD data. These measures consist of the two main predicate strategies used by signers in their responses:

i. Only Handling iconicity use in their VP response (i.e. [VP_{H}]),

ii. Only Object iconicity use ((i.e. [VP_{O}]); or

iii. In few cases they might have combined Handling and Object iconicities (the 'M' portions in Figure 28 above) in one of the following three iconic ways:

   a) separate, independent VPs with different iconicity types (e.g. [VP_{H} NP_{1} VP_{O}]),

   b) using serial verb constructions ('sandwich' e.g. [$VP_{H\text{-}O\text{-}H}$]); or

   c) changing the handshape iconicity within a single movement, which I refer to as "shift iconicity" (e.g. [$VP_{H>O}$]);

where (a) is composed of multiple morphologically and prosodically simple signs, while (b) is prosodically complex (multiple morphemes in one prosodic chunk) and (c) is morphologically complex but prosodically simplex (multiple morphemes in one simplex movement. Combined strategies make up less than 5% of the entire dataset: separate VPs with different iconicities 0.3%; serial verb constructions 4%; and handshape changes within one movement 0.6%.

In Chapter 1, I presented the literature on the observation that the handshape iconicity found in a classifier predicate interacts with its argument structure. Benedicto & Brentari

(2004) established that in ASL transitive-agentive events are expressed with the use of Handling iconicity and intransitive-unaccusative with the use of Object iconicity. The same argument has since been extended into various other sign languages. Kimmelman & Pfau (2019) found that the distinction between the two iconicity types in Russian Sign Language is not as clear cut as what Brentari and Benedicto observe in ASL. In my ASL dataset in this dissertation, which consists exclusively of agentive events, the Handling-Object dichotomy does not hold one hundred per cent of the time. In 23% of their responses (207 count), ASL signers exclusively used an Object classifier in the VP without complementing it with Handling iconicity. Overall, if we count signer responses that had both Handling and Object iconicity in the VP, the number increases to 27%. That being said, the majority of the ASL data (68%) still uses only Handling iconicity in the predicate, albeit not exclusively. The use of Object iconicity in the VP to encode agentive events is more pronounced in HKSL and TiD. HKSL has a 35% Object iconicity only portion of the data, while the number in TiD is 33%. If we include the Handling and Object strategy, the Object iconicity numbers go up to 42% in HKSL predicates and 37% in TiD predicates, well over one third of both datasets.

One of the main purposes of this dissertation is to study the interactions between classifier predicates and the argument structure of the constructions under investigation. The graphs in Figure 29 show how the signers of each language behaved with respect to the overt presence of the Agent noun and the Target Object noun:

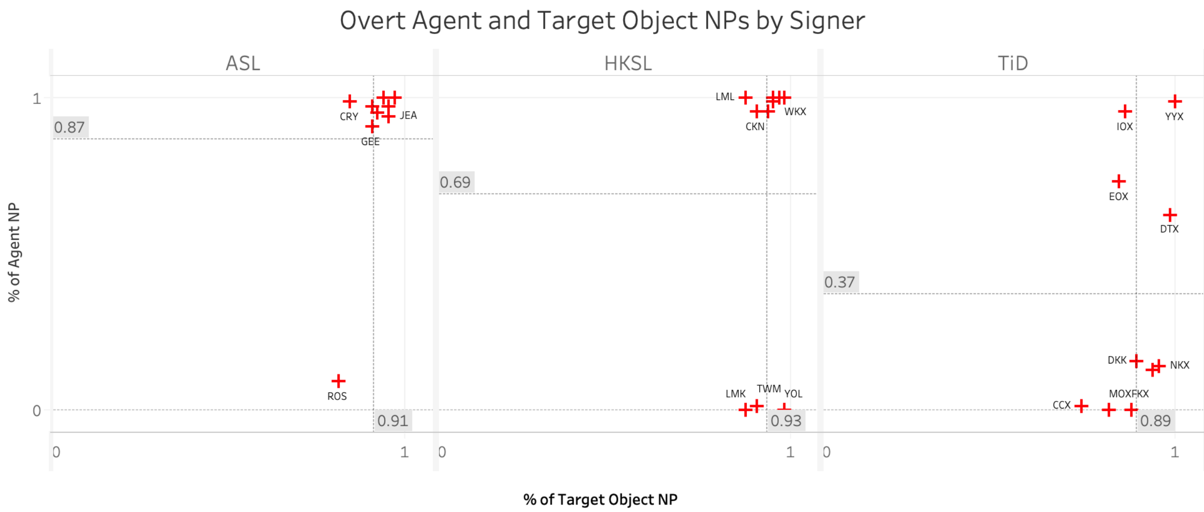


FIGURE 29 The overt expression of the Agent and the Target Object NPs.

The x-axis shows the percentage of an overt Target Object noun, and the y-axis shows the percentage of an overt Agent noun per signer.

The graphs in Figure 29 above asks a naïve question about how consistent each signer was in expressing the Target Object information as an overt argument (on the x-axis) and the Agent information as an overt argument (on the y-axis). Each red plus sign corresponds to a signer and its [x, y] coordinates indicate how consistently the signer expressed at least one Target Object noun (x-axis) and at least one Agent noun (y-axis). For instance, the TiD signer YYX expressed both the Agent and the Target Object noun at least once in almost all their responses while the HKSL signer LMK never used an Agent noun but expressed the Target Object information in over 80% of their responses. As far as language-wide tendencies are concerned, we see in ASL that all signers except one almost always expressed the Agent noun overtly. In HKSL, we see a group of 7 signers who almost always expressed the Agent noun and a group of 3 signers who almost never overtly expressed the Agent information (mid pane, bottom: LMK, TWM and YOL). TiD signers, on the other hand, display an erratic behavior compared to ASL and HKSL signers. The majority of TiD signers (6 of them: CCX, FKX, DKK, NKX and two others) almost never expressed the Agent noun overtly. Two signers consistently expressed the Agent information (YYX and IOX), while 2 others (EOX and DTX) did so in only around 75% of their responses. As for the Target Object noun, we see a more uniform behavior across the three sign languages. All signers in each language expressed the Target Object noun at least once in at least 80% of their responses.

An important question regarding Agency that we can answer here is whether or not Agency determines the iconicity type of the classifier. Let us make the following naïve assumptions for all three sign languages studied here based on Benedicto & Brentari (2004)'s observations on ASL:

(14) An overt agent noun is an indicator of an agentive structure.

(15) Handling iconicity encodes agency; therefore, the classifier predicates of target utterances with an overt agent noun must have Handling iconicity.

(16) Object iconicity encodes unaccusativity; therefore, target utterances where classifier predicates have Object iconicity must not have an overt agent noun.

The graph in Figure 30 studies the distribution of overt Agent NP use across signer responses in two environments: (i) Handling iconicity in the predicate, and (ii) Object iconicity in the predicate.

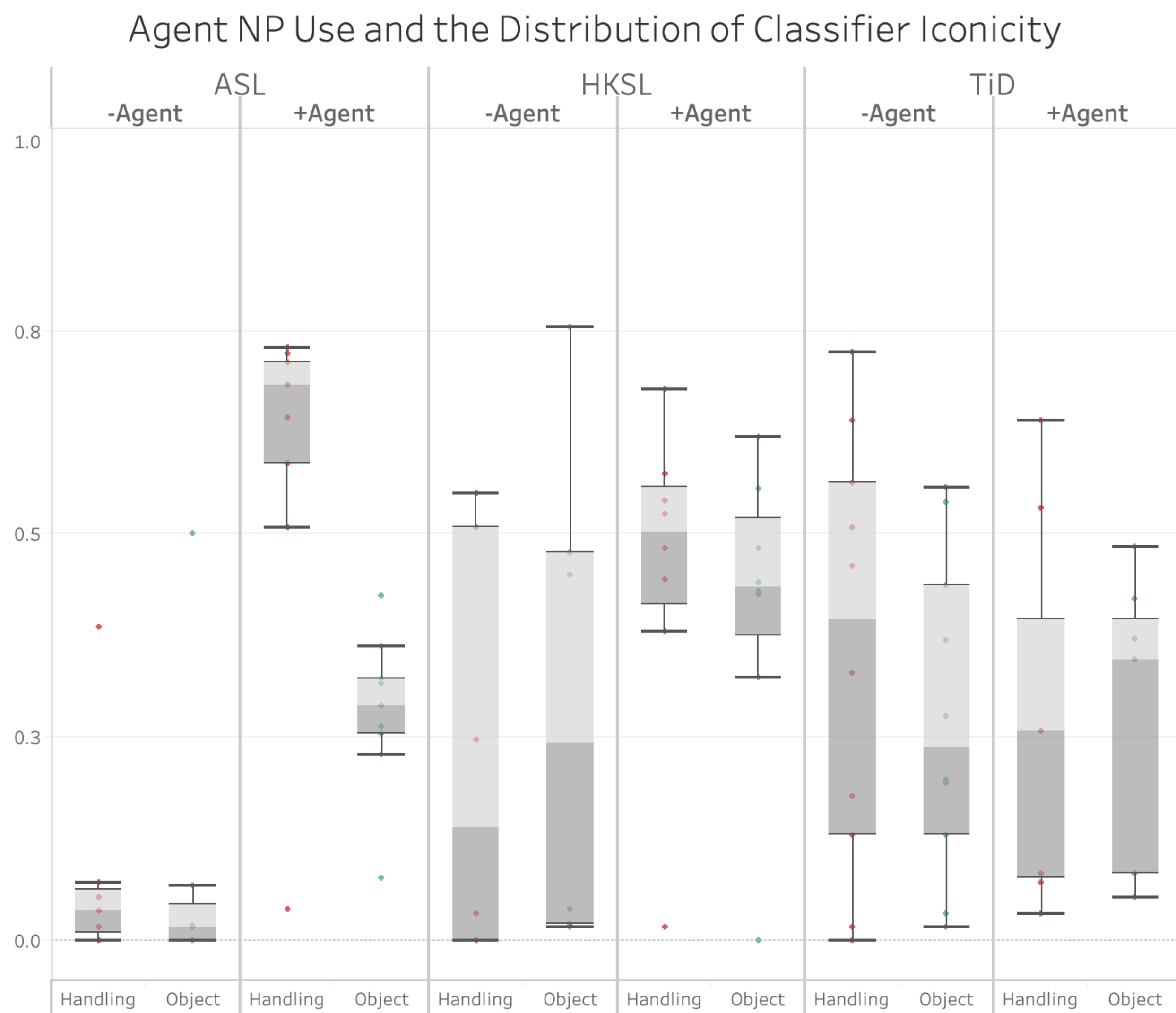


FIGURE 30 Distribution of Agent Nouns across Classifier Iconicities.

The boxplots divide each signer's responses into 4 categories: (i) when there was an Agent noun and the classifier predicate iconicity was Handling, (ii) when there was an Agent noun and the classifier predicate iconicity was Object, (iii) when an Agent noun was missing and the classifier predicate iconicity was Handling, (iv) when an Agent noun was missing, and the classifier predicate iconicity was Object. The first striking difference is between ASL and the other two languages. As I have already shown in Figure 29 above, ASL signers like to keep their Agent noun, while HKSL and TiD are more liberal in not using them. Therefore the [-Agent] environment in ASL has a very small proportion compared to the [+Agent] environment. This difference is reminiscent of Fausey et al. (2010)'s study on Japanese and English, where English speakers are more likely to use agentive language than Japanese speakers. A second point is the differences between the use of Handling and Object under each of the two [+Agent] and [-Agent] environments. There is a statistically significant difference in ASL in the use of Handling and Object iconicities when there is an Agent noun. Object use is consistently and significantly lower than Handling use ($p=0.001$). This provides evidence to Benedicto & Brentari's 2004 claim that Handling iconicity encodes agency. It is crucial, however, to note that there is still a considerable amount of Object classifier use when there is an overt Agent noun. As for TiD and HKSL, there is no statistically significant difference between Handling and Object use in the [+Agent] condition (HKSL: $p=0.43$, TiD: 0.94), which brings us to a third important point: the greatness of variation available in HKSL and TiD, which is absent in ASL – notice the height of the boxes and their whiskers. When there is no Agent noun [-Agent], for which there is not enough ASL data, the difference between Handling and Object use across signers is not significant in any of the languages ($p>0.3$ in all three). We can conclude the assumption in (15) above by saying that Handling iconicity is an indicator of Agency in ASL, while it is not in TiD and HKSL. There is no significant difference in Handling and Object iconicity use in those languages when the Agent noun is present; therefore, in TiD and HKSL Agency and Object iconicity are not mutually exclusive.

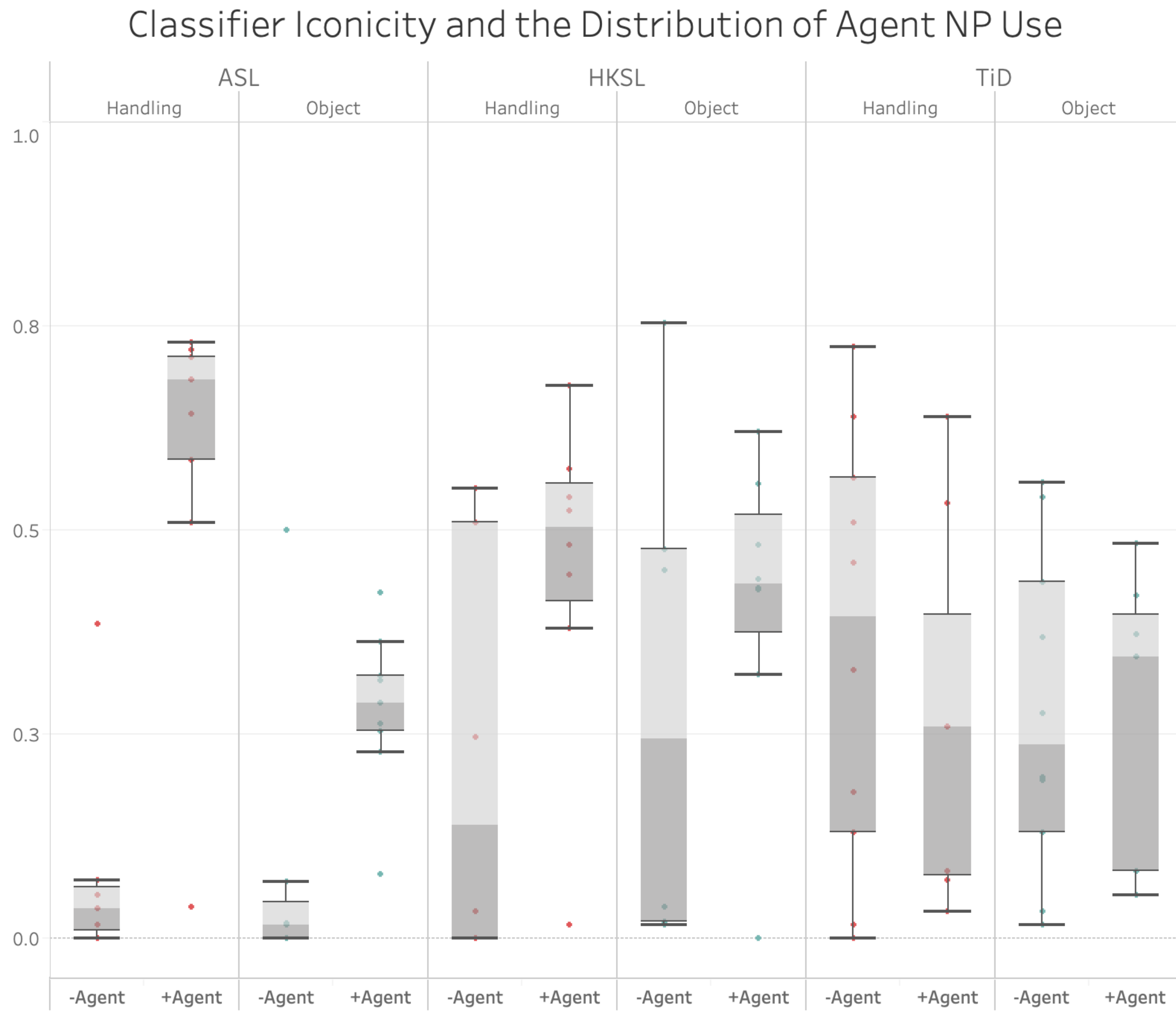


FIGURE 31 Distribution of Classifier Iconicity across Overt and Missing Agent Nouns.

The plot in Figure 31 above studies the same 4 categories but targets the assumption in (16). When the classifier predicate has Object iconicity, is the target utterance necessarily missing an overt Agent noun? Another t-test shows that this assumption holds in ASL (p=0.03) but not in HKSL or in TiD (p=0.36, p=0.45 respectively). What does this mean? It looks like Handling is strongly associated with Agency in ASL but not in HKSL or in TiD.

Moreover, Object is likely strongly associated with the lack of Agency, and again not in HKSL or in TiD. Object classifier use in the ASL responses given to these agentive stimuli, although more limited (around 25% of responses) compared to HKSL (42%) and TiD (39%), can likely be interpreted as the promotion of the instrument information to a syntactically prominent position, while backgrounding the agent information and likely changing the valency of the construction. This observation on ASL is in line with Benedicto & Brentari (2004). As for TiD and HKSL, although the datasets are more balanced than the ASL dataset regarding the presence of an Agent noun, there is no strong relationship between Handling iconicity and Agency, nor is there a relationship between Object iconicity and the lack of an Agent. One could argue that TiD and HKSL have implied Agent information (i.e., Agent noun drop); however, that argument. would fail to account for the presence of the Agent noun when the classifier predicate has Object iconicity.

In the following chapter, I present the details of my methodologies, discuss the implications that the results from my experiments have on the sign language literature on classifiers and present new findings on the grammatical distributions I have presented so far.

4 An Information Theoretic Approach to Classifier Iconicity

Gradience is a given in linguistic research and the datasets in this dissertation are no exception. We expect to find higher levels of gradient linguistic behavior especially across some native and near-native populations of sign language users whose age of acquisition vary due to some impediments in early access to a language model as a child. Another reason for pronounced gradience in sign languages is the lack of a centralized national linguistic association that controls the linguistic landscape and navigates the language by creating and distributing descriptive language material or at some extreme cases by dictating how the users of a language should use it. In this dissertation, I do not question the grammaticality of the responses that the participants provided to my experimental stimuli. I take the production data as the basis of my discussions and explain, using statistical and linguistic methods, where and how signers vary in their responses.

In this chapter, I will use the gradience in the data to the advantage of my research questions and propose new perspectives based on Information Theory (Shannon, 1948) to the four factors from the literature that are thought to have an effect on the iconicity decision in the classifier predicate: AGENCY, ICONIC HANDSHAPE PREFERENCE, INSTRUMENT SENSITIVITY and INSTRUMENT TYPICALITY. I will also propose a new major factor, PERCEPTUAL SALIENCE, which I argue is the fundamental component of the mechanism that is responsible for effectively distributing different types of iconicity across classifier predicates in language production. I discuss the statistical trends in the current data with respect to PERCEPTUAL SALIENCE and how this newly proposed factor acts as a meta-function that points the other factors, which are nested under it, in the right direction. I propose another factor that may explain some of the variation and linguistic decisions in my data, albeit to a more limited extent: INSTRUMENT FUNCTIONALITY. The structure of this chapter follows the datasets from Chapter 3, repeated in Figure 32 below. The names of the data subsets where comparisons are made comes from this schema. Recall that each data subset (each circle) differs as minimally as possible from the core group in the center ('INS1').

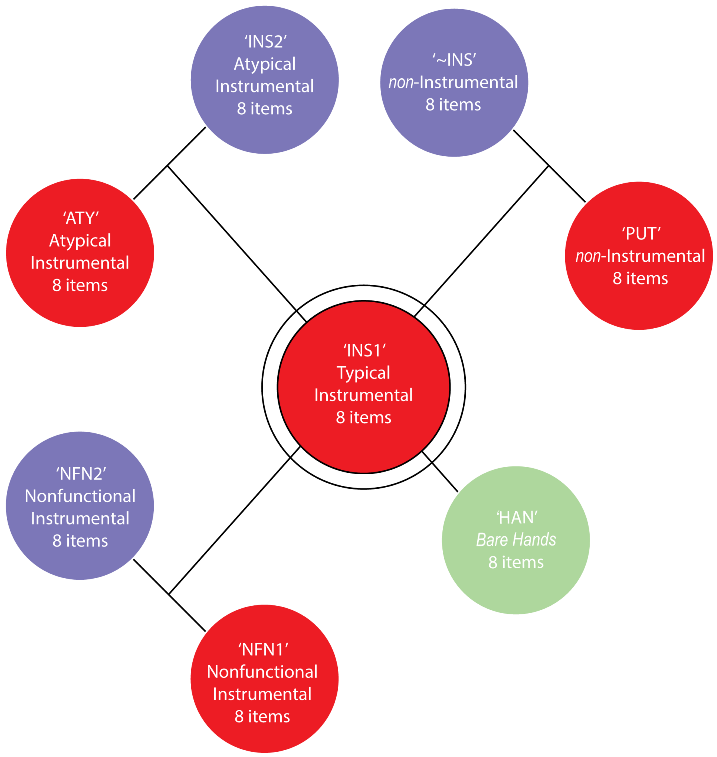


FIGURE 32 The distribution of data across groups.

I walk the reader through the hypotheses that I study one at a time and give a detailed account of how the experiments and datasets tackle the questions raised by me in the current dissertation and by other researchers in the past. Each subsection will walk the reader through the framework as well as the statistical and mathematical methods used in explaining the observed phenomena. I will then finish the chapter by segueing into the next one, where I present the computational model that I developed in order to predict the form of a classifier construction, and the logistic regression analysis trained on the factors investigated in this chapter.

4.1 Introduction: Factors from the Literature, Revisited

In this section, I go over each of the four factors that I presented in Chapter 2. Let us remind ourselves what these hypotheses say. (A) AGENCY states that the classifier predicate encoding of all agentive events should display Handling iconicity (Benedicto and Brentari, 2004). However, we have seen that all sign languages use Object iconicity in agentive environments to various degrees. To account for this variation researchers proposed certain factors. (B) ICONIC HANDSHAPE PREFERENCE (Padden et al., 2013; Brentari et al. 2016a) follows the iconic tendencies of a language's nominal lexical system and hypothesizes that this iconic tendency will be reflected in the classifier predicate. (C) INSTRUMENT SENSITIVITY (Brentari et al. 2016a) says that if an object is used as an instrument, the classifier predicate that encodes the instrumental action is more likely to have Object iconicity than if the same object were seen in a different thematic role, such as a patient. (D) INSTRUMENT TYPICALITY (Brentari et al., 2016b) claims that if an atypical object is used as an instrument for a task, the classifier predicate that encodes the instrumental task is likely to have Object iconicity.

AGENCY was first noticed in ASL and was later extended into other sign languages. ICONIC HANDSHAPE PREFERENCE and INSTRUMENT SENSITIVITY are the two criteria that Brentari and colleagues base their instrumental typology of sign languages on. Their data and methodologies show that ASL is Object-preference in the nominal lexicon and instrument insensitive, HKSL is Handling-preference and instrument sensitive, BSL is Handling-preference and instrument insensitive, and LIS is Object-preference and instrument sensitive. This is how they explain the different proportions of the distributions of Handling and Object iconicities they see in their data. According to their model, LIS uses a lot more Object-iconicity in the classifier predicate than the other languages because it is both Object-preference and instrument sensitive. Similarly, BSL uses much more Handling iconicity in the classifier predicate because it is Handling-preference in the nominal domain and instrument insensitive. Moreover, Brentari et al. (2016b) has found that INSTRUMENT TYPICALITY motivates the use of Object iconicity in the classifier predicate. In the following subsections, I go over each of these factors and present new findings and the methodologies that I used in coming to those findings.

4.2 Iconic Handshape Preference, Revisited

Padden et al. (2013) has shown that the instrument noun vocabularies of sign language lexicons vary with respect to the prevalence of different types of iconicity present in the form of the noun. They make a distinction between Handling and Object forms but also contrast a third option, Instrument forms. Instrument iconicity differs from Object iconicity in one aspect: it captures the movement associated with the instrumental activity the tool is designed for, which Object iconicity does not. For instance, the ASL sign TOOTHBRUSH has an extended index finger as its handshape, which reflects the object's physical properties, and a sideways movement in front of the mouth that reflects how the tool is used, making it an Instrument iconicity noun. They found that the tool vocabulary of Al-Sayyid Bedouin Sign Language (ABSL) prefers Instrument iconicity over Handling iconicity. In contrast, the New Zealand Sign Language (NZSL) lexicon has more Handling forms in its tool vocabulary than Instrument forms. They call this behavior of sign language lexicons 'patterned iconicity'. In this dissertation, I ignore the distinction that Padden and colleagues' make between Object and Instrument iconicity types and focus on the handshape component of the nouns and the classifier predicates, the majority of the time. Therefore, I call the iconicity type of all nouns and classifier predicates whose handshape reflect a physical property of the object they refer to, *Object*.

Brentari et al. (2016a) builds on Padden and colleagues' patterned iconicity and proposes that if a language's tool vocabulary is more Object iconicity than Handling, we should expect to see more Object iconicity in the instrumental classifier predicates that are associated with tool names from this vocabulary. They call this ICONIC HANDSHAPE PREFERENCE. Undoubtedly, this is a major factor that contributes to the iconic preference in the classifier predicate. However, neither Padden's nor Brentari's methodology was detailed enough to account for what we see in the linguistic wild. First of all, they ran naming tasks using still images, which meant that the signers were not asked to use the noun forms in a sentential context; therefore, their participants only provided the quotation form for the noun signs that came to mind. Secondly, they analyzed the iconic tendencies of a language as a whole. In my dissertation data and also in Santiago-Batista's dissertation on instrument nouns, however, in no language or the totality of signer responses, the nouns were expressed using a single, prevalent iconic strategy. Moreover, other than very few signs, all signs showed varying degrees of different strategies across all sign languages. For instance, some signers use Handling iconicity for the noun SCREWDRIVER in one response and Object iconicity for the same item noun in the next response, or they sometimes use both iconic strategies in a single response. This means that we cannot take the tool vocabulary of a language as a whole and build a generalization around it since individual nouns, let alone the entire vocabularies, do not have a uniform distribution of iconic strategies. We need a methodology that allows comparisons among noun signs, signers and languages as well – a methodology that allows comparison not merely at the lexicon-level but also and specifically at the lexeme-level.

4.2.1 Does the Noun Iconicity Type Match the Predicate Iconicity Type?

In this dissertation, I analyze each of the responses individually, and test, for each of them, whether the iconicity of the target object noun matches the iconicity found in the classifier predicate. Let us remind ourselves that the experiments have 8 instrument target objects (FAN, HAMMER, KNIFE, PLIERS, SCREWDRIVER, SPATULA, SHOVEL, and TEASPOON), 8 non-instrument target objects (BOOK, COIN, CARDBOARD, CUTTING BOARD, COOKING POT, S-HOOK, MUG, and PITCHER) and bare hands. The following sentences exemplify how I analyze my data individually for each of the 16 experiment items and bare hands following this approach:

(17) [MAN KNIFE_**H** BREAD] [CUT_**H**] – *match*, H-H

(18) [MAN KNIFE_**O** BREAD] [CUT_**O**] – *match*, O-O

(19) [MAN KNIFE_**H** BREAD] [CUT_**O**] – *mismatch*, H-O

(20) [MAN KNIFE_**O** BREAD] [CUT_**H**] – *mismatch*, O-H

(21) [MAN KNIFE_**HO** BREAD] [CUT_**HO**] – *mismatch*, HO-HO

If the types of iconicity in the Target Object noun and the predicate are the same, like in sentences (17) above and (18) above, then I call those 'match' cases and indicate what kind of iconicity it is. If they are different types of iconicity as is the case in sentences (19) and (20), then it is a case of 'mismatch' and I again indicate the types of iconicity found in both the Object noun and the predicate. One-to-many, many-to-one and many-to-many mappings (21) are left out for this portion of the dissertation, as a singleton decision between Handling or Object cannot be made. This issue will be tackled later. The following graph in Figure 33 shows how each language behaves with respect to coordinating the types of iconicity between their Object nouns and classifier VPs.

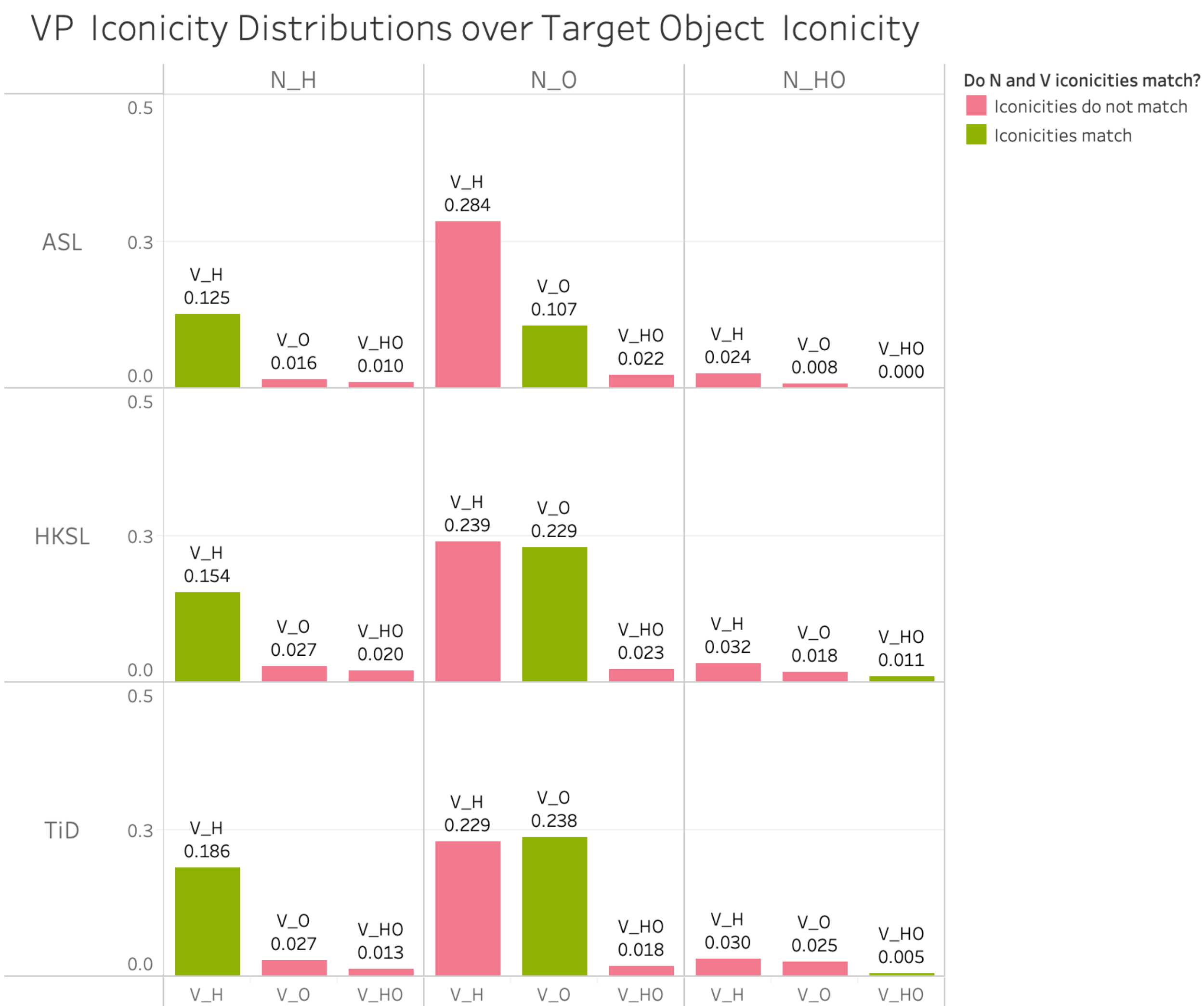


FIGURE 33 The distributions of predicate iconicity over target object iconicity.

For visual simplicity, these graphs present only the portions of the data where both the target object and the VP were iconic utterances. Therefore, each language row may not add up to 1.00. Green bars indicate the portions of the data where the iconicity in the target object matches the iconicity found in the predicate. [N = Target Object noun; V = Classifier predicate].

Each row of graphs in Figure 33 corresponds to a language. Each vertical pane divides the data by the iconicity configurations found in the target object NP and each green and pink bar then gives the proportions of the iconicity type found in the classifier predicate of the same utterance. Therefore, it only looks at the proportions of the data where (i) there was at least one nominal iconic reference made to the target object and (ii) there was at least one classifier predicate that was also iconic (Handling or Object, or both). The parts of the data where either the target object NP or, in very few cases, the predicate was not iconic or dropped are omitted from these graphs. 60% of all signer responses in ASL have both an iconic target object NP and an iconic classifier predicate in the same response. 75% of all HKSL data consist of such signer responses and the same measure for TiD responses where both constituents are present and iconic is 79%.

The green bars show the proportions of the data where the iconicity in the target object noun matches the iconicity of the classifier predicate in the same utterance, these are also the parts of the data that I have been referring to as "match cases". Only about 23% of the ASL data consist of matching iconicity types in the target object NP and the classifier VP: 12% H-H match + 11% O-O match. The numbers are higher in HKSL (a total of 38% match; 15% H-H + 23% O-O) and in TiD (a total of 43% match; 19% H-H + 24% O-O).

The pink bars indicate the portions of the data where while both the Target Object noun and the classifier predicate are iconic their iconicity types are not in concordance. Note the cases where both types of iconicity (Object and Handling – O&H) are present in the target object noun or in the predicate. We could have considered those as match cases as they act as some sort of a wild card between Handling and Object. However, this would be an ill-considered decision from an information depth point of view. Signers, when they exploit both iconicity possibilities, do it for a reason. While the multiple iconicities data are too sparse to make predictions, they are kept in the calculations that follow.

While we do see some tendency to match the iconicities of the two constituents, especially across TiD and HKSL responses, just by looking at these distributions we are not able to explain exactly what motivates this behavior nor can we be sure whether this behavior. is above chance level. We also cannot tell how many patterns there are. Moreover, the closer we look at the data the better we see that almost no lexical noun for a target object consistently displays either exclusively Handling iconicity or exclusively Object iconicity. In fact, most of the lexical signs were not even close to displaying a polarized behavior toward just one type of iconicity. Either strongly Object or strongly Handling applies to only one handful of object signs that the experiments target.

4.2.2 Lexical Rigidity/Consistency

To study the effect of Iconic Handshape Preference, we need to analyze the data at the lexeme-level. In the previous section, I have shown how I handle the cases where the iconicity of the target object noun matches the iconicity in the classifier predicate. In this section, I circle back to ICONIC HANDSHAPE PREFERENCE and present how my analysis differs from the research lines led by Padden and Brentari.

The graph in Figure 34 below showing the probability distributions of the iconic preferences of the 16 object nouns, repeated from Chapter 2, shows the proportions of the iconic and non-iconic strategies found for marking nominal references made to each target object in each language. In my entire dataset, I identified five morphological strategies in the form of item nouns: Handling (H), Object (O), complex/shift iconicity (H2O), SASS-Trace (ST), and non-iconic. Note that, only the first four are iconic strategies; the final strategy, non-iconic, is composed of fingerspelled signs (FS; especially in ASL), and lexical signs that are not iconic (LEX).

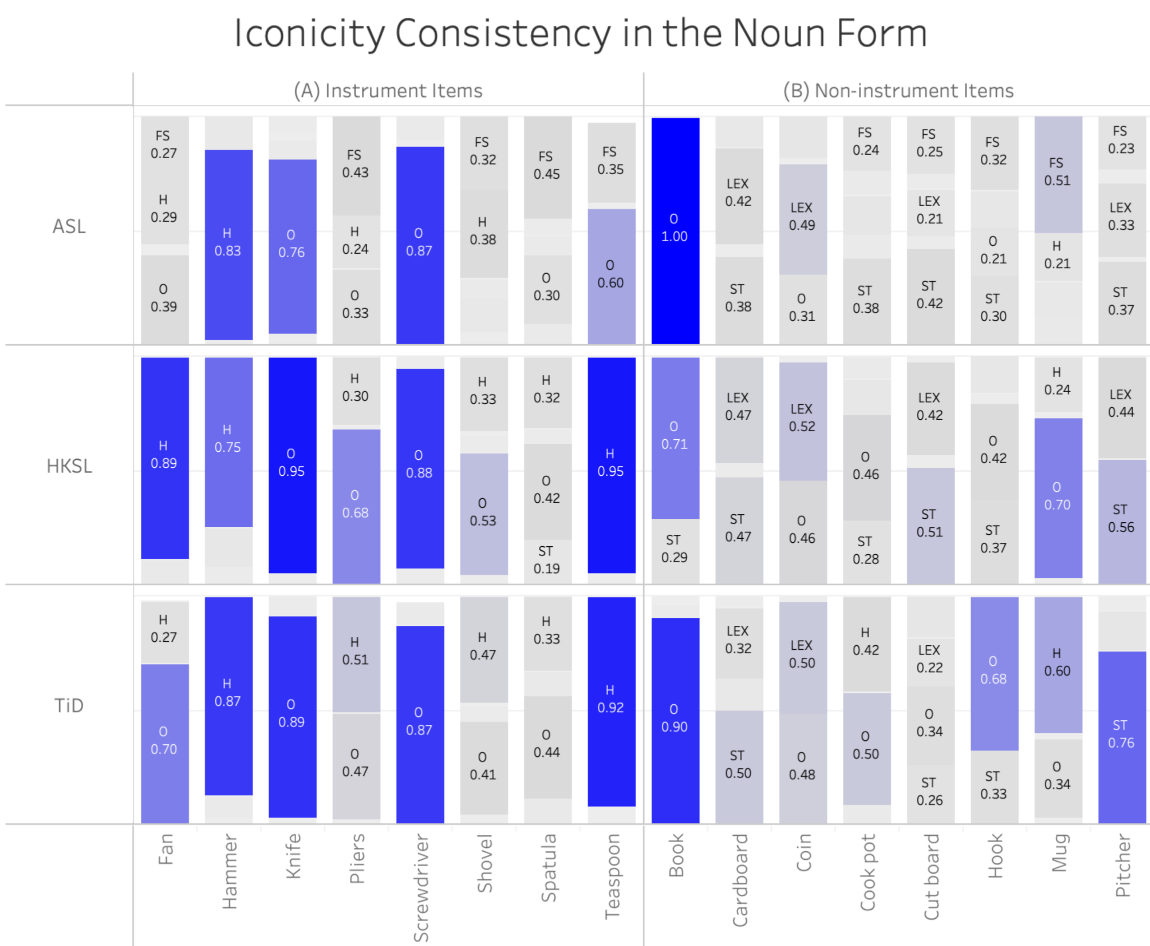


FIGURE 34 Consistency in the Iconicity Type in Nouns.

How consistent signer responses were in the iconicity found in the nominal references made to target objects. Bright blue means consistently one iconicity over the other; gray colors indicate inconsistency. (*Labels* H: Handling, O: Object, ST: SASS-Trace, Lex: Non-iconic lexical, H2O: Shift, FS: Fingerspelled).

The graph in Figure 34 above studies (A) Instrument items (left pane) and (B) non-Instrument items (right pane) separately. This corresponds to the distinction between the two target object classes that I presented earlier in this section. The more saturated the blue the higher the consensus among signer responses for the morphological strategy indicated within that box. On the one hand, we have signs such as the one for BOOK in ASL, which has a 100% consensus of Object iconicity across all signer responses. This sign is unique in displaying a uniform, polarized iconic behavior in all of its iterations across all of the three sign languages. On the other hand, in HKSL 71% of the time the iconicity found in the form of the noun sign BOOK was Object and 29% of the time it was a SASS classifier. The TiD noun for HAMMER displayed Handling iconicity 87% of the time while the iconicity found in the noun for PLIERS in TiD responses was almost equally distributed between Object and Handling. Overall, we see much higher rates of language-wide consensus in the left half of the graph (A), which consists of instrument items, than the right half of the graph (non-Instruments, group B) with the exception of BOOK in non-instruments. This distinction, while not important to my discussions in this dissertation, may be stemming from a lexical distinction between tool nouns and other nouns, or it may be accidental due to how the target objects are picked in the experiment.

This is a very interesting pattern, especially from the point of view of what Brentari et al. (2016a) says about iconicity preference in the instrument noun affecting (or even predicting) the iconicity in the classifier predicate. However, while their claim is very intuitive, that alone cannot account for the full picture that we see in my data for two reasons: (i) simply not many signs display 100% consensus around one iconic strategy[22], and (ii) signers do not always match the noun iconicity and the predicate iconicity within a single clause either. In other words, we are looking at a phenomenon that we cannot simply explain by a single factor. We should be studying the phenomenon at a higher level, that is, independent of the specific preference between Handling and Object for the [noun, VP classifier] pairs. In other words, an important question that we should be seeking an answer for is the following. What makes certain nouns and corresponding classifier predicates where the noun is referenced converge in iconicity within the same response, but not the other target nouns and predicates? In answering this question, the type of iconicity should not matter[23]. In order to quantify and describe this behavior, I use a metric from statistics (logarithmic odds ratio) and a mathematical metric from Information Theory (Shannon's Entropy). Logarithmic odds ratio looks at the two possible outcomes of an event (A or not-A) and quantifies the polarization of the possible outcomes towards one end. Shannon's Entropy, while at an intuitive level similar to logarithmic odds ratio, quantifies uncertainty in the data. These metrics will be further explained with examples.

