Telicity and iconic scales in ASL

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Abstract
In a series of papers (Wilbur 2003, i.a.), Ronnie Wilbur shows that a number of sign languages display a non-arbitrary form-to-meaning correspondence in the verbal lexicon: telic verbs end with sharp deceleration (’end-marking’); atelic verbs do not. In ASL, Wilbur also shows that the phonetic form of a verb may be manipulated with semantic effect. In this paper, I provide an analysis of these facts in terms of structural iconicity, where the interpretation of a sign preserves abstract structure of the form of the sign. I follow Kennedy and Levin (2008) in assuming that the meanings of change-of-state verbs are derived from scales; I argue that verbs in ASL iconically represent these scales, and that end-marking on telic verbs is the iconic representation of the maximum of a closed scale.

1 Overview
In a series of papers (Wilbur 2003, 2008, 2009), Wilbur shows that there is a non-arbitrary form-to-meaning correspondence in the verbal lexicon of several unrelated sign languages. Specifically, in these sign languages, she observes that the phonetic form of telic verbs systematically differs from that of atelic verbs: the former show abrupt deceleration to a stop; the latter do not. The basic pattern can be illustrated with the signs ARRIVE and PLAY in American Sign Language (ASL). The verb arrive is telic in ASL and English, as evidenced in English by its incompatibility with for-adverbials (as in (1a)); the verb play is atelic in ASL and English, as evidenced in English by its grammaticality in the same environment. Wilbur and Malaia (2012) show that related tests hold in ASL. In ASL, these verbs differ in an important phonetic way as well. The telic verb ARRIVE ends with sharp deceleration (’slamming on the brakes’), as the dominant hand makes contact with the non-dominant hand (see Figure 1a)). In contrast, the atelic verb PLAY has no sharp stop, being signed with a back-and-forth twisting motion of the two hands that can be extended to an arbitrary length (see Figure 1b)).

(1) a. * John arrived for twenty minutes. → telic
   b. John played for twenty minutes. → atelic
This phonetic generalization holds across a wide range of lexical predicates, including psychological and social verbs like PONDER vs. DECIDE and NEGOTIATE vs. BUY.

This phenomenon has been argued to be grounded in a more general cognitive representation of event structure. Malaia (2014) draws connections to psychological work (Zacks et al. 2007) which shows that the same visual cues (e.g., rate of deceleration) are employed in event segmentation in completely non-linguistic tasks. In a forced-choice meaning-guessing task, Strickland et al. (2015) show that naive non-signers, too, are sensitive to the connection between telicity and the phonetic form of a sign. These findings illustrate a surprising, robust connection between the visual system and abstract, conceptual space.

In sign language, this connection plays an active part in the grammar: Wilbur (2003, 2009) shows that in ASL, the phonetic form can be manipulated in the synchronic grammar with semantic effects. These manipulations include stopping the motion of a telic verb before completion, slowing the motion of a verb, and reduplicating a verb in various ways. For example, the verb SIT-DOWN in ASL ends with contact between the signer’s two hands; if the sign is produced without this contact at the end, the verb is interpreted roughly as ‘almost sat down.’

How are these phonetic effects encoded into the grammar? While acknowledging the iconic origin of these effects, Wilbur (2003, 2009) takes this connection to be purely historical. As far as the synchronic grammar is concerned, Wilbur proposes that phonetic features are discretely codified in the grammar as a finite set of combinatorial morphemes; she argues that the productive patterns emerge from the combination of these sub-lexical morphemes, spelled out in terms of Ramchand’s (2008) state-based decomposition of verbs. Notably, under her analysis, there is nothing fundamentally different in the syntax between phonetic modifications in ASL and morphemes like the -ing of swimming in English.

In this paper, contra Wilbur, I advocate for an analysis in terms of structural iconicity, in which an iconic, structure-preserving mapping from a verb form to its meaning remains active in the grammar (as opposed to just a grounding for a set of morphemes). As evidence, I present

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1 Wilbur discusses findings from American Sign Language (ASL), Croatian Sign Language (HZJ), and Austrian Sign Language (ÖGS); Strickland et al. (2015) show similar results hold for Italian Sign Language (LIS), Sign Language of the Netherlands (NGT), and Turkish Sign Language (TID).

2 Sources of images: The images of ARRIVE and CLOSE in Figures 1 and 2 appear courtesy of Bill Vicars and http://www.lifeprint.com/. The diagrams in Figure 6 and 7 also include an image from http://www.lifeprint.com/. The image of PLAY in Figure 1 was drawn using images from Gallaudet-TT font by David Rakowski.
examples with gradient interpretive effects that cannot be generated by a discrete combinatorial system alone. Formally, I retain the Ramchandian assumption of sub-lexical decomposition, but follow a large body of recent work in which verbal meanings are derived from scales, not states (Hay et al. 1999, Kennedy and Levin 2008, i.a.). I argue that verbs in ASL iconically represent these scales: motion of the sign is mapped to progress of the event, and end-marking iconically maps to the maximum of a closed scale.

The resulting analysis has several important implications for the way that iconicity interacts in the grammar. First, we observe that pictorial information can be categorized according to logical properties; thus, the output of an iconic mapping can feed grammatical distinctions like diagnostics for telicity. Second, we show that the iconic component of meaning cannot always be analyzed as a separate message that is interpreted conjunctively; in certain cases, the iconic mapping must be analyzed as an intensional function that operates on a logical argument. The final picture is a system in which iconicity is interleaved throughout the computation of a logical form.

2 Background

2.1 Telicity many ways

Natural language is known to grammatically categorize verbs based on their abstract temporal properties. The relevant property—telicity—can be observed in a variety of syntactic and semantic phenomena. Most famous in English is the choice of temporal adverbials: atelic predicates are compatible with for-adverbials but not with in-adverbials; the opposite holds for telic predicates.

(2) Atelic predicates
   a. John \{played/pondered the question/negotiated\} for 20 minutes.
   b. * John \{played/pondered the question/negotiated\} in 20 minutes.

(3) Telic predicates
   a. * John \{arrived/decided what to do/bought the car\} for 20 minutes.
   b. John \{arrived/decided what to do/bought the car\} in 20 minutes.

Semantically, the division between telic and atelic predicates can be characterized by a property of divisibility: if an atelic predicate holds of an event \( e \), then it also holds of temporally short sub-parts of \( e \) (Vendler 1957). Formally, (4) implements this insight as the ‘subinterval

\[ (4) \quad \text{if } \phi(\text{atelic}) \text{ then } \phi(\text{telic}) \}

Methodology: New data that is presented in this paper was gathered through fieldwork with a native signer of ASL. Judgments were gathered following the ‘playback method’ (Schlenker 2011). The signer was asked to sign a paradigm of sentences for a video recording. The resulting video was then played back for the same signer, who gave grammaticality judgments using a 7-point scale (7 = best) and answers to any interpretation questions. Judgments could then be repeated on separate days. Generalizations in the present paper are based on at least three ratings of a construction; all sentences reported as grammatical had average ratings of 6 out of 7 or greater.
property’ (Bennett and Partee 1972): atelic predicates have this property; telic predicates do not\(^4\). (Here, \(\tau\) returns the interval of time over which an event occurs; \(<\) indicates parthood.)

\begin{equation}
\text{(4) Definition: Subinterval property (SUB: adapted from Bennett and Partee 1972)}
\end{equation}

\[\text{SUB}(P) := \forall e[P(e) \rightarrow \forall i[i < \tau(e) \rightarrow \exists e'[P(e') \land \tau(e') = i]]]\]

‘A predicate \(P\) has the subinterval property iff, whenever it holds at an interval, it also holds at every one of its subintervals.’

For example, if Eva slept for several hours, every 10-minute subevent also a sleeping event. But, if Eva painted a picture in several hours, it is not possible to divide up the event into short ‘painted-picture’ events, since most subevents will not include a completed painting. \textit{Slept} satisfies (4) so is atelic; \textit{paint a picture} does not so is telic.

