Analysis of Visual Properties in American Sign Language

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Analysis of Visual Properties in American Sign Language

Visual Image Statistics

= quantitative analysis of ***regularity*** *patterns and* ***variation*** *in images*

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Visual Image Statistics

-contrast
-orientation
-spatial frequency
-position
-eccentricity
-motion speeds
-distance traversed
-duration

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WHY study these?...

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Does extensive exposure to sign language alter visual sensitivity?

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Does extensive exposure to sign language alter visual sensitivity?

Yes, examples:

-mental imagery

-face processing

-attention

-motion processing

-Most results show nonspecific changes.

-There could be a multitude of reasons for these changes.

Evidence for a specific causal “link” between experience and sensitivity shown in many animal studies:

-Kittens reared in unique environments

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-Visual sensitivity is BEST for what is experienced

-WORSE than normal for patterns never seen

HYPOTHESIS:

If visual sensitivity improvements are linked to *sign language*, then these changes must be *specific* to the exposed properties contained in the sign language signal.

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Hypothetical example:

Sensitivity of signers is:

A) improved ONLY for speeds seen in sign language

B) and NOT improved for speeds outside this range.

PROBLEM: We don't know what these ranges are.

CURRENT AIM:

Describe and quantify hand speeds of moving ASL images

METHODS:

-Data were collected using a Virtual Reality InterSense 3-Dimensional motion system

-Ultrasonic position trackers on gloves, worn during sign production

-3 native/highly fluent signers of ASL

-Samples of hand position in x, y, z coordinate space were obtained at 15 Hertz (every 66 msecs)

METHODS: DATA

44 signs, 15 elicited sentences, and 3 spontaneous stories.

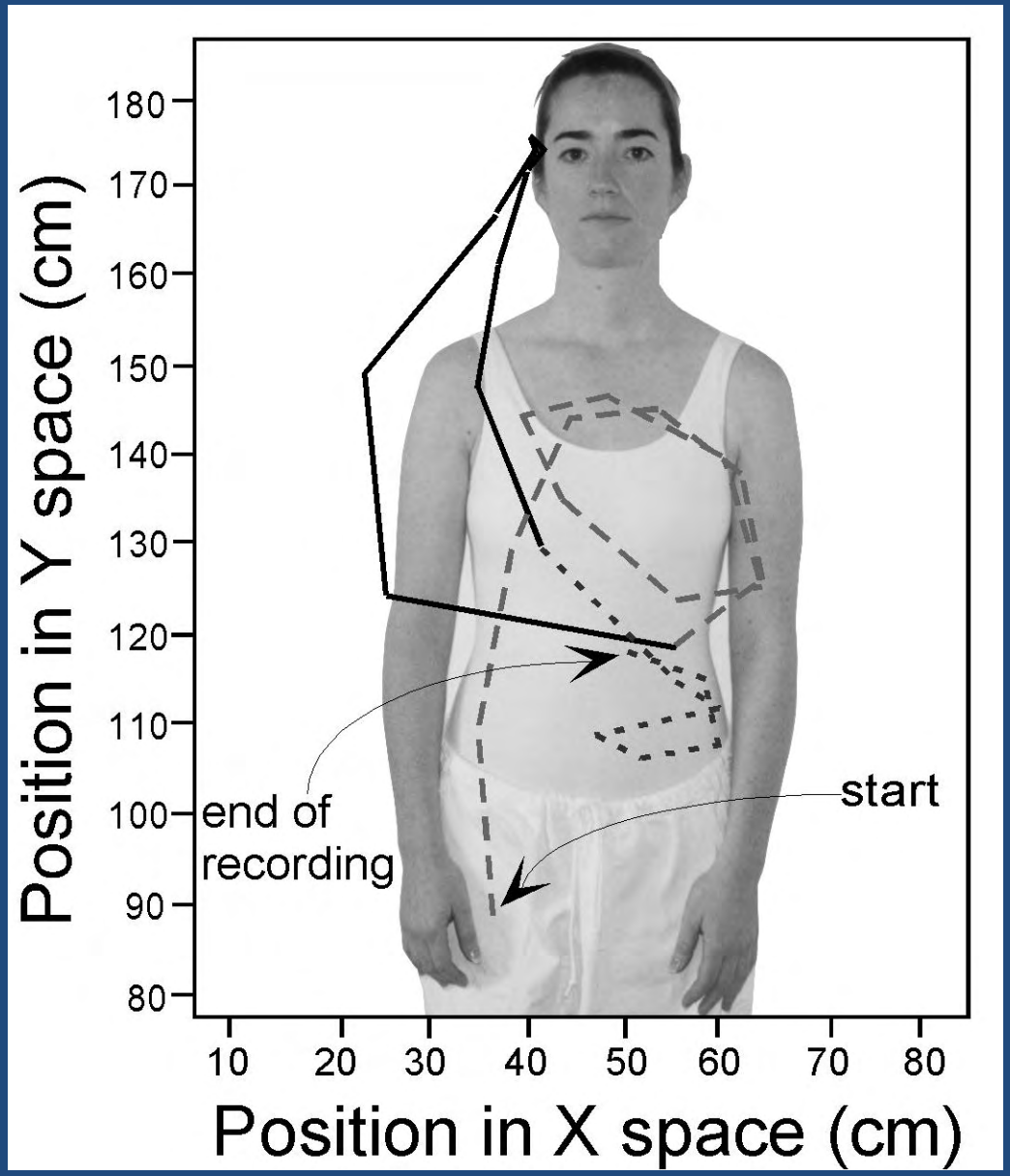
Sign Categories:	Examples:
1) Repetition, with no change in HS or location	DOCTOR, CANADA
2) Circular motion, with no HS change	BICYCLE, GESTURE
3) Single contact, with no change in HS or location	HAVE, KNOW
4) Path with HS and location change:	SEND, ASK
5) Location change, with no HS change	SMART, IMPROVE

METHODS:

-Each sign was embedded in a carrier phrase, "SIGN X EASY".

-Each phrase was repeated three times, yielding 132 total sign targets.

-Constructed an algorithm (S+ by Mathsoft) to extract target sign.