22 In fact, there's only one sign that does: book in ASL.

23 Iconicity strategies Handling and Object may behave inherently differently from one another. Studies show certain imbalances in their function and use in different stages of linguistic development (see, for instance, Hunsicker & Goldin-Meadow, 2013). However, I do not seek an answer to this distinction in my data and treat them as strategies with equal qualities throughout the dissertation.

4.2.3 Entropy in the Form of the Noun

In Figure 33, I presented the language-wide probabilities of how target object iconicity is distributed across classifier predicate iconicity. In the following schema and before I move on to present the results from the odds ratio and entropy metrics, I show how I study the relations within and across the target object noun and the classifier predicate with regards to iconicity.

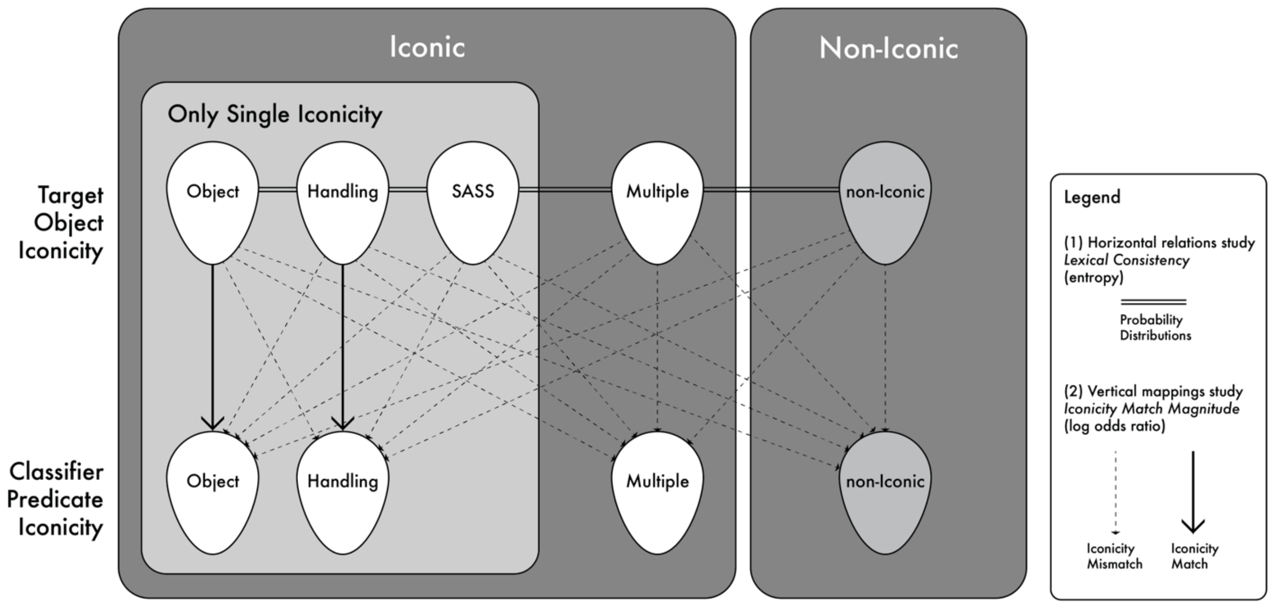


FIGURE 35 Iconic relations studied between the target object noun and the predicate.

Horizontal relations study a noun's consistency of iconic strategy in the lexicon (Lexical Consistency; measured in entropy). Vertical relations study whether or not the noun iconicity matches the classifier predicate iconicity (Match Magnitude; measured in logarithmic odds ratio).

The diagram in Figure 35 above shows how the data are structured for each target object at the noun (lexical-level) and the classifier predicate level (morphosyntactic-level) as well as the iconic relation between the two grammatical constituents. For instance, if we take the target object SHOVEL in TiD, we can populate the diagram to extract data by following these steps:

1. Count the number of times TiD signers uttered the noun sign SHOVEL,
2. How many times did it have only Object iconicity within a single signer response?
3. Repeat Step 2 for Handling-Only, SASS-Only, Multiple iconicities and non-Iconic-only;
4. Each time the iconicity in the NP SHOVEL was Object-Only count the number of times that the predicate in the same signer response was Object-Only, Handling-Only, Multiple iconicities or non-Iconic[24] only;
5. Repeat Step 4 for each iconicity type in the NP (Handling-Only, SASS-Only, Multiple Iconicities, non-Iconic-Only)

After I counted the numbers for each of the relations listed in the steps above, I normalized the counts to arrive at their probability distributions. Following the same TiD example, the following are the probability distributions for the noun SHOVEL in TiD:

(22) Probability distributions of iconic strategies in the noun SHOVEL in TiD:

Object: 0.**42** – *Handling*: 0.**58** – *SASS*: 0.**00** – *Multiple*: 0.**00** – *non-Iconic*: 0.**00**

24 SASS classifiers cannot form verbal predicates (cf. Chapter 1)

The numbers in (22) above correspond to the horizontal relations in the diagram in Figure 35. It studies the probability distributions of iconicity types within the pool of every time the noun SHOVEL was uttered by the signers. The distribution in (23) below corresponds to the vertical relations in the diagram and shows the probability distributions of the logical combinations of [NP Iconicity, VP Iconicity] dyads:

(23) Probability distributions of [NP Iconicity-VP Iconicity] for the target object SHOVEL in TiD:

[*Object-Object*: 0.**17**] – *Object-Handling*: 0.**13** – *Object-Multiple*: 0.**03** – *Object-nonIconic*: 0.**00**;
Handling-Object: 0.**0** – [*Handling-Handling*: 0.**43**] – *Handling-Multiple*: 0.**07** – *Handling-nonIconic*: 0.**00**;
Multiple-Object: 0.**07** – *Multiple-Handling*: 0.**07** – *Multiple-Multiple*: 0.**00** – *Multiple-nonIconic*: 0.**00**;
nonIconic-Object: 0.**00** – *nonIconic-Handling*: 0.**03** – *nonIconic-Multiple*: 0.**00** – *nonIconic-nonIconic*: 0.**00**

For the first relation (i.e., horizontal relations: Lexical Consistency) I use Shannon's Entropy to calculate the uncertainty in the iconicity preference of a target object. Entropy is a metric, initially used in classical thermodynamics and then adapted in Information Theory by Claude Shannon. It is a positive value that typically ranges from 0 to 1 (depending on the logarithmic base) and quantifies the uncertainty present in a given probability distribution. How certain are we that an observation in a series will follow suit with the rest of the series in its qualities? Shannon's Entropy is the negative sum of the products of each probability with its logarithm to base *N*, where *N* is the number of possible outcomes, in our case N=5 because there are 5 morphological strategies observed: H, O, H2O, SASS and non-Iconic (fingerspelled and non-iconic lexical are added and taken as one strategy).

$$H(X) = -\sum_{i=1}^{n} p_i \, log_N \, p_i$$

Shannon's Entropy formula applied to my NP Iconicity probabilities looks like the schema in (24) below:

(24) Entropy applied to morphological strategy probabilities in the lexeme:

H(*lexeme*) = - ((P(*Object*) * log5(P(*Object*)))

+ (P(*Handling*) * log5(P(*Handling*)))

+ (P(*SASS*) * log5(P(*SASS*)))

+ (P(*Multiple*) * log5(P(*Multiple*)))

+ (P(*non-Iconic*) * log5(P(*non-Iconic*))))

Note that the logarithm of 0.00 is *undefined* due to division by zero. I added each probability a tiny mass m' to avoid the division by zero problem. The following are the adjusted probability masses for the iconicity types of the noun SHOVEL in TiD:

(25) Smoothing probabilities to avoid division by zero:

m' = 0.00001

P(*Object*) = 0.408 + m'

P(*Handling*) = 0.469 + m'

P(*SASS*) = 0.06 + m'

P(*Multiple*) = 0.02 + m'

P(*non-Iconic*) = 0.04 + m'

Let's apply this formula to the probability distributions to find the uncertainty in the noun SHOVEL in TiD (X):

(26) Finding the lexical entropy of the target object SHOVEL in TiD

$$
\begin{aligned}
H(\textit{SHOVEL}) \quad = \quad & - ((0.40801 * \log5(0.40801)) \\
& + (0.46901 * \log5(0.46901)) \\
& + (0.06001 * \log5(0.06001)) \\
& + (0.02001 * \log5(0.02001)) \\
& + (0.04001 * \log5(0.04001)))
\end{aligned}
$$

$$
\begin{aligned}
= \quad & - ((0.40801 * -0.55700414918) \\
& + (0.46901 * -0.47043205765) \\
& + (0.06001 * -1.7479668164) \\
& + (0.02001 * -2.4303659682) \\
& + (0.04001 * -1.9998446857))
\end{aligned}
$$

$$
\begin{aligned}
= \quad & - ((-0.2272632629) \\
& + (-0.22063733935) \\
& + (-0.10489548865) \\
& + (-0.04863162302) \\
& + (-0.08001378587))
\end{aligned}
$$

$$
H(\textit{SHOVEL}) \quad \cong \quad 0.681
$$

The noun SHOVEL in TiD has an entropy (uncertainty) of 0.681 as calculated from its probability distributions obtained from my data. This is a pretty high entropy measure. The ASL sign BOOK, on the other hand, has 0.00 entropy because P(*Object*) for ASL BOOK is 1.00, while all the other probabilities are zero. The logarithm of 1.00 to base 5 is zero and from there the formula ends up giving us zero entropy. Conversely, the HKSL sign SPATULA has very high entropy: H(*SPATULA*) = 0.765. This is simply because the probability distributions of iconicity types are very dispersed for that sign: P(*Object*) = 0.42, P(*Handling*) = 0.31, P(*SASS*) = 0.19, P(*-iconic*) = 0.08. There is no consensus of signer responses around a single iconicity or, in other words, the probability distribution across the nominal iconic and non-iconic strategies is not skewed in favor of a single iconicity type, although non-iconic is the less likely option among the three. Note that the multiple iconicities strategy was not observed in HKSL SPATULA. However, from a statistical perspective, our small sample size, while an adequate representation of the population, cannot be considered to predict that we will never see that strategy in natural language production. Therefore, the small probability mass of m' that we added into the equation to smooth the distribution in order to avoid division by zero, has the added benefit of giving that unobserved strategy a tiny probability.

How can we interpret these values? We have said that entropy shows uncertainty. But what does it mean for a lexeme to have high entropy and uncertainty in its form? A visual way to represent this is the coloring in Figure 34. The saturation/brightness of the blue color in each bar can be argued to be depicting entropy. The more saturated a bar the less entropy it has. The grayer and more divided a bar the more entropy and therefore uncertainty it has.

There are a couple of observations that can be made here. The first and obvious message here is that high entropy target nouns are not conventionalized. In other words, signers are likely not aware of a single and optimal way to express these objects, either because of their lack of knowledge of the sign or because a conventionalized sign simply does not exist in the language[25], or maybe, although an unlikely reason, it may be because they believe that the form may not be clear to their interlocutor (in this case the researcher who would collect their responses) – so, they either make up signs for these nouns on the fly or they utter multiple signs, and while doing that they exhaust many morphological strategies to ensure that their message is correctly communicated. The heatmap in Figure 36 shows the entropy in the morphological strategies found in each target object's form.

25 Nominal references to objects are collected from responses to agentive stimuli; therefore, the nouns were produced in context. A picture naming task may yield different results.

Entropy in Noun Forms

		ASL	HKSL	TiD
(A) Instrument	Fan	0.72	0.22	0.37
	Hammer	0.33	0.45	0.28
	Knife	0.46	0.12	0.25
	Pliers	0.66	0.43	0.49
	Screwdriver	0.28	0.28	0.21
	Shovel	0.73	0.69	0.68
	Spatula	0.68	0.77	0.76
	Teaspoon	0.47	0.12	0.22
(B) Non-instrument	Book	0.00	0.37	0.20
	Cardboard	0.53	0.55	0.70
	Coin	0.45	0.48	0.48
	Cook pot	0.74	0.77	0.57
	Cut board	0.66	0.58	0.84
	Hook	0.65	0.66	0.39
	Mug	0.54	0.50	0.54
	Pitcher	0.58	0.43	0.42

FIGURE 36 Entropy in the production of each target object's noun form.

The rows in top half are designated instrument items, bottom rows are non-instrument items. Items that have a low entropy are colored blue. The more vibrant the blue, the less entropy, therefore more lexical consistency. Gray boxes show items with a high entropy, the darker the gray the greater the entropy. Signers have no consensus in those signs in dark boxes as to which morphological strategy they choose.

Another possibility might be that using only one strategy would cause ambiguity in the message or, in other words, that the concept cannot be expressed with a single sign – for instance, in the case of SPATULA and HAND SHOVEL, both signs have a handle and a small flat surface designated to hold matter. These similarities in their physical properties would be problematic to iconically distinguish between the two concepts – simply put, their iconic forms (Handling or Object) would be confusable; therefore, signers employ multiple iconic and non-iconic possibilities in order to make sure that their message is transmitted successfully. In some ASL cases, we see fingerspelled signs that complement an iconic sign, which clearly is a strategy that disambiguates the referent that they see in the stimuli. In any case, the signers turn to multiple strategies because the information content of the individual strategies they use is low or they possibly hold the belief that it is not adequate.

Signers utilize multiple strategies to express some of the objects such as the HKSL SPATULA and the TiD SHOVEL, but we see only one pattern for the ASL sign BOOK. The reason why signers use multiple strategies for the HKSL SPATULA and the TiD SHOVEL, and many other signs alike, lies in the information content of each of the times these signs were used. The sign BOOK in ASL uses Object iconicity only, and that is the highly conventionalized form of the sign for BOOK across the board. In fact, we see relatively low entropies for the sign BOOK in HKSL (H(*book*) = 0.371) and TiD (H(*book*) = 0.202) as well. This means that the expressiveness of the forms of the signs BOOK in all three of these languages are quite high such that the signer does not feel the necessity to maximize its information content by adding extra signs with different morphological strategies. For highly conventionalized low entropy nouns, what motivates the choice between Object and Handling iconic types remains unclear and will not be addressed in this dissertation.

As for the signs that have very high entropy such as the TiD CUTTING BOARD, the HKSL COOKING POT and the ASL HAND FAN, their information contents are likely very low

– there is no single optimal strategy available to the signers. Therefore, they are making up for the single sign strategy, what would result in low informativity, by using multiple morphological strategies that increase the information content of their linguistic message, such as producing signs that trace the outline of the object, using both Handling and Object iconic strategies or just straightaway fingerspelling them as is the case in ASL responses. Only when multiple and adequate options are used together can their message express a complete meaning. The graph in Figure 37 shows the ratio of the number of morphologically unique references made to the target object and signer response for each target object, and on the right the entropy graph from earlier is repeated for comparison.

# of Nouns/Response

		ASL	HKSL	TiD
(A) Instrument	Fan	1.67	1.10	1.18
	Hammer	1.17	1.33	1.10
	Knife	1.20	1.05	1.03
	Pliers	1.42	1.33	1.18
	Screwdriver	1.11	1.10	1.05
	Shovel	1.89	1.25	1.25
	Spatula	1.63	1.43	1.35
	Teaspoon	1.11	1.05	1.05
(B) Non-instrument	Book	1.00	1.40	1.07
	Cardboard	2.04	1.77	1.60
	Coin	1.52	1.63	1.83
	Cook pot	1.85	1.67	1.23
	Cut board	1.81	1.87	1.77
	Hook	1.93	1.97	1.43
	Mug	1.74	1.10	1.27
	Pitcher	1.93	1.80	1.17

Entropy in Noun Forms

		ASL	HKSL	TiD
(A) Instrument	Fan	0.72	0.22	0.37
	Hammer	0.33	0.45	0.28
	Knife	0.46	0.12	0.25
	Pliers	0.66	0.43	0.49
	Screwdriver	0.28	0.28	0.21
	Shovel	0.73	0.69	0.68
	Spatula	0.68	0.77	0.76
	Teaspoon	0.47	0.12	0.22
(B) Non-instrument	Book	0.00	0.37	0.20
	Cardboard	0.53	0.55	0.70
	Coin	0.45	0.48	0.48
	Cook pot	0.74	0.77	0.57
	Cut board	0.66	0.58	0.84
	Hook	0.65	0.66	0.39
	Mug	0.54	0.50	0.54
	Pitcher	0.58	0.43	0.42

FIGURE 37 Number of references to the target object per signer response.

[Left] The ratio of the number of times a morphologically unique nominal reference was made to a target object to the number of times that target object was in a stimulus. Bright red means a higher ratio. [Right] Entropy in the form of nouns, repeated for comparison.

The graphs above show that signers did not only resort to multiple morphological strategies (i.e., high entropy), but they did so in the same response. In other words, signers used multiple iterations of nominal reference to the same object using different morphological strategies within the same individual responses. But look at BOOK in ASL and TiD for instance – not only were the signers uniform in the iconicity of the form (ASL and TiD entropies for the sign BOOK are 0.00 and 0.20, respectively; right graph), but they also uttered the sign BOOK only once per response (BOOK noun count/response ratio is 1.00 or close to it in both languages, left graph). This tells us that the sign BOOK in these languages contributes maximally to the information content of the linguistic message; therefore, signers see no reason to add another sign with a different morphological strategy. A sign such as COOKING POT in HKSL, has an entropy of 0.77 and a noun count/response ratio of 1.67, meaning, on average, more than one reference to the target object COOKING POT was made in signer responses. Signs such as KNIFE, SCREWDRIVER, HAMMER and TEASPOON that have lower entropy also tend to have a lower count of numbers per response in all of the three languages. The number of nouns per response ratio highly correlates with entropy in noun forms (ASL: pearson $r = 0.761$, $p=0.0002$; HKSL: pearson $r = 0.7$, $p<0.0012$; TiD: pearson $r = 0.69$, $p<0.0015$).

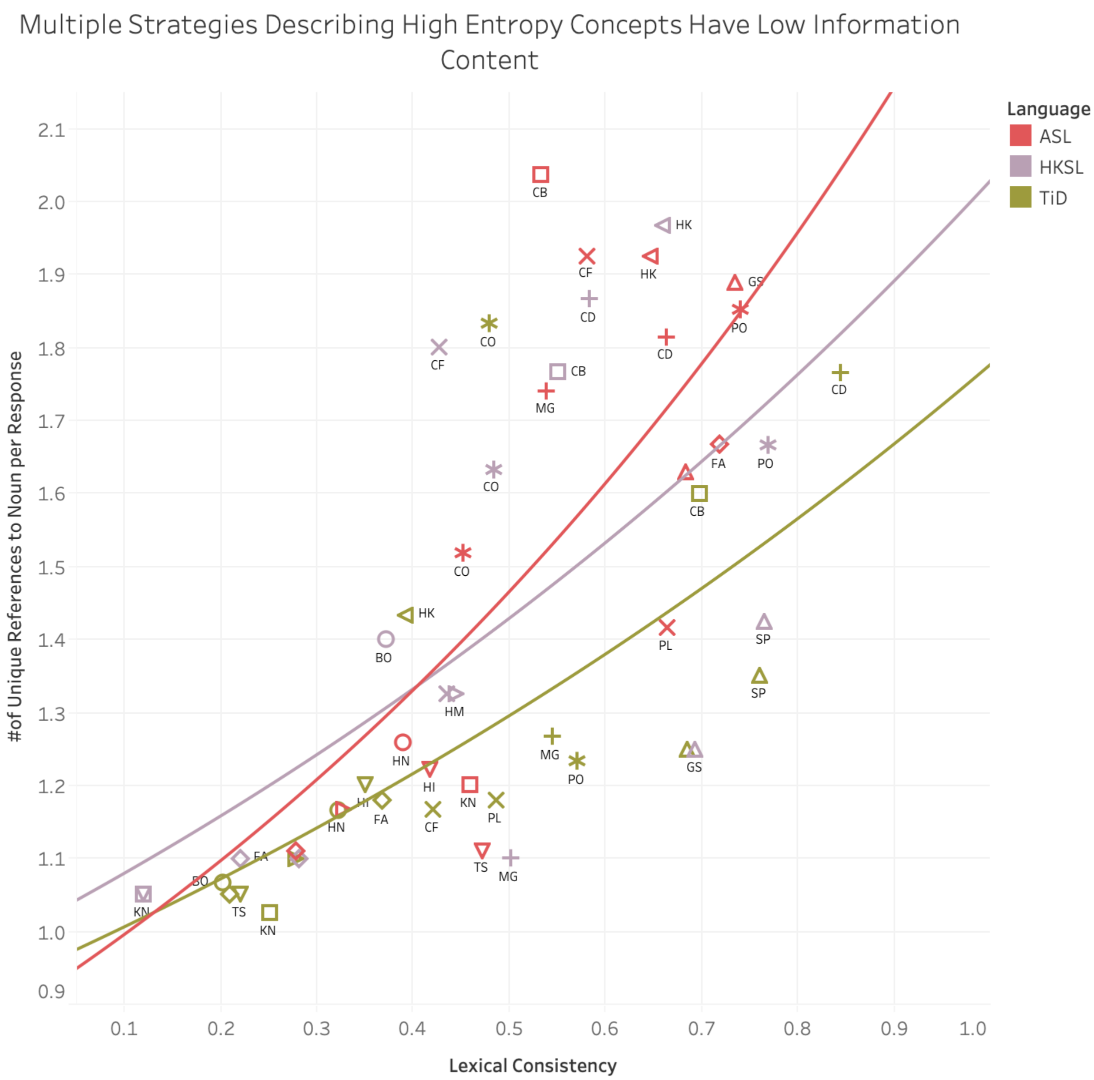


FIGURE 38 High entropy concept nouns have low information content.

The average number of nominal references made to an object correlates strongly with that object's entropy in its nominal form.

The finding in Figure 38 above provides independent evidence to the validity of entropy as a measure and cements LEXICAL CONSISTENCY/RIGIDITY as a factor that influences linguistic form. Interestingly, the number of nominal references per response made to the same high entropy object consistently decreases as the signers advance in their production of the stimuli and see more cases of the objects that initially were new to them. It is almost as if signers establish a standard way to refer to those objects as they progress in the experiment. This would be in line with surprisal effect in Information Theory. Decreasing surprisal brings with it more orderly structures and sharpens the expectation about the constituents that follow (Levy, 2008). Unfortunately, the data is too sparse and not suitable to test the significance of this behavior. In the following section I present my findings on predicate iconicity with regards to LEXICAL CONSISTENCY.

4.2.4 Match or Mismatch? What are the Odds?

Let us now turn to how signers and target objects behave with respect to the second relations in the diagram in Figure 35 namely the vertical relations: How often does the type of iconicity in the noun form match the type of iconicity in the classifier predicate form? In order to answer this question, we have to have a clear definition and understanding of what is meant by "iconicity matching". This notion follows from Brentari and colleagues' observations on the preferred iconic handshape in the instrument noun having an effect on the classifier predicate, or even predicting it. I have said earlier in this section that the following schemata repeated below are examples of iconic match cases:

(27) [NP_**H**] [VP_**H**] – *match*, H=H

(28) [NP_**O**] [VP_**O**] – *match*, H=H

The first one is a match case of the type Handling. In the second one, the NP and the VP converge on the iconicity Object. The following two, on the other hand, are cases of iconic mismatch:

(29) [NP_**H**] [VP_**O**] – *mismatch*, H¬O

(30) [NP_**O**] [VP_**H**] – *mismatch*, O¬H

The four schemata above display a one-to-one mapping, which makes it very easy to answer whether these are matching signer responses or not. But how can we deal with one-to-many, many-to-one or many-to-many mappings like the following?

(31) [NP_**H** NP_**O**] [VP_**O**] – many NPs to one VP mapping

(32) [NP_**H**] [VP_**O** VP_**H**] – one NP to many VPs mapping

(33) [NP_**H** NP_**O**] [VP_**O** VP_**H**] – many NPs to many VPs mapping

Is the question whether the NPs and the VPs of these schemata above match in iconicity still valid since we do not have the luxury of a single NP and a single VP anymore? Can we consider the top schema in (31) a matching signer response since one of the NPs (NP_O) match the VP (VP_O) because they both display the same iconicity? What about the other nominal reference to the Target Object in the same schema that has Handling iconicity

(NP_H)? Does this mean this is a mismatching signer response? The same reasoning can be applied to one-to-many (32) and many-to-many (33) mappings too.

First of all, these constitute less than 5% of my data, and secondly, from an Information-Theoretic point of view, the first two should not be taken into account in the calculations since the nominal domain and the verbal domain not only do not match in iconicity but also do not match in information complexity. The third case, many-to-many mapping, however, can be considered a 'match' case on its own, where signers exhaust both iconicity types in both the nominal and the verbal domains. Since these schemata have a very small probability mass in my data, including or excluding them will not have a significant effect on the results[26]. Signers use multiple nouns (and multiple modifiers) or multiple predicates in order to maximize the informativeness of their responses. This, again, is related to the low information content the individual signs make available to the interlocutor.

I quantify the [NP Iconicity, VP Iconicity] relationship using logarithmic odds ratio. I raise the following questions here: how often does each target object display matching iconic behavior with the VP of the same signer response? Logarithmic odds ratio will tell us how skewed one case is over the other. How strongly are signers matching the nominal and verbal forms of a target object compared to mismatching? Log odds ratio operates over the values

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26 A note on the cases where both the NP and the VP are non-iconic lexical or fingerspelled such as [NP_FS] [VP_Lex]. My data has very few cases of this schema (less than 1%). This is clearly not a main strategy preferred over the iconic strategies. Also, the question of whether the types of iconicity match is not relevant anymore since they are not iconic. Therefore, these data points will not be included in the analysis of this factor.

of a binary variable. In other words, there can be only two outcomes. In our case the two outcomes are "matching" or "mismatching". We have only two matching schemata: [NP_O, VP_O] and [NP_H, VP_H]. The probability that a target object will display matching behavior is the sum of the probabilities of the two aforementioned schemata. The rest will be "mismatching" cases. The probability masses of 'matching' and 'mismatching' cases must add up to 1.00. Therefore:

$$P(mismatching) = 1 - P(matching)$$

Logarithmic odds ratio is calculated by dividing the two probability outcomes and returning the natural logarithm of the quotient:

$$log(odds) = ln\left(\frac{P}{1-P}\right)$$

(34) Logarithmic odds applied to our case looks like the following formula:

$$log(odds) = ln\left(\frac{P(matching)}{1-P(matching)}\right)$$

The value that this formula returns will show how strongly a target object matches or mismatches its noun and predicate forms' iconic strategies. I call this score MATCH MAGNITUDE. This score will allow us to numerically evaluate two crucial observations: (i) Is a language sensitive to ICONIC HANDSHAPE PREFERENCE? (ii) And if it is, with which objects do we see the most pronounced matching behavior and how strongly? Let us first answer the first question. Are any of the languages that we study sensitive to ICONIC HANDSHAPE PREFERENCE? Do the signers of a language overall match the iconicity of the noun with the iconicity of the classifier predicate?

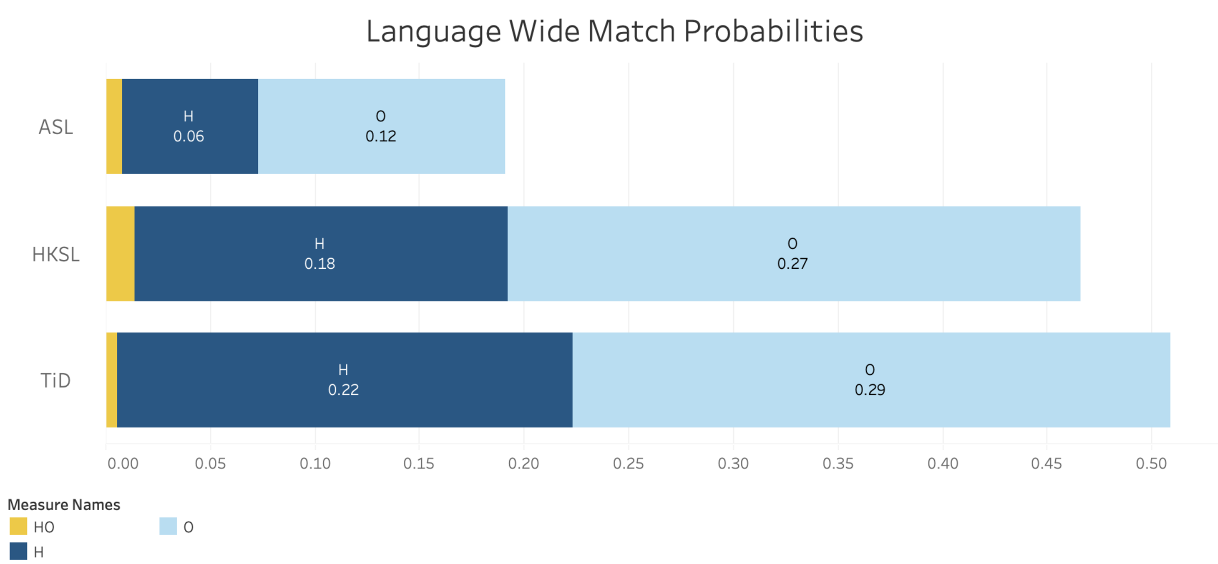

FIGURE 39 Language-wide iconic match probabilities.

How much of the signer responses had matching iconicities in the forms of the target object noun and the classifier predicate?

The bar graph in Figure 39 above gives us two important generalizations. First, TiD classifier predicates are sensitive to the lexical iconicity preference of the nouns associated with them, or more precisely, with the individual iconicity decisions the signers have made in each response. In over 51% of TiD responses, the two iconic forms in the nominal and the verbal domains match. HKSL behaves in a similar fashion to TiD – in 45% of the HKSL responses the iconic forms in the two domains are identical. ASL, on the other hand, matches less than 20% of the data. This can easily be attributed to chance. 45% for HKSL and 51% for TiD are not necessarily big proportions of the data per se; but keep in mind the fact that the experiment is designed to capture a number of factors, which, when interacting with each other, result in highly stochastic outcomes. The second important generalization acquired from the above chart has to do with the type of the iconicity that matches. Object iconicity is matched more frequently than Handling iconicity. This could be attributed to the marked nature of Object iconicity. Researchers have found that Object iconicity is a strategy most commonly found among signers, not among non-signing hearing gesturers (Brentari et al. 2015, 2017). Note that for TiD and HKSL, this behavior of Object-preference nouns of the lexicon offers a reliable explanation to the considerable amount of Object iconicity we see in these two languages' classifier predicates.

Let us now turn to the second question. Which objects show the most pronounced matching behavior and how strongly? To explain how I tackled this question, let me show how the log odds ratio of, for instance, the target object SHOVEL in TiD is calculated. 43% of the signer responses to shovel matched in Handling iconicity, 17% of the responses to shovel matched in Object iconicity. The sum of the two gives us a probability mass of 60% for the 'match' cases. This means that the remaining 40% of the probability mass is not matching:

$$log(odds_{shovel}) = ln\left(\frac{0.6}{1 - 0.6)}\right) = ln\left(\frac{0.6}{0.4}\right) = ln\left(\frac{3}{2}\right) = 0.405$$

We divide the probability of 'match' (0.6) by the probability of 'mismatch' (1 - 0.6 = 0.4) for the target object SHOVEL in TiD, and find the natural logarithm of the quotient, which gives us 0.405. What this score tells us is that in TiD, there is no nuanced preference for matching the iconicity of the noun SHOVEL with the iconicity in the classifier predicate in the same response. In other words, signers do not uniformly match or mismatch the two iconic forms of the noun and the verb in their responses. I just said one paragraph or two ago that TiD and HKSL display iconicity matching behavior. So, what gives? Before answering this cliffhanger question in the next subsection, let me conclude this one with the graph in Figure 40 below that shows the MATCH MAGNITUDE of each target object in the three sign languages and the statistics that follow:

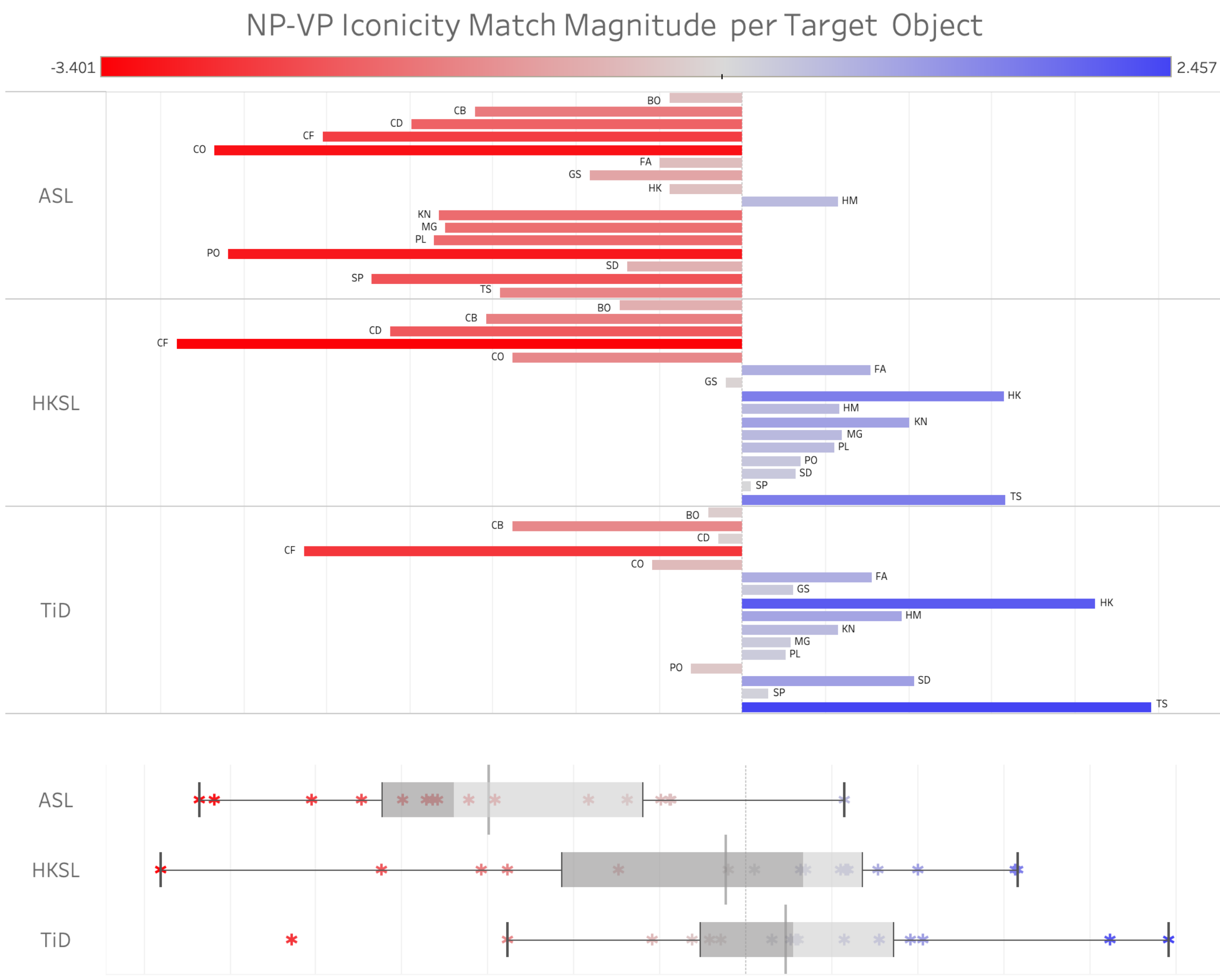

FIGURE 40 *Match Magnitude* (logarithmic odds ratio) per target object.

A score of 0.00 means matches and mismatches are equally distributed (0.5, 0.5). Negative values (red boxes) mean there are more mismatches than matches. The brighter the red the more mismatches than matches. Positive values (blue boxes) mean the target object is more heavily inclined to match the NP and the VP iconicities than to mismatch them. The brighter the blue the more heavily inclined to match the noun-verb iconicities that object is. There is no upper or lower bound on logarithmic odds ratio – depending on how great the difference in the multiplicative relation between match and mismatch cases is, the score can go to infinity in logarithmic space.

The graph above groups the data by language and target object. Each horizontal bar shows how strongly signers match that target object's iconicity with the classifier predicate in the same response using. logarithmic odds ratio. We see that the objects such as TEASPOON

(TS) and HOOK (HK) in TiD and HKSL have a higher rate of iconicity matching than pretty much all the nouns in ASL. Note that the ASL noun HAMMER (HM) is a strong Handling-preference noun, meaning the 0.53 score we see in the blue cell above is most likely an accidental match environment. This is because ASL has a strong preference for Handling iconicity in the classifier predicate. Overall, this bar graph shows that TiD and HKSL are inclined to match the nominal and verbal iconicities while ASL does not. A paired t-test for differences between the languages reveal that TiD and HKSL (TiD~HKSL: $T = -0.76$; $p=0.45$) are much more similar to one another than either one is to ASL (ASL~HKSL: $T = 3.2$; $p<0.005$, ASL~TiD: $T = 4.33$; $p<0.001$). In other words, ASL classifier constructions are not as sensitive to the type of iconic handshape found in the lexical form of the noun as TiD and HKSL are. This generalization will form the basis for a discussion on the typological distinction between 'Iconic Agreement' languages and 'Grammatical Agreement' languages in the following sections.

4.2.5 Match Magnitude Compared Against Lexical Consistency

It turns out that the generalization on matching iconic behavior applies to only some certain nouns. Interestingly, the shared property among those nouns is low entropy. Consider the graphs in Figure 41 below that correlate MATCH MAGNITUDE (logarithmic odds ratio) with LEXICAL CONSISTENCY (entropy in the lexical form).

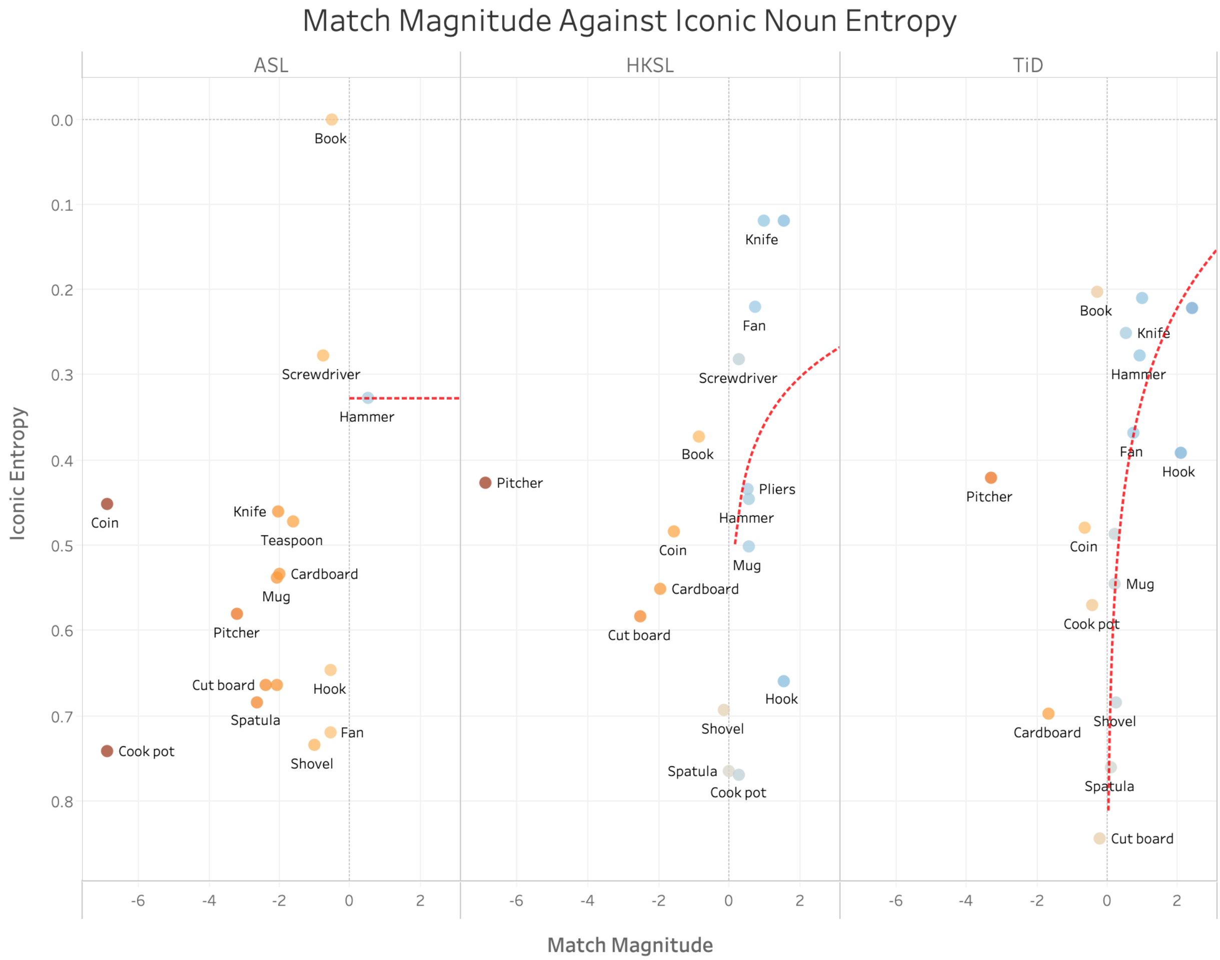

FIGURE 41 Match Magnitude (logarithmic odds ratio) against Lexical Consistency.

