Quantifying the spatial and temporal properties of nouns and verbs in American Sign Language using Microsoft Kinect

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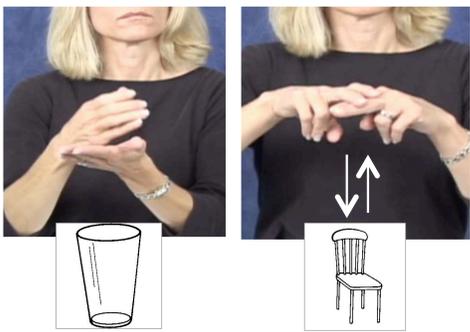
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Introduction

Nouns and verbs are distinct word classes, yet not always formally distinguished.

In some sign languages, nouns and verbs might differ in movement or spatial characteristics.
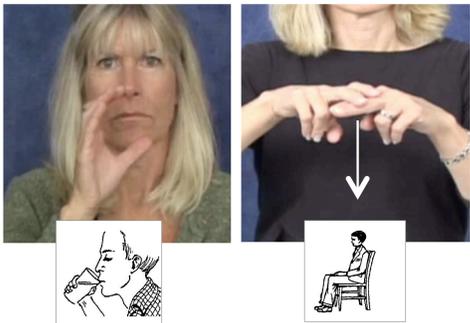
ASL Nouns

Double, restrained and/or repeated movement [1,2,3]

Shorter in duration than related verbs in noun-verb pairs [4]

ASL Verbs

A single or repeated larger movement, continuous or abrupt ending [1, 2, 3]

Questions

Are nouns and verbs formationally distinguished through spatial and temporal properties in ASL?

If so, do these patterns generalize to a lexicon-wide comparison of unrelated verbs and nouns?

- Distance (m)
- Volume (m³)
- Duration (msec)

Do spatial and temporal properties of ASL nouns and verbs vary as function of lexical frequency?

Discussion and conclusions

- Verbs were larger and longer (both in time & distance) to accommodate the spatial-temporal modulations that frequently occur with verbs; pattern generalizes to unrelated ASL verbs & nouns
- Phonological typicality: spatial-temporal typicality patterns can distinguish lexical class in ASL; Phonological cues to lexical categories may be a universal property of language [6]
- Frequent signs are optimized for size and length [7]
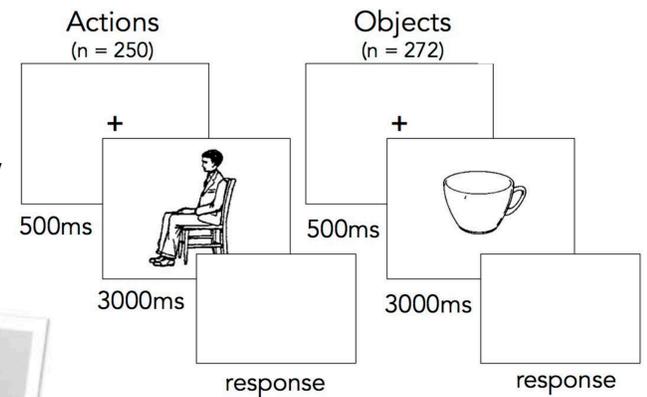
Further question:
- Variation in spatial-temporal patterns as function of verb morphology (e.g., plain vs. directional verbs)?

Methods

Participants:
21 deaf ASL signers (M_{AGE} = 31, SD = 6, 12F, 13 native)

Stimuli (from CRL-IPNP) [5]

Actions (n = 250)

Objects (n = 272)

500ms

3000ms

response

"Provide a single sign for each picture"

Microsoft KINECT ®

ChronoSense tool captures the RGB image recorded from Kinect.
The X, Y, Z co-ordinates of the wrist joints quantify the spatial and temporal movement patterns of ASL signs.