METHODS: SPEED ANALYSIS

-SPEED = change in hand position (in centimeters) over time (msec)

2D speed = x (horizontal) and y (vertical) dimension

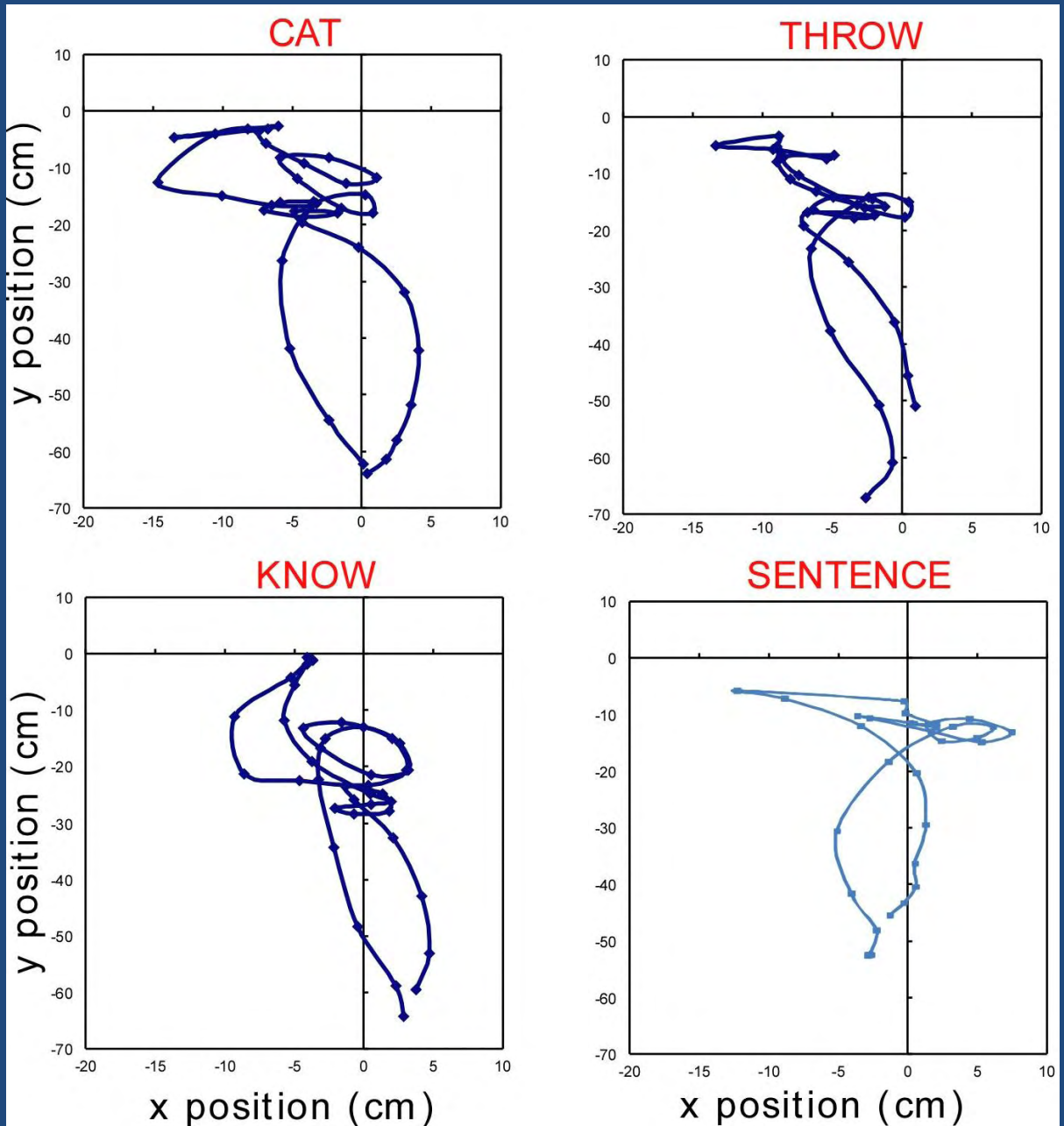
3D speed = x, y, and z (depth)

-Calculated for each sample, each sign, each repetition, and each signer *(yielded approx 4,356 sign samples)*

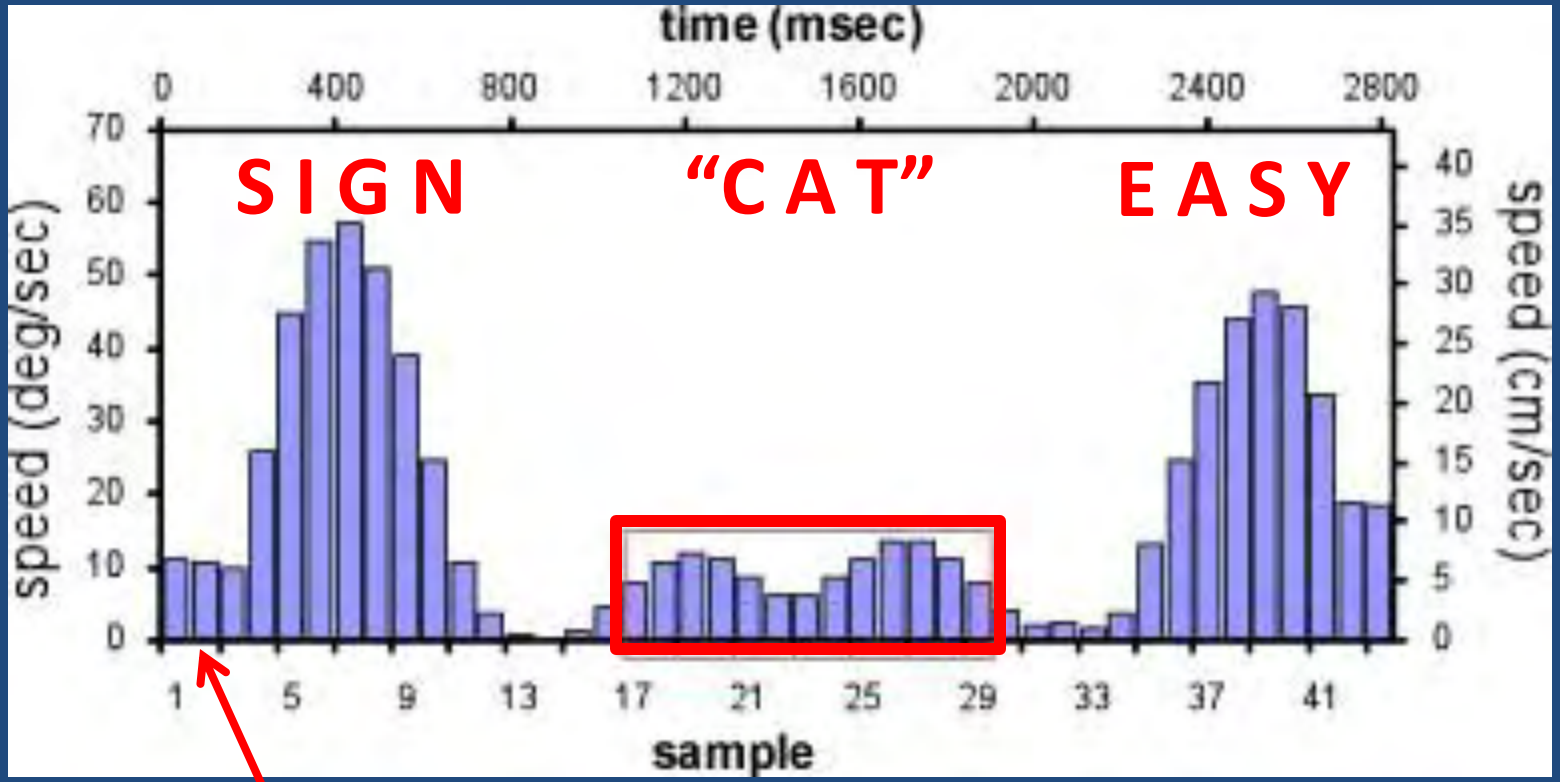
-2D is most relevant for retinal image; 3D for kinetic movement