Blue circles indicate target objects that are inclined to match, and orange circles indicate the ones that are inclined to mismatch. Trend lines are logarithmic.

In TiD and HKSL, as entropy in a noun's iconic form increases (i.e., when there are multiple possible iconic or non-iconic strategies), the strength of matching behavior between the noun and the classifier predicate decreases. Turkish Sign Language is a stereotypical example of this. Nouns such as KNIFE, HAMMER, TEASPOON and HOOK have very low entropy in their lexical form and the classifier predicates match in iconicity with the noun in the same signer response (pearson's r=0.81; p<0.005). HKSL acts in a similar way but with less statistical coverage (pearson's $r=0.51$; $p<0.09$). In ASL, contrary to TiD and HKSL, there is no relationship whatsoever between iconic matching and lexical consistency (pearson's $r= 0.13$; $p=0.296$). It could be argued that the forms of such verbs in TiD and HKSL feed heavily from the noun iconicity and that these particular nouns and verbs have completed their lexicalization cycle due to frequent usage. The handshape specification for these verbs could be argued to possibly be located in Brentari and Padden's tripartite lexicon's Native 1 compartment instead of the Native 2 compartment, where classifier predicates are located. Their handshape specification, although now lexicalized, is still transparently iconic, but not frozen in a strict sense therefore easily adjustable when the context requires.

Hypothesis 1 Iconic Handshape Preference, Revised

> If a language is sensitive to the iconic properties of an object noun in the lexicon, then only the iconic preference in highly conventionalized nouns will be reflected in the classifier predicates that encode the same object in an action. If there is no consensus in the iconic form of a noun, then the classifier predicate will also not have a rigid iconicity preference.

Let's leave ASL aside for a minute - we cannot explain the distributions of classifier predicate iconicity in ASL along the lines of ICONIC HANDSHAPE PREFERENCE; something else is responsible for the small divergence from Handling, that is, the majority iconicity preference of classifiers in ASL. There are two important questions here waiting to be answered: (i) Why is it that TiD and HKSL behave similarly and show iconic match behavior while ASL does not? (ii) What is special about the low entropy nouns in TiD and HKSL such that they allow matching while high entropy nouns do not? The answer to the first question probably lies in a typological distinction between languages, such as ASL, that are GRAMMATICAL AGREEMENT languages and those, such as TiD and HKSL, that are ICONIC AGREEMENT languages. I will tackle this typological distinction later in this chapter.

As for the second question, I can speculate that low entropy nouns are concepts that are more frequently talked about in discourse; therefore, their forms are highly conventionalized across signers. High entropy nouns are simply used in encoding less frequent concepts and therefore they do not have a conventionalized form in the language's shared lexicon across signers. While we do not have a large enough corpus for sign languages in question to find each concept's unigram frequency, a search on Google's Book N-Gram Viewer reveals that in the Chinese (simplified) corpus on books the word 'book' is at least 100 times more likely than the other nouns studied here. While this does not say anything about the frequency of nouns in HKSL, we can naively assume that a language takes form according to its surroundings. Another likely explanation is that the forms of certain nouns are transparently iconic and unambiguous, such as HAMMER, KNIFE and SPOON. More research is needed to find conclusive answers.

INTERIM SUMMARY

Sign languages may have a distributional predisposition to a certain type of iconicity in their noun lexicons as a whole, in the sense of Padden, Aronoff, Brentari and their colleagues. However, it is not this language-wide predisposition that dictates the iconicity type in the classifier predicate. The process is a lot more fine-grained than a language-wide tendency and operates on names given to individual items. We have seen that, in my data, no language is strongly Handling preference or Object preference in the iconicity seen in item nouns. While different datasets may yield different results, that is certainly not the case in this dissertation as the methodologies used take a stance independent of individual iconicity types and are more detailed than previous studies. All languages use Object and Handling to various extents and all languages have (a handful of) certain individual object nouns whose distributional iconicity is skewed toward one type over the other. Other than these nouns, which are highly lexically rigid or highly conventionalized, there are many concepts on whose forms the signers display no consensus. These concepts also happen to be expressed by making multiple references that use different morphological strategies. From an Information Theoretic point of view, this behavior points to a picture where the information content of each iteration of these signs is not found to be adequate enough by the signer, hence the sign is re-iterated with a different morphological strategy each time. An intricate, lexeme-level investigation of the types of iconicity in the nominal and the verbal domain revealed that ASL is not sensitive to this effect. The linguistic production of classifier predicates in ASL is not affected by the form of the lexical noun. Conversely, in TiD the iconic preference in the lexical noun has a very strong effect on the iconicity of the classifier predicate. But we see this effect only in highly conventionalized nouns. Other nouns do not follow this pattern. In HKSL, we see a similar pattern to TiD albeit to a weaker degree. Iconicity preference in the noun form does in fact predict iconicity in the classifier form (i.e., concord); however, it does so only in low entropy nouns. Whether or not signers necessarily avoid matching (i.e., discord) the iconic handshape in the noun and the predicate remains to be seen. From a theoretical point of view, discord in high entropy nouns would not be surprising. The components of the grammar have been shown to be shaped by balances and trade-offs between complexity and efficiency (for an extensive literature review on studies targeting how efficiency shapes the components of human language see Gibson et al., 2019).

4.3 Instrument Sensitivity, Revisited

Let us now return to the hypothesis INSTRUMENT SENSITIVITY and revise it with respect to my findings. In Chapter 2, I compared the iconicity types in instrumental classifier predicates to those in non-instrumental classifier predicates and showed that the results (i) confirm Brentari and colleagues' finding that HKSL is indeed instrument sensitive, (ii) add Turkish Sign Language as an instrument sensitive language to the picture, and (iii) cast doubt on American Sign Language's status as an instrument *in*sensitive language. Let us remind ourselves what instrument sensitive means. Basically, if in an instrument sensitive language an object is used instrumentally as opposed to non-instrumentally the classifier construction associated with that instrumental task is likely to have Object iconicity (hammering a nail using a hammer=Object iconicity, putting hammer down on the table=Handling iconicity).

4.3.1 Instrument items when they are not used instrumentally: INSTRUMENT SENSITIVITY-1

The following graph in Figure 42 repeated here from the previous chapter shows a steady increase in Object iconicity in the classifier, and a decrease in Handling from the non-instrumental condition ('PUT') to the instrumental condition ('INS1'). Simply, when we see an instrument item used as an instrument signers use more Object iconicity:

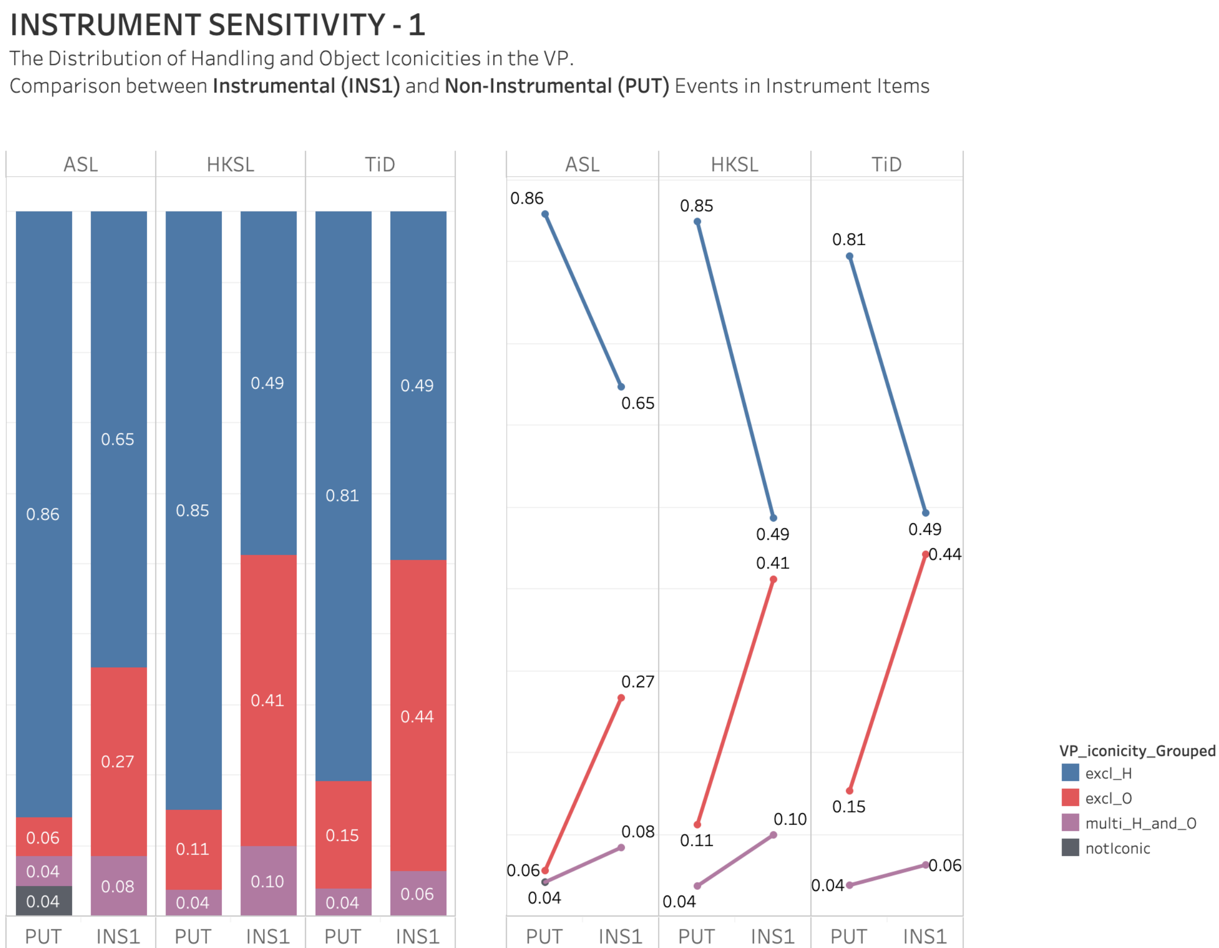

FIGURE 42 Instrument Sensitivity-1.

The direction of change as predicted by Instrument Sensitivity should be O↗H↘ from PUT to INS1. Values in each vertical column add up to 1.00 (N = 464).

T-tests between the 'PUT' condition and the 'INS1' condition reveal that the increase in Object iconicity use and the decrease in Handling iconicity use from 'PUT' to 'INS1' are indeed significant ($p<0.005$ in all three languages for both the increase in Object use and the decrease in Handling use). Simply by looking at this steady increase in Object iconicity at face value, it looks like when instrument items are not used to fulfill the instrumental task, for which they are designated, signers do in fact prefer to use Handling iconicity in the classifier

('PUT' conditions: ASL: 86%, HKSL: 85%, TiD: 81%). However, this observation unilaterally focuses on providing an account for the instrumental condition ('INS1') and does not say anything about the semantic nature of the non-instrumental, agentive condition (i.e., 'PUT'). Before jumping to any conclusions about Instrument Sensitivity simply by considering the significance level of this observation, let us look at comparisons drawn between two different portions of the data and investigate the issue in more detail: parts of the data (i) where objects without an instrumental function are used instrumentally, and (ii) where the same non-instrument objects are used to carry out their typical, agentive functions.

4.3.2 Ordinary items used as an instrument: INSTRUMENT SENSITIVITY-2

Comparisons between two other portions of my data (i) non-instrument items used as an instrument ('INS2' e.g., *using a coin to tighten a screw*) and (ii) the same item group's typical uses ('-INS' e.g., *putting a coin in purse*) are discussed in this section:

Non-Instrument Objects		
item	*typical function (~INS)*	*assigned instrumental function (INS2)*
Book	read	hammer a nail
Cardboard	write on	fan to put out flame
Coin	put in purse	tighten screw
Cutting board	cut tomatoes on	flatten dough
Hook	hang shirt	remove nail
Mug	pour liquid into	cut out cookies from dough
Pitcher	pour liquid from	stir pot
Cooking pot	put chopped vegetables on	shovel dirt

TABLE 8 Functions of the 8 non-instrument objects.

If the three languages are indeed sensitive to instrumentality, this factor must transcend boundaries and apply to objects that do not typically have an instrumental function. INSTRUMENT SENSITIVITY is a hypothesis that operates over instrumental functions, and it does not consider the type of the item, that is, whether or not it is a tool with a designated instrumental function. The expectation is that if the hypothesized factor INSTRUMENT SENSITIVITY indeed holds, we must see a similar pattern to what we see in Figure 42 above, that is, non-instrument items when used instrumentally (the INS2 group) must have a predisposition to the use of Object iconicity; and crucially, when they are seen in their typical environment ('~INS group) and not used instrumentally, the group must display a significant amount of Handling iconicity across the board; specifically, Handling must be higher than Object. Let us look at the results below.

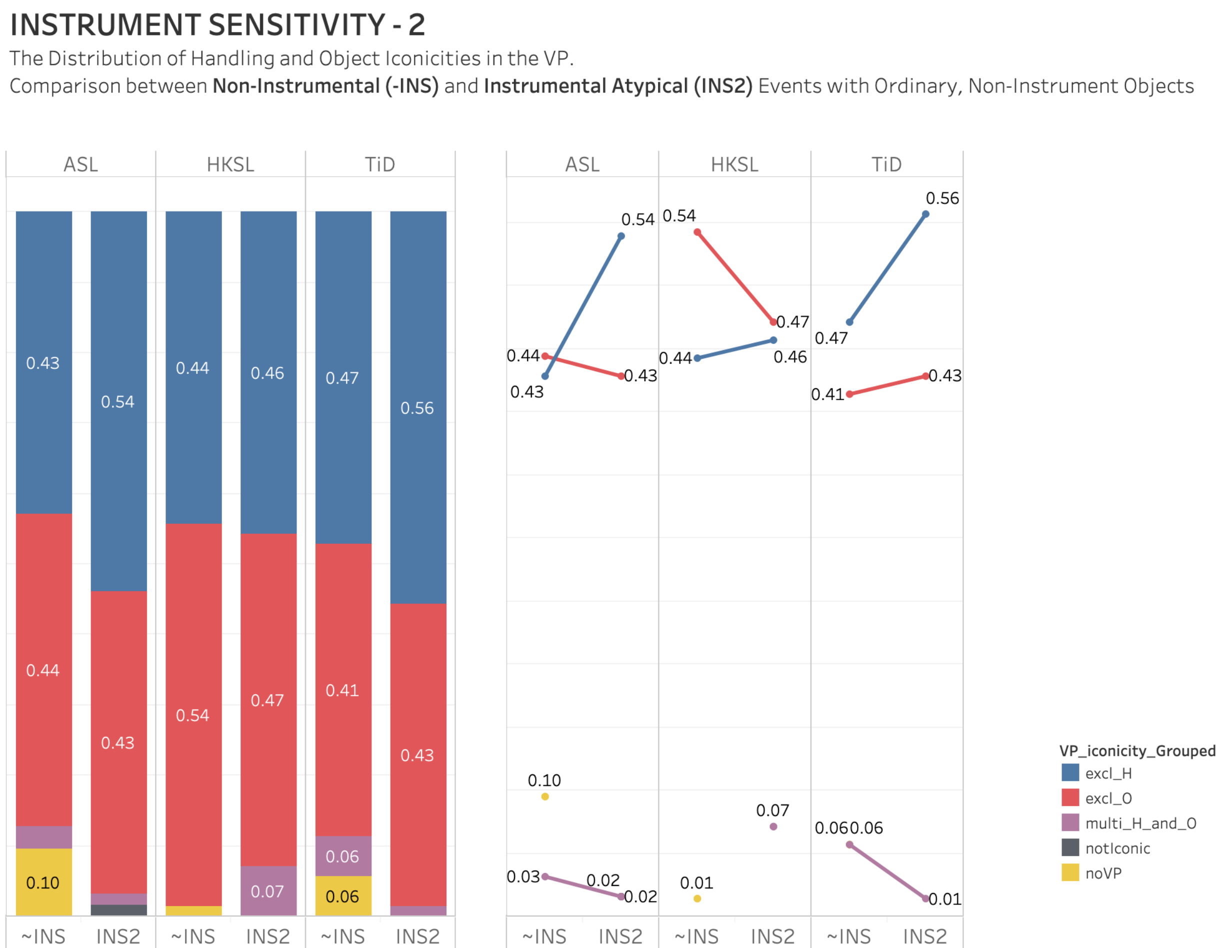

FIGURE 43 Instrument Sensitivity-2.

The direction of change as predicted by Instrument Sensitivity should be O↗H↘ from ~INS to INS2. *Values in each column add up to 1.00. (N = 464)*

The graph in Figure 43 shows a completely different picture than the previous graph in Figure 42 above in the previous section. Firstly, the Handling-only strategy (the blue portions of bars) is not the predominant iconic strategy when the object is seen in a non-instrumental semantic context (notice the '~INS' bars per language on the left-hand side of each language column). In ASL, Object use is 1 point higher than Handling use, in HKSL Object use is 10 points higher than Handling use. TiD is the only language that has a higher use of Handling when the item is used non-instrumentally but still in an agentive context, albeit by a small margin (6 points). Paired t-tests per language show that the difference in signers' Object iconicity use between the two conditions (non-instrumentals '~INS' and instrumentals 'INS2') is not statistically significant (ASL: t=-1.17 p=0.27; HKSL: t =-0.198 p=0.85; TiD: t=-1.032 p=0.33) and that the difference moves in the opposite direction of what INSTRUMENT SENSITIVITY predicts: Object iconicity actually decreases from the non-instrumental condition to the instrumental condition – the opposite of what is expected and what we saw in Figure 42 in the previous section. Interestingly, there is a significant increase in Handling iconicity use in ASL in the direction of the instrumental condition ('INS2') from the non-instrumental condition '~INS' (p<0.02). The differences in Handling use in the same direction in TiD and HKSL are not significant (HKSL: p = 0.79; TiD: p=0.13).

This portion of the data has crucial implications also for the AGENCY hypothesis and it will be discussed in the context of INSTRUMENT SENSITIVITY in the following section. Both hypotheses require certain modifications.

4.4 Agency, Revisited

Let us take a step back from instrumental sentences. Benedicto and Brentari (2004), observe that Handling iconicity is the preferred strategy for encoding agentive events in ASL classifier predicates. In Figure 43 in the previous section, I showed that there is no statistically significant difference in Object iconicity use between the non-instrumental and the instrumental conditions, and that Handling iconicity is most certainly not the predominant strategy in the typical, agentive, non-instrumental uses of the 8 non-instrument items in ASL. And interestingly Handling iconicity in ASL shows a significant increase from the non-instrumental agentive condition to the instrumental condition. This circles back to Brentari and colleagues' claim that ASL is not an instrument sensitive language.

In HKSL we see a greater divide between Handling and Object. Object is higher than Handling by a margin of 10 points in the non-instrumental agentive condition. TiD is the only language where non-instrumental events are encoded with more Handling iconicity than Object (although by 6 points), which is surprising because TiD is not a strong Handling iconicity language in the classifier predicate overall. The crucial observation here is that none of these environments provide a picture where Handling is the predominantly widespread strategy where the encoded event is non-instrumental while still agentive. Why is that? Let us have a closer look at how and in what semantic role these non-instrument items were used in their typical, agentive but non-instrumental environments:

Non-Instrument Objects			
item	*typical function*	*semantic role*	*item handled?*
Book	read	theme	yes
Cardboard	write on	ground/patient	no
Coin	put in purse	theme	yes
Cutting board	cut tomatoes on	ground	no
Hook	hang shirt	ground/goal	no
Mug	pour liquid into	goal/container	yes
Pitcher	pour liquid from	source/container	yes
Cooking pot	put chopped vegetables	goal/container	no

TABLE 9 The semantic roles associated with the 8 non-instrument nouns.

BOOK and COIN were the only two items that have the semantic role theme/patient in these vignettes. In its typical function, BOOK is being held and read by an agent. As for COIN, we see an agent handling it and putting it in a purse, which is technically a 'PUT' condition. Everything else has a different typical semantic role associated with them. CARDBOARD (more of a thick paper in the vignettes really) is used to write on with a marker. CUTTING BOARD is a surface or a ground where vegetables, the patient, is chopped on. COOKING POT is a container for food, and MUG and PITCHER are typical containers for liquids. We use a HOOK to hang things on. In all these conditions, only BOOK, COIN, MUG and PITCHER are actively handled. While the first two are the theme and patient of agentive events, the other two are containers used in storing or transferring liquids. The other four items that are not handled, while still part of an agentive event, are backgrounded discourse participants, such that CUTTING BOARD is not even expressed in the classifier predicate complex most of the time. There are two main reasons why this is the case: (i) the item is not handled by the agent, and

(ii) the stimulus had other, more prominent discourse participants - an instrument (a knife) that is actively handled by the agent and a patient (a tomato), which is also actively grasped to keep it in place. Signers choose to express the knife in the dominant hand (with either Handling or Object iconicity) and the tomato in the non-dominant hand (with Handling iconicity). The location information, CUTTING BOARD, is not mentioned at all for the most part, except rarely in the form of a locative classifier predicate when the discourse context is being set up by the signer. Although it is a participant of the event of cutting tomato, it is not a part of the main classifier predicate where the gist of the event, cutting tomato, is encoded. In other words, it remains backgrounded. In the thematic hierarchy literature, the location thematic role is consistently ranked lower than the agent and the instrument roles (Baker, 1989; Bresnan & Kanerva, 1989) except in Givón (1984), where the instrument is ranked right below location. In Jackendoff (1972) location is ranked above the theme, but this is remedied in Jackendoff (1990), where location, source and goal are ranked below everything else. This could offer an explanation to why CUTTING BOARD is referred to in the classifier predicate. I will give a more detailed account of thematic hierarchy and classifier constructions when I discuss event semantics as a factor later in this chapter.

I would like to raise the following question. Is the factor that we call AGENCY restricted only to a limited number of simple verb forms (i.e., MOVE-WITH-HANDS, PUT-WITH-HANDS, HOLD-WITH-HANDS) in certain languages? Brentari and colleagues looked at two specific environments in their agentive verb tasks: (i) putting objects on a table in different arrangements and numbers, which they call the *agentive classifier* condition, and (ii) non-instrumental ACT-ON verbs (i.e. play with toy airplane, play with marble, read book, smoke cigar, drop coin in purse, put on gloves, put on hat, put on jacket, put on jeans, put on shoes, put on socks, eat lollipop). In both environments, the object under investigation is being handled without exception. Therefore, it is not surprising that the predominant iconic strategy they find for these conditions is Handling. When a different set of objects are used in an instrumental setting (e.g., comb hair, brush teeth, tweeze eyebrows, apply mascara, cut with scissors, use screwdriver, etc.) they observe an increase in Object iconicity use in certain languages, although the events are still agentive, and the tools are actively being handled. This likely makes Benedicto and Brentari's hypothesis AGENCY a marked condition that requires Handling iconicity and operates only when the direct object (theme or patient) is being actively handled by an agent, but not necessarily when it is used as an instrument, although Handling is still a viable and highly likely option with instrumental classifier predicates.

One option is to say that the positive factor in this paradigm is not INSTRUMENT SENSITIVITY and that it is the consequence in the data, a portion of the elsewhere condition that we observe when an independent and more prominent factor is not operating. That factor is the necessity to use Handling iconicity with a certain group of verbs where the salient feature of the event is the agent holding an object, moving it or putting it down (HOLD, MOVE, PUT, LEAVE, DROP, PICK.UP, etc.) – all of which include the necessary handling of the object. Therefore, I would like to propose the following revision to Brentari and Benedicto's proposal on Agency:

Hypothesis 2 Object Handling (Agency Revised)

> Only objects that are actively handled or handleable by a human or another entity that has a joint configuration similar to primate digits will display Handling iconicity.

The revised hypothesis on Agency above is not restricted to humans or humanoid agents. It also covers construction machines such as three-pronged massive material handlers used in clearing up rubble. In other words, Handling iconicity is likely less about agency and more about the handling of the theme or the patient. In that regard, these are strongly marked and highly iconic cases of linguistic production. This has two major implications for the mapping between iconicity types and grammatical environments: (i) Object iconicity and the agentive environment are not mutually exclusive, and (ii) handling of an object is a sub-type of the agentive environment with a restricted distribution. This is likely the reason why we see a significant increase in Handling iconicity use in the ASL instrumental condition in Figure 43. In the non-instrumental condition, the target object is simply not handled, as opposed to the instrumental condition, where the experiment target object, i.e., the instrument item, is actively handled. It is likely that ASL signers are more likely than HKSL and TiD signers to perceive the instrumental event from the agent's point of view rather than the instrument's point of view, hence an increase in Handling iconicity use. This would also explain why Handling iconicity use drops from the non-instrumental 'PUT' condition to the instrumental 'TYP' condition presented in Figure 42. In both conditions we find the active handling of the instrument or of the patient. In the 'PUT' condition the most perceptually salient component of the event is handling the object; therefore, this marked condition strongly requires Handling iconicity. The instrumental 'INS1' condition has two equally salient event components to choose from: (a) the agent's handling of the instrument, and (b) the instrument's interaction with the patient. When signers take the point of view of the instrument's interaction with the patient, they use Object iconicity that foregrounds the instrument information. TiD and HKSL signers are more likely to tap into perspective (b) and ASL signers more likely to take perspective (a). In this regard, all three languages could be considered vacuously instrument sensitive, albeit to different degrees; but the marked environment here is not the instrumental event – it is the ones where an object is handled, regardless of whether the object is an instrument or a patient.

The marked and restrictive environment of Handling iconicity use is not to say that, from a token numeric distributional point of view, Handling is not a more prevalent strategy than Object iconicity in language production. It merely says that the number of unique cases where Handling can occur is likely fewer than the number of unique cases where Object iconicity can occur. It may very well be the case that humans converse more about the handling of things than not. The key takeaways here are that Object iconicity and the agentive environment are not mutually exclusive, and that the cases with Object iconicity that we see in various agentive environments are not exceptions and they can be explained. Circling back to Benedicto & Brentari (2004), the discussions presented in this section is in line with their observations – signers have the point of view of only the object available in unaccusative events. In agentive events where the object is being handled by an agent, on the other hand, the salient component is the agent's handling of the object. For instrumental classifier constructions, they assume that the ones with Handling iconicity are transitive-agentive, while the ones with whole entity (Object) classifiers are intransitive. In my data, the external argument noun, i.e., the Agent, and the classifier predicate with Object iconicity are compatible. Therefore, I would like to propose that there is no one-to-one mapping from the non-agentive/unaccusative environment to the morphological use of Object iconicity. In fact, in all three languages, signers have an above chance-level tendency to produce an agentive cue that has a widespread use across their responses, GRAB [ITEM], using an Object iconic form ($p<0.0001$ in all languages):

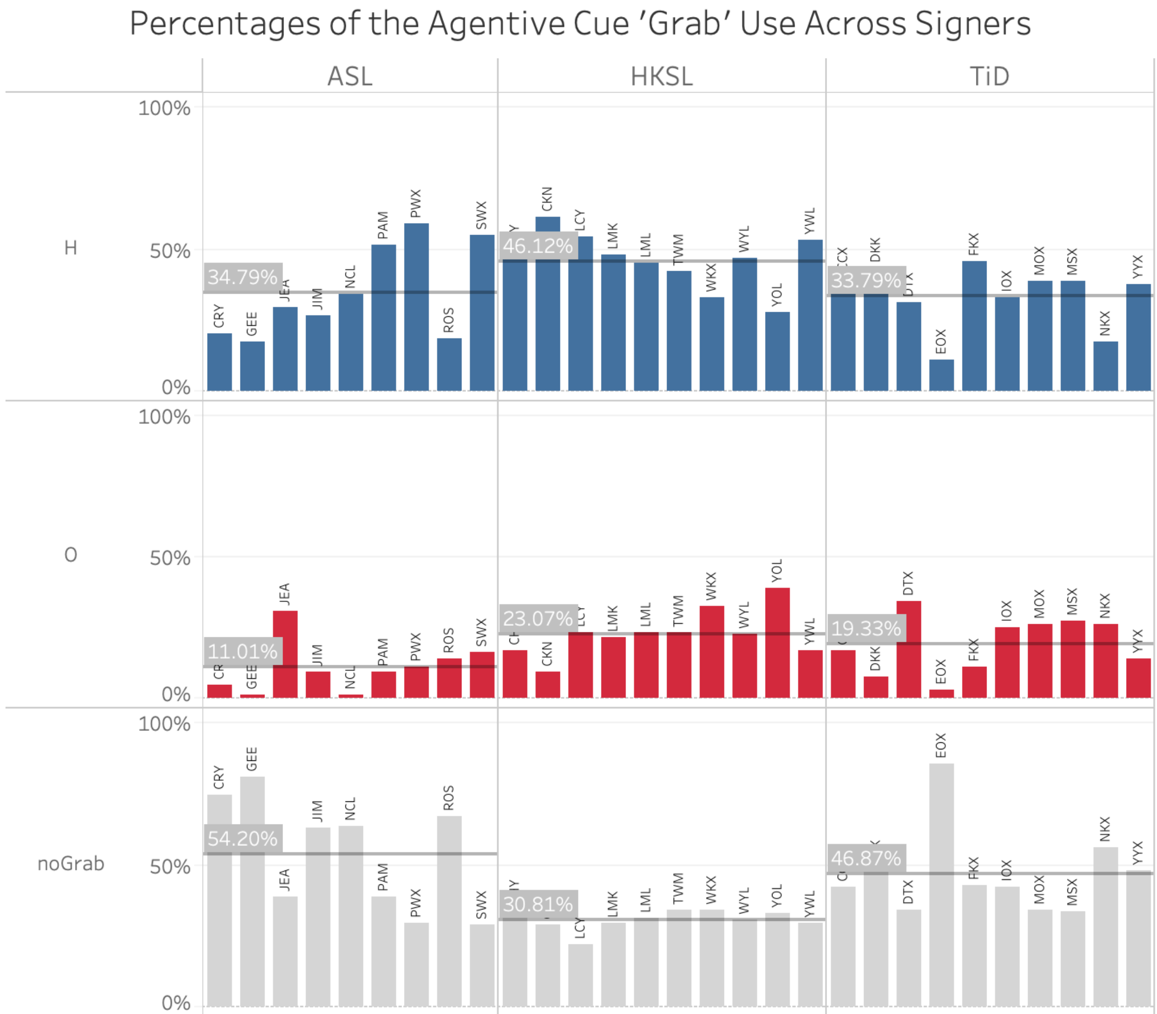

FIGURE 44 Percentages of the agentive cue 'Grab' use across signers.

The average distribution of the agentive cue 'Grab' with Handling iconicity (top row, blue) and Object iconicity (middle row, red). The bottom row is the percentage of responses per signer that did not have the agentive cue 'Grab'.

The agentive cue 'Grab' is seen mostly immediately before the classifier predicate or at the very least two signs before it. It is more likely to be seen with responses provided to instrumental stimuli than to those with non-instrumental stimuli ($p<0.0003$ in all three languages). This is likely because the agent in the instrumental stimulus items were actually consistently seen picking up the tool, although the 'Grab' cue is also present in some responses where the agent in the stimulus was already handling the objects targeted in the experiment. What's interesting about these 'Grab' signs is that they are predicates encoding a clearly agentive event, e.g., GRAB KNIFE, PICK.UP SPATULA, etc., and yet all signers display varying degrees of Object iconicity use in their form – most pronounced in HKSL responses (23.7%). In over 11% of all ASL responses there is a 'Grab' sign with Object iconicity, in TiD it is over 19% of all responses. The baseline expectation, according to AGENCY, is zero percent Object iconicity use in these stereotypically agentive predicates which require Handling iconicity. Moreover, the rate of Object iconicity use in the 'Grab' predicates, strongly correlates negatively with entropy in the noun form as expected by LEXICAL RIGIDITY while the rate of Handling does not (ASL[27]: $p<0.02$; HKSL: $p=0.01$; TiD: $p<0.001$). Note here that Object iconicity use in 'Grab' predicates likely follows an immediately preceding noun with a strong Object iconicity preference, or a low-entropy noun again with Object iconicity in its form. More research is needed to show how much of Object iconicity in this non-instrumental, vanilla 'Grab' predicates can be attributable to phonological assimilation.

While both high entropy (unconventionalized) and low entropy-Handling preference nouns use Handling iconicity in the 'Grab' predicates, only low entropy-Object preference nouns use Object iconicity in the 'Grab' predicates. This does not mean that 'Grab' predicates that encode low entropy-Handling preference nouns, e.g., HAMMER, do not prefer Handling iconicity. It just so happens that when there is no iconic preference for a noun, the 'Grab'

27 ASL has a lower rate of 'Grab' predicates than the other two languages, and the number of Object iconcity 'Grab' predicates is even lower. Take this result with a grain of salt.

predicate resorts to Handling iconicity, as it is the default iconicity type to encode the agent-patient handling relation. This puts Object iconicity at a privileged position than Handling iconicity. Only certain agentive predicates can be encoded using Object iconicity. LEXICAL RIGIDITY is one of the ways that Object iconicity can use to become manifested in the classifier predicate.

What we see is an increase in the morphological options to choose from as the event increases in complexity and other salient perspectives become available. Object iconicity is not reserved for encoding unaccusative semantics. Under certain conditions, it becomes a (or sometimes the) legitimate iconic type to encode an agentive relation. As for Handling, while it is most likely reserved for agentive relations only, it is most certainly not the only iconicity type available in encoding agentive relations. In the next section, I present how the salient components of an event determine the perspectives that are available to signers.

4.5 What Stands Out in an Event?

I have shown with the data presented in Figure 43 that Benedicto and Brentari's Agency factor does not apply to all agentive verbs. The non-instrumental portion of the data in Figure 43 contain activities where certain objects that the experiment targets have a different semantic flavor to their participation in the event than just being held or put down, as was the case in the 'PUT' paradigm in Figure 42. This is also in line with instrumental events where the tool being used actively participates in altering the theme or the patient in a certain way. The elsewhere environment, which, I claim, INSTRUMENT SENSITIVITY is a subset of, seems to be governed by a more general, overarching requirement on the form of all classifier predicates. I showed in the previous section with the 'Grab' predicates that even agentive but non-instrumental predicates can take an Object iconicity form. Therefore, I would like to propose a condition that encompasses a more generalizable and natural class where both instrumental and non-instrumental classifier predicates are allowed to have more prevalent Object iconicity in their linguistic encoding: PERCEPTUAL SALIENCE.

4.5.1 What is Preceptual Salience?

Throughout this chapter I mentioned the phrase 'the salient properties/components of an event' several times. The choice of words was not a coincidence. Here, I propose an account that heavily builds on PERCEPTUAL SALIENCE to explain the variation in Object and Handling use that we see in the data I present in this dissertation. But what is Perceptual Salience?

The title of this section is the perfect example to explain PERCEPTUAL SALIENCE. As the reader, your eyes may have caught something out of the ordinary. The word 'perceptual' is spelled wrong. Your knowledge of the English language, its written form and all of the previous spellings of 'perceptual' that you have seen up to this point in this dissertation and beyond in your life tell you that something is not quite right. In psychology and neuroscience this phenomenon is known as PERCEPTUAL SALIENCE. Some property of the signal tells you that it stands out from the other signals within its contexts and that it requires attention.

Moreover, the concept of surprisal from Information Theory is a quantifiable metric of unexpectedness and it is also closely related to PERCEPTUAL SALIENCE. Surprisal and salience have been used extensively in psycholinguistics research, although mostly in comprehension studies. In this dissertation, the focus is on production responses.

Pryor and Kriss (1977) describe salience in relation to something and its context. They suggested that a stimulus is perceptually salient when it receives a disproportionally large amount of attention compared to its context. Taylor and Fiske (1975) found that perceptual salience is responsible for altering a subject's perception of who or what the cause is in an event. In their work, perceptual salience is considered to be a stimulus that stands out from the rest of the stimuli in the same context due to some property of it or the expectations of the observer. Smith and Mackie (2000) put forth a similar working definition, where salience is described as a signal's ability to attract attention within its context.

The interactions between Language, PERCEPTUAL SALIENCE and surprisal have been studied by a number of researchers, and certain parallels have been drawn. For instance, researchers such as Freyd (1983) and Hubbard (2005) have found that when participants look at a series of static pictures with implied motion, they build a mental image of an anticipated implicit motion. Language and perception are no exception: the linguistic units at different levels of representation that we process or the visual and the auditory signals that we receive may be unexpected depending on their preceding context. The difference between expected and unexpected stimuli is determined by their frequency and the conditional probability given to rheir preceding context. Surprisal is a metric that builds on the frequency and conditional probability of a signal given its preceding context. It shows how predictable the signal is. Hale

(2001) and Levy (2008) have shown that surprisal has on effect on processing costs and choices made in production. For a comprehensive overview of how language probabilistic language models that feed on surprisal, and entropy are built, see Jurafsky (2002). How does PERCEPTUAL SALIENCE operate in our case? In answering this question, let us take a step back and look at how PERCEPTUAL SALIENCE interacts with ICONIC HANDSHAPE PREFERENCE.

4.5.2 *Cross-Interactions*: Perceptual Salience, Iconic Handshape Preference and Instrument Sensitivity

If ICONIC HANDSHAPE PREFERENCE were the one single factor that explains the comparisons made between the two groups, we would expect to see robust iconicity patterns across different iterations of each target object across the board. For instance, the classifier predicate HAMMER in expressing the event 'hammering a nail [using a hammer]' and the one in 'putting [the hammer] down' would have the same iconicity. Similarly, the classifier BOOK in 'reading a book' and 'hammering with a book' would also have to share one iconicity. In a more generalizable fashion, if ICONIC HANDSHAPE PREFERENCE truly and strongly holds, we should expect to see a picture where the iconicity of any noun stays rigid across all environments. The figure below takes an independent stance to iconicity and studies this relation in the two comparison environments between paired data from four subsets:

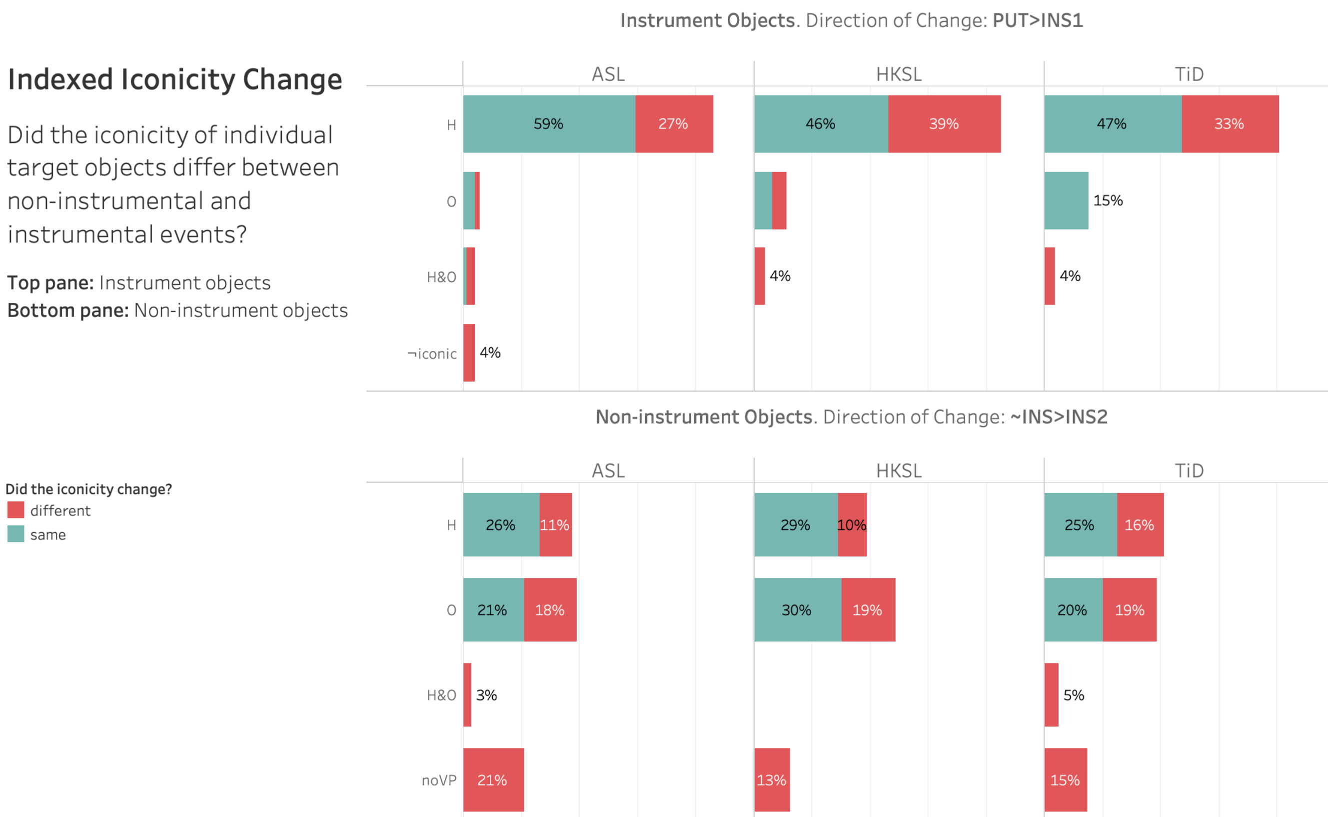

FIGURE 45 Iconicity change between instrumental and non-instrumental events.