Intuitively, the source of this difference—the reason why telic verbs do not have the subinterval property—is the presence of a \textbf{result state} in the meaning of telic verbs. The insight (dating back to Aristotle’s \textit{Metaphysics}) is that telic verbs denote events that are more than the sum of their parts. For example, the process of pondering and and the process of deciding are exactly the same; the difference is that the latter results in something new—the decision. The fact that this new state of affairs results from the process as a whole is what prevents the predicate’s denotation from holding of small subevents. (This result state is Aristotle’s \textit{telos}, or ‘purpose,’ from which telicity gets its name.)

While the telic/atelic distinction can be uniformly characterized by a logical property like the one above, a host of syntactic and semantic properties conspire to determine the whether this property holds of a given predicate (Tenny 1992, 1994; Krifka 1998). For example, for some predicates (those with an ‘incremental theme’), the telicity of the predicate is determined by the semantic properties of its nominal arguments: ‘\textit{eat an apple}’ (with a count noun) is telic, but ‘\textit{eat rice}’ (with a mass noun) is atelic. For other predicates, the telicity seems to come built-in; for example, ‘\textit{look at an apple}’ and ‘\textit{look at rice}’ are both atelic, regardless of the semantic properties of the noun. (For more on incremental themes, see Krifka 1989, among others.)

Ramchand (2008) argues that verbs are structurally complex, and that the telicity of predicates is in part determined by the sub-lexical decomposition of the verb. Most notably, she argues that a certain class of telic verbs (roughly, those that fall into the Vendler (1957) class of Achievements), derive their telicity from the presence of a syntactic head \textit{res} that introduces a result state into the lexical meaning. For example, the structure in (5) provides Ramchand’s lexical decomposition of the verb \textit{break}, applied to the argument the \textit{window}. Of relevance, the fact that this structure comes with a built-in \textit{resP} means that the verb is necessarily telic. Other English verbs in this category include: \textit{throw}, \textit{find}, \textit{explode}, \textit{enter}, \textit{arrive}, and \textit{disappear}.

\(^4\)The subinterval property can also be stated as the ‘divisive reference’ of Cheng (1973), and is related to the ‘cumulative reference’ of Quine (1960); Champollion (2010) argues for a revised formulation of divisive reference called ‘stratified reference’. Similarly, telic predicates have been argued to have ‘quantized reference’ (Krifka 1989). While these definitions differ in their precise formulation, they share the core idea that a uniform logical concept can be used to determine the grammatical class of a predicate.
Another class of verbs which may be telic are degree achievements that denote progression along some closed scale, e.g. *dry* (we return to scales in §4). These verbs have the unique property that they are systematically ambiguous between a telic and atelic meaning, evidenced by their compatibility with both *in-* and *for-*adverbials (as seen in (6)); under the telic reading with *in-*adverbials, they receive the meaning that a change in measure (e.g. dryness) reached its maximal degree. Other English verbs in this category include *cool, straighten, close,* and *fill*.

(6) a. The towel dried in an hour.
   b. The towel dried for an hour.

Since these verbs may receive an atelic interpretation, they cannot come with a built-in *res* feature; the telic interpretation must therefore come from somewhere else. Ramchand proposes that, like incremental theme verbs such as *eat*, degree achievements also inherit their telicity from an argument, but that in the case of degree achievements, it is an implicit, scalar argument.

Finally, Ramchand (2008) proposes that a *res* feature may be added to a verb of any class by the addition of a particle. Specifically, in particle-verb constructions like *eat up, break off,* and *cool down,* where a particle can be optionally separated from the verb, Ramchand proposes that the particle itself bears a *res* feature. The result is that particle-verb constructions necessarily yield a telic predicate. The example in (7) provides a minimal pair: while the former predicate may be used in an atelic frame, the latter predicate, with a particle, is necessarily telic.

(7) a. I ate the leftover turkey for two weeks.
   b. * I ate up the leftover turkey for two weeks.

Under this analysis, the particle in a particle-verb construction is essentially an overt reflection of the *res* feature in English.

In sum, telic predicates are characterized by a shared logical property, but do not derive this property from a homogenous mechanism. Above, we have seen at least four kinds of telic predicates, which pattern in empirically different ways. Of note, we should flag the relation between ‘inherently telic’ verbs like *break* and degree achievements like *dry*. As we have seen, Ramchand’s state-based analysis requires these two categories to derive their telicity through syntactically distinct mechanisms: the former via its lexical entry; the latter via an implicit argument. In what follows, I will adopt an opposing view in which the two categories are united. In both cases, the sublexical decomposition encodes a scale; the distributional differences between the two categories arise from the logical properties of the component scales.
2.2 Visible telicity

Wilbur (2003) observes that, in ASL, the telic/atelic distinction is correlated with certain phonetic properties. Roughly speaking, telic verbs tend to end with a sharp stop (and often contact with another part of the body); atelic verbs generally have no such phonetic end-marking. Malaia and Wilbur (2012) provide experimental support for this generalization based on quantitative measurements of lexical predicates in two unrelated sign languages, ASL and HZJ. Using 3D motion-capture recordings, they report that both languages show a significant correlation of telicity with several phonetic features (including maximum peak velocity and rate of deceleration following peak velocity). These phonetic effects are dissociable from other properties affecting signing rate like phrase-final lengthening.

However, in light of the many factors that conspire to generate a telic predicate (as discussed in the previous section), the interpretation of Wilbur’s generalization is not entirely straightforward. In particular, does the presence of phonetic end-marking correspond to a semantic property of the output form (e.g. lack of Stratified Reference), an abstract morpheme in the syntax (e.g. res), or something else? Wilbur (2008, 2009) takes an explicit stand on this question. Under the ‘Event Visibility Hypothesis,’ Wilbur proposes that the phonetic end-marking of telic events in sign language is a reflection of an abstract result state in the sub-lexical decomposition; in Ramchand 2008’s terms, it is an overt manifestation of the res feature. Essentially, then, the sharp stop of ARRIVE is a reflection of the same abstract morpheme instantiated by the up of eat up. On Wilbur’s analysis, the sign language data thus provides another kind of evidence for a state-based sub-lexical decomposition of verbs.

Wilbur 2008 provides evidence for the claim that phonetic end-marking in ASL has a syntactic status by showing that it can be manipulated with semantic effect. For example, the sign for ARRIVE is made by moving the dominant hand to make contact with the non-dominant hand, as shown in Figure 1a; if the sign is produced without this end-marking, the sign is interpreted roughly as ‘almost arrived’ (Liddell 1984). Wilbur 2008 argues that this meaning results from an ‘incompletive’ morpheme (similar to English almost) that modifies the result state instantiated by contact between the hands.

When we consider Wilbur’s theory in the more precise terms discussed above, however, the generalization becomes somewhat more shaky. In particular, we face seeming counterexamples when we consider telic degree achievements like close and fill. In ASL, the sign CLOSE (a door) is made by moving the dominant hand to make contact with the non-dominant hand, as seen in Figure 2a. The verb fill is signed in several ways in ASL; Figure 2b shows the sign GET-FULL (as in, ‘I got full from eating so many cookies’), where the hand makes contact with the chin.

These two verbs show end-marking and are telic; thus, at a first pass, they may seem to support Wilbur’s hypothesis. But although the verbs are telic, we saw evidence from English that they do not bear a res feature; instead, they inherit their telicity from an implicit scalar complement. These verbs thus provide a counterexample to the claim that end-marking is the overt spell-out of res. Naturally, we can’t conclude anything about ASL signs just by looking at their closest English translation; these arguments must be made based on ASL-internal data. Nevertheless, the examples with CLOSE and FILL are suggestive that Wilbur’s generalization
about the distribution of end-marking (namely, as the spell-out of res) is not quite the correct natural class.

In what follows, I will argue that, in general, Wilbur’s theory is not able to capture the full range of data; in particular, I will show that there are more manipulations that can be done to verbs in ASL than can be described by manipulating res and other discrete morphemes. I will argue that these data must be described through an iconic mapping. Like Wilbur (and Ramchand, etc.), I will adopt a theory with sub-verbal decomposition. Departing from these theories, however, I will follow Hay et al. (1999) and Kennedy and Levin (2008) in the proposal that all verbs (not just degree achievements) are decomposed into a logical form with a scale (e.g. for widen, the scale is the totally-ordered set of possible widths). I will propose that verbs in ASL display an iconic mapping that represents change along this scale. End-marking is the iconic representation of the closed end of a scale.