-This talk focuses only on 2D and 3D speeds for *dominant right hand*

EXAMPLE 2D MOVEMENT TRACES:

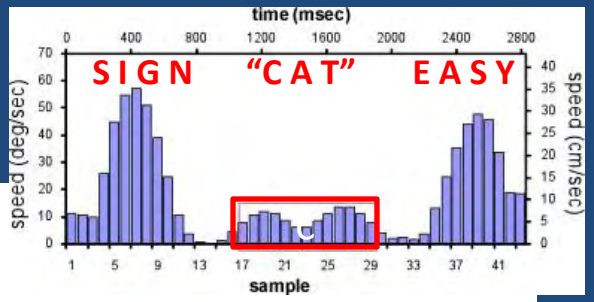


RESULTS: EXAMPLE RAW 2D SPEED DATA



Each bar = one sample, obtained every 66 msec

RESULTS: EXAMPLE *RANKED HISTOGRAM*



Excised Sign "CAT"

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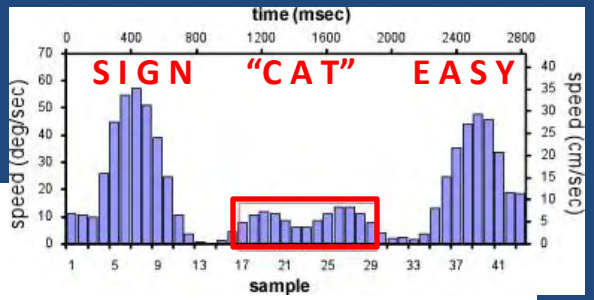

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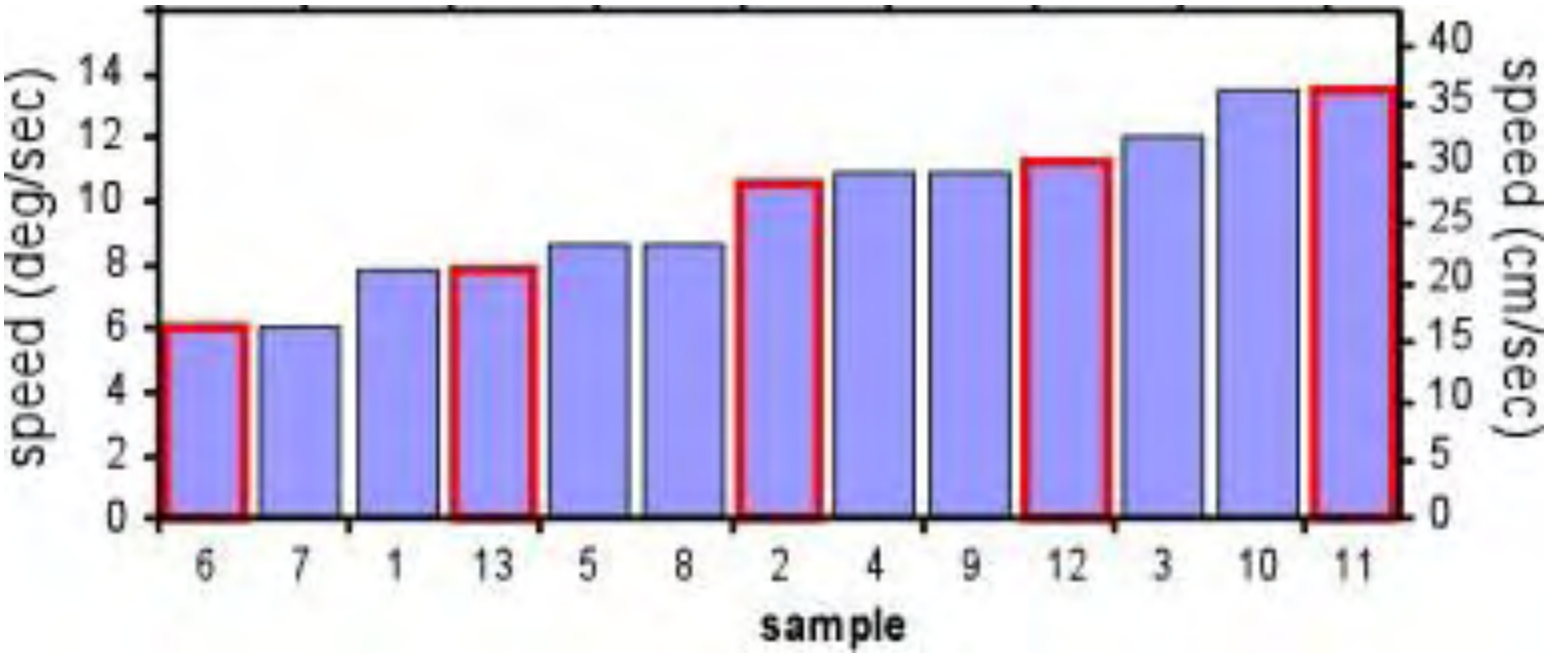