How did the change in iconicity type manifest between the instrumental and non-instrumental iterations of a target object? The change is indexed by target object between the instrumental and non-instrumental conditions. Vertically stacked horizontal columns in each pane add up to 100%. (N=928)

The graphs in Figure 45 above study whether the predicate iconicity in each of the 16 target objects differs between non-instrumental and instrumental events. The top graph examines the 8 instrument objects (FAN, SHOVEL, HAMMER, TEASPOON, SPATULA, KNIFE, PLIERS and SCREWDRIVER) and the bottom graph the 8 non-instrument objects (BOOK, COIN, CARDBOARD, CUTTING BOARD, PITCHER, MUG, COOKING POT and HOOK). Non-instrumental events are taken as the basis of comparison (for the top graph the base condition is 'PUT', for the bottom graph it is '~INS'. The comparison condition in the top graph is 'INS1', for the bottom graph it is 'INS2'). Green color encodes the portion of the iconicity of the classifier predicate that remains the same between the non-instrumental and instrumental conditions. The red portions are the morphological strategies between the conditions that are not shared, in other words, they indicate where there was a strategy change between conditions: in the direction of from non-instrumental to instrumental.

As a demonstration on how to read the graph above, in non-instrumental events in ASL, for instance, 86% (59%+27%) of the time the iconicity of the classifier predicate with the instrument object condition was Handling (top graphs). But in the instrumental condition, 27 points of the entire 86-point probability mass changed to a different iconicity (red), while the 59% of the Handling iconicity mass remained the same (green). As a more specific example, if the HAMMER condition had Handling iconicity in the non-instrumental predicate, the iconicity remained the same in the instrumental predicate. We see in ASL that only around 5% of the data originally had Object iconicity in the non-instrumental condition and about 1% of the entire data shifted from Object to a different iconic strategy in the instrumental condition (second horizontal bar, top left cell). Likewise, in HKSL 85% (46+39) of the non-instrumental responses had Handling iconicity in the predicate but only 46% remains Handling in the instrumental task condition, and 39% of the entire probability mass from the original portion of Handling in the non-instrumental condition (85% total) changes to a different iconicity (i.e., either to exclusive Object iconicity or to a combination of Handling and Object iconicities). TiD has a higher number of Object iconicity in the classifier in the non-instrumental condition, all of which remained unchanged in the instrumental condition.

The bottom graph examines the 8 non-instrument objects. We see a much more diffuse distribution of iconicity types across the predicates of non-instrumental sentences in all of the three sign languages. In other words, while in the top graph signer responses are concentrated around Handling iconicity in the non-instrumental case, in the bottom graph, in contrast, Handling and Object iconicities receive a somewhat equal distribution[28], i.e., no concentration around one iconicity. Building on this distributional imbalance, we can effectively say that ICONIC HANDSHAPE PREFERENCE is greatly flouted in the instrument objects condition (top graph), while the effect of ICONIC HANDSHAPE PREFERENCE is more readily visible in the non-instrument objects condition (bottom graph), simply due to the fact that the iconic morphological strategies in the bottom graph have a more diffuse distribution and because they show less variation between the instrumental event and the non-instrumental event conditions.

Unsurprisingly and as briefly mentioned earlier, certain objects that, when used typically in the non-instrument items condition, are not expressed in the classifier predicate at all, are expressed overtly with an iconic form in the instrumental condition. These objects are CUTTING BOARD, COOKING POT and in fewer cases HOOK and CARDBOARD. What is special about these objects? The answer is that there is nothing that makes them extraordinary when used in their typical context (especially CUTTING BOARD and COOKING POT); therefore, signers do not foreground them by placing them in a privileged constituent, i.e., the predicate. CUTTING BOARD is for chopping vegetables and there are always at least 3 other more

28 Even more Object than Handling in the ASL and HKSL non-instrumental agentive conditions (second horizontal bars in the bottom graph)

prominent and salient event participants when CUTTING BOARD is in a typical scene: an agent (a human chef), an instrument (usually a knife) and a patient (usually some ingredient). The limited resources of the sign articulators are reserved for these more prominent discourse participants. The same reasoning goes for COOKING POT. The chef who puts the ingredients into the pot and the ingredients themselves are more discourse salient than the cooking pot. This picture contrasts with the other objects that assume more prominent pragmatic roles in the discourse: BOOK, COIN, PITCHER and MUG. All of these four objects are actively handled in the vignettes, and they play a crucial role in the event. BOOK is the theme of reading, COIN is a theme that a person handles and puts in a purse, PITCHER and MUG are two containers that are handled during the transfer of liquid between the two. Only when we see CUTTING BOARD, COOKING POT, HOOK and CARDBOARD used as an instrument do they become prominent discourse participants and therefore situated in a highly privileged constituent, the morphologically complex predicate, as some form of a classifier that resembles the object iconically. The graphs below in Figure 46 elaborate on the graphs in Figure 45 by dividing the same data further by target object per language.

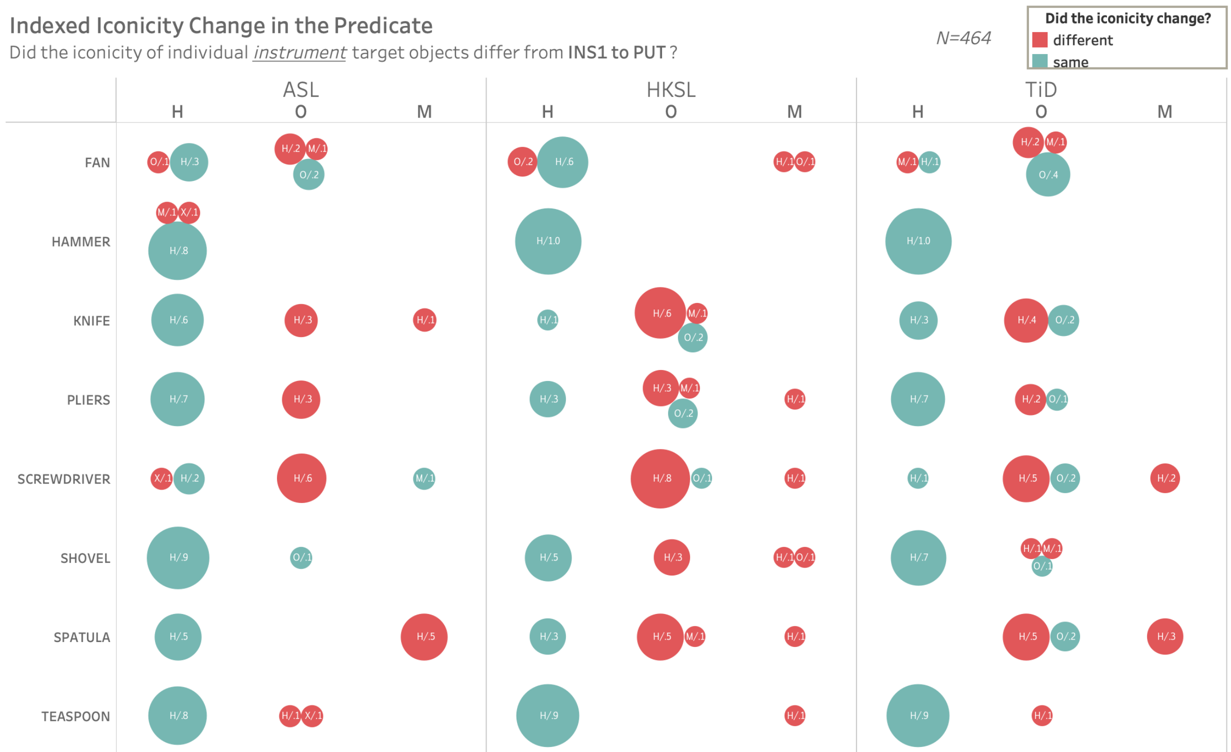

FIGURE 46 Indexed iconicity change between 'INS1' and 'PUT' by target object.

How did the change in iconicity type manifest between the instrumental ('INS1') and non-instrumental ('PUT) iterations of individual instrument target objects? Circles in each row per language add up to 100%. (N=464). H=Handling only, O=Object only, M=Handling & Object, X=Not Iconic.

The indexed iconicity change graph here in Figure 46 above take one condition as the basis of comparison and compare the iconicity of the predicate per each [target object, signer] pair across conditions; the typical use ('INS1') is taken as the basis of all comparisons. The x-axis is first grouped by language (ASL, HKSL and TiD) and expressed in the topmost level of columns, and then each language pane is divided by the unique types of iconicities distributed in the 'TYP' condition (H for Handling, O for Object and M for multiple iconicities (H+O)). The rows on the y-axis correspond to individual target objects per language. The circles encode iconicity change between conditions.

For instance, in the graph above we see that the instrument HAMMER (HM), when it is used instrumentally ('INS1' condition), displays Handling iconicity in the classifier predicate 100% of the time in all three languages. In TiD and HKSL, when the hammer is part of a non-instrumental environment the predicate iconicity stays the same, that is Handling. This is indicated in the graph with single large, green-filled circles. If the color of a circle is green, it means that the indicated portion of the predicate iconicity) remains unchanged across the two conditions (the base condition and the comparison condition; in the graph above these would be (typical) instrumental ('INS1') and non-instrumental ('PUT') respectively). In other words, we see in HKSL and TiD that 100% of the time the signer responses with the target object HAMMER had Handling iconicity in the predicate in both conditions. In ASL, on the other hand, while HAMMER in the 'INS1' condition had Handling in the predicate 100% of the time (the three circles H, M and X, under the columns [ASL, H], add up to 1.00), 10% of that shifted to the multiple iconicities strategy (indicated with an 'M' in the red circle) and 10% was shifted to non-iconic (indicated with an 'X' in the other red circle) in the 'PUT' condition. 80% remained the same, i.e., Handling (indicated with an 'H' in the green circle). Similarly, SHOVEL (GS), TEASPOON (TS), PLIERS (PL) and KNIFE (KN) in ASL are 4 other instrument objects that very rigidly display Handling iconicity in the classifier predicate. SCREWDRIVER (SD) in ASL has Object iconicity in 60% of the predicates of instrumental responses ('INS1' condition) – all of which shift to Handling iconicity in the 'PUT' condition. This is indicated in the graph with the red color of the circle and the letter 'H' in it. In HSKL we have, TEASPOON (TS) and FAN (FA), aside from HAMMER (HM), that pass the 50% mark in preserving the Handling iconicity in both the instrumental and non-instrumental conditions on predicate types. The majority of the HKSL signer responses in the instrumental condition for SCREWDRIVER (SD), PLIERS (PL), SPATULA (SP) and KNIFE (KN) have Object iconicity in the predicate, which switch to Handling in the 'PUT' condition for the most part. TiD has a similar picture for TEASPOON (TS), SHOVEL (GS) and PLIERS (PL) besides HAMMER (HM), all of which have Handling in the instrumental predicate and stay as such in the non-instrumental condition ('PUT'). The objects FAN (FA), KNIFE (KN), SCREWDRIVER (SD) and SPATULA (SP), each have a strong tendency for Object iconicity in the TiD instrumental predicate; however, with the exception of FAN, they all migrate to Handling iconicity for the most part in the non-instrumental 'PUT' condition. Note that some target objects have a small tendency (small except spatula (SP) in ASL) to have multiple iconicities (the 'M' column in each language pane) in the instrumental condition; however, multiple iconicities is prevalent across the board and only small proportions of other iconicities may migrate to multiple iconicities in the 'PUT' condition. The following graph examines the remaining 8 items, the non-instrument target objects set, under the non-instrumental ('~INS') and instrumental ('INS2') conditions.

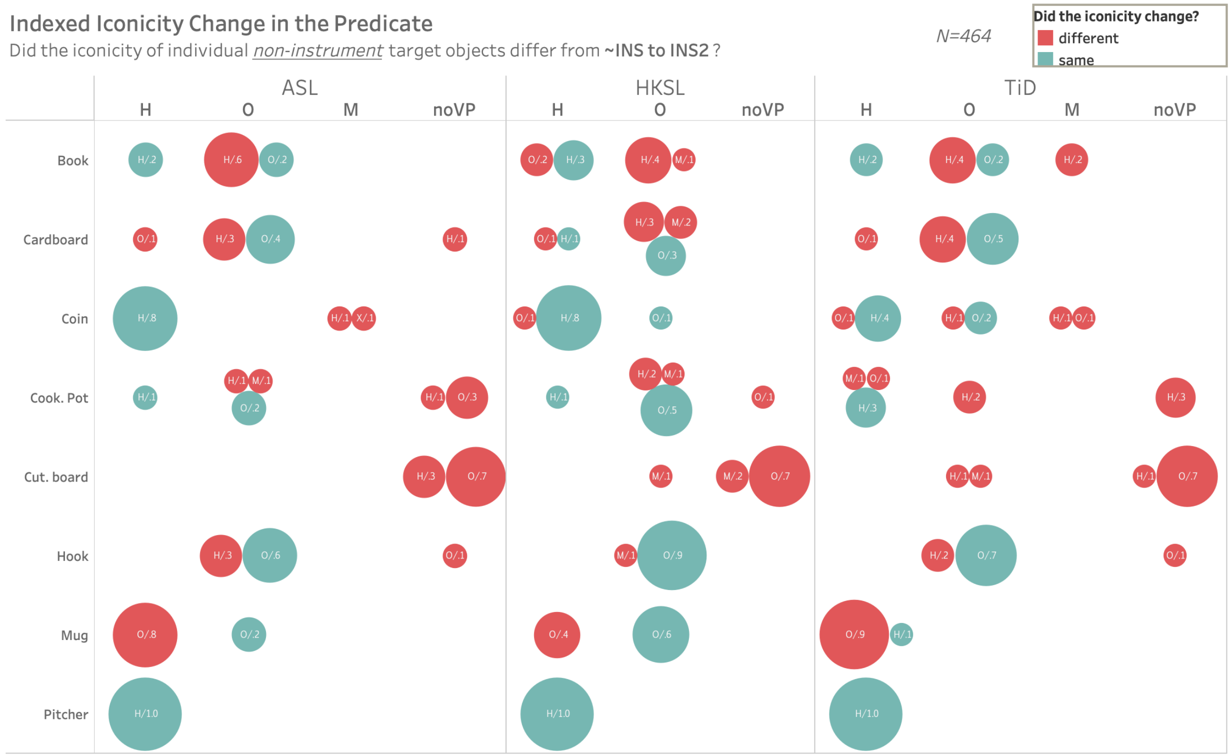

FIGURE 47 Indexed iconicity change between '~INS' and 'INS2' by target object.

How did the change in iconicity type manifest between the non-instrumental ('~INS') and instrumental ('INS2') iterations of individual non-instrument target objects? Circles in each row (targe tobject) per language add up to 100%. (N=464). H=*Handling only*, O=*Object only*, M=*Handling & Object*, X=*Not Iconic,* noVP=*Missing Targeted VP.*

The typical uses ('~INS' condition) of the 8 non-instrument objects are non-instrumental (at the very least they are non-intermediary uses in the strictest sense). This condition forms the basis of comparison in the graph above and the circles indicate how the iconicity in the typical, non-instrumental condition changed (red) or remained the same (green) in the instrumental condition ('INS2'). We see, for instance, that pouring water from a PITCHER[29] (non-instrumental condition) in all 3 sign languages is expressed exclusively using

29 It's an old school, cylindrical, glass water carafe with no handle.

Handling iconicity in the predicate, and this iconicity stays the same in the instrumental atypical condition ('INS2'), which is stirring water in a pot using the same pitcher. COIN (CO) in ASL and HKSL preserved the Handling iconicity in the predicate across the two conditions most of the time. MUG (MG) was Handling in the non-instrumental predicate for the most part in ASL (80%) and 100% of the time in TiD. However, the entirety of the Handling probability mass of it in ASL and the majority of it in TiD (90%) switched to Object in the instrumental condition. HOOK (HK), on the other hand, consistently displays Object iconicity in the predicate that does not differ much between instrument and non-instrument events, especially in HKSL and TiD. And as mentioned earlier, CUTTING BOARD (CB) goes from not being mentioned in the non-instrumental predicate at all to high amounts of Object strategy when used to carry out an instrument task in all of the three languages.

The graphs in Figure 45, Figure 46, Figure 47 and the discussions that follow show that only a few of the items have rigid iconicity in the predicate across conditions, and that iconicity is Handling for the most part. This is directly related to ICONIC HANDSHAPE PREFERENCE. Recall from earlier in this chapter that certain nouns have a rigid preference for one kind of iconicity (see Figure 34) and that that preference is reflected in the classifier predicate. However, these strong nominal tendencies alone do not exactly explain why, for instance, SCREWDRIVER in ASL is rigidly Object-preference in the noun form, while the non-instrumental activity 'put down screwdriver' is strongly Handling. If ICONIC HANDSHAPE PREFERENCE were a factor that operates neatly, we would expect to see Object-preference in the non-instrumental events where a SCREWDRIVER is put on the table. This is likely because the salient component of the event is not the screwdriver itself but a combination of the movement motion and crucially the handling of the screwdriver. This is not to say that ICONIC HANDSHAPE PREFERENCE is not a factor. It is one, and a strong one too, indeed. However, it is only enabled when the salient features of the screwdriver align with the salience requirements of the event. In this regard, ICONIC HANDSHAPE PREFERENCE is a factor that is nested under the PERCEPTUAL SALIENCE hypothesis. It is allowed to operate only when the linguistic and perceptual conditions are right. The fact that the morphological iconic strategies of, for instance, HAMMER matches in the instrumental and the non-instrumental condition for the most part, is really a linguistic coincidence that we see because the rigid ICONIC HANDSHAPE PREFERENCE of the noun HAMMER and the iconic requirements of the conditions work in tandem. In the case of SCREWDRIVER, a pretty rigid Object-preference noun in all three languages, the iconic preference and the iconic requirements of the condition are not in agreement, so in the non-instrumental 'PUT' condition we see prevalent Handling iconicity in the classifier, while we see the iconic preference of the noun SCREWDRIVER, Object iconicity, surfacing in the instrumental condition, especially in HKSL and TiD, because the tool screwdriver assumes a salient role in the instrumental event whereas in the 'PUT' condition the salient property was the act of handling it while moving it to put it down on the table.

Consider KNIFE. KNIFE is a very rigid Object-preference noun in all three languages. But only in HKSL and TiD it maintains this lexical nominal rigidity and surfaces as Object-iconicity in the instrumental predicate. In the majority of the non-instrumental condition the HKSL and TiD predicates have Handling iconicity for encoding putting down knife. A detailed examination reveals a similar story for PLIERS (PL) and SPATULA (SP) in all three languages, albeit to different extents. From the distribution of iconicity in the classifier predicates, it is clear that ASL predicates are the *least* sensitive to the ICONIC HANDSHAPE PREFERENCE found in the noun form of an object among the three languages. This is likely because ASL makes a stronger distinction between the grammatical uses of the two morphological strategies, Object and Handling, while TiD and HKSL make a weaker distinction, if at all. The grammatical functions of Handling and Object iconicities in ASL is none other than the agentive/non-agentive distinction put forth by Benedicto and Brentari (2004) for ASL. Object iconicity is reserved for unaccusatives for the most part and Handling iconicity is found in agentive events. In that regard, HKSL patterns with TiD, and the two differ from ASL, creating a typological difference: HKSL and TiD are likely ICONIC AGREEMENT languages; ASL is likely a GRAMMATICAL AGREEMENT language. While the iconicity type that we see in ASL classifier predicates is strongly determined by a grammatical distinction between unaccusatives and agentives, we do not see the same distinction in HKSL and TiD. This is not to say that HKSL and TiD will not use Object iconicity in expressing unaccusative events, they do so indeed if we look at locative classifier predicates (e.g., CL-OBJECT: 'scissors are on the table'); however, it is not a strategy that is solely reserved for unaccusatives the way it is in ASL for the most part.

Where does INSTRUMENT SENSITIVITY fall in all this? At face value, a simple comparison of target objects between instrumental and non-instrumental ('PUT') conditions has revealed that INSTRUMENT SENSITIVITY is a strong factor in TiD and HKSL, and a weak factor in ASL (see Figure 42 earlier in this section). However, testing INSTRUMENT SENSITIVITY on another comparison drawn between two other groups of data showed that we might be undergeneralizing a phenomenon by limiting it to instrumental classifier predicates only, which in reality should apply to a wider range of environments. I have shown that a more widely generalizable hypothesis, Perceptual Salience, can address and speak to the differences in the data that we have seen in this section.

4.5.3 Perceptual Salience as a Meta-Function in Language Production

Perceptual Salience is an aspect that differs from one scenario to another. The salient component of the event 'putting a knife on the table' is handling the knife and putting it on the table, whereas the salient component of the event 'cutting tomato with a knife' is the knife itself cutting the tomato but also the agent handling the knife.

The PERCEPTUAL SALIENCE hypothesis requires that the most salient component of the event get promoted in the predicate. We know that in ASL, TiD and HKSL the most common iconicity for KNIFE is Object. PERCEPTUAL SALIENCE requires that knife be promoted in the classifier predicate when it is the salient part of the event (i.e., cutting *with knife;* Object Salience). From this point on, Object Salience passes the ball to ICONIC HANDSHAPE PREFERENCE in HKSL and TiD: the most commonly used noun iconicity, if there is one as shown by LEXICAL RIGIDITY earlier in this chapter, becomes the iconicity of the predicate too. For KNIFE, that is Object iconicity. This is why we see an increase in Object preference with instrumental events where the knife is used as the tool. Conversely in ASL, ICONIC HANDSHAPE PREFERENCE is not a strong factor and therefore the strong Object preference in the noun form is likely to become overridden by Handling iconicity – the iconicity type that the grammar of ASL expects in agentive events. This forms the basis of the differences that we see in ASL vs. HKSL and TiD.

The fact that we see Object iconicity with 'cutting tomato with a knife' in HKSL and TiD is not necessarily because the events are instrumental, but because the salient component of the event is an instrument whose noun form happens to favor Object iconicity. If the knife were merely an object that is handled, handling it would be the salient feature and therefore become the salient component of the event in languages such as HKSL and TiD. In this scenario, we would expect to see Handling iconicity across the board, and we do. Putting down knife gets 100% Handling in ASL, 70% in HKSL and 77% in TiD. Conversely, HAMMER is a strong Handling-preference noun in all of the three languages. Then the expectation would be that the predicates have Handling iconicity in both instrumental and non-instrumental events, and that is the case: ASL: 80%, HKSL 100%, TiD 100%, with no change in iconicity recorded. Let us look at how the iconicity decision is made in each language with respect to the factors discussed so far.

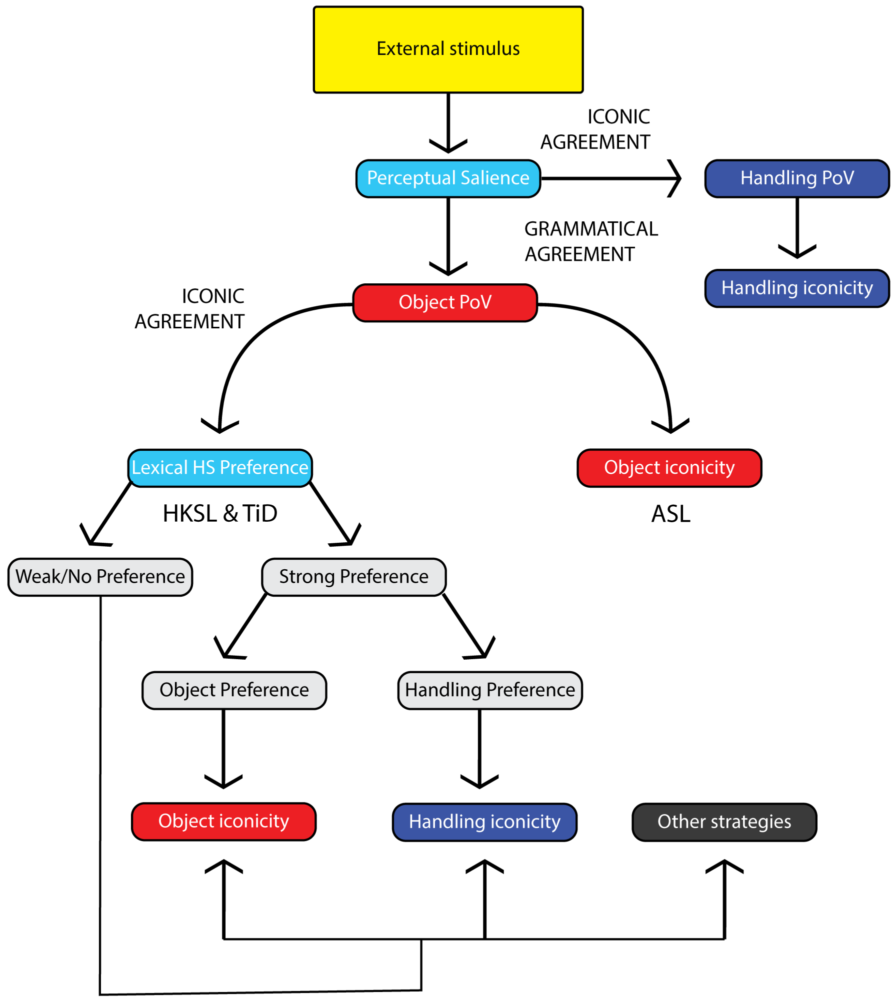

FIGURE 48 Typological membership with respect to iconicity in the predicate.

Object or Handling preference in the classifier predicates. The decision tree shows how the iconicity type in the predicate is determined in (A) Iconic Agreement languages, and (B) Grammatical Agreement languages.

The schema in Figure 48 above visualizes the proposed typology and iconicity decision tree for classifier predicates in two types of sign languages: ICONIC AGREEMENT and GRAMMATICAL AGREEMENT languages. First, Perceptual Salience filters the external stimulus and directs signers to determine what is salient to them in an event. Different types of stimuli provide different points of view. For instance, events where only the handling of an object is available (verbs such as HOLD, PUT.DOWN, LIFT, etc.) are highly likely to activate Handling point of view. Both language types, Iconic or Grammatical Agreement, will choose Handling iconicity if the only available point of view is Handling point of view. The main between the two languages is when Object point of view becomes available as determined by Perceptual Salience. If the language is sensitive to the concept's iconic preference in the nominal lexicon (e.g., HKSL and TiD), and if it is a strong preference for that iconicity, then we will see that iconicity in the classifier predicate. If the perceived object does not have a strong preference, then we will see the engine of visual iconicity used on the fly to produce a myriad of iconic forms that reflect either a physical feature of the object or the handling of it. At this step, iconicity decision is also highly affected by the involvement of the object in the event semantics. If there is no sensitivity to iconic preference (for instance, ASL), the classifier predicate will likely have Object iconicity. In that regard, while not without exception, Object and Handling strategies reflect the argument structure and valency of utterances in ASL. Contrary to what we see in ASL, Object and Handling strategies in HKSL and TiD do not necessarily reflect the argument structure of the utterance, although this is not without exception either. This typology has implications for how sign languages manipulate gesture in order to produce linguistic output. While the iconic agreement between highly conventionalized noun lexemes (low entropy) and their use in the classifier predicate that reflect the same iconic type is systematic and linguistic without doubt, signers' unpredictable linguistic behavior with low conventionalization nouns (high entropy) cast doubt on their status as lexicalized entries and therefore as linguistic instead of the other alternative, gesture.

I would like to leave the issue of these unconventionalized nouns' status as linguistic versus gestural as an open-ended question.

A closer examination of the phenomena at the object level revealed that Perceptual Salience operates across factors, somewhat a meta-function that decides how the available morphological resources need to be allocated across the language, but one that does not say anything about the iconic strategy to be used, instead pointing signers in the correct path:

Hypothesis 3 Perceptual Salience

> If a sign language is an ICONIC AGREEMENT language, then the most salient component of the event, as perceived by the signer, must be encoded iconically in the predicate of its linguistic description. The type of iconic encoding depends on the type of salience and the preferred iconic properties of the salient component of the event.

In the following sections, I tackle PERCEPTUAL SALIENCE head on and test this hypothesis by using INSTRUMENT TYPICALITY as a litmus test. If salience is indeed a main factor, then we should see a steady use of Object-preference in the predicate, as some objects, when they are used outside of their designated functions, render the event marked and therefore make a property of the object salient. This markedness may require references to be made to the sub-parts of the event or the object. The visual modality enables certain iconic adjustments to be made to the predicate and the signed language morphology effectively executes those adjustments. Recall that the datasets in the second comparison are composed of objects that do not have a designated instrumental/intermediary use (e.g., BOOK, COIN, CUTTING BOARD, etc.) but can be used instrumentally. This effectively renders their status as atypical objects for instrumental tasks. Another data set that I am yet to present is the instrument objects (HAMMER, KNIFE, TEASPOON, etc.) when they are used outside of their designated functions, albeit successfully. For instance, a pair of heavy metal pliers can successfully hammer a nail into wall in the absence of a hammer; or a screwdriver can assume the role of a teaspoon in stirring tea. The following section studies such atypical instrumental events that are successfully carried out with an unconventional tool for the task, making them the perceptually salient components of the instrumental event.

4.5.4 Testing Perceptual Salience: INSTRUMENT TYPICALITY, *Revisited*

In the previous sections, I studied INSTRUMENT SENSITIVITY, the hypothesis put forth in Brentari et al. (2016), which states that instrument sensitive sign languages are more likely to motivate the use of Object iconicity in the predicates of instrumental sentences, as opposed to non-instrumental sentences. I argued that INSTRUMENT SENSITIVITY is part of an overarching phenomenon that applies to a wider range of constructions that can be explained with PERCEPTUAL SALIENCE, a concept from psychology which states that certain event participants stand out more than the others in the same context. I established that handling an object during the event of putting it on a table is the salient component of that event. I have also discussed that the same object becomes a more salient component of an event where it is used as an instrument. I also discussed how PERCEPTUAL SALIENCE interacts with ICONIC HANDSHAPE PREFERENCE, and acts as a meta-function that distributes available morphological strategies in a language across its classifier predicates under different circumstances.

We know from the literature on instrumentals that speakers of various languages tend to perceive the instrument noun as a quasi-argument (see §1.1). This follows the logic that instruments, especially the intermediary kind, assumes partial agency in the instrumental event by enabling its successful execution. Without a certain kind of instrument, the instrumental function would not be successfully carried out. The quality of the instrument as a salient discourse participant acts in sign languages as a helper function to map the predicate's iconicity to the predominant iconicity found in the noun form of the instrument object, if there is any. This mapping is permitted only when there is no other intervening factor. In this section, I test my PERCEPTUAL SALIENCE hypothesis by altering the salient component of events by adding another layer of complexity to the event's information contents, namely using an atypical object for an instrumental task, and show that in HKSL and TiD, PERCEPTUAL SALIENCE is indeed the engine that navigates other factors into determining the iconicity of the classifier predicate. In ASL, on the other hand, the grammar tends to by-pass PERCEPTUAL SALIENCE and makes a morphological distinction between Handling and Object iconicities from a grammatical perspective.

We know that the task of 'cutting cheese' typically requires a knife to be carried out successfully. Knife is the designated tool for cutting cheese. However, if we did not have a knife around, the task can still be accomplished with the use of another object, a teaspoon for instance. A teaspoon may not be the best candidate to be used as a tool to cut cheese as it lacks a sharp edge, but it will nonetheless successfully break the cheese into pieces. This section uses the atypical ('ATY') dataset coming from the 8 instrument objects group (HAMMER, FAN, SHOVEL, SCREWDRIVER, TEASPOON, SPATULA, KNIFE and PLIERS) to tackle my PERCEPTUAL SALIENCE hypothesis head on by using INSTRUMENT ATYPICALITY as a litmus test.

The stimuli are created as follows. Each of the 8 typical instrumental functions are detached from the designated tool for that task and paired with another tool from the same group of 8 objects. The table below shows the instrument item on the left, the typical function it's designated for in the middle and the atypical function that uses the item to successfully carry out the task, on the right.

Instrument Objects		
item	*typical function*	*atypical function*
Hand fan	put out flame	shovel dirt
Hammer	hammer nail into wall	remove nail
Knife	cut tomato	tighten screw
Pliers	remove nail	hammer nail
Screwdriver	tighten screw	stir tea
Shovel	shovel dirt	flatten dough
Spatula	flatten dough	put out flame
Teaspoon	stir tea	cut cheese

TABLE 10 Functions of the 8 instrument objects in the core group.

Each of the 8 instrumental functions in the core typical group has a unique phonological movement component. Hammering involves a repetitive local movement on the elbow, and a minimal movement on the wrist, stirring requires a circular repetitive movement on the wrist, and so on so forth. Phonologically speaking, the classifier predicate in the atypical data is expected to keep the same unique movement associated with the action but replace the handshape component (i.e., the classifier) with a suitable one for the instrument being used. If INSTRUMENT TYPICALITY indeed has close ties with PERCEPTUAL SALIENCE, then atypical instrumentals are likely to exhibit a higher degree of Object iconicity in the predicate. This higher incidence of Object iconicity would be partially due to the fact that unconventional or unexpected events have higher surprisal (Information Theory; Shannon, 1948).

We can be certain, after what the data in the previous sections as well as the psycholinguistics literature tell us, that salience and surprisal are important components of language production. Signers, when encoding an event where an undesignated object is used as a tool, will surely want to highlight that information. The classifier predicate is one grammatical venue where this can be achieved. If a language is sensitive to PERCEPTUAL SALIENCE, then signers should use more Object iconicity in their responses when an atypical object is used to carry out an instrumental task. This is due in part to the fact that unconventional tools enable the successful execution of an instrumental task thanks to some physical property that they have, which can be exploited to fill the shoes of the original, designated tool.

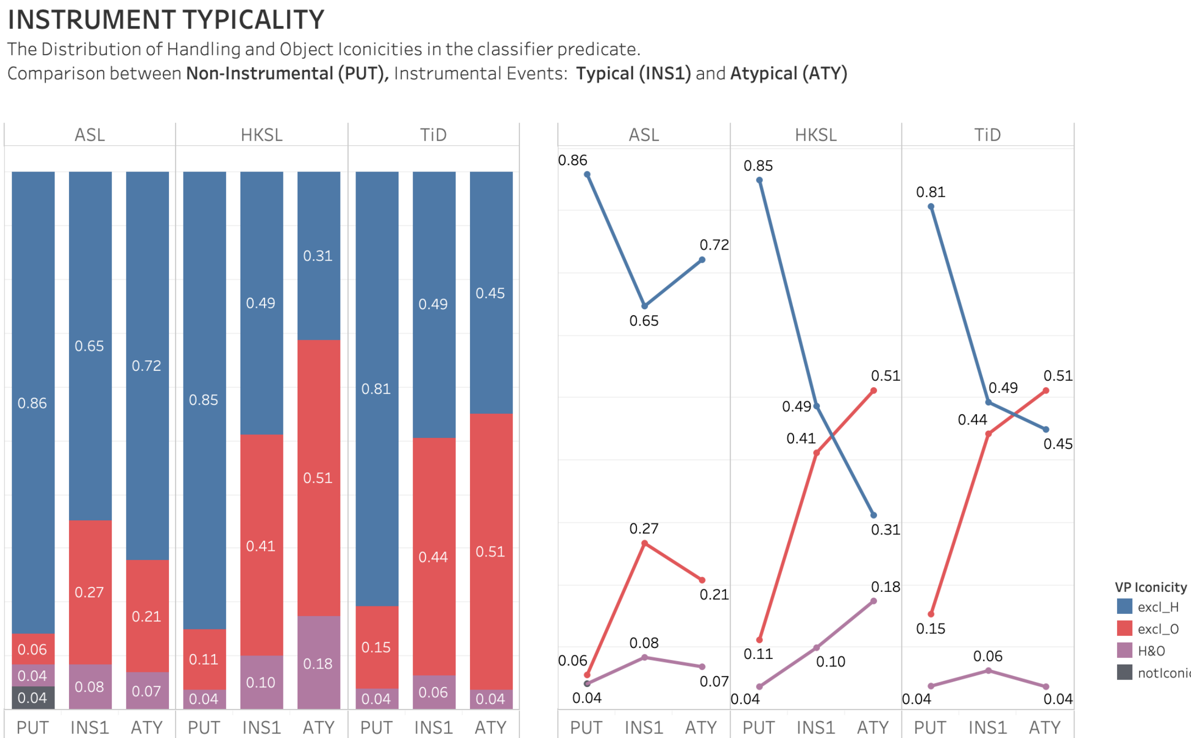

FIGURE 49 Instrument Typicality.

The distribution of Handling and Object strategies in the classifier predicates of (i) non-instrumental/agentive sentences ('PUT'), (ii) instrumental typical sentences with a typical tool ('INS1') and (iii) instrumental sentences with an atypical tool ('ATY'). Each column adds up to 100%. (N=696)

The graph in Figure 49 shows that the probability mass of the Object only iconic strategy in the predicate increases from 41% in the typical condition to 51% in the atypical condition. Moreover, the use of classifier predicates with multiple iconicities increase by 8 points to 18%. The two increases in total, diminish the probability mass of exclusive Handling iconicity by 18 points: from 49% in the typical condition to 31% in the atypical condition; and make the combined masses of Object iconicity and the multiple iconicities (i.e., Handling+Object 'H&O') strategies the prevalent morphological pattern at a total probability mass of 69%. The non-instrumental data ('PUT') is included for your attention. Overall, from the non-instrumental to the atypical instrumental condition the combined probability masses of Object and Object+Handling strategies increase from 15% in 'PUT' to 51% in 'INS1' and finally to 69% in 'ATY'. Note the dramatic dip of the Handling line (blue) and how it crosses the Object line (red) in the middle pane on the right graph, making Object the predominant strategy in the atypical condition. INSTRUMENT TYPICALITY is likely a stronger factor in HKSL than it is in the other two languages. Statistical t-tests show that both the increase in signers' Object iconicity use and the decrease in their Handling iconicity use between the typical instrumental ('INS1) and the atypical instrumental ('ATY') paradigms are significant in HKSL (Object increase $p<0.05$; Handling decrease $p<0.01$). In TiD, the effect is not as pronounced as it is in HKSL, but still present. Handling iconicity drops from 81% in the non-instrumental condition ('PUT'), to 49% in the typical instrumental condition ('INS1') to 45% in the atypical instrumental condition ('ATY'). The 7-point increase in Object use from the 'INS1' paradigm to the 'ATY' paradigms is not significant ($p=0.14$). The 4-point decrease in Handling between the same conditions, on the other hand, is far from significant ($p=0.49$). ASL signers provide a completely different picture. Handling iconicity use in the predicate actually increases from the typical instrumental condition to the atypical instrumental condition, completely the opposite of what one might expect from a language whose grammar is sensitive to PERCEPTUAL SALIENCE. A chi-square test reveals that, while TiD's behavior is not statistically significant, HKSL and TiD behave more like one another ($p>0.27$) but ASL is significantly different from the two languages with respect to typicality ($p<0.001$ for both HKSL and TiD). In what follows, I present the same data divided by how individual target objects change or remain the same across conditions.

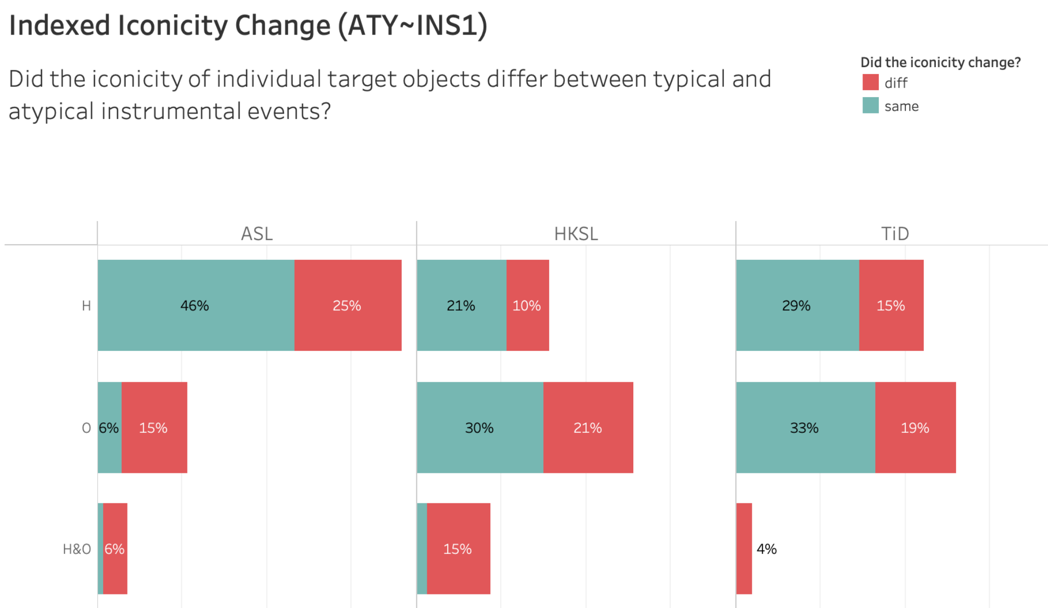

FIGURE 50 Indexed iconicity change between 'ATY' and 'INS1'

Does the iconicity of individual target objects differ between typical and atypical instrumental utterances? Horizontal columns in each cell add up to 100%. (N=464).