This analysis will yield a natural class that cleanly encompasses both ‘inherently telic’ verbs like ARRIVE and telic degree achievements like CLOSE: both are built from scales with a maximum degree. The difference between the two is that verbs like ARRIVE are built from degenerate scales that only have two points (although a richer scale can often be coerced by iconic manipulations). In either case, reaching a phonetic endpoint generates the inference that a maximum degree is attained, producing a telic predicate.

3 Iconic manipulations

In this section, I will argue that manipulations of the phonetic form of verbs are interpreted iconically in ASL. As background, I will start with the manipulations described by Wilbur, along with her analysis. I will then show that the phenomenon is more general than Wilbur’s analysis allows, and that the manipulations Wilbur describes arise as a special case of this more general mapping.

3.1 Wilbur’s observations

Wilbur (2003, 2008, 2009) shows that the phonetic form of a sign can be manipulated with semantic effects. She discusses several classes of examples, including extended path movement,
incompletive marking, and reduplication. Wilbur analyzes these as arising from the combination of discrete morphemes.

First, Wilbur (2008) observes that the motion of a sign may be elongated to indicate an elongated event. Specifically, when a sign includes a ‘path motion’—i.e. movement from one position to another—the duration of the motion can be extended from the default speed, often by adding an arc movement. The resulting semantic inference is that the event occurred slowly. For example, when ARRIVE is signed slowly in (8), the interpretation is that the arrival happened slowly.

(8) FINISH–LINE I SEE, ARRIVE-slow.
    ‘I saw the finish line, then arrived at it slowly.’

Wilbur analyzes this elongation of the sign as a morpheme [extra] with an adverbial meaning (something like ‘over an extended time’). This analysis makes the prediction that there are only two possible forms of a verb with respect to this manipulation: either the verb has [extra] or it doesn’t.

Second, as mentioned above, a path movement can be halted before completion of the sign to produce an incompletive meaning for a telic verb (as mentioned above for ARRIVE). Wilbur (2008) reports, following Smith (2007), that there are in fact two forms of the incompletive. If the sign is halted immediately after it begins, then it is interpreted as meaning that the event barely even started to happen.

(9) I SIT-DOWN-unrealized-inceptive. (Wilbur 2008)
    ‘I almost started to sit down.’

If the sign is halted immediately before it would otherwise be completed, then it is interpreted as meaning that the event started to happen but didn’t quite finish.

(10) I SIT-DOWN-incomplete. (Wilbur 2008)
    ‘I almost sat down (but stopped myself before contacting the seat).’

Wilbur proposes that both of these forms are the spell-out of an incompletive morpheme that has a meaning similar to English almost. In particular, she notes that English almost is known to be ambiguous with telic events in English, producing meanings similar to the ones described for (9) and (10) above. This ambiguity has been argued to result from an attachment ambiguity (e.g., Dowty 1979, Pustejovsky 1991).

(11) I almost sat down. (English)

In (9) and (10), I am faithful to the notation used by Wilbur (2008); however, these glosses imply a binary distinction that I will ultimately argue against. The following alternative, for both (9) and (10), is somewhat more cumbersome, but is truer in spirit to the analysis to come: ‘I SIT-DOWN-incomplete-to-the-degree-shown’.

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Wilbur argues, following Smith (2007), that the two forms in (9) and (10) correspond to the attachment of the incompletive morpheme at different heights. Though Wilbur is not explicit about this point, we are led to understand that the morpheme is spelled out by deleting the phonological realization of its complement. The result is that the two structures are disambiguated, depending how much phonological material is deleted. This analysis makes explicit predictions: namely, there can be only as many incompletive forms as there are syntactic levels where the incompletive morpheme can attach. If there are two levels (as suggested by the two readings English *almost*), then there should be exactly two distinct incompletive forms in ASL.

Finally, Wilbur (2009) discusses cases of reduplication in ASL, which give a predicate a pluractional meaning. Myriad reduplicative verbal forms have been described in ASL, including ones labeled ‘durative,’ ‘iterative,’ ‘continuative,’ ‘incessant,’ and ‘habitual’ (Klima and Bellugi 1979). Wilbur argues that a wide typology of these forms can be generated based on what subtree of the verbal decomposition is targeted by the reduplicative morpheme, and whether the morpheme [extra] appears on these subtrees. Because the issues introduced by plurality are quite complicated, I will not discuss reduplication in depth here; however, see Kuhn and Aristodemo (2017) for a discussion of pluractional inflection in French Sign Language (LSF) and American Sign Language, where it is argued that these constructions also display an iconic mapping.

### 3.2 The iconic mapping

Following Schlenker, Lamberton, and Santoro (2013), I take ‘iconicity’ to refer to a mapping that preserves abstract structure from the form of a sign to its meaning. In the case at hand, I will argue that an iconic mapping preserves gradient temporal information contained in the phonetic form of a verb. Specifically, when a verb has a phonological path motion (i.e. when it moves without regression from one position in space to another), I will argue that this path is iconically mapped to the temporal progression of the event the verb denotes.

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6 Note that Wilbur is forced to say that the incompletive construction is formed by the *addition* of an incompletive morpheme (instantiated by removing segments from the phonological form) as opposed to the *removal* of the result state in the syntax. This is necessary because the events denoted by incompletive verbs are still telic events (as seen in (13)); literally removing the result state would incorrectly make the predicate atelic.

(13) ?? ME SIT-incomplete (FOR) ONE MINUTE.
Intuitively, the effect of this mapping should feel very similar to the patterns described by Wilbur: for example, an extended phonetic path is interpreted as a temporally extended event; an incomplete motion is interpreted as an incomplete event. The difference, though, is that an iconic mapping is more general and more powerful, allowing manipulations that cannot be captured by discrete morphemes alone. In particular, I will argue that the iconic mapping preserves geometric structure, yielding gradient interpretation of gradient phonetic manipulations. Following Emmorey and Herzig (2003), I will use gradient interpretation as a diagnostic for iconicity.

If indeed there is a measurement-preserving iconic mapping, then why does Wilbur not find any gradient effects? The explanation arises from the fact that the mapping preserves only relative measurement, not absolute measurement. For example, the form for the verb DIE may be completed in a matter of seconds, yet still denote an event which takes months to elapse. Nevertheless, if two forms of DIE signed at different speeds are brought into comparison, then the slower sign must denote the slower event. What this example illustrates is that, when an event preserves only relative information, it is impossible to make any iconic inferences without a standard for comparison.

When a sign is produced in isolation, the only standard for comparison is the default form of the sign (relative to the rate of signing). If a sign is produced in an unexpected way—for example, at a speed that is markedly slower than the overall rate of sign—then it is interpreted in a meaningful way. However, since the default form and canonical meaning are determined by context, the result is an inherently vague interpretation. The situation is familiar from the case of vague adjectives, discussed by Kennedy (2007). In isolation, the adjective tall is vague, since the standard for comparison—i.e., what counts as ‘tall’—must be inferred from context. In contrast, the sentence ‘Ivan is taller than Dmitri’ yields crisp judgments: nothing needs to be taken from context, so half a centimeter difference in height is enough to verify or falsify the sentence. Wilbur’s examples, which look at signs in isolation, can only communicate information about marked or unmarked speed, so are inherently vague. In order to get crisp judgments on gradient forms, it is necessary to provide an overt comparative form.

### 3.3 Gradient iconic manipulations

First, we turn to cases of extended path movement, focusing on paradigms where instances of the same verb are produced at a variety of different speeds.

As it turns out, verbal reduplication provides a conveniently minimal example where many forms of a verb can be put into comparison at once. In ASL (like many other sign languages), a verb can be reduplicated multiple times to express that an event happened again and again. Critically for us, pronunciation of each repetition can vary in speed. When repetitions of the verb are produced at different speeds, the interpretation reflects the difference.