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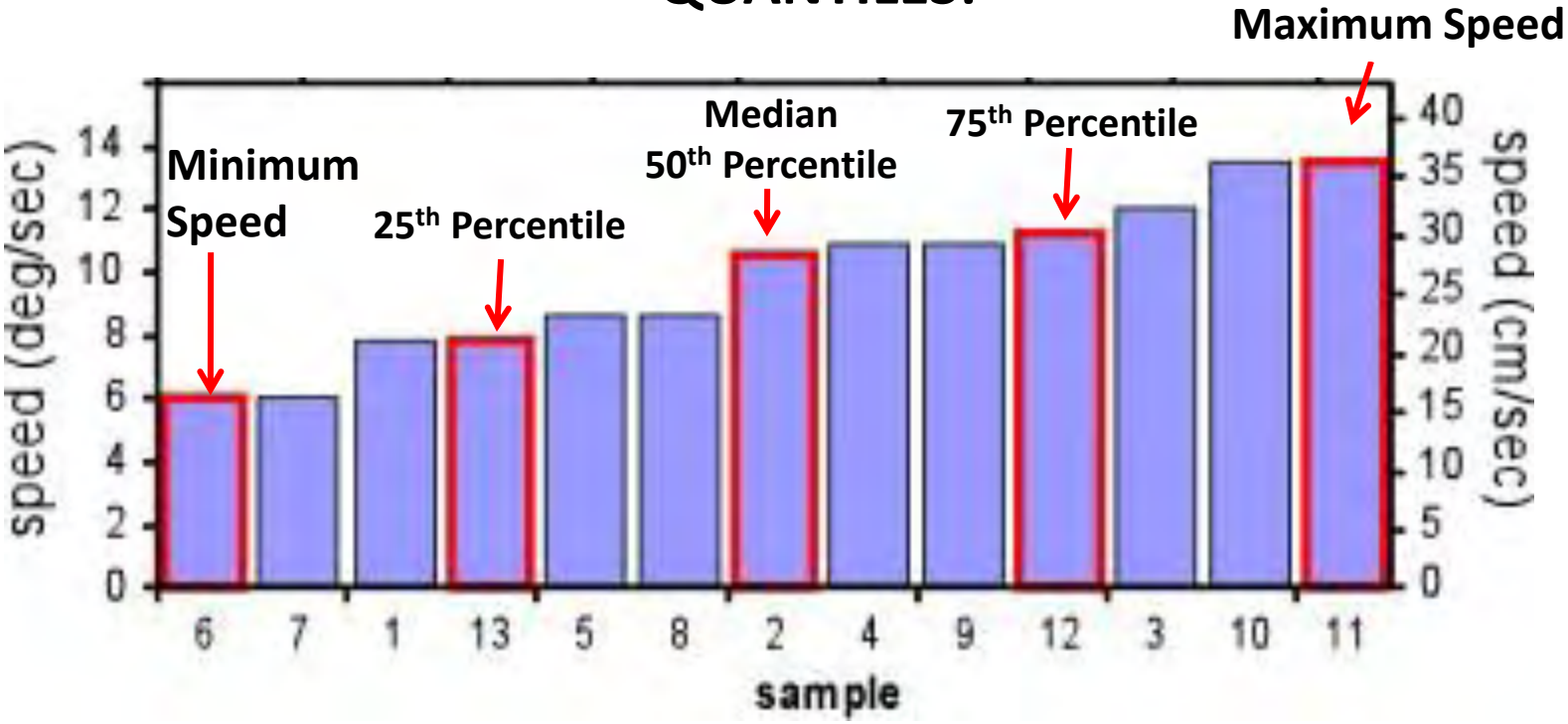

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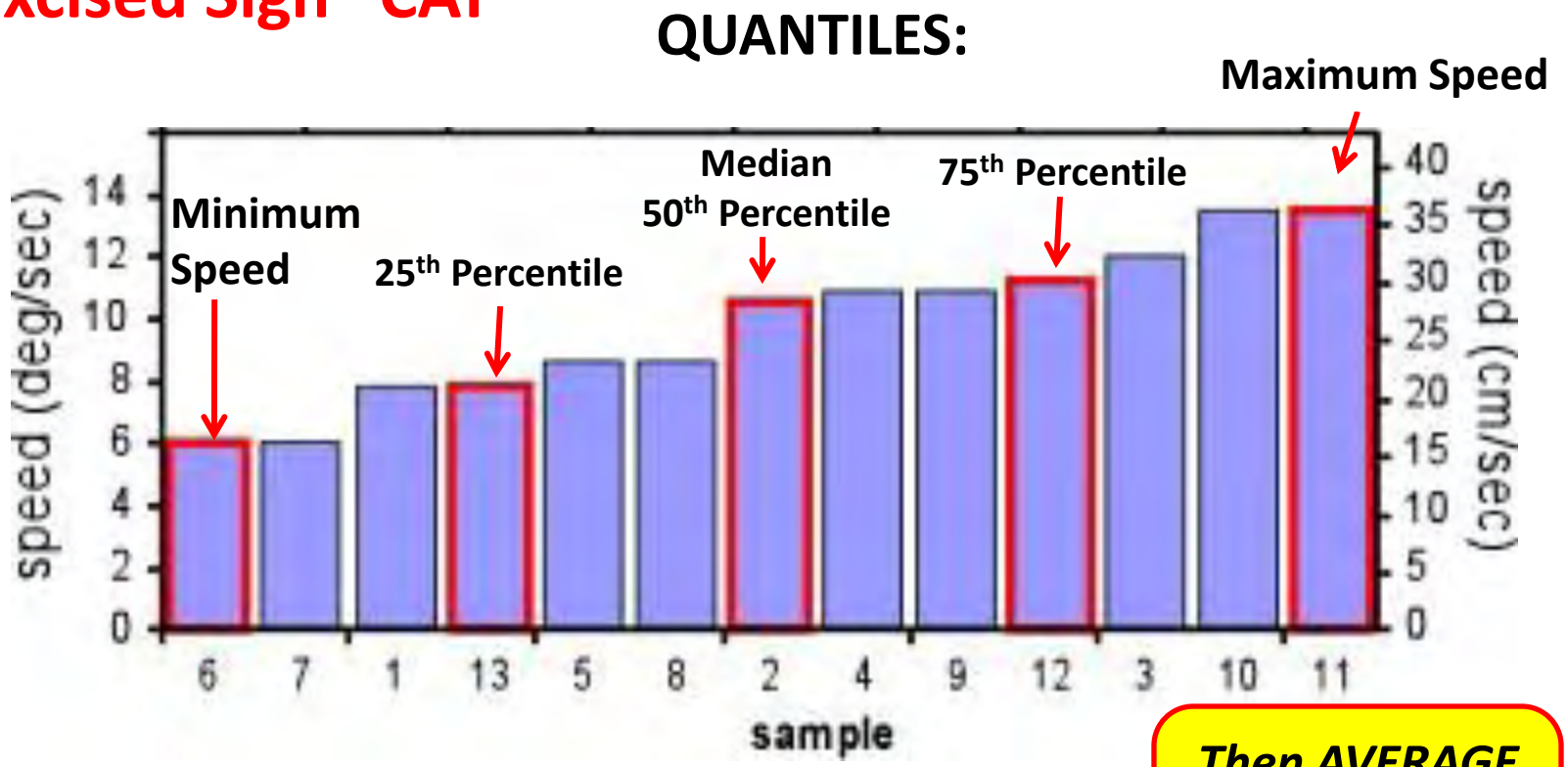
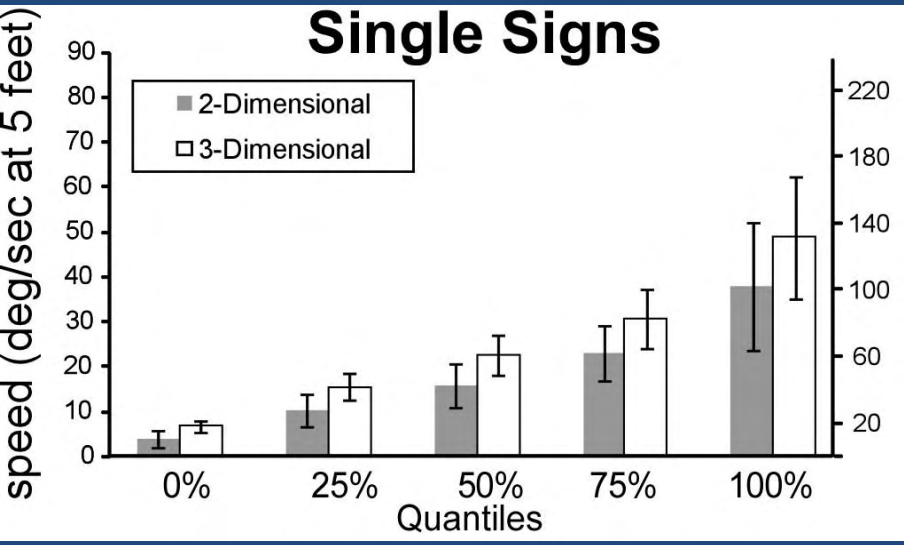
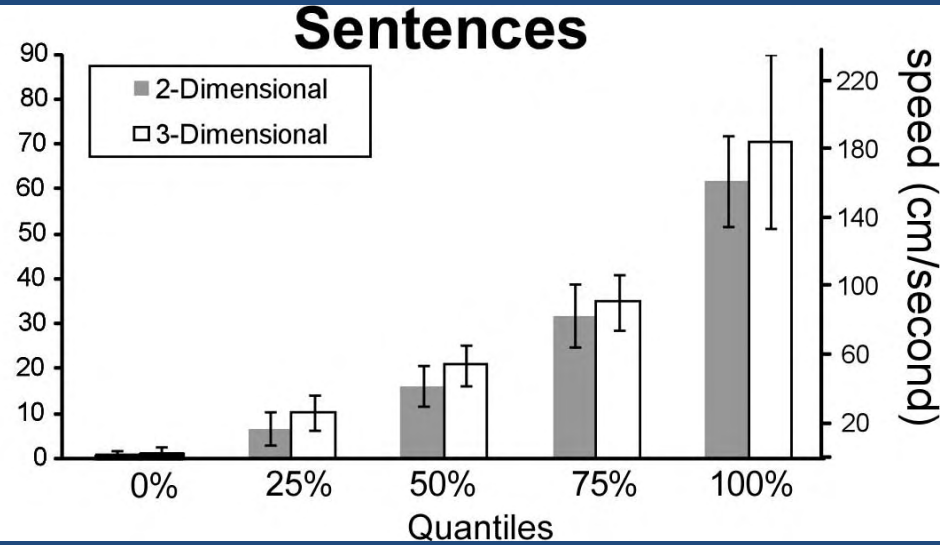