The graph in Figure 50 above shows how the atypical data are distributed across different predicate iconicities. The green bars show the portion of that iconicity that is shared in both the typical and the atypical conditions. The red bars indicate a shift to a different strategy. Most of the time the trade-off is between Object iconicity and Handling iconicity. The multiple (Handling+Object) strategy is not as prevalent as the Object only or the Handling only strategies. Language-wide tendencies show that in HKSL and TiD Object iconicity in the atypical predicate made up (30+21) 51% and (33+19) 52% of the probability masses respectively. 15% of HKSL's probability mass that corresponds to the multiple iconicity strategy goes to another strategy when the condition was typical. Crucially, the red portions of the Object iconicity in HKSL and TiD are larger than the red portions of the

Handling iconicity in the same two languages. In other words, the typical condition came with more Handling than it did with Object when the instrumental condition was typical. This means that the observations on the non-indexed probability distribution presented in Figure 49 above hold when we track the data by individual changes in the predicate iconicity and compare [typical, atypical] pairs of the same target object between the two conditions. Let us look at how the data are organized at a lower level. The graph in Figure 51 expands on the graph in Figure 50 above by dividing the data by target object.

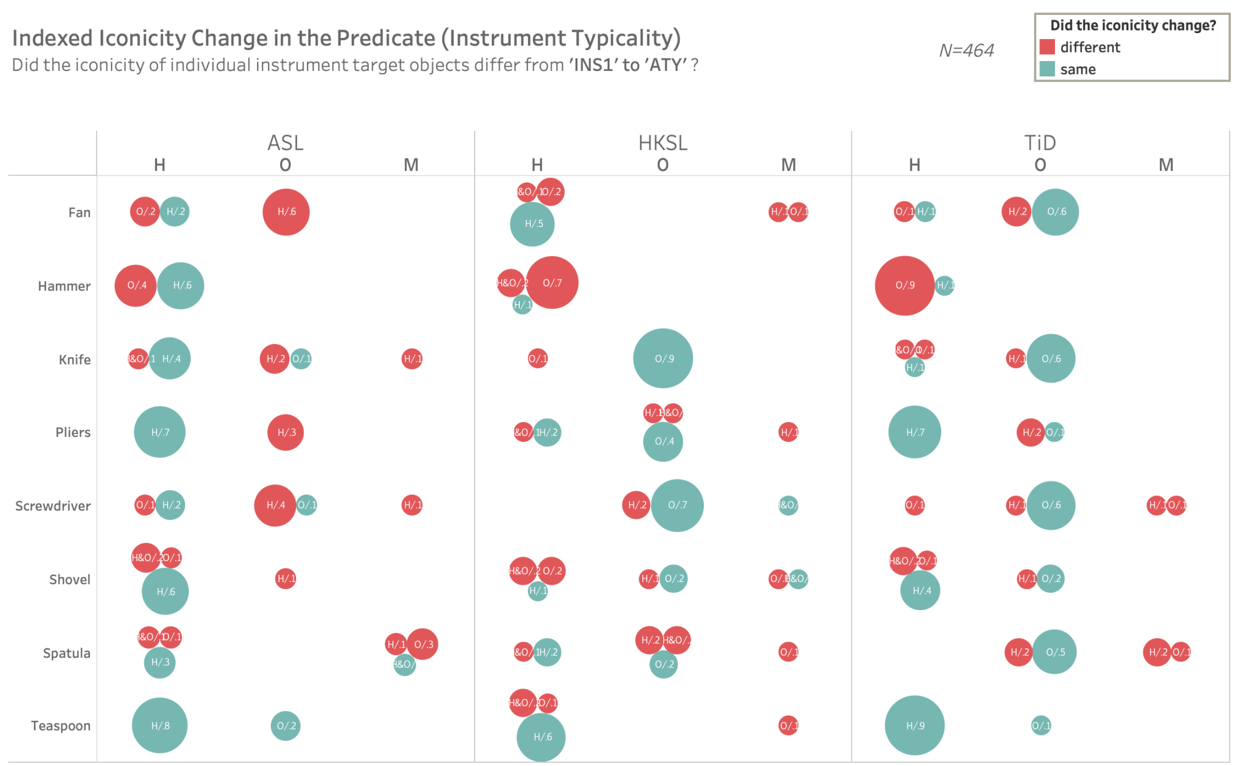

FIGURE 51 Indexed iconicity change between 'ATY' and 'INS1' by target object.

Indexed iconicity change in the direction of the typical instrumental 'INS1' condition to the atypical instrumental 'ATY' condition. Circles in each row (per target object) add up to 100% per language. (N=464). *H=Handling only, O=Object only, M=Handling + Object, X=Not Iconic, noVP=Missing Targeted VP.*

Perhaps the most striking patterns to be found are in the target objects HAMMER, KNIFE, TEASPOON, PLIERS and SCREWDRIVER. In Turkish Sign Language, 90% of HAMMER's probability mass in the atypical condition is made up of Object strategy. Note the red colored circle which indicates that the same signers produced Handling iconicity for HAMMER in the typical condition and that was without exception (90%+10%). The proportion of Object iconicity use in HKSL for the atypical environment for HAMMER was 70% - one hundred percent of the time HAMMER received Handling iconicity in the typical instrumental predicate in HKSL and 70 points of that shifted to Object iconicity and 20% to multiple iconicities in the atypical instrumental predicate. Only a mere 10% remained the same as Handling in the atypical condition. Recall that HAMMER in the nominal domain in all three sign languages has a strong tendency for Handling iconicity. We saw in the previous section in Figure 42 that the iconicity of HAMMER did not differ between the non-instrumental ('PUT') and the instrumental ('INS1') conditions. I claimed that that was because in the non-instrumental condition ('PUT'), PERCEPTUAL SALIENCE required the iconic strategy in the predicate to be Handling. Moreover, the very same hypothesis enables the ICONIC HANDSHAPE PREFERENCE of the noun HAMMER to surface in the instrumental condition, as the instrument becomes more prominent in the event. Because the ICONIC HANDSHAPE PREFERENCE of HAMMER in all three sign languages is Handling, we do not see a difference in handshape iconicity between the two conditions: ICONIC HANDSHAPE PREFERENCE (IHP) permeates right through PERCEPTUAL SALIENCE and goes unnoticed because the iconic requirements of the two conditions overlap:

HAMMER	Environments		
	'PUT'	**'INS1'**	**'ATY'**
Perceptual Salience	H	H or *[IHP=H]*	O
	Predictions		

TABLE 11 Form predictions for HAMMER in the TiD and HKSL predicate.

However, in the atypical instrumental condition, what's prominent is not the instrument HAMMER anymore but how a certain part of it is used, i.e., the claw. The image sequence in Figure 52 below shows the vignette for the atypical condition for HAMMER:

FIGURE 52 Atypical use of hammer.

We see a woman removing a nail that was previously hammered to a piece of box. She uses the double-pronged side in the back of the hammer (i.e., the claw) to achieve this. This may not be the most atypical use of a hammer; however, it is also not the first function of a hammer to come to mind. What matters under the PERCEPTUAL SALIENCE hypothesis is, regardless of typicality, that the hammer, although still handled by the agent where it normally would be handled, is used in reverse; therefore, signers use Object iconicity in the predicate to highlight this salient piece of information in their responses: the claw's active involvement in the event. This atypical use of the tool HAMMER renders its nominal ICONIC HANDSHAPE PREFERENCE (i.e., rigid Handling in all three languages) void and allows Object iconicity to surface in order to promote the shape of the claw and the important piece of information that the hammer is used in an atypical way: to remove a nail with its claw.

FIGURE 53 Hong Kong Sign Language atypical use of hammer

Signer's response (just the predicate) to the atypical instrumental use of hammer vignette. Object iconicity is used in the predicate despite the noun HAMMER'S rigid Handling preference in the HKSL lexicon.

Let me detail with another example how the inner machinations of PERCEPTUAL SALIENCE combined with other factors work. We saw in the previous section that when KNIFE is used instrumentally, we see the prevalence of the Object iconic strategy in the predicate. This is in accordance with knife's nominal ICONIC HANDSHAPE PREFERENCE. In HKSL, 100% of the probability mass of KNIFE in the atypical instrumental condition (i.e., *tightening screw with the tip of a knife*) received Object iconicity. This contrasts greatly with the non-instrumental condition presented in the previous section (i.e., the 'PUT' condition), where Handling was by far the winning iconic strategy in the predicate (70%). This is because in the non-instrumental condition handling of the knife is a more salient event component than the knife itself. In the typical instrumental condition, 60 points from the 70% probability mass of Handling iconicity in the non-instrumental 'PUT' condition is transferred to Object iconicity. The atypical condition boosts that up to 100% when KNIFE is used instead of an actual screwdriver, making the blade and its sharp tip the most prominent components of the event as well as the knife itself. When you come to think of it, some of these tool-task pairs are not even that atypical. Removing nail with a claw or breaking cheese in half using a teaspoon are not unheard of. It is really about how prominent a role the tool plays in the event that makes the signers reflect in the typical instrumental predicate whatever rigid iconic strategy the noun has in the lexicon.

KNIFE	**Environments**		
	'PUT'	**'INS1'**	**'ATY'**
Perceptual Salience	H	H or *[IHP=O]*	O
	Predictions		

TABLE 12 Form predictions for KNIFE in the HKSL and TiD predicate.

In ASL, the effect of PERCEPTUAL SALIENCE is very limited. It is very unlikely that ASL signers will use the ICONIC HANDSHAPE PREFERENCE of a noun in the predicate of a typical instrumental condition ('INS1'), unless it accidentally matches what Agency requires: Handling.

KNIFE	**Environments**		
	'PUT'	**'INS1'**	**'ATY'**
Agency	H	H	H (or O)
	Predictions		

TABLE 13 Form predictions for KNIFE in the ASL predicate.

The image sequence in Figure 54 below shows the behavior of an ASL signer in choosing an iconic strategy in the predicate for KNIFE seen in the three environments discussed in this section. In the 'PUT' condition, we have Handling, an almost invariable behavior in ASL and the other two languages. In the typical instrument condition 'INS1', we see Handling again. This is one of the conditions ASL differs from HKSL and TiD. Although KNIFE is an Object-preference noun in ASL, this preference is not reflected in the typical instrumental condition ('INS1'). This signer a multiple sequential strategy in the atypical instrumental condition 'ATY', a very rare observation in ASL responses. The first handshape uses Object iconicity to express the blade of the knife, the second handshape uses Handling iconicity, as required by the grammar of the language (Agency).

FIGURE 54 Paradigm of iconic strategies in ASL signer across conditions.

The iconic strategies in the predicate used by an ASL signer for 'put knife down' [PUT], 'cut tomato in half with a knife' [INS1] and 'tighten screw with a knife' [ATY].

Interestingly, the Object iconicity used in the first handshape is not the same handshape as the one we find quite consistently in the lexical form of the noun KNIFE in ASL. The noun form has an ASL 1-handshape – the Object iconicity in the first handshape in the response to the 'ATY' condition has an ASL B-handshape. This is a similar behavior as the handshape behavior we have seen with HAMMER in the atypical condition 'remove nail with the claw of hammer'. In HKSL and TiD, using Object iconicity in that atypical condition was the norm, in ASL Handling and Object were almost equally likely. The important point here is that the Object handshape used in expressing the claw of the hammer removing a nail is not specified in the lexicons of any of the three languages. Signers are using the iconic affordances of the visual modality to create an Object handshape on the fly to encode the important piece of information that the screw was tightened with the blade of a knife instead of a screwdriver and that the nail was removed with the claw of the hammer (instead of pliers maybe).

In 2016, when we ran a pilot study on Instrument Typicality in ASL, LIS, HKSL and TiD (Brentari et al. 2016b), we found an interesting and unexpected pattern in non-instrumental classifier constructions. Although the stimuli were composed of events depicting an agent putting an object down, which requires Handling iconicity along the lines of what I have discussed in this dissertation up to this point, we found extensive use of exclusive Object iconicity in all four sign languages across the board (Figure 55):

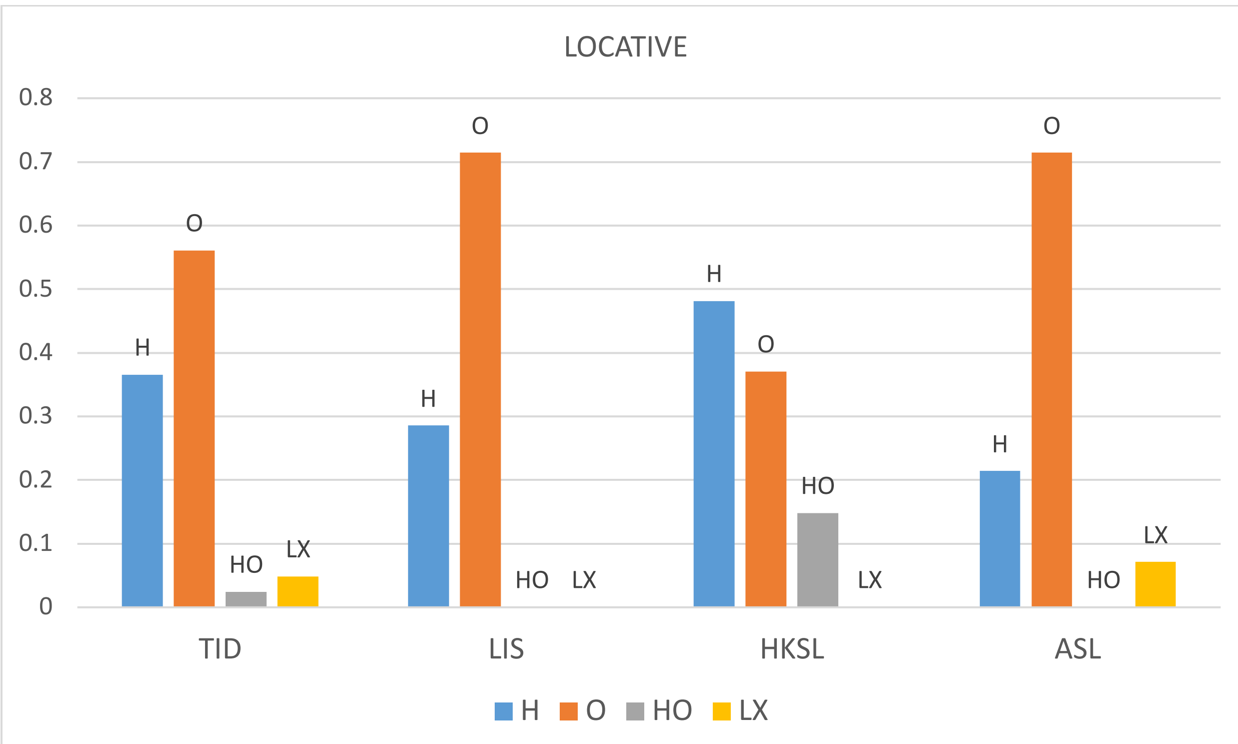

FIGURE 55 Atypical location.

Graph adapted from Brentari et al. (2016b).

This condition had one major difference from the typical 'put on table' condition that I presented in my dissertation dataset. The objects were seen being handled and placed on atypical locations, such as a woman holding and placing a book or a pair of scissors on her head. While the dataset was very small and I do not have a structured and reliable quantitative explanation to what we observed, the data suggests that what we observed was an effect of putting an object to a location where it did not belong. We would probably not find exclusive Object iconicity use had the item being placed on head were, for instance, a hat.

Hypothesis 4 Instrument Typicality

> If a language's morphology is sensitive to PERCEPTUAL SALIENCE, it is likely to mark classifier predicates featuring the use of an atypical instrument with Object iconicity.

Circling back to INSTRUMENT SENSITIVITY, it is not necessarily a factor that promotes Object iconicity. It is part of a greater overarching factor, PERCEPTUAL SALIENCE, which allows the prevalent (and rigid) iconicity of the nominal form to surface when the object in question becomes a more prominent or marked discourse participant, although still used typically. I used INSTRUMENT TYPICALITY as a litmus test to show just how PERCEPTUAL SALIENCE operates under this one specific circumstance and acts as the mastermind behind overseeing how the iconic affordances of the visual morphology are effectively allocated across language production. The form of the Object iconicity specified in the ICONIC HANDSHAPE PREFERENCE of a noun will not necessarily match the Object iconicity found in the predicate of an atypical instrumental utterance. It reflects the salient part of the atypical object that plays a crucial role in the event; therefore, they are likely determined spontaneously during language production. As for the form of the Object iconicity specified in the ICONIC HANDSHAPE PREFERENCE of nouns in the languages that are strongly sensitive to it (HKSL and TiD), that handshape is part of the grammar, and it does not alter cross different iterations. Finally, HKSL and TiD are more sensitive to PERCEPTUAL SALIENCE than ASL is. We see Object use here and there in both typical instrumentals and atypical instrumentals in ASL, but it is not prevalent enough to capture a grammatical phenomenon as is the case in the grammars of HKSL and TiD.

One question that remains is how the salient component of an event is detected and how salience is measured. Visual attention and the encoding of the visual stimuli into the visual short-term memory are two candidates for the empirical grounding of the PERCEPTUAL SALIENCE hypothesis. Studies that investigate the differences between signers and non-signers in visual processing and where the visual attention is distributed have been conducted (see Bavelier et al., 2000; Bosworth & Dobkins, 2002; among others), however, more research is needed to close the gap between these studies and how salience is detected. Studies on psychophysics, attention and perception have been conducted with an aim to measure and model perceptual salience computationally (see Krüger et al., 2017). A venue for future research on PERCEPTUAL SALIENCE is collecting eye gaze data on the stimuli prior to language production in order to establish a link between visual attention and how the salient components of the visual stimuli shape language production on the fly.

4.6 The Semantic Role of the Target Object in the Sentence

Earlier in this chapter when discussing INSTRUMENT SENSITIVITY, I drew the reader's attention to the semantic role of the targeted object in the non-instrument items paradigm

(BOOK, COIN, CARDBOARD, CUTTING BOARD, COOKING POT, S-HOOK, MUG, and PITCHER) and showed that they behave differently, according to their semantic role in the event, with respect to whether or not signers will encode them in the classifier predicate, and if they do, what iconic strategy they will use. In this section, I tackle the issue of event semantics and the target object's semantic role in the event by first presenting another not-yet-seen portion of the data where I examine a set of the same instrumental tasks, but this time carried out with bare hands instead a tool, and then by restructuring the experiment paradigm with regards to the involvement of the target object in the event semantics.

4.6.1 Using the Hand as an Instrument

In the experiment, there is a proportion of the stimuli where the 8 original instrumental tasks, which are associated with the 8 core instrument items, are carried out using only the hand. For instance, an agent is seen removing a nail using her fingers instead of pliers; in another, another agent is seen hammering a stick into a muddy ground using his fist. This experiment paradigm is intended to conflate the distinction between the hand and a tool external to the body and therefore motivating signers to make a decision between Object and Handling iconicities in their responses.

In this section, I study how these two iconicities would be distributed if signers saw an agent carrying out a task with their bare hands, a task that normally requires an instrument or is greatly alleviated by the use of one. Up to this point we have seen how hands are used by the morphology in a variety of ways to encode physical objects. We have seen that HAMMER and TEASPOON have a predisposition across the three languages studied here to the use of Handling iconicity in both the nominal domain and the verbal domain when it is expressed as a classifier in the predicate. Similarly, we have seen that KNIFE, SCREWDRIVER and BOOK have a predisposition for Object iconicity. But what happens when hands, which are used so very effectively to encode linguistic information pertaining to physical objects, are required to linguistically encode the hand itself or the parts of the hand?

I have taken the 8 instrumental functions from the typical instrumental group and removed the instrument from the picture. Agents are now seen doing the same action but with their bare hands, instead of with the help of a tool. The agent removes a nail with her thumb and index finger or flattens dough with his palm. I refer to this portion of the experiment as 'hand' data (environment code 'HAN' in the graphs).

FIGURE 56 Stimulus examples from the Hand data.

[Top] Flatten dough with the palm. [Bottom] Remove nail from a wooden box using fingers.

The following table shows the entire 'hand' paradigm:

Hand data (no tool) 'HAN'
Split pile of dirt in half
Tighten screw
Put out a flame
Hammer a stick into ground
Remove nail
Transfer dirt
Flatten dough
Stir tea

TABLE 14 Hand data ('HAN').

No tools are present in the vignettes. Tasks are carried out with bare hands and fingers.

In all these stimuli, the agent is seen handling the patient or the container that the patient is in with their non-dominant hand and using the dominant hand to actively act on the patient. In the previous data presented, the agent's nondominant hand still had the task of holding the patient but the dominant hand was in charge of holding the instrument object, which was the cause that altered the patient in a certain way. In the 'HAN' data, this intermediary level is effectively removed, and the hand is in charge of directly altering the patient. This is where the distinctions between the Handling and Object morphological strategies converge. The hand represents an object, by virtue of the 'linguistic signal' hand being the object that the 'linguistic articulator' hand is representing. However, the iconicity of the hand can also be argued to be Handling since in some of the vignettes the agent is actually handling the patient (as opposed to handling the instrument in the instrumental conditions) and actively causing a change in its form or location.

All but one condition in the 'HAN' dataset displays direct physical contact of the hand with the patient. The odd one is *put out flame*, where the hand assumes the role of a fan and creates a draught without touching the burning incense stick, which puts out the flame. In the *remove nail* and *tighten screw* conditions the hand is actively holding the patient. In *stir tea*, the finger is used as an intermediary to stir the tea, therefore there is contact with the patient but no handling. *Split pile of dirt in half* is somewhat similar to *stir tea* in that the hand is used as a shovel to separate a pile of dirt into two parts but without actively handling it. *Transfer dirt* is a tricky one, as we the agent uses his hand as a shovel (and makes the hand's shape look like one, too) to transfer dirt from one place to another. There is no grasping the patient (the dirt), but he is using his palm as a container. *Hammer stick into ground* uses the fist as an intermediary for hammering, and *flatten dough* uses the palm, again as an instrument without grasping the dough. While some of these events are clear cases of 'patient handling', some others lie in a semantically murky area which could be interpreted as the hand used as an actual instrument; therefore, I would like to split this data into two classes: (i) grasp patient; and (ii) hand-as-instrument:

'HAN' data (restructured)	
grasp-patient	***hand-as-instrument***
Tighten screw	Put out a flame
Remove nail	Hammer a stick into ground
	Stir tea
	Flatten dough
	Split pile of dirt in half
	Transfer dirt

TABLE 15 Hand data, restructured by how the hand was used.

Signers, in the predicates of all of their responses, mimicked exactly what the agent did with their hands in the video; therefore, their responses were invariably uniform in the type of iconicity. The most striking aspect of their answers was their observed need to indicate in the noun form that it was the hand of the agent that carried out the task, not a tool. They did this sometimes by fingerspelling H-A-N-D in ASL. Besides signing the word 'hand', they sometimes raised the hand and pointed at it, or paused with direct prolonged eye contact with the camera or directed their eye gaze at the raised hand. I call these strategies non-lexical references to hand. The examples below show the two non-lexical strategies they have used: (i) showing the hand to the camera with eye contact with the camera and raised eyebrows, and (ii) lifting their hand up while looking at it.

FIGURE 57 Signers indicating 'hand' or 'finger' in a non-lexical way.
From top left to bottom right: TiD, ASL, HKSL, HKSL, TiD, TiD.

Hand is most certainly an atypical tool for these tasks and the signers had to disambiguate the situation. In the cases where the hand was grasping the patient, i.e., *remove nail* and *tighten screw*, signers exerted minimal effort to indicate that it was the human hand that was doing the action and not a screwdriver or pliers. In these two cases, the hand was not the salient component of the event – it was the handling and removing of the nail; therefore, the hand was not among the discourse participants that were mentioned as arguments. The hand is assumed as an extension of the agent who is handling the patient. The type of iconicity in the classifier predicate was Handling with joints reflecting the grasping of the patient. In Handling iconicity, the hand represents the hand (*hand-as-hand* iconicity; Padden et al., 2013).

In the remaining six tasks where the hand was not grasping the patient but was used as an intermediary, the hand had an instrumental flavor. Therefore, signers had to express the hand in the form of a nominal reference as the instrument used to carry out the task. The classifier predicate in these conditions had Object iconicity, where the linguistic articulator still represents the hand, but as *hand-as-instrument*.

This shows us two crucial generalizations: (i) the linguistic articulator *signing hand* is a highly grammaticalized and versatile morphological tool, which is capable of effectively articulating complex physical relations between objects, and (ii) the hand can easily and effectively assume the role of objects other than the hand itself and can reflect the transparent iconic properties of the event. The surprisal effect in the events where the hand is used atypically as a tool shows that the hand's grammatical functions go far and beyond its identity as just a hand; and therefore, signers need to disentangle this puzzling conflation between the hand as a physical entity and the hand as a linguistic articulator that encodes grammatical relations, by using prominent and out-of-the-ordinary linguistic constructs with greater phonological prominence and stronger engagement with the addressee.

The hand's prominence in the discourse provides further support for the PERCEPTUAL SALIENCE hypothesis: when signers are cornered into situations where the iconic engine of the language falls short or if an iconic strategy is ambiguous, they will go out of the regular morphological ways in order to encode the important piece of information that requires relaying. We will see another case of this in the following sections where I present the portion of the data studies INSTRUMENT FUNCTIONALITY.

4.6.2 Semantics of the Verb: The Hand-Instrument-Patient Chain

Recall from earlier when I presented INSTRUMENT TYPICALITY that there are a total of 9 unique movements which correspond to our verb heads in the instrumental paradigm and the 'PUT' paradigm. In this section, I raise the question whether the verb type has an effect on its classifier type. The graph in Figure 58 below shows how different types of iconicity are distributed across different verb types.

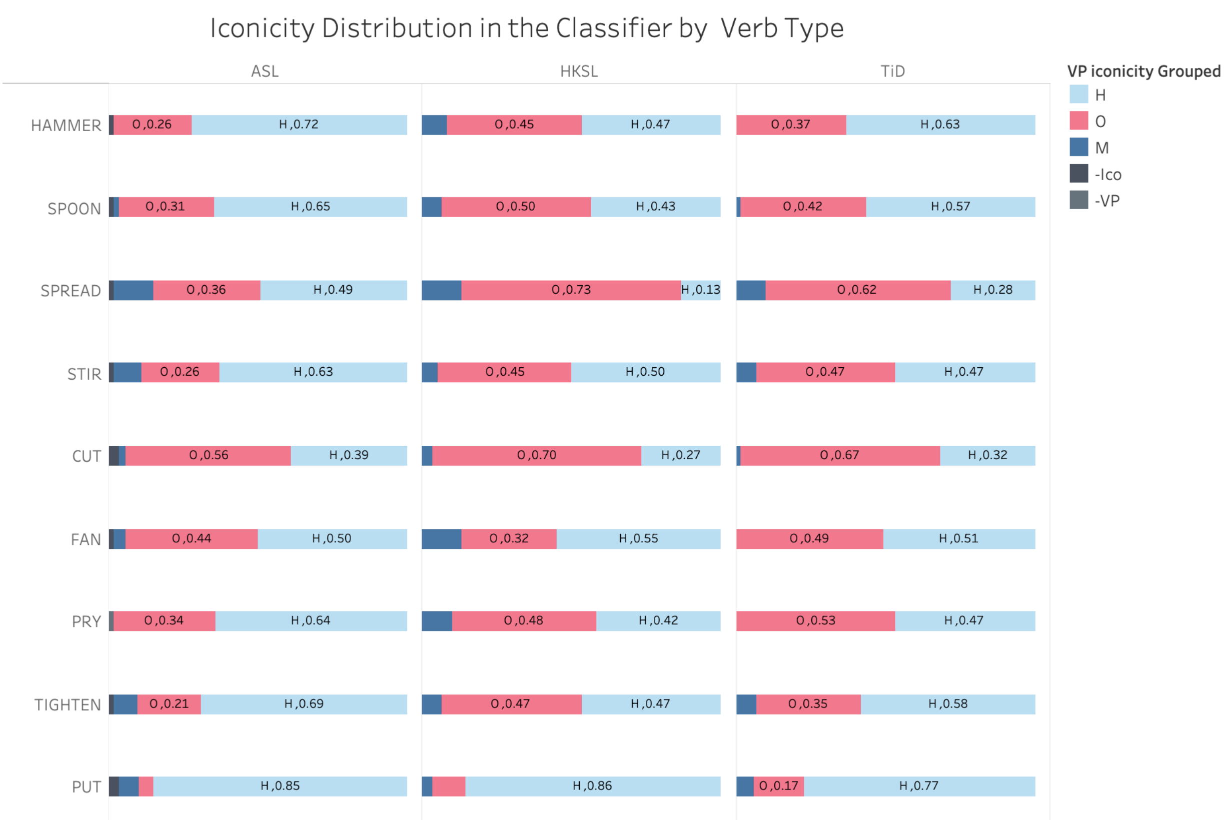

FIGURE 58 Iconicity distribution in the classifier predicate by individual verbs.

ASL has very little variation in the iconicity type in the classifier handshape across all verb types – it is always predominantly Handling, especially in the verb condition 'PUT'. In HKSL and TiD, on the other hand, there is quite a lot more variation with certain verbs receiving more Object iconicity than Handling. While this graph does not provide an adequate distribution to study the effect of verb type more in depth, we can still find some insights. In HKSL, SPREAD, PRY, CUT and TIGHTEN have the highest incidence of Object iconicity. In TiD, it is the same. Also, interestingly, in ASL, while Object use is very low in general, those 4 verbs still receive the some of the highest number of Object iconicity in ASL across the board. What's important about those four verbs, and why don't we see a similar pattern with the other 4?

Fillmore (1968)'s Thematic Hierarchy shows imbalances between the agent, the instrument and the theme/patient roles in English sentences. If there is an agent, it becomes the subject; otherwise, if there is an instrument, then the instrument will become the subject; if neither are present the theme/patient argument will become the subject:

- Jill opened the door with her key.
- Jill opened the door.
- The key opened the door.
- The door opened.
- *The key opened the door by Jill.
- *The door opened by Jill

Relations in the structural prominence among the semantic interactions of a verb's arguments is likely to be linguistically encoded in the morphosyntax. A hierarchy of perceptual salience is also likely to affect the grammatical processes that reflect the importance of arguments relative to one another. Following these footsteps, we need to group my dissertation data at a higher semantic level than just the individual verbs. I consider verbs to be bundles of semantic features. Which semantic features are distinctive and which ones are shared across different verbs? To answer this, let's dig deeper into the physical properties of the event that signers are expressing, namely what I call the *Hand-Instrument-Patient chain*. An important note here is that this was not a part of the experiment design; therefore, the data are not balanced. However, it is likely a strong factor that explains the distributions of iconicity in certain environments really well. Moreover, it provides evidence that PERCEPTUAL SALIENCE is an overarching factor that encompasses a variety of phenomena and operates under the radar when other more prominent factors are at play.

I have divided my dissertation data into 5 groups with respect to the physical properties of the event and labeled them with respect to how involved the hand or the instrument were in manipulating the patient:

Label		Involvement with the Patient	N of stimuli	Examples
-1	noTouch	The hand or the instrument does not touch the patient	6	All of the stimuli with the action *fanning*
0	onlyTouch	The hand or the instrument has contact with the patient but no other involvement	4	Cutting board used typically; hammer failing to tighten screw
1	alterPatient	The hand or the instrument has active involvement in altering the patient	25	All cutting, hammering, spreading, stirring events
2	[-hold][+move]	The hand or the instrument has an active involvement with the patient's movement or location in space	14	All prying, tightening, spooning and hanging events
3	[+hold][+move]	The hand or the instrument actively grasps the patient with joints involved	15	All handling events; tightening screw with hands, removing screw with hands, removing nail with claw (claw 'handling' the nail)

TABLE 16 Distribution of stimuli across patient involvement.

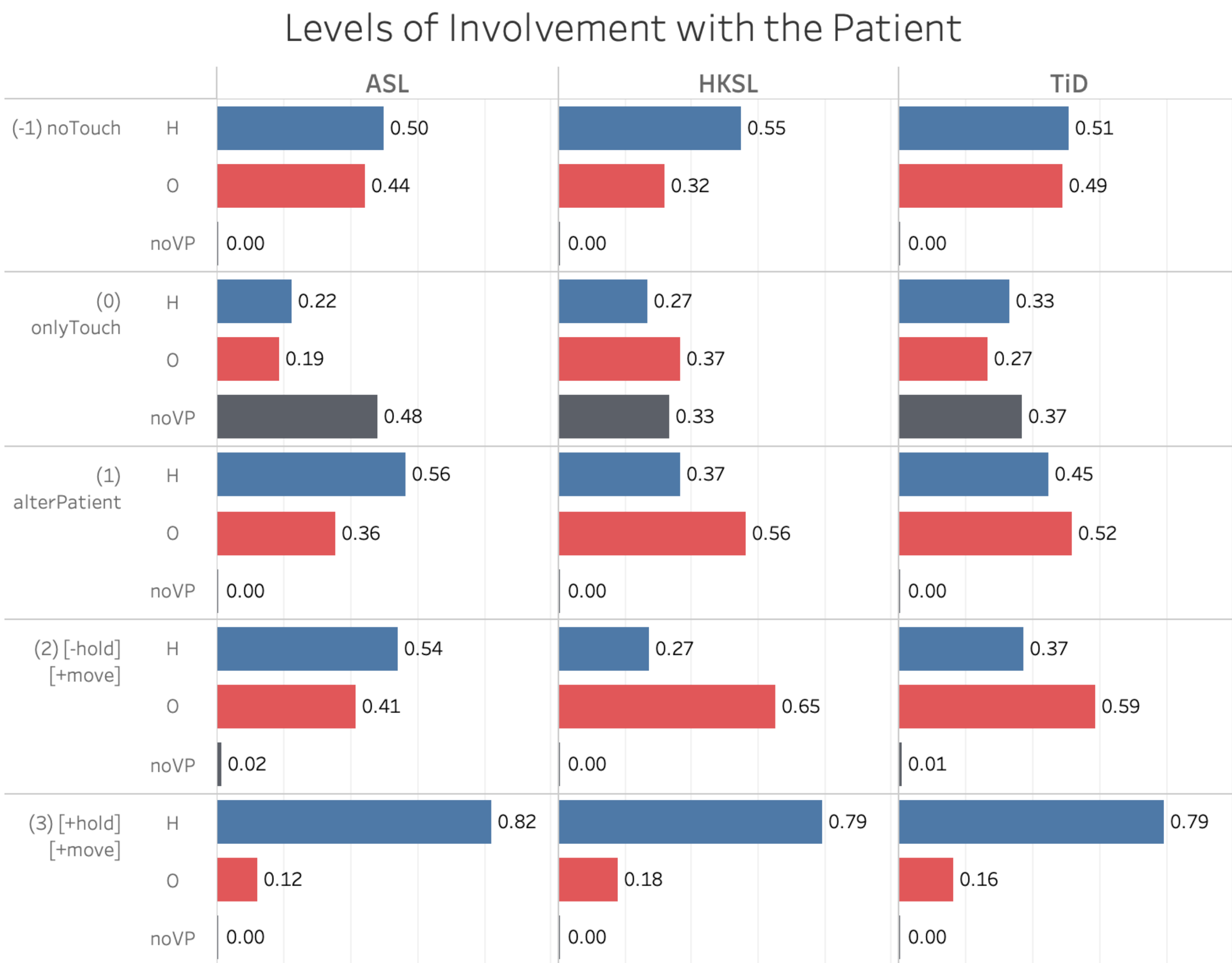

FIGURE 59 Handshape iconicity distributed across patient involvement.

The distribution of iconicity types across different semantic groups with respect to the levels of the hand or the instrument's involvement with the patient. The low probability strategies multiple iconicities and non-iconic are left out to reduce the visual clutter.

Dividing the data into such 5 groups with respect to the agent or the instrument's involvement with the patient reveals important generalizations about HKSL and TiD. ASL is still pretty much a strong Handling preference language, however, this may help to explain the distribution of Object iconicity to some extent in that language. HKSL and TiD show noteworthy differences between the distributions of Handling and Object across the 5 semantic environments. First of all, all three sign languages mark the bottom row where the agent is both holding and moving the patient is marked with Handling iconicity in the predicate (3 – [+hold] [+move]). Unfortunately, I do not have an example of where, for instance, a robotic arm or a massive material handler grasping the patient; however, I would expect *Handling* iconicity to surface with these events. *Handling* is italicized here because it would actually be representing the object being talked about, the robotic arm or the material handler, an object that is capable of handling another object. This chicken-or-egg question also came up when I presented the 'HAN' data previously in this chapter. Is Handling iconicity a subtype of Object iconicity since the hand is representing the object 'hand'?

In the second row from the bottom (2 – [-hold] [+move]), where the instrument is not actively grasping the patient with digits but moving it by virtue of having a suitable tip for a screw head or to remove a jar cover, or a surface to transfer dirt, we see Object iconicity winning the race against Handling in HKSL and TiD classifier predicates. In ASL, although the margin is very small, there is a considerable portion of Object iconicity in this condition (41%), however, Handling is still the dominant strategy (54%). In the middle row (1 – alterPatient), where the instrument is not responsible for moving the patient in space, but merely altering it such as stirring tea or cutting tomato, we also see a significant number of Object iconicity. Note that these results are independent of the instrument being used – in the vignettes we see a knife cutting a tomato but also a coin cutting cheese in half, which also received a significant amount of Object iconicity. In this condition, in HKSL and TiD the use of Handling iconicity, although still second to Object iconicity, is increased over the previous condition. The second row from the top (0 – onlyTouch), is where the patient is merely touching the object that I targeted, but not necessarily getting involved in altering it or moving it, and absolutely not handling it. The stereotypical example of this is the typical use of CUTTING BOARD – just being the stable and flat ground for chopping tomatoes. The CUTTING BOARD has such a low level of importance in this vignette that half the signers did not encode it in the predicate.

The topmost column (-1 noTouch) is exclusively for the fanning condition – a condition where an agent is seen holding a burning incense stick and putting out the small flame with a FAN, a CARDBOARD or her HAND; or trying to put it out with a TEASPOON. There is no physical contact between the instrument and the patient – the fire goes out due to the air draught that the instrument creates. From the point of view of PERCEPTUAL SALIENCE, the even distributions we see make perfect sense – signers have two equally salient options to promote: the agent handling the tool for fanning, or the flat surfaces of the objects used to create the draught to put out the flame. This is one of the few conditions where we see the effect of PERCEPTUAL SALIENCE on the responses of ASL signers: Object use, while still not the predominant strategy, is at its highest in comparison to Object iconicity use in the other conditions.

While only an observation which should not be tested for significance due to the imbalanced distribution of the experiment items in the dataset, I would like to suggest that the semantics of the verb plays an important role in the classifier predicate's iconic type, especially in HKSL and TiD responses where the target object is a high entropy one, i.e., without a prevalent ICONIC HANDSHAPE PREFERENCE. The semantics of the verb works with two factors that operate with different levels of significance: Structural Prominence (Bresnan &

Kanerva, 1992) and Perceptual Salience. Structural Prominence requires Handling iconicity when the target object has no function in the event other than being handled. Perceptual Salience allows the signer to encode the salient component of the event in the classifier predicate through that component's perspective.

Non-instrumental events in this dissertation where the 8 instrument nouns are involved have only one salient component: the agent handling the object (and moving it in space). This is why we see Handling iconicity with these responses in the majority of responses. Instrumental events, on the other hand, have two salient components: the agent handling the instrument and the instrument enabling the task. Signers, especially when the instrument has no rigid iconic preference in the lexicon, resort to the semantic type of the verb and choose one of the two points of view available in the instrumental event to promote in the classifier predicate: the agent's perspective or the instrument's perspective. If the signer chooses the perspective of the agent handling the instrument we see Handling iconicity, if she chooses the point of view of the instrument enabling the instrumental task then we see Handling or Object depending on the iconic handshape preference of the targeted object. If the target object has no iconic preference in the lexicon, then the signer chooses a suitable iconic strategy on the fly in order to encode what the semantic features of the verb require. Sometimes an atypical condition arises, and the signer encodes the salient property of that event. Hence, we see the variation in classifier data.