Figure presents one attested example, where the sign for GIVE accelerates from a length of 0.27 seconds down to a length of 0.07 seconds. (In the graph, black bars represent the forward motion of the sign.) The resulting interpretation is that the event occurred at a speed that increased over time. Critically, the interpretation of acceleration is only possible with
more than two levels of speed represented. Wilbur’s analysis, with a single [extra] feature, undergenerates.

Thus, we conclude that the iconic mapping keeps track of gradient information regarding the relative speed of events. The binary examples reported by Wilbur are the special case that emerge when the only comparison class comes from context.

Next, we turn to rapid deceleration to a stop, as it appears at the end of telic verbs and on incompletive forms. Unlike the speed manipulations above, we observe that rapid deceleration is *not* directly interpreted by the iconic mapping. For example, when the sign ARRIVE is signed slowly, as in (8), it may nevertheless speed up then decelerate immediately before contact. This does not generate the inference that the individual changed their speed right before arrival—it just emphasizes that the individual finally arrived. I thus adopt the insight from Malaia and Wilbur (2012) and Malaia (2014) that rapid deceleration is a cognitively domain-general mechanism for identifying distinguished points of events. I take this to be a separate system that feeds into the iconic mapping described here.

I depart from Wilbur by proposing that these boundary markers can be placed anywhere in the course of the sign and that the iconic mapping is gradiently sensitive to the extent of motion that has transpired by the point of the marker. Final end-marking, then, is just a special case when this marker happens to line up with the end of the path motion. The cases of incompletive forms discussed by Wilbur already suggest that something like this may be the case: stopping the motion of SIT-DOWN at the beginning of the sign produces a different interpretation than stopping the motion at the end of the sign (see above, in (9) and (10)).

To test the availability of further levels, we turn to examples where motion of the sign stops multiple times during production, generating a ‘bit by bit’ interpretation. I will construct the argument with the verb DIE in ASL, shown in Figure 4: one hand turns palm-down to palm-up as the other turns the opposite direction. (For space reasons, the subsequent images in Figure 5 depict only the motion of the right hand, but the motion of the left hand is parallel.)

As we have seen for SIT-DOWN and ARRIVE, DIE allows motion to be stopped before completion, as in Figure 5a, resulting in the interpretation that the subject almost died. However, the motion need not stop completely after this intermediate pause; it may continue to its normal end point, as shown in Figure 5b. The resulting inference of this second form is that the subject died, but that the death was interrupted by a period with no decline of health. Finally, the sign DIE can be interrupted by arbitrarily many such pauses, as in Figure 5c; the resulting inference of this ‘bit-by-bit’ inflection is that the subject died gradually, reaching successive states of decreased health until death.
What is of note about this final form is that arbitrarily many stops can be included, distributed throughout the production of the sign. In order to get the attested meaning, it must be possible to track different extents of completion of the event. Notably, Figure 5c has a distinct meaning from simply reduplicating the incompletive form in 5a: a reduplicated 5a can mean that health increased in between the points; 5c means that the health did not.

Moreover, these intermediate markers are sensitive to fine-grained temporal and spatial modifications. For example, if there are an increased number of pauses as the motion of the sign nears its end point, this is interpreted as meaning that the subject’s health declined more and more slowly until the moment of death. In order to capture this meaning, the interpretive system must be able to preserve information from at least two different dimensions: the time elapsed and the distance that the hand has traveled.

Recall that Wilbur’s theory predicted that interruptions to a sign should generate only two possible interpretations, depending on location of the attachment ambiguity. What we see here is far more general: there may be arbitrarily many interruptions in a sign; the interpretation of the form is gradiently sensitive to the extent of motion that has transpired at a given point. The situation is not a matter of scope ambiguity; it’s a mater of a gradable pictorial interpretation. As before, the examples described by Wilbur are the special cases that emerge when the only standard for comparison comes from context.
3.4 Summary: iconicity

We have seen that Wilbur’s discrete, morphological analysis fails to generate the full range of manipulations that are available in ASL. As an alternative, I have proposed that verbal manipulations are subject to an iconic mapping that preserves information about the form of the sign. This iconic mapping is sensitive to at least two dimensions—namely, the amount of time elapsed at a given point and the distance that the hand has traveled at that point. In the next section, I develop an analysis of change-of-state verbs based on scales that allows us to formalize this iconic mapping.

4 Scales, not states

In §2.1, I introduced the fact that a result-state analysis is not viable for degree achievements like dry and close, in light of their variable telicity. On such an analysis, a special mechanism needed to be assumed by which these verbs inherit their telicity from an implicit complement.

A recent body of work on the scalar properties of adjectives and verbs flips the perspective (Hay et al. 1999, Wechsler 2005, Kennedy and McNally 2005, Rappaport-Hovav 2008, Kennedy and Levin 2008, Pedersen 2014, i.a.). Specifically, on these theories, degree achievements are treated as instantiating the general case of verbal telicity. As in Ramchand (2008) (and related theories), verbs are structurally complex; however, from the revised perspective, telic verbs and degree achievements are built from a scale, not from a result state. Telicity arises from the properties of these scales. From this point of view, inherently telic predicates like arrive arise as a special case, as degenerate scales with only two points.

Scales are defined to be a set of totally-ordered degrees along some dimension (width, dryness, etc.). Together with the lexical meaning of the verb, we are able to associate this set of degrees with a set of states (e.g. the state where \( x \) has degree \( d \)). In this respect, the scalar analysis is strictly richer than the result-state based analysis; information about a result state is fully recoverable from the scalar component. I will argue that this degree of richness gives us the necessary power to describe the iconic mapping that we have observed in ASL. Notably, the iconic representation of closed scales will derive both the interpretation of iconically incomplete forms as well as Wilbur’s generalization about end-marking and telicity.

4.1 Scales in adjectives and verbs

Kennedy and McNally (2005) observe that many adjectives come associated with scales. These scales allow adjectives to show gradability with degree modifiers like very (e.g. very tall, very wet). Constructions like how-questions also provide direct reflection of these scales, as their meaning must be stated in terms of an ordered set of points.

(14) a. How large is the box?
    b. How wet is the towel?
    c. How straight is the path?
A scale, as a totally ordered set, can be characterized by certain mathematical properties. Kennedy and McNally (2005) show that adjectives can be classified by whether their associated scale contains a maximal and/or minimal element (in set terms, a supremum and/or infimum).

(15) Possible structures of gradable adjectives:

- **totally open**
  - *tall, wide*

- **top closed**
  - *straight, dry*

- **bottom closed**
  - *bent, wet*

- **totally closed**
  - *full, closed*

Kennedy and McNally (2005) demonstrate that natural language reflects this classification in a variety of ways. For example, some degree-modifiers are only available for scales with certain properties: *slightly* can only modify scales that are closed on bottom (e.g. *slightly wet* vs. *slightly {tall, dry}*); *completely* can only modify scales that are closed on top (e.g. *completely straight* vs. *completely {tall, bent}*); *half* can only modify scales that are closed on top and bottom (e.g. *half full* vs. *half {tall, straight, wet}*).

Non-gradable adjectives can be subsumed into this point of view: non-gradable adjectives (e.g. *very dead*) correspond to degenerate scales consisting of only two-points. For example, the adjective *dead* is associated with the two-point scale {*alive, dead*}.

(16) Scale structure of non-gradable adjectives:

- **two-point**
  - *dead, awake*

As it turns out, verbs are sensitive to exactly the same categories as adjectives (Hay et al. 1999, Kennedy and Levin 2008, *i.a.*). The clearest examples are adjective/verb pairs with an overt morphological connection, like *wide/widen, straight/straighten, open/open, awake/awaken*. Importantly, the different categories pattern differently with respect to telicity. As we have seen, verbs based on closed scales have a telic and an atelic reading, as in (17). In contrast, verbs based on open scales are always atelic, as seen in (18). Finally, the category of ‘inherently telic’ verbs, such as *awaken* and *die*, turn out to be exactly those verbs that are built on two-point scales (Wechsler 2005, Beavers 2008, Rappaport-Hovav 2008).