Then AVERAGE quantiles for all signed items.

RESULTS: MEAN SPEED QUANTILES





- 3-D motion is faster than 2-D motion
- Sentences are significantly faster and more variable than excised signs

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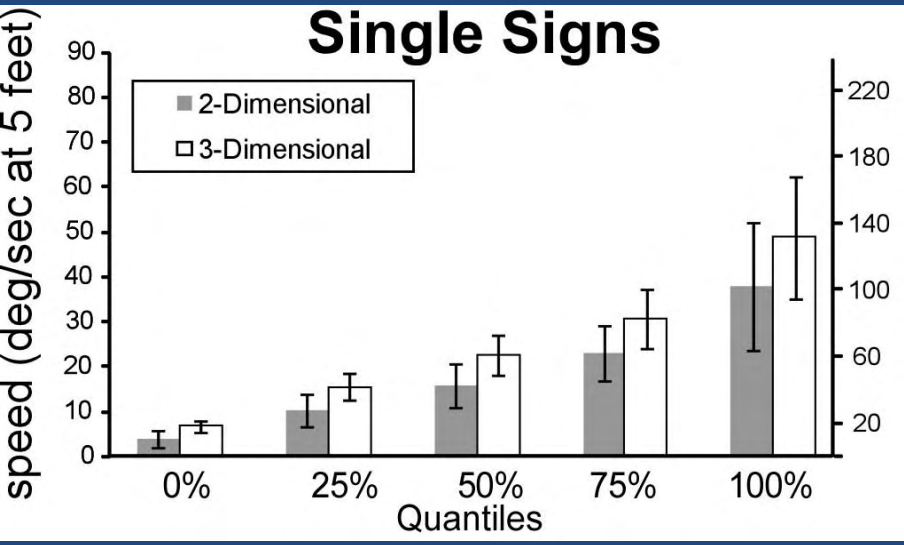

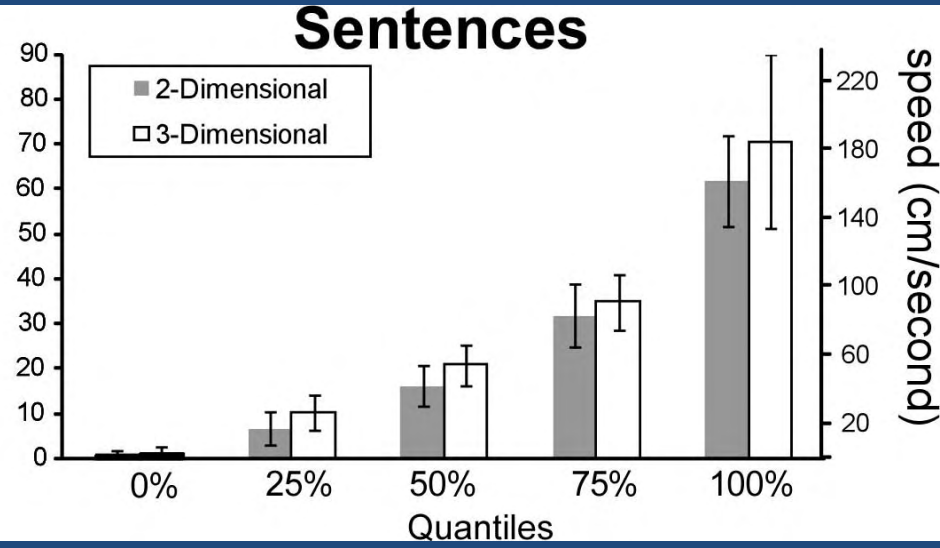

- Mean slowest non-zero speeds :
  Signs/sentences: 3 to 9 cm/sec
- Median speeds (cm/sec):
  Signs: 2D: 39 (± 12) 3D: 39 (± 14)
  Sentences: 2D: 43 (± 13) 3D: 50 (± 12)
- Mean fastest speeds (cm/sec):
  Signs: 2D: 88 (± 37) 3D: 121 (± 40)
  Sentences: 2D: 160 (± 27) 3D: 188 (± 51)