4.7 When Iconicity Falls Short: INSTRUMENT FUNCTIONALITY

In this section, I examine a portion of the data that I have not yet presented elsewhere in the dissertation. The 16 items (8 instruments and 8 non-instruments) are each seen in an atypical vignette where the tool that is used fails to accomplish the instrumental task. The failure in accomplishment results not from the agent's incapability but from certain aspects of the tool used that makes the tool not a good fit for the task. I use these comparisons between the functional and nonfunctional portions of the data to address my Perceptual Salience hypothesis from an independent perspective. Is the failure information encoded in the predicate or elsewhere in the signer response? If the former, what kind of iconicity is in the predicate? If he latter, how do signers handle that? Table 17 shows how an agent in the stimuli tries to use the items outside of their typical use and why they fail to accomplish the task.

Instrument Objects			
item	***typical function***	***nonfunctional use***	***fails because***
Hand fan	put out small fire	try to remove nail	is flexible
Hammer	hammer nail	try to tighten screw	not hold the nail head
Knife	cut tomato	try to shovel dirt	surface too small
Pliers	remove nail	try to flatten dough	no flat surface
Screwdriver	tighten screw	try to cut tomato	is not sharp
Shovel	shovel dirt	try to stir tea	is too big
Spatula	flatten dough	try to hammer nail	is not heavy enough
Teaspoon	stir tea	try to put out flame	is too small

TABLE 17 Nonfunctional instrumental uses of the core group and why they fail.

The graph in Figure 60 below shows the results from the 8 instrument items in all 3 conditions that we have seen them in so far plus the functionality paradigm: (i) 'PUT': non-instrumental, agentive; (ii) 'INS1': instrumental, typical; (iii) ATY: instrumental, atypical, functional; and (iv) 'NFN1': instrumental, atypical, dysfunctional. All three sign languages make extensive use of Handling iconicity in the 'PUT' condition. ASL, HKSL and TiD see the highest increase in Object strategy in the 'INS1' condition: removing the pressure coming from the revised Agentive condition on the classifier morphology clears the way to the lexical iconicity preferences of individual target signs to surface in the predicate iconicity. In HKSL, we see a significant increase in Object use from the 'INS1' condition to the 'ATY' condition as discussed earlier in this chapter. Greater salience of the instrument object in the discourse brings with it greater Object iconicity use.

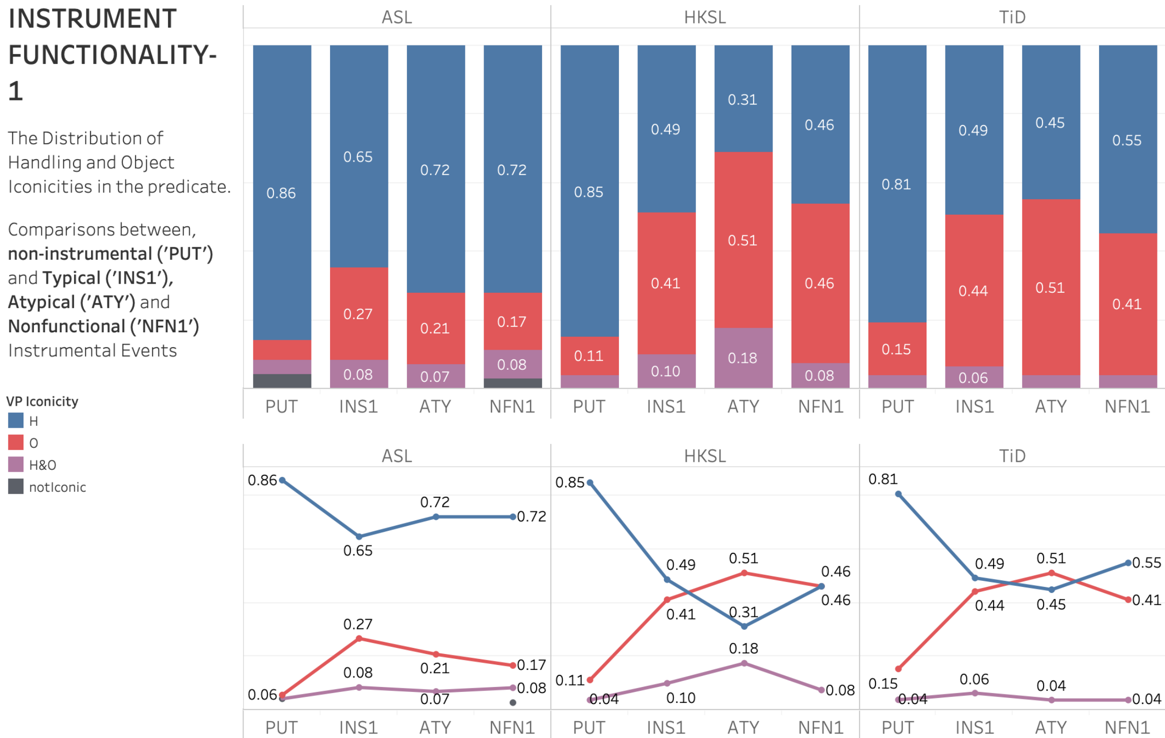

FIGURE 60 Instrument Functionality-1.

Is information regarding INSTRUMENT FUNCTIONALITY encoded in the classifier predicate? – Each column adds up to 100%. (N=928)

The graphs show that functionality does not have an effect on classifier decision. If anything, what we see is a migration towards Handling in the predicate's iconic strategy in TiD and HKSL and no change in ASL. In ASL, Object strategy decreases by 10 points between the 'INS1' condition and the 'NFN1' condition. Likewise, in TiD we see a 3-point decrease of Object use in the 'NFN1' condition compared to the 'INS1' condition. Only in HKSL do we see a small increase (5 points) from 'INS1' to 'NFN1', however that is still less than the margin of difference between 'INS1' and 'ATY'. In fact, in all three languages the nonfunctional condition scores lower in Object strategy compared to the atypical condition. In ASL and HKSL this is a small decrease (4 and 5 points respectively), it is a relatively larger decrease in

TiD (10 points). Why do we see a decrease in Object iconicity from the atypical to the nonfunctional condition? Nonfunctional is by default an atypical environment for the tool being used. Shovel is not a tool for stirring tea, and we cannot hammer a nail using a spatula. Are the changes meaningful or per chance? T-tests run on the signer behavior in the 'NFN1' column with the other three columns show that the only statistically significant difference in iconicity change is when compared with the 'PUT' condition. There is no meaningful change in iconicity type between the 'NFN1' condition and each of the 'INS1' and 'ATY' conditions ($p<0.2$ in all three languages).

Let us first have a closer look at the 8 non-instrument items, the remaining of the 16 target objects in the main experiments. BOOK is not an ideal tool for stirring a cup of tea. It is too big to fit through the rim of the mug and we would not want to wet a book. You can maybe cut a tomato with a COIN if you tried hard enough but it would be a predicament; and CARDBOARD is too wobbly and not heavy enough to hammer a nail into a wooden box. The following table shows the nonfunctional trials to use these objects as an instrument and why that was not a good idea from a functional point of view.

Non-Instrument Objects			
item	typical function	nonfunctional use	fails because
Book	read	stir tea	is too big
Cardboard	write on	hammer nail	is not heavy
Coin	put in purse	cut tomato	is not sharp
Cutting board	cut tomatoes on	pry open jar	edge too thick
Hook	hang shirt	spread paint	surface too small
Mug	pour liquid into	put out flame	no flat surface
Pitcher	pour liquid from	shovel dirt	convex shape
Cooking pot	host vegetables	tighten screw	not hold nail head

TABLE 18 Nonfunctional instrumental uses of the 8 non-core objects.

The graph in Figure 61 below paints a similar picture to the 8 instrument items I presented above. We see a steady increase in Handling strategy in all three sign languages as we go from non-instrumental ('~INS') to atypical instrumental 'INS2' and finally to nonfunctional 'NFN2'. TiD is the only language where Object strategy increases by 2 points only from '~INS' to 'INS2' but then drops 8 points from '~INS' to 'NFN2'. So, what gives? Why is there a decrease in Object iconicity use when the properties of the target object become the most salient participant of an event?

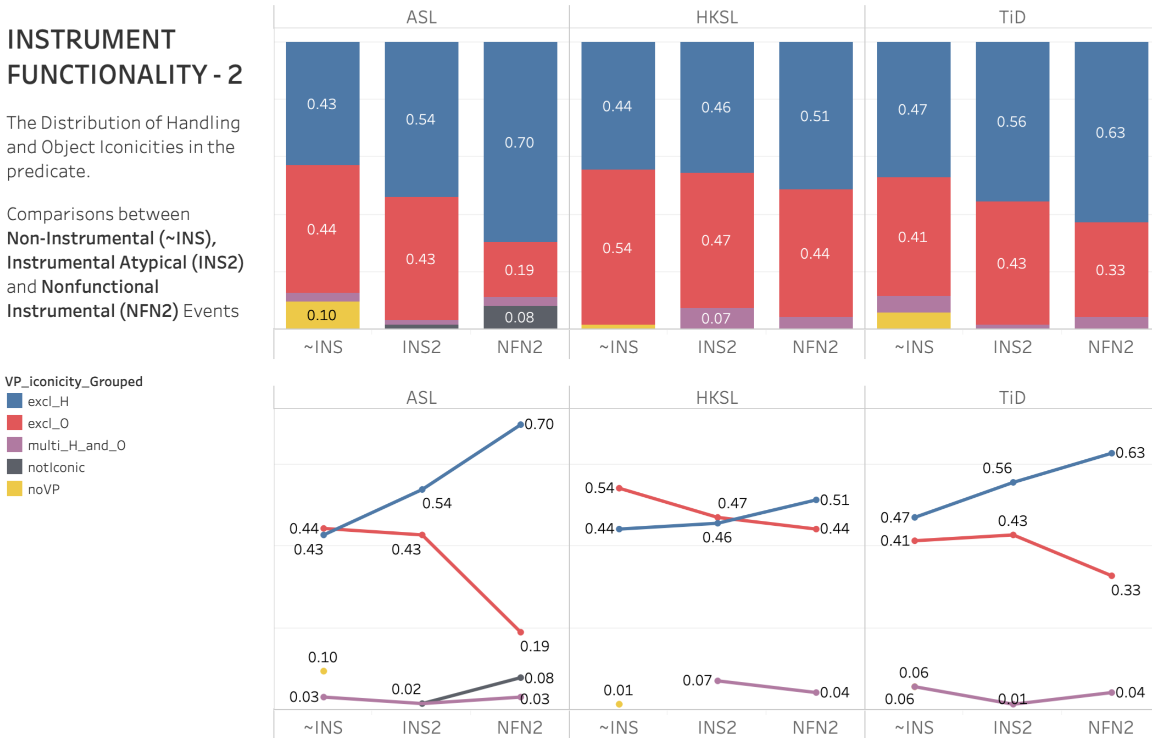

FIGURE 61 Instrument Functionality-2.

Iconicity change in the non-instrument items paradigm from typical, non-instrumental to instrumental, atypical and to instrumental, dysfunctional. Each column adds up to 100%. (N=696)

Before moving further, let me present the indexed results grouped by target object to see if we can find any object-specific patterns.

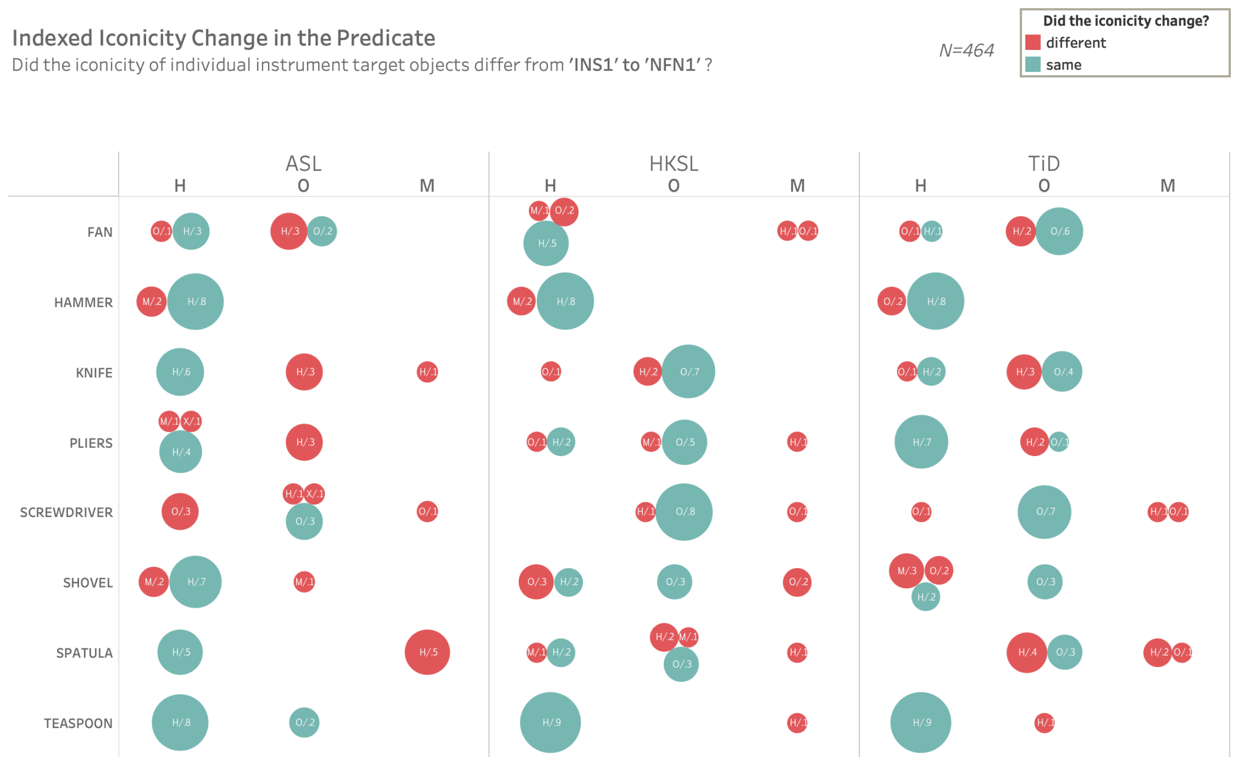

FIGURE 62 Indexed iconicity change between 'INS1' and 'NFN1'

Circles in each row (per target object) add up to 100% per language. (N=464). H=Handling only, O=Object only, M=Handling + Object, X=Not Iconic, noVP=Missing Targeted VP

The graphs in Figure 62 above study the iconicity patterns between typical instrumental and dysfunctional instrumental uses, grouped by the 8 instrument objects. The first thing to notice is probably how the green color dominates the graph. Overall, over 65% of the iconicity preference in the typical instrumental condition 'INS1' remained the same in the nonfunctional condition. This contrasts with the comparisons made between non-instrumental/instrumental and typical instrumental/atypical instrumental pairs where the rates of iconicity shift were more drastic. In the 'NFN1'~'PUT' comparison just over 55% of the iconic strategy remained the same between the two condition. In the 'NFN1'~'ATY' comparison the overlapping portion of iconic strategies were under 50% between the two conditions. But what does this mean? Nonfunctionality does not have as great an effect on altering the predicate iconicity as do the functional atypical instrumental conditions and the non-instrumental condition, putting on table. In ASL, unsurprisingly, the prevalent iconicity type is again Handling. Compared to the other conditions, in HKSL and TiD, nonfunctionality seems to by-pass the PERCEPTUAL SALIENCE filter instead and go straight into nominal ICONIC HANDSHAPE PREFERENCE. How can this be possible given that the failure is due to a property of the object used?

The answer lies in how the tool fails to accomplish the instrumental task. According to the PERCEPTUAL SALIENCE hypothesis, we should see an increase in Object iconicity use in the predicate when the object becomes the prominent figure. It does become prominent as it fails to carry out the task. This is true. However, there is only so much that iconicity can afford in the linguistic encoding of information. A closer inspection of the 16 target objects reveals that only the failures of BOOK, SHOVEL, KNIFE and TEASPOON can be encoded iconically. This is only 4 out of the 16 target objects. BOOK and SHOVEL are too big to fit in a mug to stir tea; and KNIFE and TEASPOON are too small to shovel dirt and to put out a flame, respectively. We almost have never seen TEASPOON shift its iconicity between conditions, and it stays unchanged in the nonfunctional condition as well: Handling.

We see some backwards migration from Object in the typical instrumental condition 'INS1' to Handling in the nonfunctional condition 'NFN1'. A most prominent example to this would be KNIFE in ASL, an item that strongly favors Object iconicity in the nominal form and shows some of that tendency reflected in the instrumental predicates, going back to

Handling in the nonfunctional predicate. Moreover, SCREWDRIVER and PLIERS in ASL display a highly split behavior in the nonfunctional condition. SHOVEL (GS) in TiD goes from 70% Handling in the typical instrumental condition to a fragmented 30% multiple, 20% Object and 20% Handling distribution in the nonfunctional condition. The 30% Object iconicity in the instrumental condition remains unchanged in the nonfunctional condition. As for the other objects, there are changes in predicate iconicity here and there but nothing prominent enough to create a pattern. How does all this fit in with my PERCEPTUAL SALIENCE hypothesis?

Looking at the signer responses at a broader level reveals how salience in nonfunctionals is encoded elsewhere in the production:

TiD:

(35) …DIRT.IN.CONTAINER KNIFE-O GRAB.KNIFE-O SHOVEL.WITH.KNIFE-O **BAD**…

The man grabs the knife and (tries to) shovel dirt with it [but it doesn't work].

HKSL:

(36) MAN DOUGH PLIERS-H FLATTEN.WITH.PLIERS-H **BAD**…

The man (tries to) flatten the dough with pliers [but it's not good].

ASL:

(37) MAN MUG-FS USE BOOK-O STIR.WITH.BOOK-H **NOT WORK NOT SUCCESS…**

The man (tries to) use book to stir [the mug] [but it doesn't work, it is not successful].

As can be seen in the examples in Figure 63 below, the signers turn to a new strategy to encode the piece of information that using these items to carry out these tasks is not a great choice. They indicate this by the simultaneous use of the nonmanuals PURSED LIPS and negative HEAD SHAKE and additionally with segmental manual signs such as BAD and NOT.WORK or NOT.SUCCESSFUL.

FIGURE 63 Strategies in expressing dysfunctionality.

Strategies in responses to the dysfunctional stimulus item 'trying to stir tea with a book'. [Left] ASL: NEGATIVE HEADSHAKE + classifier predicate. [Middle] HKSL: PURSED LIPS + BAD. [Right] TiD: PURSED LIPS + classifier predicate.

In the dysfunctional stimuli, the agent is first seen trying to carry out the instrumental task with the wrong tool and subtly expresses their frustration with the lack of success before picking up the typical, functional tool for the instrumental task and moving forward with accomplishing it with the help of the functional tool. Some signers have exploited the affordances of the Object iconicity in the predicate to express the failure, especially if it was caused by the size of the wrong tool (e.g., SHOVEL not fitting in the mug). However, many of the other objects failed to accomplish the task due to a different property than their size or shape. One such object is the FAN, which is too wobbly and flimsy to remove a nail from a wooden box. Many ASL signers migrated to Handling strategy for those cases and preferred to express the failure using an additional segmental and nonmanual strategy, i.e., by inserting a sign which indicates that it is a failure and why that is the case.

In this section I have shown that some reasons for failure have to do with the size or the shape of the tool used. BOOK, SHOVEL, KNIFE, TEASPOON fail because of their size. Some of these receive Object strategy in the predicate at certain times if the Object iconicity can effectively reflect the reason why the tool fails. Some others such as FAN, SPATULA and CARDBOARD fail because of some property of their material, i.e., they are too flimsy to carry out the heavy-duty tasks required of them. Some others fail because of their surface properties: hook, pliers and mug fail because they do not have a flat surface to spread paint, flatten dough or create draught to put out fire, respectively. SCREWDRIVER and COIN fail because their edge is not sharp enough to cut tomato. HAMMER and COOKING POT fail because they do not have the surface or edge property to grasp and tighten the screw. These properties can not necessarily be reflected iconically in the predicates since they are more intricate and somewhat less three-dimensional properties than just the shape or the size of the object. Therefore, signers conform to the use of Handling iconicity and to other segmental and simultaneous strategies to cover the bases for effective linguistic encoding. This does not go against PERCEPTUAL SALIENCE – instead it further supports the claim that salience does in fact act as the meta-function that regulates the distribution of iconic morphology across multiple domains. It just so happens that some of these pieces of information fall outside the domain of what can be explained using visual iconicity. In the 'HAN' data as well – presented in the previous section – we have seen that signers turn to added sequential and unconventional strategies to express the message. Where the visual iconicity falls short or when the iconicity may cause ambiguity, they successfully convey what is important with certain other strategies, rather than trying to work the information into the classifier predicate, like they successfully would with the typical and the atypical instrumental conditions.

5 Modeling Predictions

This chapter presents the details of the quantitative methods that I have used in describing the distribution of iconicity type in the classifier predicates of the three sign languages – I recapitulate my findings and present my predictions for what paradigms of signer responses given to the experiment stimuli would look like if I had a larger population size. I also present the model's predictions for predicate iconicity on hypothetical conditions – combinations of the experiment conditions that are unseen by participants, such as *spooning dirt with a coin*.

5.1 Probability Distributions and Entropy

In the previous chapter, I have taken different perspectives in describing the probability distributions of a dataset of 1,856 responses I gathered during production experiments that were completed by 9 ASL, 10 HKSL and 10 TiD signers. Signers have shown a great deal of variation in all conditions – and importantly, due to the sheer number of factors studied in a restricted and palatable number of stimuli, in many cases I was not entirely able to isolate my findings neatly. In an ideal world with unlimited financial resources and time, I could have studied a much larger set of stimuli which would help to isolate my hypotheses and provide independent answers to my research questions and do it with great confidence. However, this is not possible – and as a result, due to the lack of isolability and clear boundaries in the data, we see the cumulative effects of factors stacking up and shaping signer responses. Fortunately, current statistical models can deal with these issues effectively. I would like to take the following space to present the steps that I have taken in quantifying sign language data, and in using probability distributions and other metrics to make predictions about what we are likely to see in natural data from the relatively small sample of the language production data that I have at hand.

A metric that I have used quite a lot in the previous chapter is entropy. Entropy is a concept and metric borrowed from thermodynamics into Information Theory – the scientific study of the quantification, storage, and communication of information. The theory and field were established in the 1920s by the electronic engineering researcher Harry Nyquist and Ralph Hartley and was furthered in the 1940s by mathematician and cryptographer Claude Shannon. Information Theory lies at the intersection of probability theory, statistics, and computer science. In a nutshell, entropy quantifies the amount of uncertainty involved in the value of a random variable or the outcome of a random process. Merriam-Webster defines entropy simply as "the degree of disorder or uncertainty in a system". For example, the probability of a rainy day in Seattle or Portland conveys a lot less information than the probability of a rainy day in Las Vegas or Phoenix. The Pacific Northwest receives around 100 inches of rain in a year, and it rains 150 days on average year around. In Las Vegas, on the other hand, the average rain per year is 5 inches - the last time it rained over 2 inches on a single day was August 21, 1957 (numbers acquired from currentresults.com). So, what happened during that one fine day in Las Vegas that resulted in a downpour? If we knew more about the conditions that affected weather that day, we could make a prediction about what conditions make for a downpour in an otherwise really dry region. This is exactly what I have been doing with my data: looking at the probability distributions of observed variable values under certain circumstances, measuring uncertainty and maximizing the amount of information I can acquire from my dataset.

I built my discussions and analyses on the natural environments for certain types of iconicity around the many previous observations made by linguists such as Aronoff, Padden and Brentari; and taken them one step further to study a fresh dataset in detail and with a new perspective. In the following subsection, I present the factors that I have used in quantifying my data and elaborate on the mathematics behind the calculations. Finally, I present my predictions for the probability distributions of what we are likely to observe in real world data.

5.2 Factors

In this subsection, I put together my observations, which I presented for each factor in the previous chapter, into a weight-based model for predicting the distribution of iconicity types in classifier predicates across ASL, HKSL and TiD that we are likely to see if, for instance, we had a large enough[30] corpus annotated for iconicity type in these languages. I will go over each observation on the relevant factor and show how I incorporated it into the predictive model. The metrics are based on a number of observations on the data, ranging from specific to

30 I do not have a definition of what would constitute a large enough corpus; however, the predicted distributions are based on weights that I acquired from the production data, and I seek to minimize variability across predictions.

general distributions of iconicity across each language. The metrics that I used are probability distributions and their weights, which are acquired using the additive inverse of entropy (i.e., 1-entropy), as well as the multiplicative inverse of *inverse document frequency* (1/idf), which will be explained later. Before moving further, let us remind ourselves the 5 morphological strategies that we observe across the board in the classifier predicates of the three sign languages:

H	*Handling*	Exclusively Handling strategy is used
O	*Object*	Exclusively Object strategy is used
H&O	*Multiple*	Both Handling and Object strategies are used in the predicate either sequentially (e.g. H-O-H) or in one sign (e.g. handling-to-object shift iconicity)
¬Icon	*Not Iconic*	Target object's function referenced non-iconically in the predicate (fingerspelled or a non-iconic lexical verb used)
noVP	*No reference*	Target object's involvement is not referenced in the predicate

TABLE 19 The five morphological strategies in the predicate.

The distributions of these five strategies are observed (a) on a language-wide basis, and (b) variably under different conditions. To quantify their language-wide distribution, I use inverse document frequency (idf); a heuristic measurement put forth by Karen Spärck Jones (1972), that quantifies the specificity of a term *as an inverse function of the number of documents in which it occurs*. In my dissertation data, 'term' corresponds to a predicate that comes in any of the five morphological strategies listed above, and 'document' corresponds to any of the 1,856 signer responses. To quantify the distribution of these five strategies under specific conditions, I have used the additive inverse of entropy. Entropy is a number between 0 and 1, and it shows uncertainty. Subtracting entropy from 1 gives us its additive inverse, which has been heuristically used as a metric to measure certainty or confidence in a probability distribution.

Secondly, as the baseline for my calculations, I have the actually observed probability distributions of the five strategies for each of the 64 stimuli. In a nutshell, what the model does is readjust these stimulus-level distributions using the distributional observations made on the condition-level. The probabilistic weight given to these condition-level distributional observations come from idf and the additive inverse of these distributions' entropy. Please note here that the responses that came from 8 stimuli in the bare hands 'HAN' condition has been left out of some of the calculations that follow because the iconicity distributions in the 'HAN' condition are always invariable – if I had included them, it would skew the results which would not reflect reality and would not be representative of the 16 other targeted objects. Now let us turn to each individual factor and see how they participated in the model. After presenting each factor, I will demonstrate how they came together to form the model.

5.2.1 Language-Wide Distributions of Morphological Strategies in the Predicate

In this subsection, I present the steps that I have taken in converting the language-wide probability distributions of morphological strategies in the predicate. The purpose of this step is to measure the likelihood that we observe the five strategies in each language. The following graph shows the number and proportion of signer responses in each language distributed across these five strategies:

Language Wide Predicate Strategies

	H_only	O_only	M	notIconic	noVP	Grand Total
ASL	0.645 (324)	0.251 (126)	0.050 (25)	0.022 (11)	0.032 (16)	**1.000 (502)**
HKSL	0.488 (273)	0.418 (234)	0.077 (43)		0.018 (10)	**1.000 (560)**
TiD	0.548 (305)	0.390 (217)	0.041 (23)		0.022 (12)	**1.000 (557)**

FIGURE 64 Language-wide frequencies of the 5 predicate strategies.
Empty boxes are 0.00%.

The graph in Figure 64 tells us the term count and probability distributions of each strategy independent of under what condition they occur. In other words, it doesn't tell us, for instance in ASL, under which conditions the 25 "multi_H_and_O" signer responses occurred (4.98% of the entire ASL data) – this is the condition where we see both the Handling and the Object strategy in the predicate. It only tells us how likely overall the signers of this language are to use the "multi_H_and_O" strategy. While this strategy is likely to occur under a certain condition more frequently than under other conditions, it is not an impossible strategy under any condition. In other words, as evidenced by what I have presented so far in this dissertation, we are dealing with a stochastic grammar that requires probabilistic explanations to where we see what we see.

In ASL, the "multi_H_and_O" strategy was used in 4.98% of all signer responses (25 occurrences). This is its language-wide probability. In other words, anywhere in the US we go, if we sample a large enough ASL data population we are likely to find that around 5% of all the classifier predicates in that sample will resort to the use of multiple iconicities. The same reasoning goes for all the other cells in this distribution. In ASL we are likely to find around 70% Handling iconicity in all classifier predicates, in TiD we are likely to find around 40% Object iconicity in all of its classifier predicates. What good are these distributions to us? We will use it to readjust our actual observed distributions in individual signer responses. Just because the "multi_H_and_O" strategy occurred in, let's say, 45% of the responses given to the stimulus X does not mean that, if we were to collect much more data, we would see the 45% probability mass of the "multi_H_and_O" strategy remain steady. Given that this strategy's distribution in ASL is so restricted, we should *penalize* the actual distribution that we find in the current dataset. However, we cannot simply multiply the observed rate of "multi_H_and_O" in stimulus X (=45%) with 4.98% as that would bluntly penalize the observed distribution in the data – probability distributions do not show "likelihood", they are simply distributions from the set of observed occurrences. How can we turn these distributions to weights that show likelihood then?

One heuristic metric that has been successfully implemented in information systems is "inverse document frequency" (*idf*, Jones (1972)). Although researchers have not been able to find an explanation to why idf works so well in Information Theory, Jones links it to Zipf's Law (Zipf, 1935, 1949). Let's stay on the same example, we said that the "multi_H_and_O" strategy was used 25 times in the ASL data (on average 4.98% of the time – a small probability of 0.001% or 0.01% was added later to each cell in order to avoid division by zero and to give a tiny probability to things we did not see before but may see in any case). Idf is the log on base 2 of the inverse of document frequency *df* of a term *t* in *N* documents within a corpus *C*:

$$idf(t) = log_2 \frac{N}{df}$$

In other words, we divide the number *N* of all documents (i.e., our signer responses) in *C* (the entire ASL dataset), by the number of documents *df* in which the term *t* (i.e., the count of multi_H_and_O strategy) occurs. In our case, the term is the morphological predicate strategy, and the documents are signer responses. We divide the total number of signer responses in ASL (*N*=502) by the number of all documents in which the predicate strategy is "multi_H_and_O" (=25), which gives us 20.08.

$$idf\left(multi_{H_{and_O}}\right) = log_2 \frac{502}{25}$$

$$idf\left(multi_{H_{and_O}}\right) = log_2 20.08$$

The log of 20.08 on base 2 is around 4.32:

$$idf\left(multi_{H_{and_O}}\right) \approx 4.32$$

In order to convert this to a weight that we can use to adjust our language-wide distributions, we find the multiplicative inverse of idf (1/idf), which in this case 1/4.32 = 0.231.

$$\Omega\left(multi_{H_{and_O}}\right) = \frac{1}{idf\left(multi_{H_{and_O}}\right)}$$

$$\Omega\left(multi_{H_{and_O}}\right) = \frac{1}{4.32}$$

$$\Omega\left(multi_{H_{and_O}}\right) = 0.231$$

This score tells us how much importance should be given to the strategy "multi_H_and_O" when seen in a small dataset such as mine here. 0.231 is a low score, because we do not see this strategy used frequently in ASL. The same score for "excl_H" in ASL, for instance, is much higher: Ω(excl_H) = 1.558 – this is because in over 60% of all responses in ASL signers used exclusively Handling iconicity in the classifier predicate. This score tells us that every time we see a certain amount of "excl_H" use distributed across a paradigm of ASL responses we should simply multiply it by 1.55 – because Handling iconicity is possibly more likely in that condition in general than what we observe in our small sample. This will ensure that Handling strategy in ASL gets rewarded while other strategies get proportionally penalized. The following in Table 20 show the multiplicative inverse of the idf scores for the five morphological strategies for each language:

	ASL	*TiD*	*HKSL*
excl_H	1.558735	1.140201	0.957786
excl_O	0.500712	0.731935	0.790145
multi_H_and_O	0.23335	0.219806	0.271542
noVP	0.204149	0.184027	0.175973
notIconic	0.185155	0.109476	0.109384
neg_entropy	0.240884	0.208342	0.17677

TABLE 20 Language-wide idf scores for the 5 morphological predicate strategies. The bottom row 'neg_entropy' is the weight to be used in the model when combining the inverse idf score with other factors.

The table above shows that in ASL exclusive Handling is a prevalent strategy compared to the other strategies and the model will take that into account while making predictions. The model will work in a similar way in HKSL and TiD, however in those languages, especially in HKSL, the difference between exclusive Handling and exclusive Object strategies is not as strongly nuanced as it is in ASL; therefore, the inverse idf scores of these two languages in the model will accordingly make less strong predictions about these strategies – the weights given to the inverse idf score in TiD and HKSL are also lower than that of ASL because the differences between the probabilities of the five strategies are more diffuse in TiD and HKSL. While idf is a measure I used in readjusting the probability distributions of the observed experiment paradigms, I will also use it as the baseline for making predictions for unseen hypothetical examples. In the following subsections, I zoom in on the experiment conditions and present the steps that I have taken in extracting fine-grained weights.

5.2.2 Individual Iconic Handshape Preferences

In the previous chapter we looked at the data from many different perspectives under different conditions that were controlled for in the production experiment – by the targeted object, by whether or not that object is used instrumentally, by whether or not it is used typically and whether it helps to achieve the task. In this section, I present how my findings pertaining to individual target objects are fed into the model. In Chapter 4, I built on the findings of Brentari and colleagues and established that in TiD and HKSL there is a rigid and statistically significant correlation between the amount of variance in the lexical form of a noun, which we referred to as LEXICAL RIGIDITY, and the preferred iconicity in the classifier predicate associated with those nouns. For example, in TiD if the sign for the noun HAMMER uses Handling iconicity, and if that is invariably the case, then we are pretty certain that when TiD signers are encoding an action that includes hammering they will use Handling iconicity in the classifier predicate. The same reasoning goes for nouns that have a rigid preference for Object iconicity in their lexical form, such as SCREWDRIVER in HKSL. We are more likely to see Object than Handling iconicity when an event where a screwdriver actively participates in is linguistically encoded. On the other end of the spectrum, we have lexically non-rigid nouns – when the lexical rigidity of a noun decreases, in other words, when signers use multiple strategies to refer to an object, the classifier predicates that encode the use of these low lexical rigidity objects employ multiple morphological strategies in a disorderly fashion. We have also seen that LEXICAL RIGIDITY of a noun form is not a strong factor in ASL.

For instance, in HKSL and TiD the types of iconicity found in the nouns such as HAMMER, TEASPOON and SCREWDRIVER are very rigid in the lexicon, i.e., they are either strongly Handling or strongly Object, and this rigid iconic preference in the lexicon is reflected in the predicate when we see these tool concepts used in a classifier predicate. This section builds on that observation and feeds it into the model as one of the major factors for TiD and HKSL. We impressionistically saw in the graphs studying those two languages (Figure 41) that in the collected small data sample of the languages that I study, TiD and HKSL are not equally sensitive to ICONIC HANDSHAPE PREFERENCE. We cannot be sure with the data that I have in this dissertation whether this is stemming from an entire language's sensitivity to Iconic Handshape Preference or whether it is because the behavior of the individual objects selected in the experiment are different; therefore, for each target object I propose a different set of measurements to readjust the observed distributions into model predictions.

In TiD for instance, the nouns SCREWDRIVER and TEASPOON are almost invariably Object and Handling iconicity respectively in the lexicon, likewise in HKSL the nouns KNIFE and again TEASPOON are also almost invariably Object and Handling respectively in the lexicon. We know that these iconic preferences will be reflected in the predicate. Other nouns on the spectrum also have varying degrees of iconic rigidity in their lexical form and that is reflected in the classifier predicate. If a noun has low iconic rigidity, factors other than Iconic Handshape Preference will play a stronger role in determining the iconic strategy found in its classifier form. Therefore, to convert these observations into a factor of the model, I have found the probability distributions of the five morphological strategies in the classifier after dividing the data into chunks by the target object.

For instance, in TiD, in 33 out of 37 (89%) responses given to experiment stimuli targeting the object TEASPOON, the type of iconicity in the lexical noun and the one in the classifier predicate in the same response were a match – the iconicity was Handling. This classifier matching score (89%) was multiplied by the additive inverse of entropy found in the form of the noun TEASPOON, which served as a weight to indicate how much importance we should be giving to the noun TEASPOON'S Iconic Handshape Preference. The entropy for the noun TEASPOON is 0.221 – the additive inverse of the entropy is 1 - 0.221 = 0.779. This is the number that the probability of Handling iconicity in the classifier predicate of TEASPOON will be multiplied with (89 x 0.779 = ~69.33). 69.33 points is the new, adjusted likelihood of finding Handling iconicity in any TiD classifier predicate that includes the meaning TEASPOON. This score covers all cases independent of the grammatical type of the classifier where the use of teaspoon is encoded.

For the other types of iconicity found in the classifier predicate, their probability masses were multiplied by the entropy instead of the additive inverse of the nominal entropy associated with that noun. For instance, in the TiD TEASPOON condition, the remaining 5.1% received Object iconicity in the classifier predicate. The probability mass of the observed Object iconicity in the classifier is penalized by multiplying it with 0.221, instead of its additive inverse 0.779. This was a step taken in order to ensure that the model captures the imbalance between the most probable noun strategy and the other strategies reflected in the predicate (5.1 x 0.221 = ~1.13). According to the weight adjustment, the new likelihood of finding

Object iconicity in the predicate with the target object TEASPOON in TiD is 1.13 points, which is around 60 times less likely than Handling. Under the (false[31]) assumption that no other morphological strategies are present in the TEASPOON data or no other conditions have an effect on the distribution of morphological decisions, there is around 1.6% (1.13/70.46) likelihood that we will find Object and 98.4% (69.33/70.46) likelihood that we will find Handling. However, when multiple weights come together, the math becomes more complicated than this. What's missing from these calculations in this section and the previous one is a linking function for the two measures and the measures to come from the factors presented in the following subsections. I will define this function in the final subsection.

I expect ICONIC HANDSHAPE PREFERENCE to be a strong factor for certain nouns in languages that are sensitive to that. We can safely predict that in TiD and HKSL if a noun has a rigid form in the lexicon that behaves invariably both in the language as a whole and within its individual speakers, it is very likely that the classifier will have the same iconic strategy as the noun form, that is unless there is an intervening factor such as the perceptual salience of holding an object, or if the prevalent iconic type in the noun form is Object. In the following subsection, I study the data type factor, where certain grammatical conditions dictate the use of a certain type of iconicity – undoing and overriding what the ICONIC HANDSHAPE PREFERENCE of the object requires or boosting it even further.

31 False because there are other factors that help determine the iconicity type in the classifier. These adjusted numbers show only the likelihoods had no other factor intervened. This problem will be remedied later in this chapter with a linking function for the extracted weights.

5.2.3 Data Type

In a similar fashion to individual iconic handshape preferences, we have seen that certain conditions on grammatical environment have an effect on classifier decision. Brentari and colleagues call these Instrument Sensitivity and Instrument Typicality. From a theoretical perspective, I have shown that what they considered Instrument Sensitivity may be a phenomenon that is part of an overarching factor, that affects languages such as HKSL and TiD specifically. In other words, rather than Instrument Sensitivity motivating Object iconicity with the instrumental uses of a tool, it might be that Perceptual Salience is requiring the same tool to be expressed using Handling iconicity when it is merely handled and not used instrumentally. The proportions of Object iconicity that we see when the same object is used instrumentally is attributable to the assumption that Instrumentality is one of the salient environments where the motivation to use the Iconic Handshape Preference of a noun is strong. We have seen that with HAMMER, TEASPOON, SCREWDRIVER and KNIFE in TiD and HKSL. Now it is time to quantify these observations into weights that will go into the predictive model. We talked about five environments:

INS1 / ~INS	The item is used in its typical environment: as a tool if it is an instrument (e.g., hammering a nail using hammer) or some other way if it is a non-instrument object (e.g., reading a book)
PUT	The item is not used instrumentally. It is merely handled and put down on a table.
ATY / INS2	The item is used instrumentally and successfully but outside of its typical function (e.g., use a book to hammer a nail)
NFN1/NFN2	The item is used instrumentally, outside of its function but due to a caveat it has it fails to achieve that instrumental function (e.g., trying to hammer a nail with a wooden spatula but it is too light)
HAN	Using bare hands to carry out a task which would normally be done using a tool (i.e., stirring tea with index finger)

TABLE 21 The five data types in the experiment.

Of the five environments above, 'HAN' is the one that showed almost zero variation (hand-as-instrument, handle-patient) - only some variation depending on the instrumental type. 'PUT' showed very little variation across all three languages and most of the time it was Handling iconicity in the classifier. The rest have shown quite a bit of variation in the distribution of the use of the five morphological strategies in the predicate (i.e., only Handling, only Object, Handling and Object, non-iconic and missing from the predicate).