(17) a. The towel dried for an hour.
   b. The towel dried in an hour.
(18) a. The gap between the boats widened for a few minutes.
   b. *The gap between the boats widened in a few minutes.
(19) a. *My grandmother died for two months.
   b. My grandmother died in two months.
The parallels between adjectives and verbs motivates an analysis on which both adjectives and verbs are morphologically complex, built out of a shared semantic scale. We sketch the core of these analyses here, based largely on the proposal by Kennedy and Levin (2008). For a given scale $S$, let a measure function $\mu$ be a function that maps each individual and time to a measurement with respect to that scale. For example, a measure function associated with wide/widen maps an individual to a degree corresponding to its width at a given time. Scalar adjectives are generated by the application of a positive morpheme $\text{pos}_A$ to the measure function $\mu$; this returns true of an individual $x$ and time $t$ if $\mu(x)(t)$ is contained in a salient upward closed subset of the scale.\(^7\) (For open scales, the cut-off comes from context; for closed scales, it generally comes from the maximum or minimum element; see Kennedy 2007 for details). Example (20) illustrates with a derivation for the adjective wide.

(20) \[ \text{[wide]} \] = $\text{pos}_A(\text{width})$

= True of $x$ and $t$ iff the width of $x$ at $t$ is greater than some standard.

As with adjectives, scalar verbs are decomposed; however, since verbs denote a change of state, the positive morpheme must manipulate a \textit{pair} of measures—the measure of $x$ at the start of $e$ (‘start($e$)’) and the measure of $x$ at the end of $e$ (‘end($e$)’). The positive morpheme $\text{pos}_V$ applies to $\mu$, an individual $x$, and an event $e$, and considers not the full scale $S$, but rather the subset $T$ of $S$ that includes all degrees greater than or equal to the measure of $x$ at the start of $e$; that is, $T = S \cap \{d : d \geq \mu(x)(\text{start($e$)})\}$\(^8\) The positive morpheme $\text{pos}_V$ is true of $\mu$, $x$, and $e$ if $\mu(x)(\text{end($e$)})$ is contained in a salient upward closed subset of $T$, thus entailing that there is a positive change in $\mu(x)$ over $e$. Example (21) illustrates with a derivation for the verb widen.

(21) \[ \text{[widen]} \] = $\text{pos}_V(\text{width})$

= True of an individual $x$ and and event $e$ iff the width of $x$ at the end of $e$ is greater than some standard—namely, the width of $x$ at the start of $e$.

= True iff $x$ increases in width over $e$.

As seen in (21), a scalar verb meaning can be quite weak, entailing only that there is positive change along the scale. Additionally, verbs may optionally entail that $\mu(x)(\text{end($e$)})$ attains a certain salient value—notably, verbs based on top-closed scales may entail that the change

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\(^7\) $P$ is an upward closed subset of $Q$ if $\forall x, y \in Q[\{x \in P \land y \geq x\} \rightarrow y \in P]$.  

\(^8\) By taking the subset of a scale closed on the bottom by the measure at the start of an event, $\text{pos}_V$ effectively adds a minimum to any scale, whether it originally had one or not, thus putting widen in the same category as moisten (bottom-closed), and dry in the same category as fill (totally closed). That all scales have a minimum in the verbal domain can be observed directly through the same adverbial tests that were used for adjectives: completely still targets only top-closed scales (see (i)), but slightly is compatible with all verbs (see (ii)).

(i) a. * The river widened completely.
   b. The towel dried completely.

(ii) a. The river widened slightly.
   b. The towel dried slightly.
reaches the scalar maximum, yielding a telic meaning. This derives the facts regarding telicity described above. Open scales have no maximum, so verbs built on open scales are never telic. Change along a closed scales can either reach the maximum or not, so verbs built on closed scales are ambiguous. Finally, change along a two-point scale always reaches maximum, so verbs built on two-point scales are always telic.

5 Iconic scales

I propose that phonological path movement iconically represents the scale associated with a change-of-state verb in ASL.\(^9\)

The claim that scales can be iconically represented in sign language has been argued independently by Aristodemo and Geraci (to appear) for adjectives in Italian Sign Language (LIS). They show that when the phonological form of an adjective includes a path motion, a comparative form can be constructed by signing the adjective at two different positions along the path motion. For example, in both LIS and ASL, the adjective TALL is signed with a bent flat hand held at some height in front of the speaker. The same sign can then be repeated at a higher height to indicate that a second individual is taller than the first. The distance between the two phonological forms is interpreted to indicate the relative degree of difference in the two heights. Aristodemo and Geraci (to appear) demonstrate that an analogous pattern holds across a wide range of gradable adjectives, including ones involving abstract scales like CULTIVATED.\(^10\)

(22) **Italian Sign Language** (from Aristodemo and Geraci to appear)

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MARIA TALL-x GIANNI TALL-x-iconic-more-y.
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‘Gianni is taller than Maria.’

As discussed in §4, scales may be open or closed at either end; Aristodemo (ms.) shows that closed scales may be iconically represented in LIS by phonetic motions that are bounded on one end by contact of the dominant hand with another part of the body. For example, the adjective FULL in LIS is signed by making contact between the two hands; the result is that the adjective lacks the imprecision that generally characterizes gradable adjectives. For example, the English adjective full can be used to characterize a glass of wine with enough space at the top to swirl the wine; in contrast, the predicate FULL in LIS only holds of wine glasses that are completely full—full to the brim. Like the closed scale it represents, the hand literally can’t move any further along the relevant spatial axis.

\(^9\)It may turn out that verbs iconically represent even more information than just the scale associated with a verb. For example, Philippe Schlenker (p.c.) reports gradient judgments for paradigms involving the sign HIT-MISS ‘tried to hit but missed,’ where the distance by which the hit was missed is gradiently interpreted depending on the distance between the two hands. What is necessary for the current analysis is that the iconically represented scale that I describe here is available, either as a primitive in itself or as derived from a more general iconic mapping.

\(^10\)Note that these scales need not always be iconically instantiated; for example, the scale associated with smart is no more abstract than the scale associated with cultivated, but SMART in LIS does not have the necessary morphophonological properties to represent a scale.
5.1 Iconic scales on verbs

I propose that the same scales that are iconically represented in adjectives are also iconically represented in change-of-state verbs in ASL. As discussed in §4, the same scale may form the semantic core of both an adjectival form and a verbal form, generating pairs like *wide* and *widen* in English. In ASL, similar pairs can be found, differing only in their phonological movement. For example, TALL in ASL is signed with bent hand and a small forward movement; the sign for GROW-UP in ASL is identical, except that the hand moves in a straight, upwards movement.

Notably, the scale that forms the basis of both the adjective and verb is iconically represented in both phonological forms. For the verb, movement along this scale is represented as movement along the phonological path. An analogous pattern can be seen with the adjective BIG, and the verbs GET-BIGGER (with a movement outwards) and SHRINK (with a movement inwards).

If scales are iconically represented in verbal forms, then the gradient manipulations described in §3.3 can be explained as an iconic mapping that preserves both scale structure of the event (as represented by distance along the phonological path movement) and time-course of the event (as represented by the time-course of the phonetic motion). More precisely, for each point in the production of a verb, we say that (a) the time that has elapsed after the onset of the sign is proportional to the time that has elapsed after the start of the event, that (b) the distance traveled by the hand is proportional to the change along a scale, and finally, (c) when a phonetic form reaches a maximal distance (perhaps due to body contact), the event reaches the maximal degree of a closed scale.
5.2 Iconic constraints

In order to formally state these iconic constraints, we will need to introduce a well defined way to compare ratios of scalar intervals. Here we follow Krantz et al. (1971) in defining measure functions with respect to homomorphisms on the real numbers, so that the mathematical functions $+$, $-$, $\times$, $\div$ are well defined with their standard meaning. This approach to degrees in natural language has been advocated for by Lassiter (2011), following insights from Cresswell (1976) and van Rooij (2010), among others.

For a given scale, let a measure function $\mu$ be a function $X \rightarrow \mathbb{R}$ that maps each individual to a real number measurement with respect to that scale. A given scale may have multiple admissible measure functions—for example, temperature is measured in either Celsius or Fahrenheit—but the set of admissible functions are constrained to preserve structural properties. Most notably, transformations between measure functions are order-preserving: if $\mu$ and $\mu'$ are two measure functions for the same scale, then $\mu(x) > \mu(y)$ if and only if $\mu'(x) > \mu'(y)$. Here, we additionally assume that all discussed scales are interval scales, as defined in (23).