Results

LOCK (verb)

KEY (noun)

Distance

Volume

Duration

Sign handedness

Actions   Objects
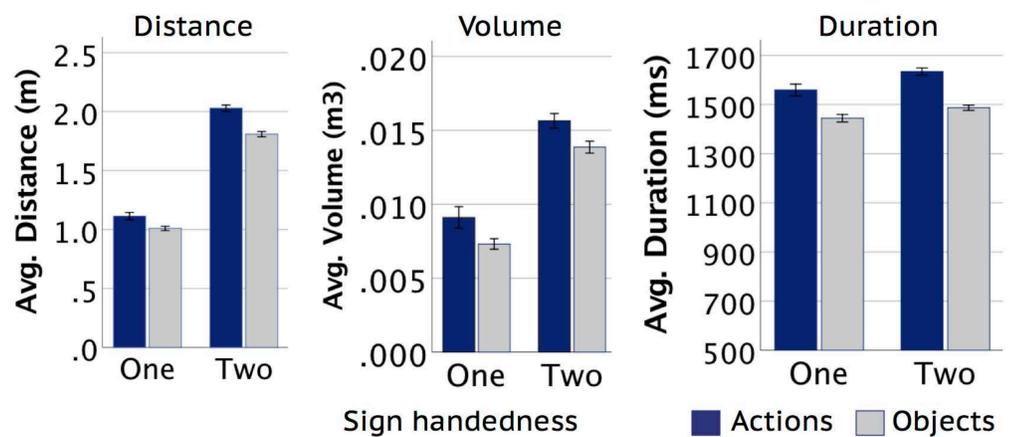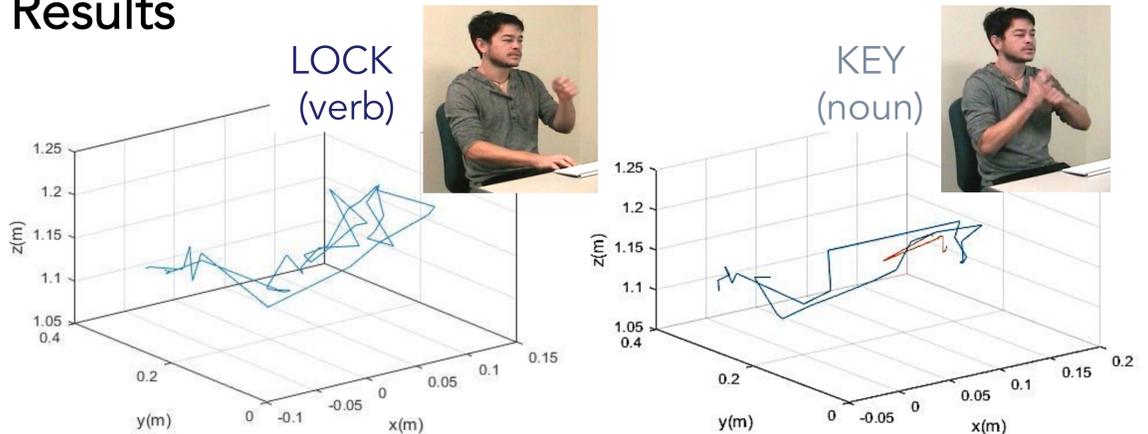
- **Distance:**
  - Longer movement path for verbs than nouns, β=.19, t=−15, p<.001
  - Movement length decreased with frequency, β=−.06, t=−5, p<.001
- **Volume:**
  - Verbs were larger than nouns, β=.10, t=8, p<.001
  - Frequent signs occupied smaller volume than less frequent signs, β=−.04, t=−3.5, p=.001
- **Duration:**
  - Verbs took longer to produce than nouns, β=.10, t=9, p<.001
  - The more frequent sign, the shorter the response duration, β=−.10, t=−.10, p< .001

Target accuracy, naming consistency, & RTs

	Actions		Objects	
	M	SD	M	SD
Target responses	76%	43	86%	35
H statistic	.61	.45	.39	.44
RT Tar (ms)	1190	438	878	317

- Objects were named faster, more accurately & consistently than actions.

References: [1] Johnston, T. (2001); [2] Kimmelman, V. (2009); [3] Supalla, T. & Newport, E. (1978); Hunger, B. (2006); [5] Bates, E. et al. (2003); [6] Farmer et al (2006); [7] Zipf, G. (1949)