Similar to what I have done in the Individual Iconic Handshape Preferences section earlier in the chapter, and without factoring in the *idiolectal* differences across signers in their responses, I look at the probability distributions of the five predicate strategies and find how much they vary and how much uncertainty there is in their distribution by finding their entropy value, then I subtract the entropy from 1 to find its additive inverse – this gives us how much certainty there is in the probability distribution. The probability mass of each strategy is then multiplied by the inverse of entropy in order to bring it down to a point where its probability distribution is informative for our purposes. There are two independent factors included here:

(1) Is the object used typically?

(2) Is it used functionally?

We have seen in the previous chapter that instrument typicality and instrument functionality have different degrees of effect on certain language classifiers – from zero to minimal effect on ASL to more pronounced ones in HKSL and TiD. Moreover, whether or not the object is used instrumentally is intentionally not included as a factor because the five degrees of involvement with the patient accounts for the subcomponents of the instrumental event, which including both would cause multicollinearity, reducing the precision of the model. Degrees of involvement with the patient is a more general factor than instrumentality and it covers more linguistic ground; therefore, it is chosen over instrumentality in model building.

5.2.4 Degrees of Involvement with the Patient

Another variable factor in the experiment was the verb. The semantics of the verb is reflected iconically in the classifier predicate with a combination of the movement of the arm and the hand as well as the hands' involvement with the patient. In the previous chapter, I followed generalizations by Fillmore (1968) on Thematic Hierarchy and those by Bresnan & Kanerva

(1992) on Structural Prominence as well as Perceptual Salience (Bresnan & Kanerva (1992)'s salience on "argument topicality") in building a schema of verbs with different degrees of involvement of the instrument and the agent with the patient. The same methodology as the previous factors, involving probability distributions and entropy, in predicting the linguistic production was used. In the following subsection, I turn to how I put these factors together and present my predictions for (i) the distributions we are likely to see if I had a much larger dataset, and (ii) the distributions that we are likely to see for combinations of conditions we have not yet seen.

5.3 Putting all factors together

In the previous sections I presented each factor that goes into the predictive model. In this section, I take the space to explain how the weights acquired from those factors were put together (i) to make predictions about some of the unseen combinations of the conditions present in my experiment design, and (ii) to enrich the distributions that I have already observed in the data that I collected, which I will use to make predictions about the probability distributions we are likely to see in natural language production, that is, if we had a larger dataset.

Each of the 5 factors presented so far comes with certain probability distributions and how much weight (inverse entropy) should be given to those distributions. Regardless of whether certain factors are relevant in a language – for instance, ASL was quite rigidly

Handling in all environments across the board, which meant that most factors either were irrelevant, or that they had very little effect on ASL – all factors are applied to all three languages. If a factor is previously identified as unimportant to a language (e.g., Iconic Handshape Preference in ASL), the model will wash out its effects. In other words, the model will not consider that to be a strong factor for that language – it will have minimal effect on the model's predictions.

As a linking function between the probability distributions in factors and their weights, I use joint probability. The factors I identified seem to operate independent of each other, or they interact very little. Cumulative effects of factors are quite likely to be seen, which can be explained with conditional probability, however, the dataset is not large enough to justify the use of conditional probability. Joint probability between two variables is simply acquired by multiplying the individual probabilities – joint probability gives us the intersection where both events are observed simultaneously:

$$P(A \cap B) = P(A) \times P(B)$$

In our case, how much these probabilities contribute was limited by the amount of certainty (additive inverse of entropy) we have in that distribution:

$$\Omega(\alpha) = 1 - \mathrm{H}(\alpha)$$

$$P(A \cap B) = \Omega(A)\, P(A) \times \Omega(B) P\, (B)$$

In a paradigm of all signer responses given to the same experiment stimulus, if we see, for instance, a certain amount of Object strategy in the actual distribution of the classifier iconicities, we multiply the probability mass of that strategy under that certain condition by the language-wide idf weights and by all of the other 4 condition-level factor weights associated with that stimulus (iconic handshape preference, atypicality, functionality and degrees of involvement with the patient) and give them specific weights with respect to how likely and confident we actually are to see that strategy surface under that condition. This is done for each observed morphological strategy in that paradigm of signer responses. For instance, certain stimuli received only Handling predicate iconicity in the paradigm of signer responses given to those stimuli (for instance, any stimulus with the target object TEASPOON in TiD), while others displayed a number of strategies, for instance Handling, Object and multiple iconicities in stimuli with the target object SPATULA in HKSL. Each of these observed strategies are accounted for and readjusted by the predictive model. The second job of the weighted model is to predict hypothetical stimuli – unseen combinations of experiment conditions. Let us start with that in the following subsection.

5.3.1 Predicting Unseen Combinations of Conditions

Let us turn to the model's predictions on unseen, hypothetical combinations of conditions from the experiment. I combined handpicked conditions and built 10 unseen "stimuli" for the model:

descriptions of unseen conditions
spoon dirt with coin
stir pot with spatula
tighten a pipe with pliers
put pitcher on table
pry open jar with book
try to fan with screwdriver
try to hammer with knife
fan with cutting board
flatten ice cream with teaspoon
put screwdriver on head

TABLE 22 Unseen conditions.

Descriptions of the 10 unseen combinations of conditions that would elicit classifier constructions in the three sign languages.

As the baseline distribution for these hypothetical conditions, I used the multiplicative inverse of idf scores (see Table 20) for each strategy obtained from the language-wide classifier iconicity distributions in each language, since I do not have production data collected for these new conditions. The predictions that came from running the model on the hypothetical conditions will follow and they show how differently the three sign languages are likely to behave in these new, unseen environments. The results of the predicted distributions of the model are visualized using polygons. The number of edges in a polygon visualization depends on the number of possible strategies in that condition. For instance, if there are three possible strategies, as is the case in the examples below, we will have a triangle with a point inside that corresponds to the Fermat-Torricelli point – a point within the polygon where the beams between the point and each corner in the shape are distributed with equal angles – in the case of a triangle that angle is 120°. If a strategy has less than 0.01% chance (less than 1 in 10,000) to surface it is not included in the visualizations as one of the corners that make up the polygon. In the visualizations, the closer the point to one corner, the more likely the iconicity indicated in that corner; and the farther the Fermat-Torricelli point from a corner, the less likely the iconicity indicated in that corner. The more spread out the corners, the less certainty (high entropy) in the distribution.

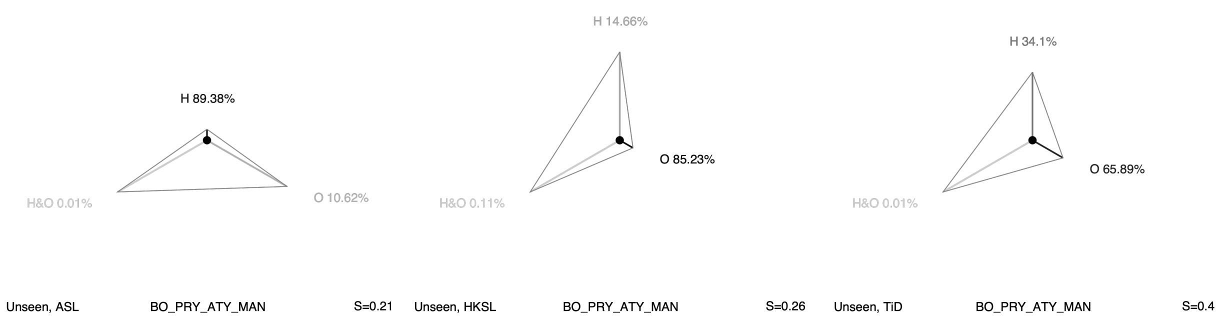

FIGURE 65 Predictions for 'prying a jar lid using a book'

If someone were using a book to pry open a jar lid, in the ASL predicate we would see Handling in the majority of signer responses (89%). In around 10% of the cases, we would see Object iconicity. This is because ASL, despite the rigid iconicity preference of the noun BOOK in the lexicon, i.e., Object, is a strong Handling-preference language in the form of classifier predicates. In TiD and HKSL, on the other hand, we are much more likely to see

Object iconicity because both languages are first of all sensitive to ICONIC HANDSHAPE PREFERENCE and secondly, in both languages, BOOK is a strong Object iconicity preference noun in the lexicon.

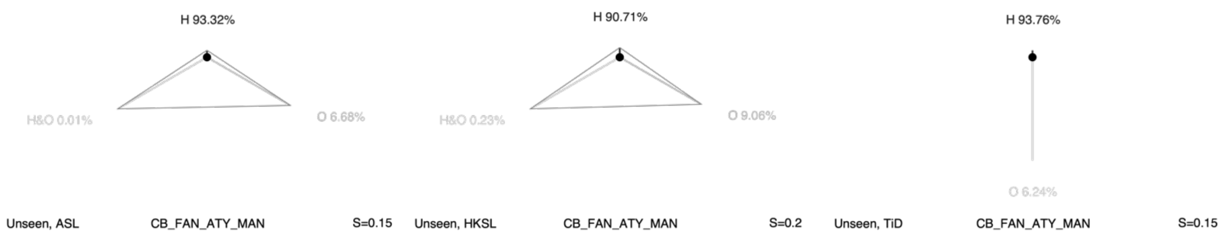

FIGURE 66 Predictions for 'fanning an incense stick with a cutting board'.

Had the signers of all three sign languages seen a person fanning an incense stick with a cutting board, we would see a predominant use of Handling iconicity across the board, despite the fact that this is an atypical use of CUTTING BOARD. This is because, aside from ASL's strong general tendency for Handling iconicity in the predicate, in over half of all responses given to fanning events in all three sign languages, the iconicity was Handling. The preference for Handling in the fanning condition comes from the semantics of the verb - the instrument has no contact with the patient. The object's solid shape is irrelevant to the type of change it causes in the patient. Structural Prominence requires the agent's handling of the instrument to be promoted, rather than the instrument itself. Moreover, the noun CUTTING BOARD is a high entropy lexical entry with no isolable preference for one iconicity; therefore, in HKSL and TiD we do not see the effect of Iconic Handshape Preference. When all these variables come together under specific conditions the model predicts that Handling iconicity will be the dominant predicate strategy in this hypothetical condition.

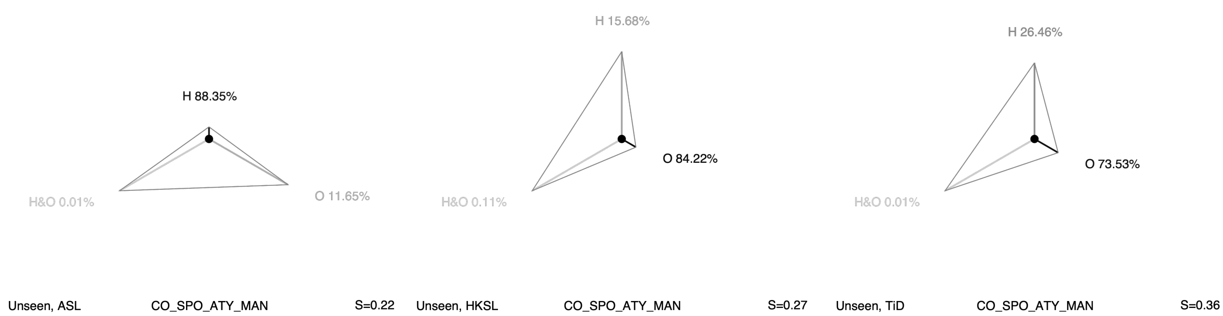

FIGURE 67 Predictions for 'spooning dirt with a coin'.

In the spooning dirt with a coin condition, we would again see Handling in ASL, however, predict a strong preference for Object use in HKSL and TiD. This is because there are three forces attracting the signers toward Object: (i) a weak albeit present iconic preference for Object strategy in the noun COIN, (ii) atypicality of coin used to spoon dirt, and (iii) the semantic properties of the act of spooning/shoveling. The instrument has direct contact with the patient, it causes it to move in space and it also holds it – three motivations that make the coin a perceptually salient part of the event.

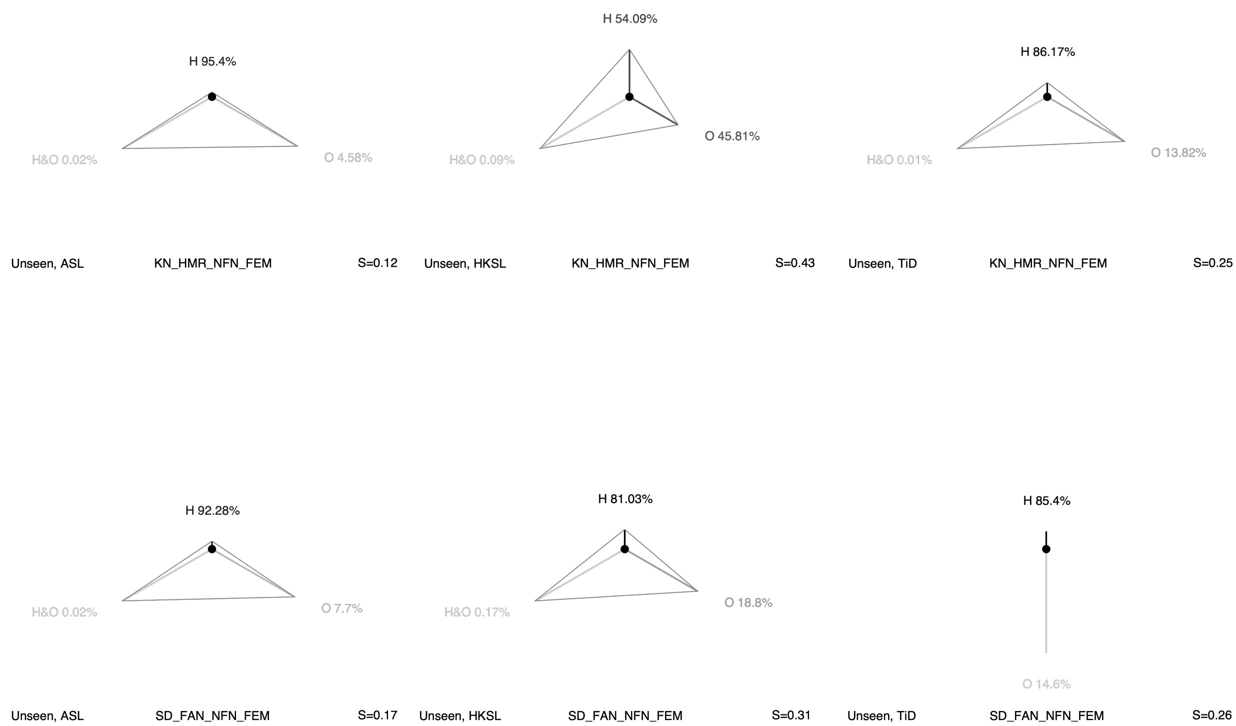

FIGURE 68 Predictions for unseen dysfunctional conditions.

[top row] Predictions for trying to hammer a nail with a knife. [bottom row] Predictions for trying to fan an incense stick with a screwdriver.

In a nonfunctional, atypical condition where an agent would be trying to hammer a nail with a knife, HKSL would have a split between Handling and Object among signer populations. Handling is there because the knife's failure to hammer the nail is not because of the object's size or shape – it's simply because it is not heavy, a type of iconicity which cannot easily be encoded in the phonology of a classifier predicate. Object is there because this is an atypical use of knife, the knife has repetitive contact with the patient, the nail – it causes it to move in space, and KNIFE is a strong Object-preference noun in HKSL. TiD would prefer

Handling for the most part, because the language does not regard atypicality and nonfunctionality as important as HKSL does. ASL would again almost invariably be Handling, despite the fact that KNIFE is a strong Object-preference noun in the language. Conversely, in another condition, *trying to fan with a screwdriver*, although the noun SCREWDRIVER is strong Object-preference in the lexicon, we would see much less use of Object iconicity across the board because the verb FAN is a Handling-preference task from a semantic point of view. The instrument does not have contact with the patient.

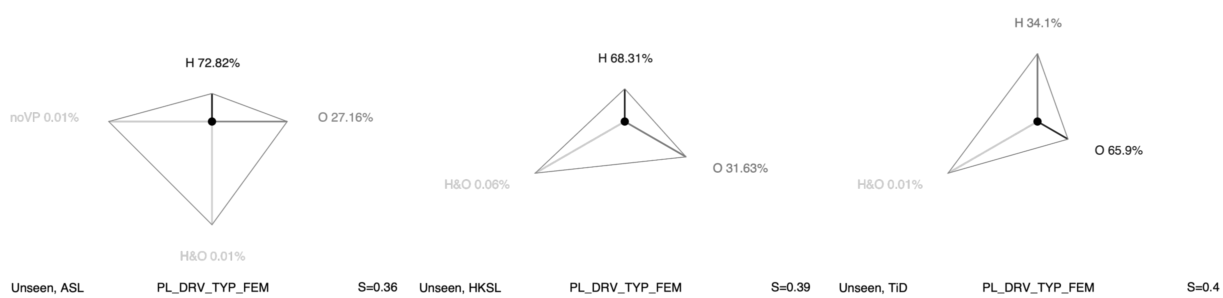

FIGURE 69 Predictions for 'tightening a hex nut on a pipe using pliers'.

Had pliers been used typically to tighten a hex nut on a pipe for instance, even in ASL (~27% of the time), we would see a significant use of Object iconicity, although, except in TiD, Object iconicity would not be the leading strategy. This has to do with the semantics of the event – the jaws of the pliers grip the hex nut while turning it, which makes the instrument a perceptually salient participant of the event. It is not the leading strategy in ASL and HKSL because (i) ASL is simply almost always Handling preference, (ii) it is typical event. Another reason why Object use did not skyrocket in HKSL and TiD is because the noun PLIERS does not have a rigid lexical iconicity preference in these languages. Despite that, Object would be the leading strategy in TiD because level of involvement with the patient is a strong factor in the language.

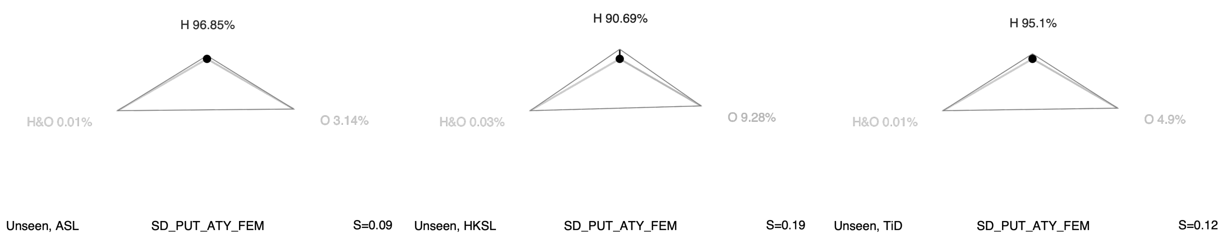

FIGURE 70 Predictions for 'placing a screwdriver on one's head'.

Contrary to what we observed in Brentari et al. (2016b), the weighted joint probability model in this section predicts that when an object is placed in an atypical location (e.g., the head), it will have high proportions of Handling iconicity in the classifier predicate. Building on the observations we made in Brentari et al. (2016b), I would expect more Object iconicity to surface. This is a problem with the model and the lack of such examples in the data that was fed into the model - it is simply not fine-tuned to work with the cases where it is the location that is atypical, as opposed to the atypical tool used in an instrumental task.

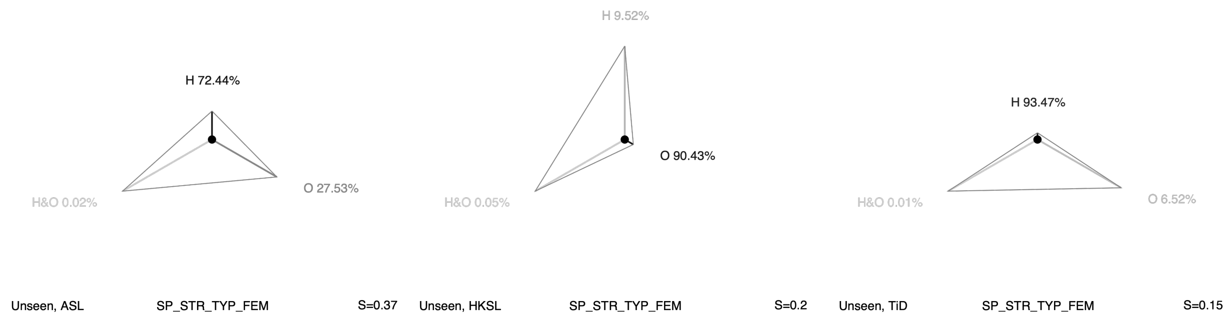

FIGURE 71 Predictions for 'stirring meal in a cooking pot using a spatula'.

Another possible typical stimulus that was not present in the experiment paradigm would be stirring a meal in a pot with a spatula. SPATULA is a high entropy (weakly conventionalized) noun in all of the three sign languages; therefore, I do not expect to see an effect of ICONIC HANDSHAPE PREFERENCE. Stirring is a level 1 verb in my paradigm of degrees of involvement with the patient. The instrument of stirring has contact with the patient and it alters it, but it does not move it to a different location in space, and it most certainly does not grasp the patient. I can only attribute the surfacing of predominant Object in HKSL in this condition to the task being a level 1 verb, where the instrument has direct contact with the patient, and it alters its form – HKSL displays the highest amount of Object iconicity in level 1 verbs (56%) among the three languages – and HKSL classifiers having a high portion of Object iconicity – 42% of all signer responses were Object iconicity only – which is taken as the basis for these predictions.

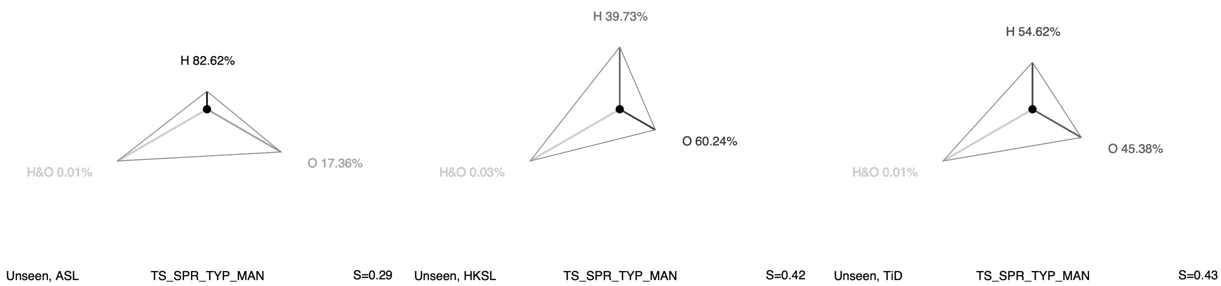

FIGURE 72 Predictions for 'flattening ice-cream on a cone using a teaspoon'.

Flattening/spreading ice-cream on a cone with a teaspoon. In HKSL and TiD, TEASPOON is a rigid Handling noun in the lexicon. Despite their iconic preference, we see a significant amount. of Object iconicity in these languages. This is because SPREAD/FLATTEN is a level 1 verb, where the instrument has direct contact with the patient, and it alters its form.

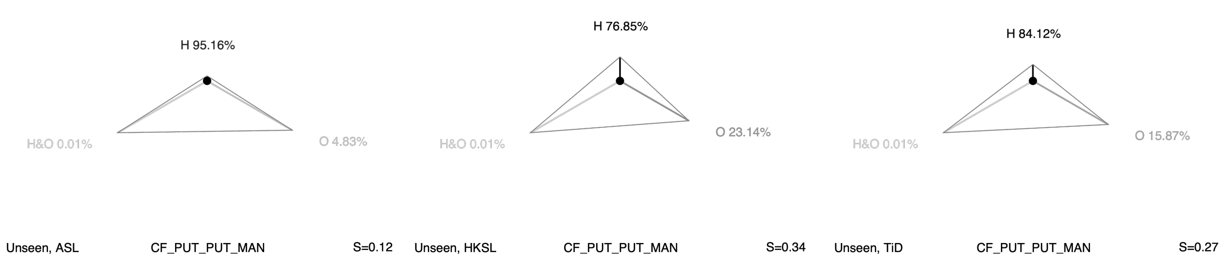

FIGURE 73 Predictions for 'putting a pitcher on the table'.

Finally, the model correctly predicts Handling as the leading strategy for handling and putting down PITCHER on the table. However, there is a mysterious amount of Object iconicity present, especially in TiD and HKSL predictions. First of all, in responses involving PITCHER Object iconicity in the classifier was never observed – it was uniformly Handling. Object may not be a viable visual iconic option for pitcher due to its shape. In many iterations of the noun PITCHER, in TiD and HKSL it was predominantly expressed with a SASS iconicity, a sub-type of Object iconicity, however a type that is phonologically not compatible to be present in a classifier predicate. Secondly, this is a 'PUT' environment, which, due to Perceptual Salience, almost exclusively requires Handling iconicity in all three languages regardless of what the handled object is. I attribute this divergence to the problems with the model as well.

5.3.2 Readjusting Observed Paradigms

Let us now turn to the model predictions for the observed paradigms of responses. The predictions in this section build on the paradigms within production data. The model readjusts their probability masses with respect to the five factors presented earlier and predicts what they would look like if we had a larger data set. This is very similar to what I did in the previous subsection with hypothetical combinations – the only difference is that the predictions are guided by the observed probability distributions of classifier strategies within each stimulus. To give a more specific and step-by-step example – in the ASL *putting fan on the table* condition, which is of patient involvement type [+move][+handle], i.e., level 3, we observed the following probability distributions for the morphological strategies in the predicate:

P(H) = 55.56%

P(O) = 33.33%

P(H&O) = 11.11%

P(noVP) = 0.00 %

P(notIconic) = 0.00 %

Each of the above probability masses are taken as the baseline for predictions multiplied by the five factors presented above as well as their weights. For instance, P(H) = 55.56% is multiplied by each of the following scores:

(i) the Handling (H) strategy's language-wide idf and the weight that should be given to that idf score:

$$\Omega(\text{Handling}|\text{ASL}) \times P(\text{Handling}|\text{ASL}) = 0.24 \times 1.55 = 0.372$$

(ii) the weighted probability of classifier strategy Handling in the distribution of all the times it occurred with the sign FAN in ASL:

$$\Omega(FAN|ASL) \times P\ (H|FAN|ASL) = 0.52 \times 0.61 = 0.317$$

(iii) the weighted probability of classifier strategy Handling in the distribution of all of the times it occurred under the condition TYPICAL in ASL:

$$\Omega(typicality|ASL) \times P\ (H|typ|ASL) = 0.45 \times 0.66 = 0.297$$

(iv) the weighted probability of classifier strategy Handling in the distribution of all the times it occurred under the condition FUNCTIONAL in ASL:

$$\Omega(functionality|ASL) \times P\ (H|func|ASL) = 0.39 \times 0.56 = 0.218$$

(v) the weighted probability of classifier strategy Handling in the distribution of all the times it occurred under the condition [+MOVE, +HANDLE] in ASL:

$$\Omega([+move, +handle]|ASL) \times P\ (H|[+move, +handle]|ASL) = 0.61 \times 0.81 = 0.494$$

Finally, all these scores were multiplied with one another and with the actual observed distribution of Handling strategy in the ASL putting fan on the table condition:

$$0.55 \times 0.372 \times 0.317 \times 0.297 \times 0.218 \times 0.494 = 0.00207446$$

The same was repeated for all of the morphological strategies that we saw in putting fan on table condition: Object strategy and Object & Handling multiple strategy[32]. All achieved scores were then multiplied by a randomly picked factor to raise them to a non-fractional number. The adjusted probability distribution for each strategy was then calculated relative to each other within the experiment item putting fan on table. The original probability distribution and the predicted distribution are visualized in the following way:

32 The strategies that were not observed in the actual production experiment (noVP and notIconic) were modified using add-α (Lidstone) smoothing and given a small probability mass of 0.001 point in order to avoid multiplication or division by zero, but also due to the fact that they are not completely impossible. Even though that is the case, they and any probability lower than 0.05% are not included in the predicted visualizations in order to reduce visual clutter.

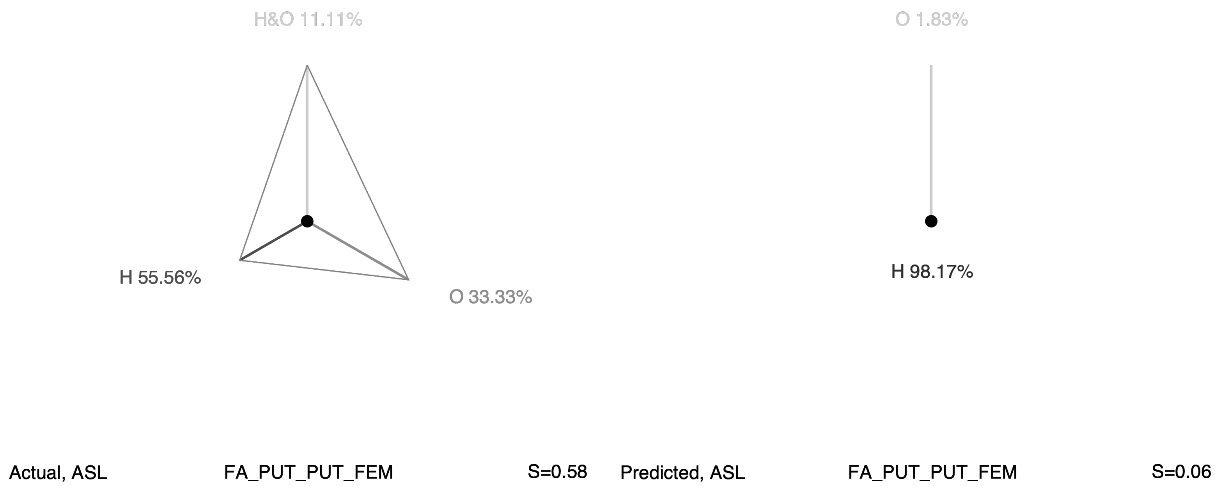

FIGURE 74 Model prediction for 'putting fan on table' in ASL.

Experiment stimuli are bundles of conditions that were featurized by how they distribute iconicity in the classifier predicate. [left] Observed actual distribution. [right] Predicted distribution if in a larger dataset. Probabilities are rounded to two decimals.

In the case above, the observed distribution of Handling went from 55.56% to a predicted 98.17% after the weighted calculations, and the actual Object iconicity dropped from 33.33% to 1.83% in the prediction. The H&O (multiple iconicities) strategy we observed was so unlikely in the language anyway that it's predicted probability mass practically diminished to zero, and the third corner that corresponded to H&O in the observed distribution on the left disappears because when a strategy has less than 0.01% predicted chance to surface, I did not include it in the visualizations. The entropy indicated, in the right bottom corner, went from 0.58 down to 0.06. Some examples from the other results are included below. The left polygon is the observed cases, the right polygon (a straight line really) is predicted. In what follows I will go over a few other examples. For all the other predictions see Appendix IV.

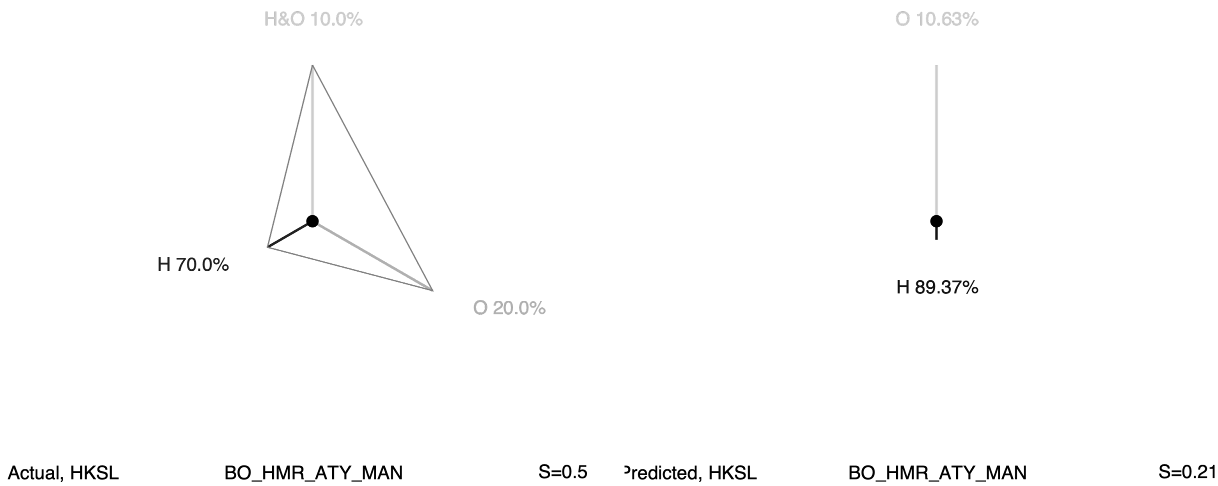

FIGURE 75 Prediction for 'hammering a nail with a book', HKSL.

In the HKSL example above, *hammering a nail with a book*, we see a less dramatic change between the actual distribution and the predicted distribution. What happens is the H&O strategy goes from 10%, which equals to 1 signer response in the collected data, to zero; and Handling strategy increases by around 20 points. Object strategy diminishes to 10.63% from 20% (= 2 observed signer responses with Object strategy).

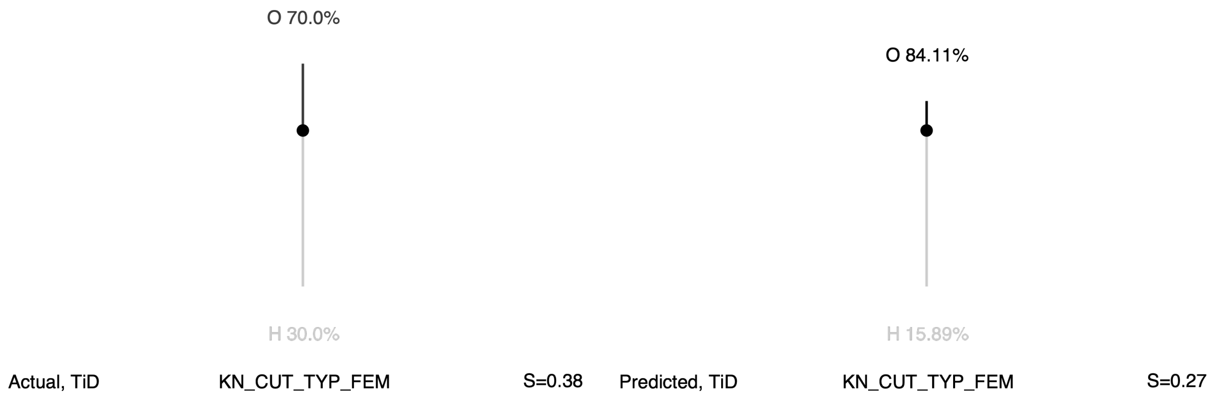

FIGURE 76 Prediction for 'cutting tomato with a knife', TiD.

The TiD example in Figure 76 above shows two probability distributions, which is represented as a straight line – different from the triangles we have seen so far. This is because in *cutting tomato with a knife* condition in TiD, we have observed only two strategies: Object and Handling – there were no multiple iconicity or non-iconic strategies observed. Although the model gives these unobserved strategies a tiny amount of probability to avoid problems in the calculations, they are not included in the visualizations as they are practically zero. In this example, the model allocates a more nuanced probability distribution for Object (from 70% to 84.11%) and penalizes Handling. This is because KNIFE in TiD is a strong Object preference noun. The model predicts that because this a typical instrumental condition, we are likely to see the iconic preference of KNIFE surface in the classifier predicate.

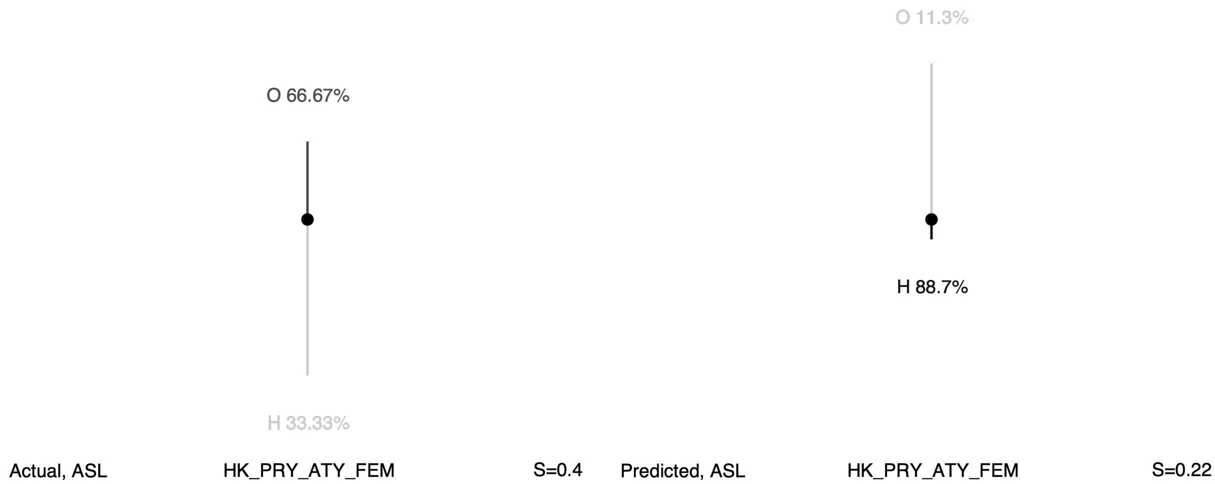

FIGURE 77 Predictions for ‘removing a nail with an S-hook’, ASL.

The figures above from ASL paint a different story for *removing a nail with an S-hook* than the examples so far. Although we have seen Object iconicity as the more probable strategy than Handling, the model predicts that the distribution would be closer to what we see in the figure on the right: the heavier probability mass is flipped from Object to Handling. This is because the model takes into account ASL’s strong tendency for Handling iconicity in the predicate – this is also because the Object strategy we have observed in this condition and the other conditions involving the target object S-HOOK is not prevalent enough to preserve the 66% (= 6 signer responses out of 9) probability mass hence the flip from Object to Handling in the model prediction.

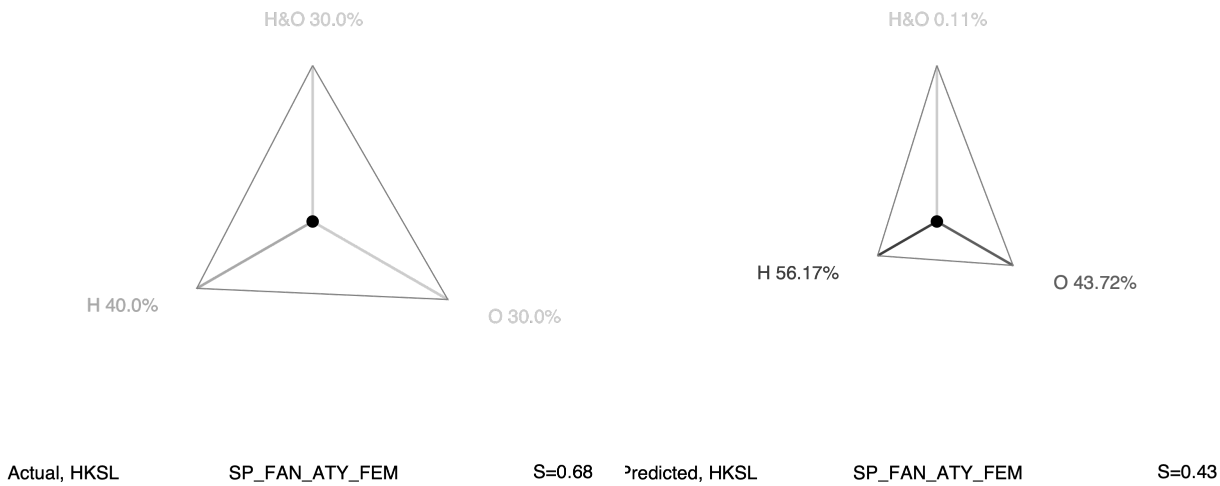

FIGURE 78 Predictions for 'putting out a flame with a spatula', HKSL.

An interesting prediction comes from HKSL, depicted in the figures above. SPATULA in HKSL is a high entropy noun with a highly split iconicity preference in the lexical noun form. While Object iconicity is the leading, albeit weak, preference at 42% in the lexical form of the noun, Handling is a close second at 32% and Tracing strategy comes third at 19%. When this weak preference for Object in the noun form meets the atypical use of SPATULA, the model predicts an increase in Object use in the predicate while Handling use also increases. The 30% probability mass of the multiple H&O strategy is basically split between Handling and Object strategies. While entropy in the distribution of verbal iconic strategies decreases from 0.68 in the actual observation to 0.43 in the model prediction, this is still quite a high entropy score – this shows that the model reflects and preserves the stochastic nature of the grammar, while washing out strategies that are very unlikely such as the multiple H&O iconicity strategy in HKSL and giving more weight to more likely strategies.