(23) If $S$ is an interval scale, and if $\mu$, $\mu'$ are measure functions of $S$, then there exists $\alpha \in \mathbb{R}^+, \beta \in \mathbb{R}$ such that for all individuals $x$, $\mu'(x) = \alpha \times \mu(x) + \beta$.

Importantly, on interval scales, the ratio of differences is does not depend on the choice of measure function,$^{11}$ allowing us to compare the rate of change of two events, as in (24). This is exactly what is needed in order to formalize the iconic constraints described above, in which the rate of change of an event is compared to the rate of change of a phonetic movement.

(24) The temperature rose twice as fast during the second hour as it did during the first hour.

We state the iconic constraints formally in what follows. Let $\Phi$ be the phonetic form of a particular production of a verb. Let $\mu$ be any measure function associated with the verb. Let $e$ be an event and $x$ an individual. We would like to define a function $\text{Icon}_\Phi(\mu)(x)(e)$, that is is true if the change in the measure of $x$ over the course of $e$ matches the change in hand-position over the course of $\Phi$. For example, Figure 8 provides a graph corresponding to a possible form of the verb CLOSE, in which the phonetic form starts out fast, decelerates half-way through, and is never completed. $\text{Icon}_\Phi(\mu)(x)(e)$ will ensure that an identical graph tracks the degree of closure over the course of $e$.

First, we define a function $\tau_e$ that corresponds the time-course of $\Phi$ with the time-course of $e$. For any time $t_\Phi$ in the pronunciation of the verb, $\tau_e(t_\Phi)$ is the time in the runtime of an event $e$ such that the same percentage of time has elapsed in the runtime of $e$ at $\tau_e(t_\Phi)$ and in the runtime of the pronunciation at $t_\Phi$. Below, start$(e)$ returns the start time of $e$; end$(e)$ returns the end time of $e$; onset$(\Phi)$ returns the start time of $\Phi$; coda$(\Phi)$ returns the end time of $\Phi$.

$^{11}$Proof that the ratio of differences is invariant for interval scales:

$$\frac{\mu'(w) - \mu'(x)}{\mu'(y) - \mu'(z)} = \frac{\alpha \mu(w) + \beta - (\alpha \mu(x) + \beta)}{\alpha \mu(y) + \beta - (\alpha \mu(z) + \beta)} = \frac{\alpha(\mu(w) - \mu(x)) + \beta - \beta}{\alpha(\mu(y) - \mu(z)) + \beta - \beta} = \frac{\mu(w) - \mu(x)}{\mu(y) - \mu(z)}$$
Figure 8: Phonetic form and event progression of a decelerating incompletive form.

(25) Definition ($\tau_e$):
$$\frac{\tau_e(t_\Phi) - \text{start}(e)}{\text{end}(e) - \text{start}(e)} = \frac{t_\Phi - \text{onset}(\Phi)}{\text{coda}(\Phi) - \text{onset}(\Phi)}$$

For example, as in Figure 8, suppose that $\Phi$ is a production of the verb close that lasts 0.6 seconds, and that $e$ is a closing event that lasts 4 seconds. Under the definition in (25), the time-point 0.3 seconds after the onset of phonetic production is mapped by $\tau_e$ to the time-point 2 seconds after initiation of the closure (since $4 \div 2 = 0.6 \div 0.3$).

Second, we posit an iconic constraint that corresponds the distance that the phonetic form has traveled at time $t_\Phi$ with the degree that the measure has changed in the event at the corresponding time. Namely, for all $t_\Phi$, (26) ensures that the distance that has been crossed at time $t_\Phi$ is proportional to the change in measure at time $\tau_e(t_\Phi)$. Below, $\mu(x)(t)$ is the measure of $x$ at $t$; $d(t)$ returns the location of the articulator along a phonological path at time $t$.

(26) Iconic condition on scalar change:
$$\mu(x)(\tau_e(t_\Phi)) - \mu(x)(\text{start}(e)) \propto d(t_\Phi) - d(\text{onset}(\Phi))$$

For example, suppose again that $\Phi$ is a production of close that lasts 0.6 seconds, and that $e$ is a door-closing event that lasts 4 seconds. As in Figure 8, suppose that at 0.3 seconds into the production of close, the signer’s hand has traveled 75 millimeters, and after 0.6 seconds, the signer’s hand has traveled an additional 15 millimeters. The condition in (26) is true of a closing event $e$ only if the door in $e$ closes five times as fast during the first two seconds as it does during the second two seconds (since $5 = 75 \div 15$).

Finally, we represent the iconic interpretation of end-marking on telic verbs. As indicated above, the maximal distance of a phonological motion (perhaps due to contact with another part of the body) is mapped to a maximum of a closed scale. When such maxima exist, an iconic constraint on endpoints ensures that the remaining distance to the phonetic end-point at time $t_\Phi$ is proportional to the remaining measurement to the scalar maximum at time $\tau_e(t_\Phi)$.
Below, \( \max(d_v) \) returns the maximum distance for a production of the verb \( v \); \( \max(\mu) \) returns the maximum degree in the codomain of \( \mu \).

(27) Iconic condition on scalar endpoints (defined when \( \max(d_v) \) and \( \max(e) \) exist):

\[
\max(\mu) - \mu(x)(\tau_e(t_\Phi)) \propto \max(d_v) - d(t_\Phi)
\]

Observe that \( \max(d_v) \) might not be attained by a particular phonetic production. For example, as in Figure 8, imagine that a production of the verb \( \text{CLOSE} \) ends after having only traversed 90 millimeters of the 100 millimeter gap to the other hand. The condition in (27) is true of a closing event \( e \) only if the door in \( e \) stops when it is 90\% of the way shut. In this way, the condition in (27) accounts for iconically incompletive forms in a manner that is sensitive to the distance that has been traveled by the end of production. As a special case, observe that when the production of a telic verb \( \text{reaches} \) its maximal distance —i.e., when \( \text{coda}(t_\Phi) = \max(d_v) \)— the iconic condition in (27) states that the associated event reaches its scalar maximum. For example, if a production of the verb \( \text{GET-FULL} \) includes contact between the hand and the chin (see Figure 2b), the individual in a corresponding event must reach maximal fullness.

We are now in a position to define an iconic predicate that adheres to the iconic constraints above. This definition is given in (28).

(28) For a phonetic form \( \Phi \) and a measure function \( \mu \), \( \text{Icon}_\Phi(\mu) \) maps an individual \( x \) and an event \( e \) to true iff (26) and (27) are met.

5.3 The meaning of iconic verbs

In §4.1, we defined the meaning of \( \text{pos}_V \), which returns the basic meaning of a scalar verb. Given the new definitions in §5.2, we can now define the meaning of an iconically modified verb in ASL as the conjunction of \( \text{pos}_V \) with \( \text{Icon}_\Phi \), thus adding the entailment that the event progressed in the manner shown. (29) provides an example for the ASL verb \( \text{CLOSE} \).

(29) \( \text{[CLOSE]} = \lambda x.\lambda e. \text{pos}_V(\text{closure})(x)(e) \land \text{Icon}_\Phi(\text{closure})(x)(e) \)

‘There was an increase in closure, and the closure progressed in the manner shown.’

Event predicates are assumed to be existentially closed at the sentential level; thus, a sentence with an iconically-modified verb \( \text{CLOSE} \) will be true only if there is some closing event that transpired in the manner shown. This turns out to predict a rather weak meaning for iconically incomplete forms. In particular, a phonetic form of \( \text{CLOSE} \) that ends 90\% of the way to the other hand entails the existence of an event in which a door reaches 90\% closure. However, note that a fully complete event, in which the door ends up 100\% closed, also contains an initial subevent during which the door attains 90\% closure. We thus predict that an iconically incomplete form is true in situations in which a scalar maximum is in fact reached.