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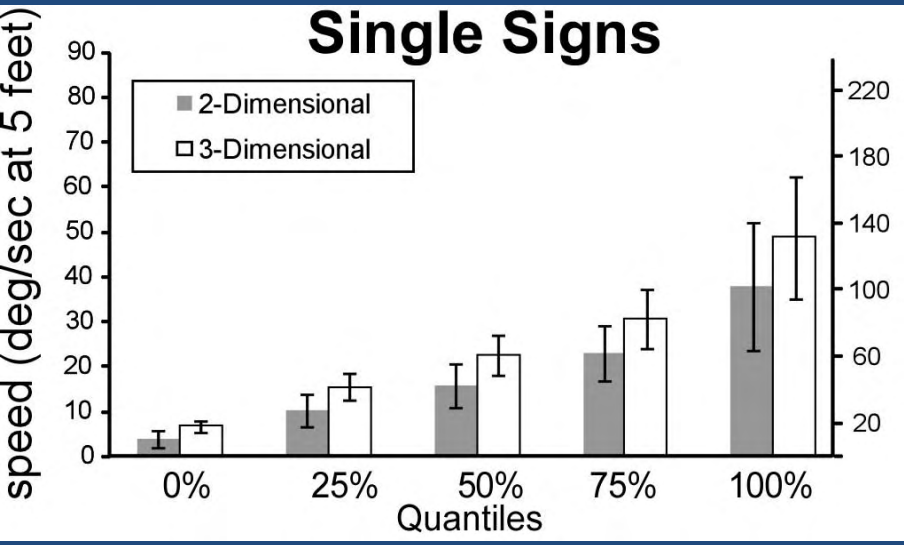

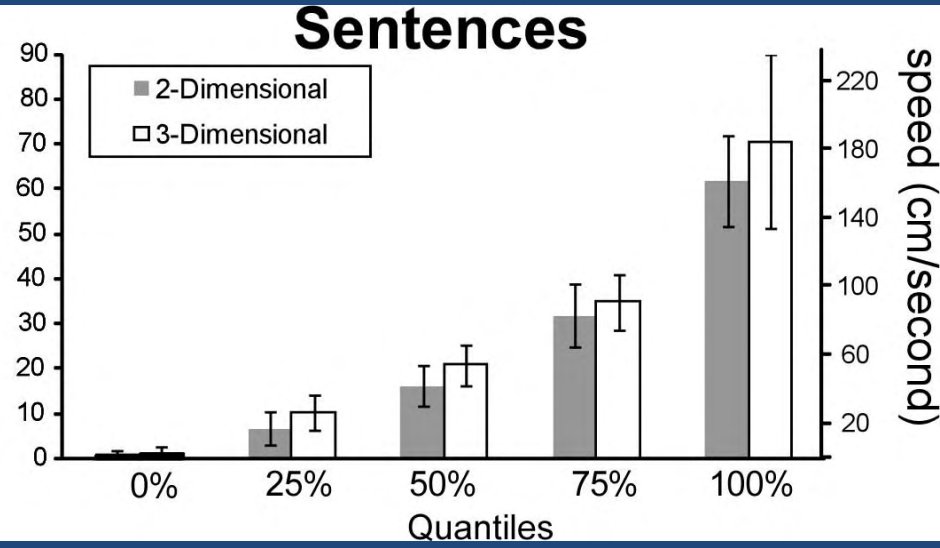

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Fischer, Delhorne & Reed (1999): Identification accuracy of signs declined at 2.5 times normal rate: *=112 cm/sec*