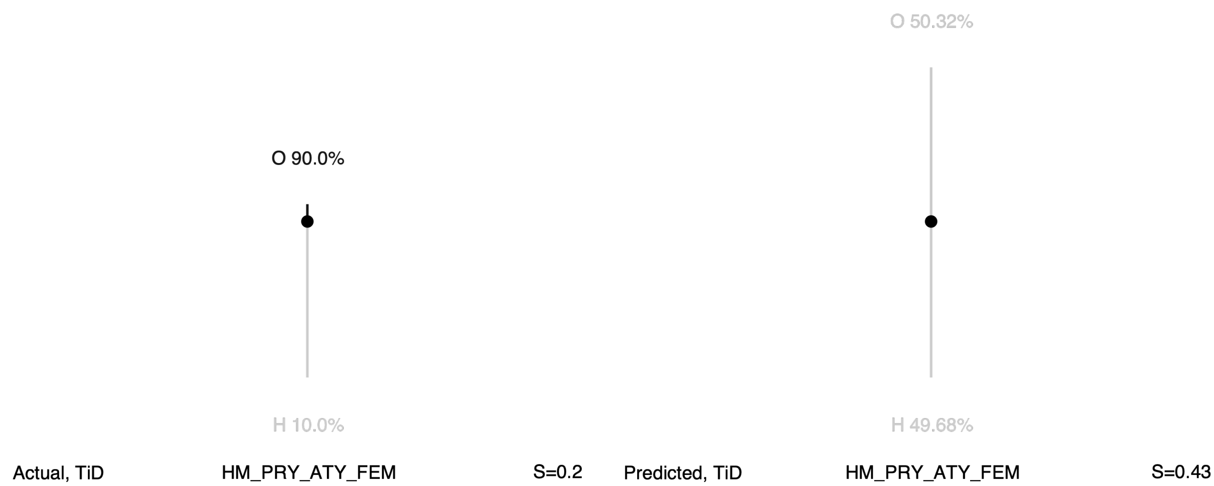

FIGURE 79 Predictions for 'removing nail with a hammer', TiD.

One of the aims of the model is to reduce entropy in the iconicity distribution in the predicate. In other words, the expectation from the model is that it should wash out the highly unlikely strategies we have observed and give appropriate weights to the ones that are much more likely – a distribution as such would translate into a lower entropy. It should be able to predict the iconicity of the predicate handshape better, leaving less room for uncertainty between strategies. This is what it achieves for the most part as we have seen in the examples above. While in most cases we see that the entropy decreases drastically (indicated in the right bottom corner of each visualization), such as *in hammering a nail with a book* in ASL (0.5 to 0.21), in some other cases we see a less drastic increase, and sometimes, in fact, we see that it increases – for instance, in *removing a nail with a hammer* in TiD pictured in the figure above. Entropy goes from 0.2 in the actual observation to 0.43 in the predicted distribution. This is also expected, albeit a rare incidence. HAMMER is a strong Handling-preference noun in TiD, and we have seen its drastic effect across signer responses throughout the language. When the claw of the hammer is used to remove a nail atypically (or rather in a *marked* environment where the claw becomes the salient component in the event and the salient part of the hammer), signers have two salient points of view to choose from: (i) to promote the *agent's handling of the hammer* in the classifier or (ii) to promote *the claw removing the nail.* This is reflected in the predicted probability distribution, which is calculated after factoring in multiple measurements and weights: the Handling strategy promotes the agent handling the hammer, and the Object strategy promotes the hammer removing the nail. The 90% Object strategy we saw in the actual distribution would not be a realistic expectation in real world language production. The model tones down the Object strategy and grants Handling strategy a probability mass that is almost equal to that of Object.

5.4 Logistic Regression Model

In this section, I present the logistic regression model that I trained in order to evaluate the precision of the predictive model. Logistic regression is a classification algorithm that is widely used in machine learning tasks for predicting a dependent variable with categorical levels. In my data, I have 5 morphological strategies that I identified in classifier constructions: (i) Handling only, (ii) Object only, (iii) Handling+Object, (iv) not iconic, and (v) no VP. For this model, I leave aside the task of making predictions for any morphological strategy other than the Handling-only and the Object-only categories, since the other three have a limited environment and not enough examples to make accurate predictions. The factors discussed earlier in Chapter 4 are featurized into a set of 12 binary predictors (Table 23).

Factor		Description
agentHandle_TO		Is the agent actively handling the target object?
Agent_NP		Is there an overt agent noun?
functionally		Is the instrumental event successful?
NP_entropy		How much entropy is there in the nominal encodings of the target object?
NP_prob_H		How probable is Handling iconicity in the nominal encodings of the target object?
NP_prob_O		How probable is Object iconicity in the nominal encodings of the target object?
object_Instrument		Is the target object a designated instrument?
TO_handle_Patient		Does the target object grasp the patient?
TO_move_Patient		Does the target object cause the patient to move in space?
TO_patientContact		Does the target object have contact with the patient?
TO_Patient_continuousContact		Does the target object have continuous contact with the patient?
typically		Is the target object used to carry out its designated function?

TABLE 23 Logistic regression model predictors.

The logistic regression model is trained with an 80-20 train-test split. I used a Generalized Linear Model assuming a binomial distribution and used Variance Inflation

Factor and Recursive Feature Elimination to find the optimal combination of factors for each language. I used a ROC curve to measure the usefulness of the model (area under curve > 80%). The following are the coefficients extracted from the logistic regression model for each language:

American Sign Language	
Factors	**Coef.**
agentHandle_TO	-2.33
Agent_NP	-0.94
functionally	0.84
TO_move_Patient	-0.83
NP_prob_O	0.64
typically	-0.62
TO_patientContact	-0.62
TO_Patient_continuousContact	0.59
NP_entropy	0.15
object_Instrument	-0.13
TO_handle_Patient	0.07
NP_prob_H	0.03

TABLE 24 Logistic regression coefficients for ASL.

In all of the following descriptions, negative coefficients work toward Handling iconicity in the predicate, positive values toward Object iconicity.

In ASL, as with HKSL, the leading predictive factor is 'agentHandle_TO', which corresponds to the verb type [+hold] [+move] – technically the 'PUT' verbs, and predict that the handshape iconicity in the predicate will be Handling. Next comes the presence of an agent noun ('Agent_NP') as a predictive factor. We have seen that in ASL the presence of an overt agent noun can be considered an indicator of agency, which determines the handshape iconicity as Handling. The atypical instrumental use of an object may favor the use of Object iconicity in ASL. If there target object has continuous contact with the patient, we are likely to see an increase in Object iconicity use. A surprising predictor for Object iconicity in the predicate in ASL is if a noun has strong Object preference in the lexicon ('NP_prob_O'), the same is not observed for those that have a strong Handling preference.

Hong Kong Sign Language	
Factors	**Coef.**
agentHandle_TO	-1.77
NP_prob_H	-1.45
NP_entropy	1.38
NP_prob_O	1.38
TO_Patient_continuousContact	1.22
typically	-1.12
object_Instrument	1.06
TO_move_Patient	-0.64
Agent_NP	-0.43
TO_handle_Patient	0.21

TABLE 25 Logistic regression coefficients for HKSL.

In HKSL, the strongest effect comes from 'PUT' verbs ('agentHandle_TO'). Then we see the effects of strong Object and strong Handling signs as two other predictive factors that determine predicate iconicity. Event semantics where the instrument is continuously involved with the patient is an indicator of Object iconicity in HKSL as well. High entropy in the noun form of the target object concepts is also a predictor for Object iconicity. Atypicality motivates Object iconicity in HKSL. The presence of an Agent noun in HKSL also predicts Handling iconicity although not as strongly as it does in ASL.

Turkish Sign Language	
Factors	**Coef.**
NP_prob_H	-1.87
NP_prob_O	1.57
agentHandle_TO	-1.3
TO_Patient_continuousContact	1.24
NP_entropy	1.22
object_Instrument	1.01
typically	-0.92
TO_move_Patient	-0.74
TO_patientContact	-0.52
TO_handle_Patient	-0.28
functionally	0.26
Agent_NP	0.23

TABLE 26 Logistic regression coefficients for TiD.

In TiD, the strongest predictors are if a noun has a strong preference for Handling or a strong preference for Object iconicity. The third strongest factor is if the agent is handling the target object. Like in HKSL, high entropy in the nominal forms of the target object also predicts Object iconicity. Atypicality plays a role in predicting Object iconicity. Continuous contact of the instrument with the patient predicts Object iconicity use.

In this chapter I put the observations that I made in the previous chapter into two models. The first model builds on metrics from Information Theory and uses them to predict the likely outcomes of classifier predicates per language given a set of conditions. The second is a logistic regression model that tests the validity of the factors that I presented in the previous chapter and finds that agent handling the target object is a highly marked environment which is responsible for a large proportion of predictions in the model. In cases where the Object point of view is activated, we see factors building up a base for Object preference. TiD and HKSL are highly sensitive to the iconic type of a noun found in the lexicon, while ASL is not. All three languages are sensitive to how involved the instrument is with the patients.

Conclusion

In this dissertation I investigated instrumental constructions in three genealogically unrelated languages: American Sign Language, Hong Kong Sign Language and Turkish Sign Language. Sign languages express instrumental meaning, especially the semantic kind 'intermediary' where the tool used has an active role in the end state of the patient, using classifier constructions. Classifier constructions are highly iconic linguistic complexes used in sign languages to encode spatial relations. The linguistic description of an event borrows heavily from its physical properties and the grammar blends this raw material with the rules of the grammar and molds them into systematic linguistic units.

One component of these constructions, the form of the handshape (or the classifier component), has been studied heavily from the point of view of iconicity and its interactions with the phonology, morphology, and syntax. There are two main types of iconicity found in the form of classifiers: Handling and Object. Handling iconicity reflects how an object would be handled and Object iconicity takes the point of view of the described object and reflects a physical property of it. These two types of iconicity have been shown to mark a grammatical distinction in American Sign Language. Benedicto & Brentari (2004) found that American Sign Language favors the use of Handling iconicity when the event being described is agentive. They also found that Object iconicity is associated with encoding unaccusative events. In this study and previous others, the grammatical distinction between Handling and Object has been shown to be not that clear cut in ASL and across other sign languages. The main purpose of this dissertation has been to find explanations to why sign languages behave differently with respect to the iconicity type in the classifier predicate. I used methods and concepts from Information Theory, statistics, and psychology to quantify and explain my observations and later to make these observations into a predictive model. The choice of three distinct sign languages is motivated by building a typological predictive model, which would rank the identified factors in different orders across different sign languages.

Among the factors studied from the literature are Agency (Benedicto & Brentari, 2004), Iconic Handshape Preference (Padden et al., 2013; Brentari et al. 2016a), Instrument Sensitivity (Brentari et al., 2016a) and Instrument Typicality (Brentari et al., 2016b). I discussed the necessity to review these factors and proposed new ones: Perceptual Salience, Lexical Rigidity, Object Handling, Instrument Functionality, and the agent/instrument's degree of involvement with the patient. I situated Perceptual Salience as a meta-function that operates on the properties of an event and navigates signers into grammatical paths that ultimately leads signers into choosing a salient iconicity type. Perceptual Salience is a strong factor in HKSL and TiD. Contrary to ASL, Handling iconicity is not strongly correlated with agency and Object iconicity not with unaccusativity.

On the one hand, in situations where Perceptual Salience requires foregrounding the handling of the object, signers strongly tend to produce Handling iconicity in the classifier predicate. These situations include semantically simplex meaning components such as 'holding an object' or 'moving an object'. I discussed the necessity to posit a hypothesis that directly addresses the marked conditions where the only perceptually salient component of the event is the handling of the object. This differs from Brentari and colleagues' account where they situate Instrument Sensitivity as the positive factor that motivates an uptick in Object iconicity use in linguistic descriptions of events where an object is used instrumentally. I discussed the motivation behind this difference along the lines of my observations on the following.

On the other hand, in certain situations, – types of semantic environments of which, I claim, instrumentality is a subset of – where Perceptual Salience provides an extra alternative salient property in the event, i.e., the object, signers have two morphological strategies to choose from. While there possibly exist multiple such situations where the object is just as salient as the handling of it is, instrumentality and the atypical use of an instrument are two environments where we see this effect pronounced. The two morphological strategies reflect the two salient components available in the instrumental event: (i) Handling iconicity, which foregrounds the agent's handling the of instrument, or (ii) Handling or Object iconicity as mapped into the form of the classifier predicate by Iconic Handshape Preference. The Handling strategy in the first option is arguably different than the Handling strategy in the second option. The first Handling strategy option is determined by the same mechanism that determines the Handling iconicity in semantically simplex verbs such as 'hold the object' or 'move the object'. The second Handling strategy, on the other hand, reflects the iconic type that is specified in the lexical form of the noun that is encoded in the classifier predicate. Example nouns to the second kind of Handling iconicity type include HAMMER in American, Hong Kong and Turkish Sign Languages and TEASPOON in Hong Kong and Turkish Sign Languages. This nominal information is almost invariably encoded using Handling iconicity in the classifier predicate. In these regards, the first Handling type bears no functional resemblance to the second Handling type. The second strategy made available by way of Perceptual Salience and Iconic Handshape Preference is Object iconicity. From a distributional point of view, this iconicity type behaves identical to the second type of Handling iconicity – they are both encoded in the lexical specification of a noun and likely calcified in the lexicon. However, not all objects have a strong preference for Handling or Object iconicity in their lexical noun form. Using Shannon's entropy from Information Theory, I showed that only the nouns that have high Lexical Rigidity, that is, conventionalization around a single iconic type in the noun form, conform to Iconic Handshape Preference. I showed that nouns that lack a conventionalized form in the lexicon have low information content and therefore signers turn to multiple unique strategies in their responses to express these meanings. Highly conventionalized nouns, on the other hand, are not ambiguous and therefore do not require the same attention that unconventionalized nouns do. Circling back to Brentari and colleagues' Instrument Sensitivity, it is likely that the uptick that they observe in the use of Object iconicity in instrumental classifier constructions is because Perceptual Salience, by way of instrumentality, is allowing the Iconic Handshape Preference specified in the lexical form of conventionalized nouns to surface.

While nouns that lack conventionalization require more research, I argued that the type of the verb, specifically the part of its meaning that encodes the agent or the instrument's involvement with the patient has a considerable impact on determining classifier iconicity and can potentially account for the high levels of variation that we see in signer responses that target unconventionalized nouns. I argued that Perceptual Salience is responsible for filtering what is important in the event and directing signers' linguistic production accordingly. In my data I identified five groups of verbs that behave maximally differently from one another. The first kind is 'noTouch', where neither the agent nor the instrument has physical contact with the patient. An example to these verbs is 'fanning'. The hand fan or the agent has no physical contact with the patient while still altering it. With this kind of verb, the usual iconicity type is Handling which reflects the handling of the tool. The second kind is 'touchOnly'. This is the type of verb where the physical relation between an object and another is none other than only touching each other. This kind of verb is similar (or probably identical) to locative spatial predicates where the physical configuration of a group of objects is encoded, these can also be assumed to be unaccusative verbs in their own right. This kind is typically encoded using Object iconicity, as is the case with other unaccusatives. The third and fourth kinds have more increased levels of engagement with the patient, such as the act of stirring tea (third kind), where the instrument has direct contact with the patient but does not alter its integrity. As for the fourth group, it is composed of actions such as tightening a screw with a screwdriver, where the screwdriver causes the screw to move in space while not actively grasping it. Another example to the fourth type is cutting tomato using a knife. The knife determines the end state of the tomato, but it does not grasp it. Therefore, in this group we see great variation between Handling and Object use. The fifth and final kind is handling and moving. Any action where the patient is being actively handled by an animate or an inanimate being will almost exclusively use Handling iconicity. I argued that Benedicto & Brentari's Agency condition does not strongly apply to HKSL and TiD. The cases of Handling we see in signer responses is a direct manifestation of either Iconic Handshape Preference or the fifth verb type. I call the latter environment 'Object Handling'. This is a strong factor in all three languages that creates a natural class of classifier predicates that depict an event whose only salient component that can be expressed in the handshape is the handling of the event. Coming back to Agency as a factor that motivates Handling iconicity use, I have shown that only in ASL among the three languages studied here do we see a significant association between Handling iconicity and Agency. I tested this with sentences that are undoubtedly agentive. Only in ASL do Object iconicity in the predicate and overt Agent noun in the signer responses behave almost mutually exclusively. In TiD and HKSL, there is no significant difference between the uses of Object and Handling iconicity when tested under the agent NP and the no agent NP conditions. Therefore, we can assert that Object iconicity in ASL is a strategy associated with agent demotion, likely changing valency, while in HKSL and TiD the Object iconic strategy is undoubtedly compatible with agentive sentences. In other words, the Handling vs. Object distinction in HKSL and TiD does not reflect a grammatical divide in the language.

I have also shown that Instrument Typicality is a factor in HKSL (and the other two languages to a limited extent) that further motivates the use of Object iconicity. Instrument Functionality, on the other hand, works against my expectations and encourages the use of Handling iconicity, while the dysfunctionality of an instrument is morphologically encoded elsewhere in the grammar.

The categorical differences are most pronounced between ASL and the other two languages, which means that we can put these languages in a typology of how the iconic affordances available to sign language morphologies is allocated. I have shown that Perceptual Salience resides on top of all the other factors in HKSL and TiD, while the ASL grammar by-passes it and determines the iconic type in the predicate with regards to grammatical relations. I call these two types of languages Grammatical Agreement and Iconic Agreement languages. ASL is undoubtedly a Grammatical Agreement language. As for HKSL and TiD, Perceptual

Salience passes the ball to Object Salience or Handling Salience where the decision tree further continues to branch out. Object Salience passes the ball to Iconic Handshape Preference, where whether the noun has a conventionalized form is determined, which later branches out further to lexically rigid nouns and those that do not have a rigid form. Finally, an iconicity decision is made after this lengthy path. HKSL and TiD are Iconic Agreement languages, where the agreement is not motivated by grammatical relations within the sentence but by a combination of Iconic Handshape Preference and what Perceptual Salience requires.

I put my findings in a predictive model that maps the specifications of factors and their weights into a classifier decision and presented my predictions for unseen combinations of factors for each language. I trained a logistic regression model in order to find the coefficients of the predictive model. The model is able to accurately predict around 80-85% of the test set in each language. In all three languages the strongest predictive factor is whether or not the verb encodes a simplex handling action (type 5; e.g., hold and move, put down, etc.), which is followed by Lexical Rigidity and the most likely specification of iconic type of nouns in the lexicon in HKSL and TiD. In ASL the secondary strongest factors are the presence of an agent noun and the 5 verb types, followed by typicality.

In this dissertation, I investigated a highly organic matter in linguistic research and proposed equally organic and probabilistic explanations to the distributions of the iconic affordances of the visual modality across the sign language grammars. While many loose ends exist, this dissertation will serve as a hub for future research especially to be conducted on the effects of conventionalization, information content of morphemes and Lexical Rigidity on how stochastic grammars are shaped, those of Perceptual Salience on how our perception of events shapes our linguistic production and other venues in sign language research where iconicity determines the rules.

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Appendix I Stimulus Items for Production Elicitation

(A) Instrument Items			
Target Object	Data Type	Description	stimID
Hammer	INS1	Hammer a nail	id12
Teaspoon	INS1	Stir tea in mug	id56
Screwdriver	INS1	Tighten screw	id36
Knife	INS1	Cut tomato in half	id63
Shovel	INS1	Shovel dirt	id42
Plastic hand fan	INS1	Put out small fire	id46
Spatula	INS1	Flatten playdough	id24
Pliers	INS1	Remove a nail	id50

TABLE 27 Typical instrumental stimuli for instrument items

Hammer	PUT	Put hammer down	id51
Teaspoon	PUT	Put teaspoon down	id44
Screwdriver	PUT	Put screwdriver down	id9
Knife	PUT	Put knife down	id58
Shovel	PUT	Put shovel down	id54
Plastic hand fan	PUT	Put fan down	id0
Spatula	PUT	Put spatula down	id62
Pliers	PUT	Put pliers down	id25

TABLE 28 Non-instrumental stimuli for instrument items

Hammer	ATY	Remove a nail	id20
Teaspoon	ATY	Cut cheese in half	id26
Screwdriver	ATY	Stir tea in mug	id18
Knife	ATY	Tighten screw	id52
Shovel	ATY	Flatten playdough	id37
Plastic hand fan	ATY	Shovel dirt	id5
Spatula	ATY	Put out small fire	id43
Pliers	ATY	Hammer a nail	id45

TABLE 29 Atypical instrumental stimuli for instrument items

Hammer	NFN1	Try to tighten screw	id61
Teaspoon	NFN1	Try to put out small fire	id10
Screwdriver	NFN1	Try to cut tomato	id8
Knife	NFN1	Try to shovel dirt	id29
Shovel	NFN1	Try to stir tea in mug	id47
Plastic hand fan	NFN1	Try to remove a nail	id38
Spatula	NFN1	Try to hammer a nail	id41
Pliers	NFN1	Try to spread paint on paper	id21

TABLE 30 Dysfunctional instrumental stimuli for instrument items

(B) Non - Instrument Items			
Target Object	Data Type	Description	stimID
Book	~INS	Read	id28
Coin	~INS	Put in purse	id4
Cardboard	~INS	Write name on	id39
Mug	~INS	Pour water into	id7
Cooking pot	~INS	Put chopped tomatoes in	id23
Cutting board	~INS	Chop tomatoes on	id2
Pitcher	~INS	Pour water from	id27
S-Hook	~INS	Hang a shirt	id32

TABLE 31 Typical non-instrumental stimuli for non-instrument items

Book	INS2	Hammer a nail	id16
Coin	INS2	Tighten a screw	id30
Cardboard	INS2	Put out small fire	id15
Mug	INS2	Cut out cookies from dough	id6
Cooking pot	INS2	Shovel dirt	id59
Cutting board	INS2	Flatten playdough	id19
Pitcher	INS2	Stir food in cooking pot	id1
S-Hook	INS2	Remove a nail	id57

TABLE 32 Atypical instrumental stimuli for non-instrument items

Book	NFN2	Try to stir tea in mug	id49
Coin	NFN2	Try to cut tomato in half	id60
Cardboard	NFN2	Try to hammer a nail	id35
Mug	NFN2	Try to put out small fire	id53
Cooking pot	NFN2	Try to tighten a screw	id11
Cutting board	NFN2	Try to pry open a jar	id40
Pitcher	NFN2	Try to shovel dirt	id48
S-Hook	NFN2	Try to spread paint on paper	id31

TABLE 33 Dysfunctional instrumental stimuli for non-instrument items

(C) Bare Hands			
Target Object	Data Type	Description	
Bare Hands	HAN	Hammer a stick into ground with fist	id34
Bare Hands	HAN	Tighten screw with fingers	id22
Bare Hands	HAN	Remove a nail with fingers	id55
Bare Hands	HAN	Stir tea in mug with index finger	id17
Bare Hands	HAN	Put out small fire with hand	id33
Bare Hands	HAN	Shovel dirt with hand	id14
Bare Hands	HAN	Separate dirt with hand	id13
Bare Hands	HAN	Flatten playdough with hand	id3

TABLE 34 Stimuli for using bare hands instead of an instrument

Appendix II Model Predictions

AMERICAN SIGN LANGUAGE (ASL)

Observed Distributions and Model Predictions for American Sign Language (INS1)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id46	0.444	0.556	0	0	0	0.43	0.809	0.191	0	0	0	0.3
id42	0.889	0.111	0	0	0	0.22	0.996	0.004	0	0	0	0.02
id12	1	0	0	0	0	0	1	0	0	0	0	0
id63	0.556	0.333	0.111	0	0	0.58	0.994	0.006	0	0	0	0.02
id50	0.667	0.333	0	0	0	0.4	0.99	0.01	0	0	0	0.03
id36	0.333	0.556	0.111	0	0	0.58	0.95	0.05	0	0	0	0.12
id24	0.5	0	0.5	0	0	0.43	1	0	0	0	0	0
id56	0.778	0.222	0	0	0	0.33	0.995	0.005	0	0	0	0.02

TABLE 35 Observed distributions and model predictions for ASL (INS1)

Observed Distributions and Model Predictions for American Sign Language (PUT)												
stimID	Observed H	Observed O	Observed Multi	Observed Non-Iconic	Observed no VP	Observed Entropy	Predicted H	Predicted O	Predicted Multi	Predicted Non-Iconic	Predicted no VP	Predicted Entropy
id0	0.556	0.333	0.111	0	0	0.58	0.984	0.016	0	0	0	0.05
id54	0.889	0.111	0	0	0	0.22	0.999	0.001	0	0	0	0
id51	0.778	0	0.111	0.111	0	0.42	1	0	0	0	0	0
id58	1	0	0	0	0	0	1	0	0	0	0	0
id25	1	0	0	0	0	0	1	0	0	0	0	0
id9	0.778	0	0.111	0.111	0	0.42	1	0	0	0	0	0
id62	1	0	0	0	0	0	1	0	0	0	0	0
id44	0.889	0	0	0.111	0	0.22	1	0	0	0	0	0

TABLE 36 Observed distributions and model predictions for ASL (PUT)

Observed Distributions and Model Predictions for American Sign Language (ATY)												
stimID	Observed H	Observed O	Observed Multi	Observed Non-Iconic	Observed no VP	Observed Entropy	Predicted H	Predicted O	Predicted Multi	Predicted Non-Iconic	Predicted no VP	Predicted Entropy
id5	0.778	0.222	0	0	0	0.33	0.975	0.025	0	0	0	0.07
id37	0.667	0.111	0.222	0	0	0.53	0.997	0.003	0	0	0	0.01
id20	0.556	0.444	0	0	0	0.43	0.997	0.003	0	0	0	0.01
id52	0.778	0.111	0.111	0	0	0.42	0.999	0.001	0	0	0	0
id45	1	0	0	0	0	0	1	0	0	0	0	0
id18	0.778	0.222	0	0	0	0.33	0.996	0.004	0	0	0	0.02
id43	0.444	0.333	0.222	0	0	0.66	0.987	0.013	0	0	0	0.04
id26	0.778	0.222	0	0	0	0.33	0.997	0.003	0	0	0	0.01

TABLE 37 Observed distributions and model predictions for ASL (ATY)

Observed Distributions and Model Predictions for American Sign Language (NFN1)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id38	0.667	0.333	0	0	0	0.4	0.981	0.019	0	0	0	0.06
id47	0.667	0	0.333	0	0	0.4	1	0	0	0	0	0
id61	0.778	0	0.222	0	0	0.33	1	0	0	0	0	0
id29	1	0	0	0	0	0	1	0	0	0	0	0
id21	0.778	0	0.111	0.111	0	0.42	1	0	0	0	0	0
id8	0.111	0.778	0	0.111	0	0.42	0.957	0.043	0	0	0	0.11
id41	1	0	0	0	0	0	1	0	0	0	0	0
id10	0.778	0.222	0	0	0	0.33	0.998	0.002	0	0	0	0.01

TABLE 38 Observed distributions and model predictions for ASL (NFN1)

Observed Distributions and Model Predictions for American Sign Language (INS2)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id16	0.778	0.222	0	0	0	0.33	1	0	0	0	0	0
id19	0.333	0.667	0	0	0	0.4	0.897	0.103	0	0	0	0.21
id15	0.444	0.556	0	0	0	0.43	0.936	0.064	0	0	0	0.15
id1	1	0	0	0	0	0	1	0	0	0	0	0
id30	0.889	0	0	0.111	0	0.22	1	0	0	0	0	0
id57	0.333	0.667	0	0	0	0.4	0.89	0.11	0	0	0	0.22
id6	0	1	0	0	0	0	0	1	0	0	0	0
id59	0.333	0.556	0.111	0	0	0.58	0.943	0.057	0	0	0	0.14

TABLE 39 Observed distributions and model predictions for ASL (INS2)

Observed Distributions and Model Predictions for American Sign Language (~INS)											
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id28	0.222	0.778	0	0	0	0.33	1	0	0	0	0	0
id2	0	0	0	0	1	0	0	0	0	0	1	0
id39	0.111	0.778	0	0	0.111	0.42	0.679	0.321	0	0	0	0.39
id27	1	0	0	0	0	0	1	0	0	0	0	0
id4	0.778	0	0.222	0	0	0.33	1	0	0	0	0	0
id32	0	0.889	0	0	0.111	0.22	0	1	0	0	0	0
id7	0.778	0.222	0	0	0	0.33	0.996	0.004	0	0	0	0.02
id23	0.111	0.444	0	0	0.444	0.6	0.775	0.222	0	0	0.003	0.34

TABLE 40 Observed distributions and model predictions for ASL (~INS)

Observed Distributions and Model Predictions for American Sign Language (NFN2)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id49	0.556	0.111	0.222	0.111	0	0.71	1	0	0	0	0	0
id40	0.556	0.333	0	0	0.111	0.58	0.983	0.017	0	0	0	0.05
id35	0.556	0.333	0	0.111	0	0.58	0.99	0.01	0	0	0	0.03
id48	0.889	0	0	0.111	0	0.22	1	0	0	0	0	0
id60	0.889	0	0	0.111	0	0.22	1	0	0	0	0	0
id31	0.667	0.333	0	0	0	0.4	0.989	0.011	0	0	0	0.04
id53	0.889	0	0	0.111	0	0.22	1	0	0	0	0	0
id11	0.444	0.556	0	0	0	0.43	0.981	0.019	0	0	0	0.06

TABLE 41 Observed distributions and model predictions for ASL (NFN2)

Observed Distributions and Model Predictions for Hong Kong Sign Language (INS1)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id46	0.8	0	0.2	0	0	0.31	1	0	0	0	0	0
id42	0.5	0.3	0.2	0	0	0.64	0.302	0.698	0	0	0	0.38
id12	1	0	0	0	0	0	1	0	0	0	0	0
id63	0.1	0.9	0	0	0	0.2	0.004	0.996	0	0	0	0.02
id50	0.3	0.6	0.1	0	0	0.56	0.168	0.832	0	0	0	0.28
id36	0	0.9	0.1	0	0	0.2	0	1	0	0	0	0
id24	0.3	0.6	0.1	0	0	0.56	0.186	0.813	0	0	0	0.3
id56	0.9	0	0.1	0	0	0.2	1	0	0	0	0	0

TABLE 42 Observed distributions and model predictions for HKSL (INS1)

Observed Distributions and Model Predictions for Hong Kong Sign Language (PUT)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id0	0.7	0.3	0	0	0	0.38	0.994	0.006	0	0	0	0.02
id54	0.9	0.1	0	0	0	0.2	0.968	0.032	0	0	0	0.09
id51	1	0	0	0	0	0	1	0	0	0	0	0
id58	0.7	0.2	0.1	0	0	0.5	0.543	0.457	0	0	0	0.43
id25	0.7	0.2	0.1	0	0	0.5	0.949	0.051	0	0	0	0.13
id9	0.9	0.1	0	0	0	0.2	0.922	0.078	0	0	0	0.17
id62	0.9	0	0.1	0	0	0.2	1	0	0	0	0	0
id44	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 43 Observed distributions and model predictions for HKSL (PUT)

Observed Distributions and Model Predictions for Hong Kong Sign Language (ATY)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id5	0.6	0.3	0.1	0	0	0.56	0.903	0.097	0	0	0	0.2
id37	0.2	0.5	0.3	0	0	0.64	0.112	0.888	0	0	0	0.22
id20	0.1	0.7	0.2	0	0	0.5	0.244	0.756	0	0	0	0.35
id52	0	1	0	0	0	0	0	1	0	0	0	0
id45	0.4	0.4	0.2	0	0	0.66	0.329	0.671	0	0	0	0.39
id18	0.2	0.7	0.1	0	0	0.5	0.034	0.966	0	0	0	0.09
id43	0.4	0.3	0.3	0	0	0.68	0.562	0.437	0.001	0	0	0.43
id26	0.6	0.2	0.2	0	0	0.59	0.996	0.004	0	0	0	0.02

TABLE 44 Observed distributions and model predictions for HKSL (ATY)

Observed Distributions and Model Predictions for Hong Kong Sign Language (NFN1)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id38	0.6	0.3	0.1	0	0	0.56	0.912	0.088	0	0	0	0.18
id47	0.2	0.8	0	0	0	0.31	0.081	0.919	0	0	0	0.17
id61	0.8	0	0.2	0	0	0.31	1	0	0	0	0	0
id29	0.2	0.8	0	0	0	0.31	0.006	0.994	0	0	0	0.02
id21	0.3	0.6	0.1	0	0	0.56	0.215	0.785	0	0	0	0.32
id8	0.1	0.9	0	0	0	0.2	0.015	0.985	0	0	0	0.05
id41	0.5	0.3	0.2	0	0	0.64	0.402	0.598	0	0	0	0.42
id10	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 45 Observed distributions and model predictions for HKSL (NFN1)

Observed Distributions and Model Predictions for Hong Kong Sign Language (INS2)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id16	0.7	0.2	0.1	0	0	0.5	0.894	0.106	0	0	0	0.21
id19	0	0.7	0.3	0	0	0.38	0	1	0	0	0	0
id15	0.4	0.4	0.2	0	0	0.66	0.503	0.497	0	0	0	0.43
id1	1	0	0	0	0	0	1	0	0	0	0	0
id30	0.8	0.2	0	0	0	0.31	0.903	0.097	0	0	0	0.2
id57	0	0.9	0.1	0	0	0.2	0	1	0	0	0	0
id6	0	1	0	0	0	0	0	1	0	0	0	0
id59	0.3	0.6	0.1	0	0	0.56	0.172	0.828	0	0	0	0.29

TABLE 46 Observed distributions and model predictions for HKSL (INS2)

Observed Distributions and Model Predictions for Hong Kong Sign Language (~INS)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id28	0.5	0.5	0	0	0	0.43	0.963	0.037	0	0	0	0.1
id2	0	0.1	0	0	0.9	0.2	0	0.995	0	0	0.005	0.02
id39	0.2	0.8	0	0	0	0.31	0.107	0.893	0	0	0	0.21
id27	1	0	0	0	0	0	1	0	0	0	0	0
id4	0.9	0.1	0	0	0	0.2	0.997	0.003	0	0	0	0.01
id32	0	1	0	0	0	0	0	1	0	0	0	0
id7	0.4	0.6	0	0	0	0.42	0.749	0.251	0	0	0	0.35
id23	0.1	0.8	0	0	0.1	0.4	0.102	0.898	0	0	0	0.2

TABLE 47 Observed distributions and model predictions for HKSL (~INS)

Observed Distributions and Model Predictions for Hong Kong Sign Language (NFN2)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id49	0.7	0.2	0.1	0	0	0.5	0.913	0.087	0	0	0	0.18
id40	0.5	0.4	0.1	0	0	0.59	0.238	0.762	0	0	0	0.34
id35	0.2	0.8	0	0	0	0.31	0.096	0.904	0	0	0	0.2
id48	1	0	0	0	0	0	1	0	0	0	0	0
id60	0.8	0.2	0	0	0	0.31	0.942	0.058	0	0	0	0.14
id31	0	1	0	0	0	0	0	1	0	0	0	0
id53	0.7	0.2	0.1	0	0	0.5	0.812	0.188	0	0	0	0.3
id11	0.2	0.7	0.1	0	0	0.5	0.117	0.883	0	0	0	0.22

TABLE 48 Observed distributions and model predictions for HKSL (NFN2)

Observed Distributions and Model Predictions for Turkish Sign Language (INS1)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id46	0.222	0.778	0	0	0	0.33	0.149	0.851	0	0	0	0.26
id42	0.7	0.3	0	0	0	0.38	0.72	0.28	0	0	0	0.37
id12	1	0	0	0	0	0	1	0	0	0	0	0
id63	0.3	0.7	0	0	0	0.38	0.159	0.841	0	0	0	0.27
id50	0.7	0.3	0	0	0	0.38	0.946	0.054	0	0	0	0.13
id36	0.1	0.7	0.2	0	0	0.5	0.022	0.978	0	0	0	0.07
id24	0	0.7	0.3	0	0	0.38	0	1	0	0	0	0
id56	0.9	0.1	0	0	0	0.2	0.999	0.001	0	0	0	0

TABLE 49 Observed distributions and model predictions for TiD (INS1)

Observed Distributions and Model Predictions for Turkish Sign Language (PUT)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id0	0.4	0.4	0.2	0	0	0.66	0.756	0.244	0	0	0	0.34
id54	0.8	0.1	0.1	0	0	0.4	0.985	0.015	0	0	0	0.05
id51	1	0	0	0	0	0	1	0	0	0	0	0
id58	0.778	0.222	0	0	0	0.33	0.903	0.097	0	0	0	0.2
id25	0.889	0.111	0	0	0	0.22	0.998	0.002	0	0	0	0.01
id9	0.8	0.2	0	0	0	0.31	0.828	0.172	0	0	0	0.29
id62	0.8	0.2	0	0	0	0.31	0.992	0.008	0	0	0	0.03
id44	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 50 Observed distributions and model predictions for TiD (PUT)

Observed Distributions and Model Predictions for Turkish Sign Language (ATY)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id5	0.4	0.6	0	0	0	0.42	0.23	0.77	0	0	0	0.34
id37	0.5	0.3	0.2	0	0	0.64	0.714	0.286	0	0	0	0.37
id20	0.1	0.9	0	0	0	0.2	0.519	0.481	0	0	0	0.43
id52	0.2	0.7	0.1	0	0	0.5	0.099	0.901	0	0	0	0.2
id45	0.9	0.1	0	0	0	0.2	0.989	0.011	0	0	0	0.04
id18	0.2	0.8	0	0	0	0.31	0.051	0.949	0	0	0	0.13
id43	0.4	0.6	0	0	0	0.42	0.81	0.19	0	0	0	0.3
id26	0.9	0.1	0	0	0	0.2	0.999	0.001	0	0	0	0

TABLE 51 Observed distributions and model predictions for TiD (ATY)

Observed Distributions and Model Predictions for Turkish Sign Language (NFN1)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id38	0.3	0.7	0	0	0	0.38	0.214	0.786	0	0	0	0.32
id47	0.2	0.5	0.3	0	0	0.64	0.459	0.541	0	0	0	0.43
id61	0.8	0.2	0	0	0	0.31	0.986	0.014	0	0	0	0.05
id29	0.5	0.5	0	0	0	0.43	0.353	0.647	0	0	0	0.4
id21	0.9	0.1	0	0	0	0.2	0.992	0.008	0	0	0	0.03
id8	0.1	0.9	0	0	0	0.2	0.033	0.967	0	0	0	0.09
id41	0.6	0.4	0	0	0	0.42	0.919	0.081	0	0	0	0.17
id10	1	0	0	0	0	0	1	0	0	0	0	0

TABLE 52 Observed distributions and model predictions for TiD (NFN1)

Observed Distributions and Model Predictions for Turkish Sign Language (INS2)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id16	0.8	0.2	0	0	0	0.31	0.972	0.028	0	0	0	0.08
id19	0.2	0.7	0.1	0	0	0.5	0.369	0.631	0	0	0	0.41
id15	0.4	0.6	0	0	0	0.42	0.793	0.207	0	0	0	0.32
id1	1	0	0	0	0	0	1	0	0	0	0	0
id30	0.6	0.4	0	0	0	0.42	0.77	0.23	0	0	0	0.33
id57	0.2	0.8	0	0	0	0.31	0.026	0.974	0	0	0	0.07
id6	0.1	0.9	0	0	0	0.2	0.277	0.723	0	0	0	0.37
id59	0.8	0.1	0.1	0	0	0.4	0.978	0.022	0	0	0	0.07

TABLE 53 Observed distributions and model predictions for TiD (INS2)

Observed Distributions and Model Predictions for Turkish Sign Language (~INS)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id28	0.2	0.6	0.2	0	0	0.59	0.942	0.058	0	0	0	0.14
id2	0	0.2	0	0	0.8	0.31	0	0.991	0	0	0.009	0.03
id39	0.1	0.9	0	0	0	0.2	0.329	0.671	0	0	0	0.39
id27	1	0	0	0	0	0	1	0	0	0	0	0
id4	0.5	0.3	0.2	0	0	0.64	0.963	0.037	0	0	0	0.1
id32	0	0.9	0	0	0.1	0.2	0	1	0	0	0	0
id7	1	0	0	0	0	0	1	0	0	0	0	0
id23	0.5	0.2	0	0	0.3	0.64	0.959	0.041	0	0	0	0.11

TABLE 54 Observed distributions and model predictions for TiD (~INS)

Observed Distributions and Model Predictions for Turkish Sign Language (NFN2)												
stimID	**Observed H**	**Observed O**	**Observed Multi**	**Observed Non-Iconic**	**Observed no VP**	**Observed Entropy**	**Predicted H**	**Predicted O**	**Predicted Multi**	**Predicted Non-Iconic**	**Predicted no VP**	**Predicted Entropy**
id49	0.5	0.4	0.1	0	0	0.59	0.957	0.043	0	0	0	0.11
id40	0.5	0.5	0	0	0	0.43	0.7	0.3	0	0	0	0.38
id35	0.5	0.5	0	0	0	0.43	0.872	0.128	0	0	0	0.24
id48	1	0	0	0	0	0	1	0	0	0	0	0
id60	0.5	0.4	0.1	0	0	0.59	0.832	0.168	0	0	0	0.28
id31	0.1	0.9	0	0	0	0.2	0.02	0.98	0	0	0	0.06
id53	1	0	0	0	0	0	1	0	0	0	0	0
id11	0.8	0.1	0.1	0	0	0.4	0.985	0.015	0	0	0	0.05

TABLE 55 Observed distributions and model predictions for TiD (NFN2)