I contend that this is, indeed, a correct prediction, and that the failure to reach a maximum is not entailed by an iconically incomplete form. In particular, example (30) replicates Wilbur’s
incompletive examples with the verb SIT-DOWN, but adds an event that could interrupt a sitting-down event without necessarily preventing it from happening. The judgement of the sentence is parallel to the English translation provided: the sentence is judged as being neutral with respect to whether the signer ultimately sat down or not.

(30) IX-1 SIT-incomplete—FIGHT!
     ‘I was in the process of sitting down when a fight broke out.’

In other cases, iconically incompletive forms do tend to generate the inference that an event is not completed, but this can be explained as a scalar implicature arising from competition with the default (completed) form of the verb. The existential assertion of an event that reaches a certain non-maximal degree is strictly weaker than the existential assertion of an event that surpasses that non-maximal degree: if the semantically stronger form is not uttered, this must then be because it is possibly not true. Indeed, Davidson (2013) shows that scalar implicatures that involve iconicity in ASL are stronger than those generated via lexical items, perhaps due to the expectation that pictorial representations are informationally exhaustive. (It bears noting that Spector (2014) proposes a similar implicature-based analysis for English almost.)

5.4 Iconicity feeds telicity

As we saw in §4.1, the function $\text{pos}_V$ yields ambiguous telicity for top-closed gradable scales, depending on what standard of comparison is chosen. On the other hand, if the production of an ASL verb reaches a maximal point, the meaning encoded by $\text{Icon}_\Phi$ entails that the event reaches a maximum degree. Regardless the contribution of $\text{pos}_V$, this iconic constraint will result in a telic predicate. Thus, while verbs built on top-closed gradable scales in English may be telic or atelic, if an equivalent verb in ASL iconically encodes an endpoint, the resulting verb must be telic. For example, while English close allows an atelic reading with enough context, as in (31), the ASL verb CLOSE, which iconically represents the maximal degree of closure, cannot be used to express an analogous meaning. The ASL verb, in its citation form, entails that the doors closed completely.

(31) The spaceship doors closed for several minutes, but stopped before they were completely closed.

On the other hand, while some ASL verbs built on closed scales iconically encode an maximum degree, it turns out that not all verbs do. One such example is the verb FILL, in the sense of ‘to fill a large vessel.’ To sign this verb, the hands (palms down with fingers outstretched) move upwards, but do not have a predefined endpoint. Since the resulting sign is built on a closed scale, but does not iconically encode the maximum, the result is that the ASL verb is ambiguous in the same way as its English translation.

(32) IX-1 READY BATH. IX-1 CL-turn-knob-on, WATER FILL.
     ‘I prepared the bath. I turned the knob, and the water filled it.’
Critically, the availability of the atelic reading can be observed by the felicity of a continuation that asserts that the bathtub was not completely full, as in (33). This contrasts with the verb GET-FULL, which we have seen includes contact with the chin. In (34), GET-FULL is judged to be contradictory, allowing only the telic meaning in which the maximum is attained. (The sentence is perfectly acceptable when the ‘but’-continuation is removed.)

(33) IX-1 READY BATH. IX-1 CL-turn-knob-on, THREE-MINUTE WATER FILL. BUT FULL BEFORE+CL-1, IX-1 CL-turn-knob-off.
    ‘I prepared the bath. I turned the knob, and the water filled it for three minutes. But, before it was full, I turned off the water.’

(34) * RECENTLY CL-lots EAT WOW. THREE MINUTES EAT IX-1 FILL-UP, BUT FULL NOT-YET, BEFORE+CL-1 IX-1 EAT STOP.
    ‘Recently, I ate a lot. I filled up in three minutes, but before getting full, I stopped eating.’

In the iconic representation of scalar maxima, we see a first simple interaction between iconicity and the combinatorial grammar. The iconic predicate Icon_Φ is fundamentally pictorial; nevertheless, this pictorial information can feed a grammatical distinction—whether or not a predicate is categorized as telic.

5.5 Intensional iconicity

A deeper point of interaction between iconicity and the grammar comes into sharp relief when considering iconically incomplete forms like ‘SIT-DOWN-incomplete’. From a theory-neutral perspective, observe that the inference that an event is incomplete requires reference to what would be the case if it were complete. By referring to other possibilities, this is an inherently modal meaning. The situation is similar to non-intersective adjectives like skillful; an individual may be a skillful doctor, but an unskillful violinist. On the standard analysis (Montague 1970, Kamp and Partee 1995), the adjective skillful must apply to the intensional meaning of the noun. Analogously, in the event described by (35), Teon may have incompletely repaired his bicycle, yet still have completely trued its wheels. The adverb incompletely must apply to the intensional meaning of the predicate.

(35) Teon incompletely repaired his bicycle.

In the definitions provided above, this intensionality is captured by the fact that Icon_Φ is defined as a function that takes a measure function µ as an argument—the same measure function µ that determines the intensional meaning of the associated verb. Thus, the constraint on scalar endpoints in (27) can make reference to the scalar maximum, max(µ), even if this degree is not attained by any event in the extensional denotation of the verb. In this manner, the definition of Icon_Φ shares similar modal properties with the English progressive, as in ‘John was crossing the road,’ as discussed by Dowty (1977) and Portner (1988). Indeed, the situation in ASL has an
additional level of modality that doesn’t appear for the English progressive—namely, the definition of \( \text{Icon} \) must also make reference to other possible forms of the phonetic production. Just as the definition in (27) makes reference to \( \max(\mu) \), a degree that might not be attained in the extension of the denotation, it likewise makes reference to \( \max(d_v) \), a distance that might not be attained in the particular production of the verb \( v \).

What is notable in the present case is that the intensional function is iconically introduced. In general, sign languages, cross-linguistically, are well known for having productive and pervasive iconicity (Cuxac 2001, Liddell 2003, Emmorey 2003). Given the apparently ‘paralinguistic’ nature of iconicity, recent work has investigated the degree to which iconicity is integrated into the combinatorial grammar. Schlenker et al. (2013), for example, show that iconic modifications of pronouns may trigger presuppositions and introduce new discourse referents. Kuhn and Aristodemo (2017) show that iconic modifications of verbs can be at-issue contributions that are evaluated below other semantic operators. In §5.4, we saw a similar example, in which an iconic predicate feeds a grammatical distinction.

Nevertheless, in all previously described cases of sign language iconicity, though the output of an iconic predicate may feed later semantic processes, the way that iconicity is introduced can generally be analyzed as purely extensional conjunction. For example, Schlenker et al. (2013) show that height at which a pronoun is signed in ASL and LSF adds the presupposition that the individual is of the indicated height. Kuhn and Aristodemo (2017) show that the rate of reduplication of a verb in LSF adds an at-issue entailment about the rate of repetition of an event. In either case, though, observe that these iconic modifications can be analyzed as an intersective, extensional modification: the height of a pronoun identifies the set of all individuals of a certain height; the speed of a reduplicated verb identifies the set of all plural events with a certain temporal contour. This is strikingly not the case for iconically incompletive forms in ASL. In order to generate the inferences of incomplete action, the phonetic production must be compared to a phonetic form that was not produced, and the denoted event must be compared to an event that was not described. Formally, the iconic predicate must take an intensional object as an argument.

### 6 The pragmatics of iconicity

In this section, we consider the role of pragmatics, focusing on several ‘problem cases,’ in which a phonetic form of a verb, if iconically interpreted, seems to contradict its lexical semantics.

Given the definitions in §5.2, an iconic modification may impose certain semantic restrictions on the scalar structure of the verb that it modifies. For example, if a verb is produced with ‘bit-by-bit’ inflection, as described in §3.3, the mapping requires the verb to be associated with a gradable scale (i.e., not a two-point scale), since the iconic modification entails that an individual attains incrementally-increasing intermediate degrees. The reader will already see a puzzle: the verb \( \text{DIE} \), illustrating ‘bit-by-bit’ inflection in §3.3, was offered in §4.1 as an archetypical case of a two-point scale. How then, does ‘bit-by-bit’ inflection apply to \( \text{DIE} \)?