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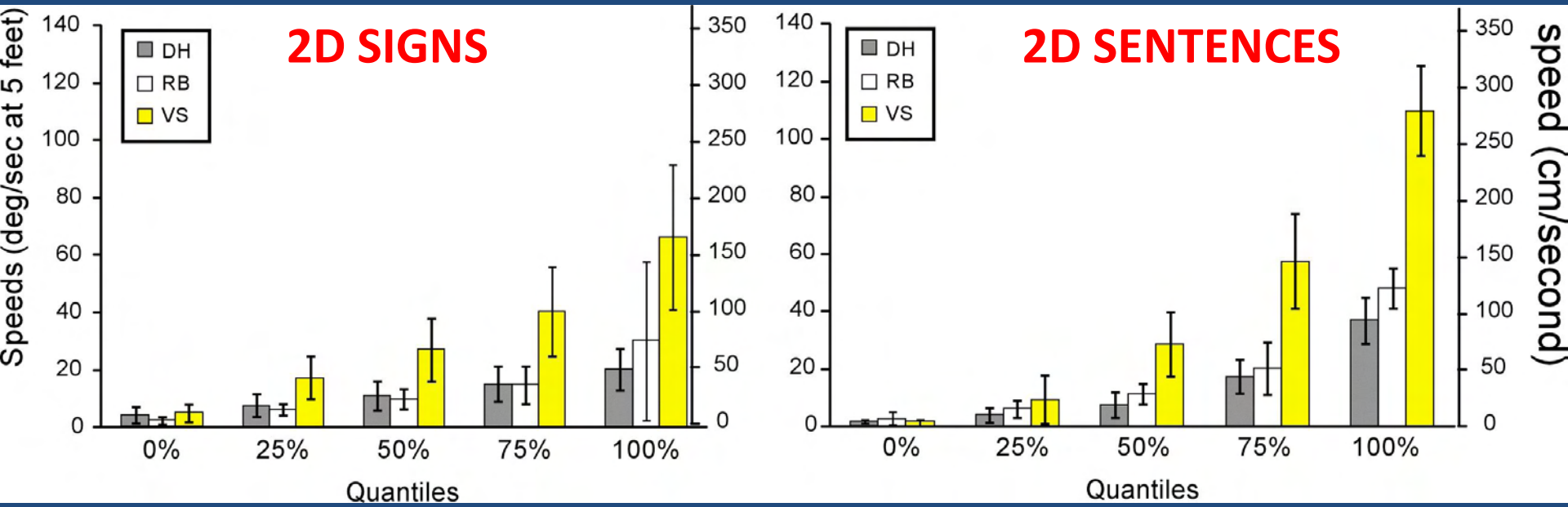
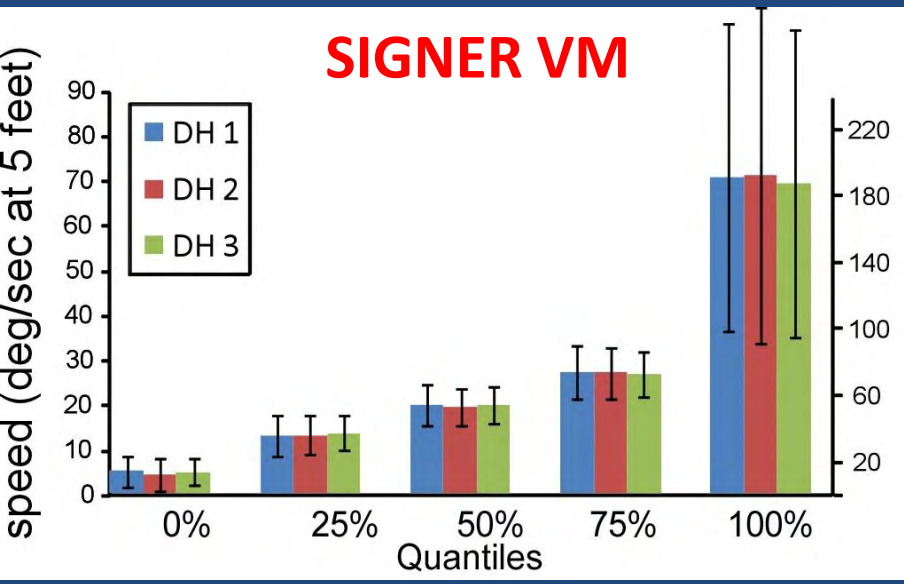
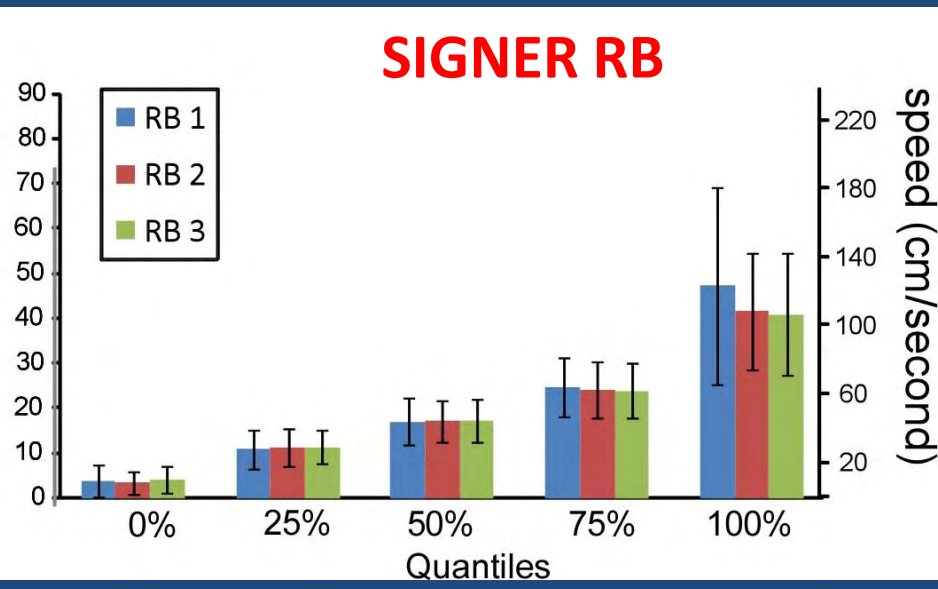


Averaged 2-D speed quantiles of signs *do vary significantly across signers,* especially for fastest sign speeds.

RESULTS: MEAN SPEED QUANTILES





Averaged 2-D speed quantiles of signs are remarkably similar within signers across the *three signed repetitions*

SPEED, DURATION, and DISTANCE

SPEED, DURATION, and DISTANCE

Do signers try to maintain a constant sign duration or a constant speed?

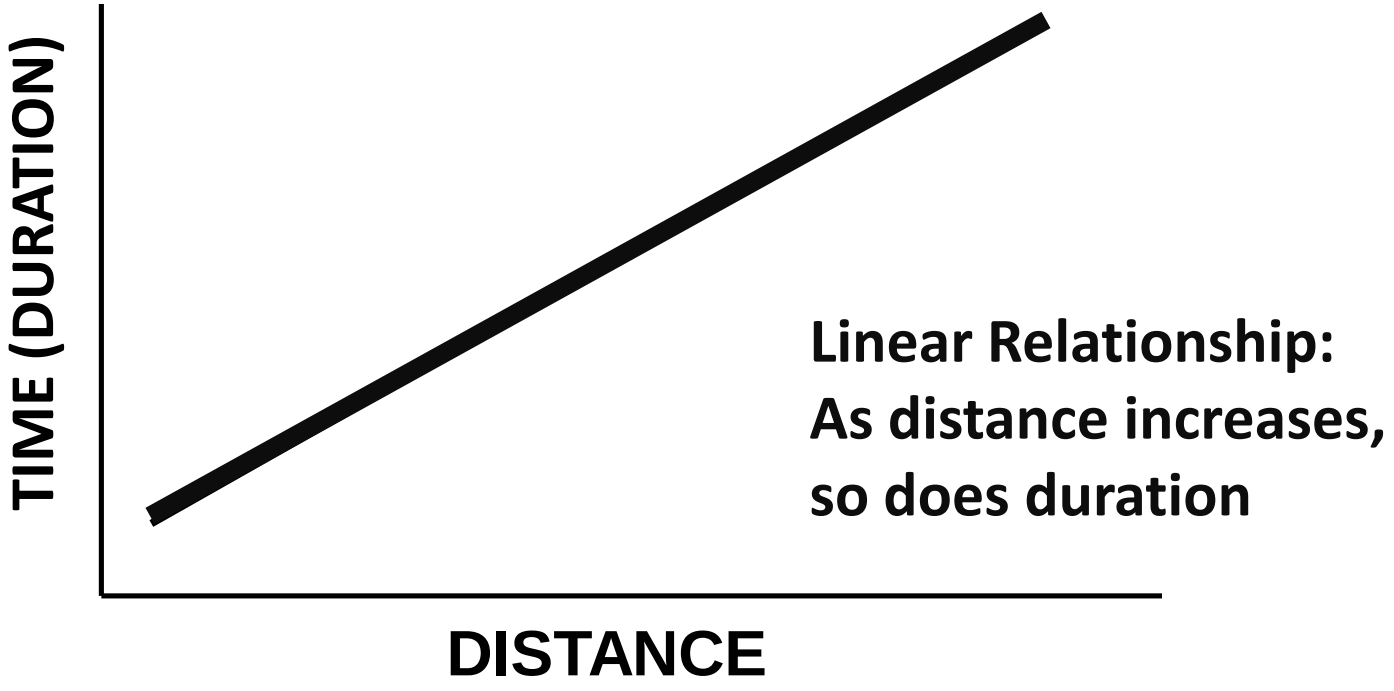
-possible phonological or physiological constraints governing articulation

Explore this by looking at slopes and correlations between ***total sign duration*** and ***total sign distance*** across signs.

