# Compositionality in 'holistic' pantomime characterizes a gesture-first proto-language

Some theories of Language emergence posit that proto-utterances were necessarily holistic. Words/ morphemes are thus derived from the analysis of whole utterances into discrete pieces (Arbib, 2010). Such theories are important assuming that Language evolved as speech, and/ or the word is the minimal syntactic unit. Similar analyses have been proposed for pantomime (McNeill, 2005). However, others suggest that pantomime is 'language-like,' containing subunits amenable to linguistic analysis (Wilbur & Malaia, 2008). One area of intense investigation is the emergence of transitivity distinctions in pantomime: gesturers use handshape to differentiate in/transitive events (Brentari et al., 2012, 2017), suggesting that aspects of pantomime are combinatorial even in single gesture utterances. However, work to date is not readily generalizable as it considers few event types, just 2 handshape features, and the average proportion of these features in each predicate type. We argue that this underestimates the total information available in the signal while overestimating the importance of a few selected features. Here, we consider a broader range of events and handshape features, and use an analysis that makes item-by-item decisions based on these features, more faithfully emulating a sender's task in communicating transitivity information.

**Method:** We elicited single-gesture utterances from 6 participants. Pantomimes were produced in response to vignettes of 72 unique events that involved the manipulation (transitive) or movement (intransitive) of a variety of objects. We annotated these 432 (6 * 72) productions for 6 handshape parameters individually linked to transitivity marking in sign languages. We trained linear support vector classifiers to predict whether each pantomime is in/transitive, using a 6-fold leave-one-out paradigm: The data were split into 6 partitions, trained on 5 of the partitions and tested on the 6th, producing an accuracy score. This was done in a round-robin fashion such that each partition was the test set once. We computed mean accuracy and compared it against chance using the probability mass function of the binomial distribution. To assess the degree semantic class affects handshape production, the analysis was run on 3 subsets of the data: *Alternating verbs* (n = 174), *Verbs of manipulation and movement* (n = 234), and *Verbs of tool-use and manner* (n = 108). (The first two sets are disjoint; the last set is a proper subset of manipulation/ movement verbs.) Finally, to assess feature importance, we averaged the model weights for each predictor in each analysis.

**Results:** Classifiers trained on the entire dataset achieved a mean accuracy of 59% (p < 0.001). Performance on alternating predicates was poor (54%, n.s.), but performance on verbs of manipulation/ movement and tool-use/ manner was good (67%, p = 0.003; and 82%, p < 0.0001, respectively). See Figure 1. No set of predictors consistently identified transitivity distinctions in alternating verbs, or when all verbs were grouped together. However, among manipulation/ movement and tool-use/ manner verbs, four predictors were consistently identified as relevant to transitivity marking (Table 1). All predictors are associated with *transitive* items, showing that transitives are overtly and exhaustively marked.

**Implications:** The analyses show that transitivity information is present in the form of pantomimes, even though single-gesture utterances appear to be holistic at first blush. Further, pantomimes do not seem to form a monolithic class: certain, narrowly defined semantic categories may enjoy a reliable coding preference that is not available to broader classes. Finally, the analysis of the predictors indicate that transitive pantomimes are phonetically more complex than intransitives and suggests that their syntax is similarly more complex (e.g., involve more projections; Minimalist Program), consistent with lexical items being associated with multiple heads (Ramchand, 2008) and the simultaneous exponence of hierarchical structure seen in sign languages. We suggest that these 'holistic' pantomimes may already be composed of features (or proto-morphemes) borrowed from other cognitive systems (e.g., manual praxis; Arbib, 2005).
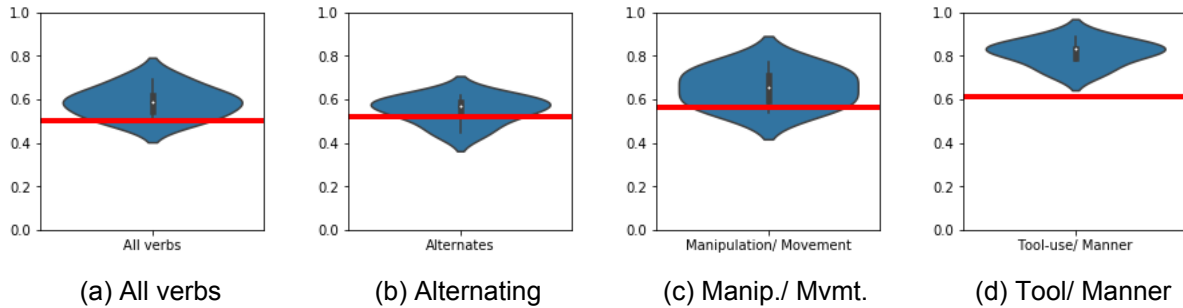
| (a) All verbs | (b) Alternating | (c) Manip./ Mvmt. | (d) Tool/ Manner |

Figure 1: Distribution of classifier accuracies. Red line represents blind baseline (chance).

| Analysis/ Features | # of hands | Finger Complexity | Flexion | Flexion (NSF) |
|---|---|---|---|---|
| All verbs | 1.1995 | 0.1928 | 0.3761 | – |
| Alternating | 1.6667 | – | – | -0.3442 |
| Manip/Mvmt | 0.6691 | 0.3559 | 0.7668 | 0.2083 |
| Tool/Manner | 0.4604 | 0.4444 | 1.0999 | 0.0723 |

Table 1: Average model coefficients for the four best predictors. Positive values correspond with 'transitive' labels. '2-handed?' = whether the production involved one or two hands; 'Finger complexity' = a measure of ease of articulation; 'Flexion' = degree of curvature of the selected (profiled) finger; 'Flexion (NSF)' = degree of curvature of the non-selected (backgrounded) fingers. Note that in the analysis of all verbs and of alternating verbs, not all predictors were consistently selected as being most informative.

# References

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