Relatedly, we started with the generalization about the ASL lexicon that end-marked verbs
receive telic meanings; this was implemented by saying that a phonetic maximum is iconically interpreted as a scalar maximum. However, in reality, there are exceptions to the lexical generalization. A clean minimal pair is exemplified by the signs LEAVE and SLEEP; both forms end with contact between the fingers of the dominant hand, and differ only in the direction that the hand moves. Nevertheless, LEAVE is telic (as expected, given the finger contact), but SLEEP is atelic. Why (or when) is end-marking not interpreted for SLEEP?

Here, I provide a two-pronged pragmatic account for these problem cases. When a verb is signed with an iconically marked production, the phonetically non-standard form triggers mandatory interpretation of \textit{Icon}_Φ. In these cases, I argue that new verbal meanings may be coerced if the prerequisite properties of scale are not available. On the flip side, when a phonetic form is signed neutrally, I argue that the iconic predicate \textit{Icon}_Φ may be ignored, yielding an unenriched meaning, like that of verbs in English.

\subsection*{6.1 Iconic coercion}

In natural language, verbs are known to be able to shift meaning to adapt their aspectual properties to the demands of temporal and aspectual modifiers. Moens and Steedman (1988) characterize these meaning-shifting operations as aspectual coercion, and describe a spectrum of ways in which a meaning can be shifted in order to conform to the semantic presuppositions of a modifier. In (36b), for example, the ordinarily telic predicate ‘bike to school’ shifts to a habitual interpretation, allowing it to combine felicitously with the \textit{for}-phrase. In (37b), the ordinarily atelic predicate ‘sleep’ shifts in meaning to describe the preparatory process of the event (i.e., falling asleep), allowing it to combine felicitously with the \textit{in}-phrase.

\begin{itemize}
  \item \textbf{(36)} a. Molly biked to school in ten minutes.
  \item b. Molly biked to school for two years.
  \item \textbf{(37)} a. John slept for eight hours.
  \item b. John took the melatonin, and slept in fifteen minutes.
\end{itemize}

Aspectual coercion may also shift punctual events into durative events. For example, as described in §4.1, the verb \textit{awaken}/\textit{wake up} describes a punctual transition on the two-point scale \{asleep, awake\}; nevertheless, the sentence in (38) is intelligible, with the coerced inference that the event progresses through a variety of intermediate stages of consciousness.

\begin{itemize}
  \item \textbf{(38)} I woke up bit by bit this morning.
\end{itemize}

Exactly the same principles hold in ASL, allowing verb meanings to be coerced to satisfy the requirements imposed by their iconic modifications. This is what we see when \textit{DIE} is modified with ‘bit-by-bit’ inflection: a two-point scale is coerced into a richer scale including intermediate degrees. As is perhaps expected, the ease with which this coercion can happen depends on how easy it is to accommodate a gradient scale for a particular verb meaning. For example, the verb \textit{die} can easily be associated with a scale measuring health that is closed at the bottom by death (a state of zero health); in contrast, it is not as clear what non-binary scale can be
associated with the verb *notice*. These differences are reflected in grammaticality judgments of iconic manipulations of different verbs. *DIE*-bit-by-bit (in Figure 5) is perfectly acceptable, as are the forms *CHANGE*-bit-by-bit (as in ‘my friend’s face changed’) and *ARRIVE*-bit-by-bit. In contrast, the verbs *NOTICE* and *BUY* receive degraded judgments with ‘bit-by-bit’ inflection.

### 6.2 Underspecified iconicity

When a verb is signed with an unmarked phonetic form, no iconic inference is generated about an event. For example, the verb *DIE*, when signed slowly, entails that a death happened slowly; however, when *DIE* is signed at a neutral speed, no inference is drawn about the manner in which the death occurred: it is compatible with slow, medium, and fast events. In other words, the degree of iconic information that is preserved is pragmatically determined. When a verb is produced in an unmarked form, the iconic predicate is uninformative—formally, the output of $\text{Icon}_\phi$ is a tautology, and the verb meaning derives entirely from $\text{pos}_V$.

This fact can explain apparent exceptions to Wilbur’s generalization. As mentioned above, the atelic verb *SLEEP* forms a minimal pair with the telic verb *LEAVE*. In both forms, outstretched fingers come together to make contact as the hand moves away from the body; the only difference is the direction: *SLEEP* moves downwards while *LEAVE* moves to the side. Nevertheless, if there is no marked indication that an iconic mapping is in play, the contact between the fingers in *SLEEP*, like the speed of a neutral form of *DIE*, remains uninterpreted, and there is no inference that a scalar maximum is reached. On the other hand, if an iconic mapping is invoked, we predict that end-tracking will be interpreted, yielding a telic meaning. This prediction is borne out. In the neutral form in (39a), *SLEEP* receives its default, atelic meaning. However, when it is signed in an iconically marked form, such as with slow movement in (39b), this meaning is no longer available; like the English sentence in (37b), the verb is coerced into a telic meaning, culminating in a maximal degree of being asleep.

(39) a. 1X-1 SLEEP ONE HOUR.
    ‘I slept for one hour.’

   b. 1X-1 SLEEP-slow ONE HOUR.
    ‘I fell asleep in one hour.’

Are there cases in which an iconic component of meaning *cannot* be ignored, even when a phonetic form is signed in neutral, unmarked way? Aristodemo (ms.) argues that this is indeed the case for a certain class of adjectives in Italian Sign Language, including *FULL* and *BALD*. For ASL, we have seen examples that seem to act analogously, such as *GET-FULL* in example (34). The explanation for these interactions, whether they be governed by morphological class (as argued by Aristodemo for LIS), by fine phonetic properties (as implied by Malaia and Wilbur 2012), or by properties of the underlying scales, we will leave for future research.
7 Conclusions

In this paper, I addressed two observations from Wilbur (2003, 2008, 2009): first, that certain properties of a verb’s phonetic form are correlated with the telicity of the verb; second, that phonetic manipulations of a verb may be semantically interpreted. I argued that the purely morphological system proposed by Wilbur is not sufficient to capture the full range of manipulations that are possible in ASL. As an alternative, I advocated a theory in which an iconic mapping preserves information about timing and event progression. I showed that this iconic mapping could be formalized if we adopted recent theories in which verbal telicity arises from the properties of associated scales (Hay et al. 1999, Kennedy and Levin 2008).

Nevertheless, the proposal here shares certain important features with Wilbur’s analysis. Notably, I adopt the assumption that verbs are structurally complex, and that semantic properties of a verb emerge from the properties of its sub-lexical decomposition. Like Wilbur, I contend that this structure, which is generally covert in spoken language, appears in a more transparent form in sign language. Relatedly, although I use Ramchand (2008) to ground Wilbur’s proposal (following Wilbur), the arguments that I have given against Wilbur’s analysis pertain to the semantics of the decompositional parts, not the syntactic structure. Given that Ramchand (2008) regards largely syntactic facts, many of its insights are orthogonal to the points addressed here.

The present proposal also fits cleanly into a body of literature which emphasizes the role of homomorphic mappings on scale structure (Krifka 1989, 1998; i.a.). It has been widely observed that predicates may inherit semantic properties from their arguments. What it means to ‘inherit’ a property is to say that logical structure of an argument is preserved in the meaning of the predicate—that is, the verb’s meaning is a homomorphism. This analytic strategy has been employed to analyze the properties of incremental theme verbs (Krifka 1989), as well as the distribution of resultative constructions (’he hammered the metal flat’) and prepositional phrases (Wechsler 2005, Beavers 2008). In the present proposal, I make use of a similar homomorphism; in this case, though, I argue that structure of the phonetic form is preserved in the semantic interpretation.

Therein lies the crux of my proposal: the interpretation of verbs in ASL crucially depends on the presence of an iconic mapping. Unlike a solely combinatory system, a combinatory system with iconicity allows gradient phonetic changes to have gradient effects on interpretation. As we have seen, the resulting analysis has a variety of ramifications for the organization of the grammar. First, we saw that pictorial meaning can feed a grammatical distinction—the telic/atelic distinction. Second, we made the novel observation that the iconic mapping must be an intensional function, making reference to the way a verb could be pronounced and how an event could transpire. For descriptive adequacy of the sign language pattern, iconicity and the grammar must be tightly interwoven.
References


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