Three predictions…..

1) If *sign speeds are relatively constant*, then for signs that traverse farther distances, they will be longer in duration.

= **positive linear** relationship between duration and distance.



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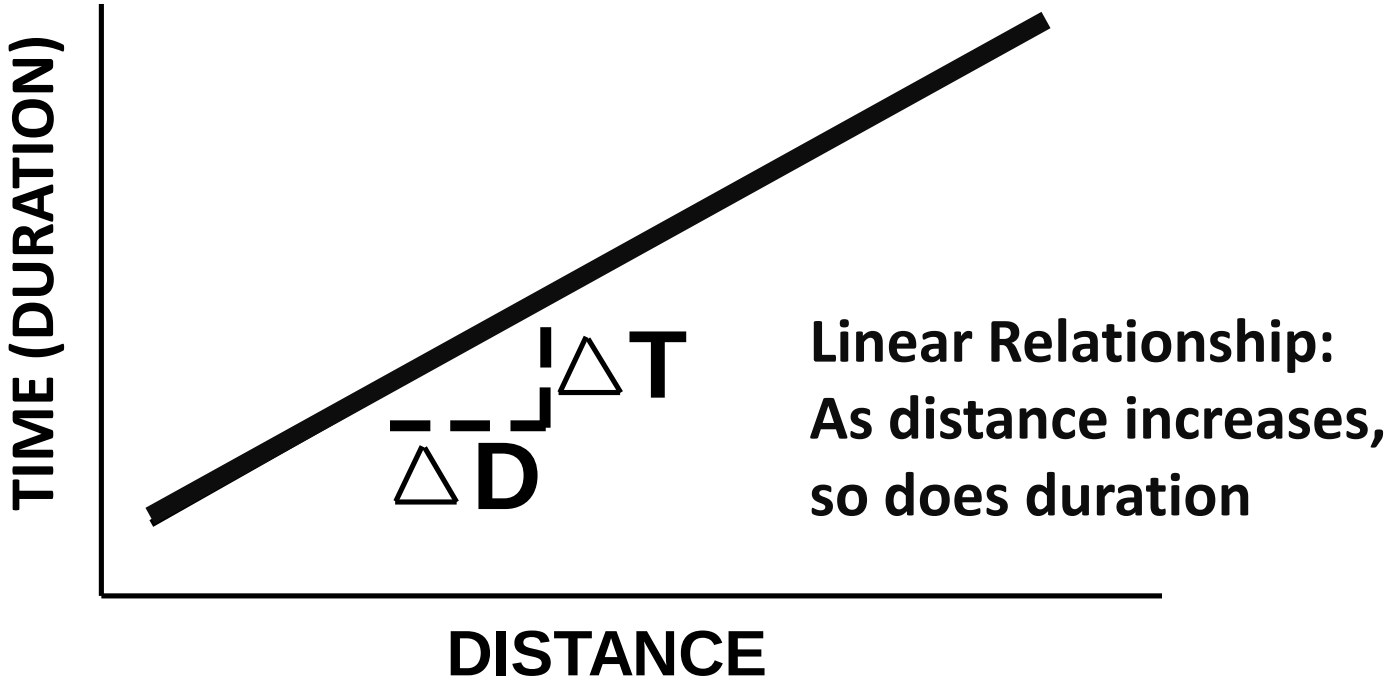

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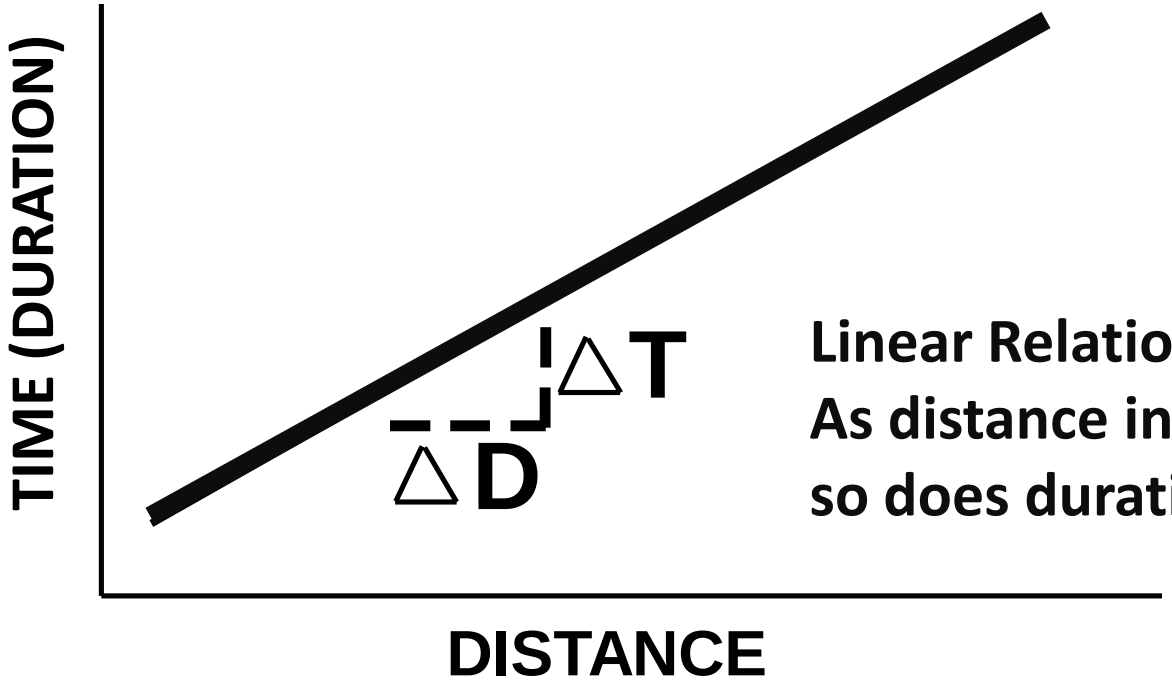

Linear Relationship:
As distance increases, so does duration

$$\text{SLOPE} = \frac{\triangle D}{\triangle T} = \textit{SPEED}$$

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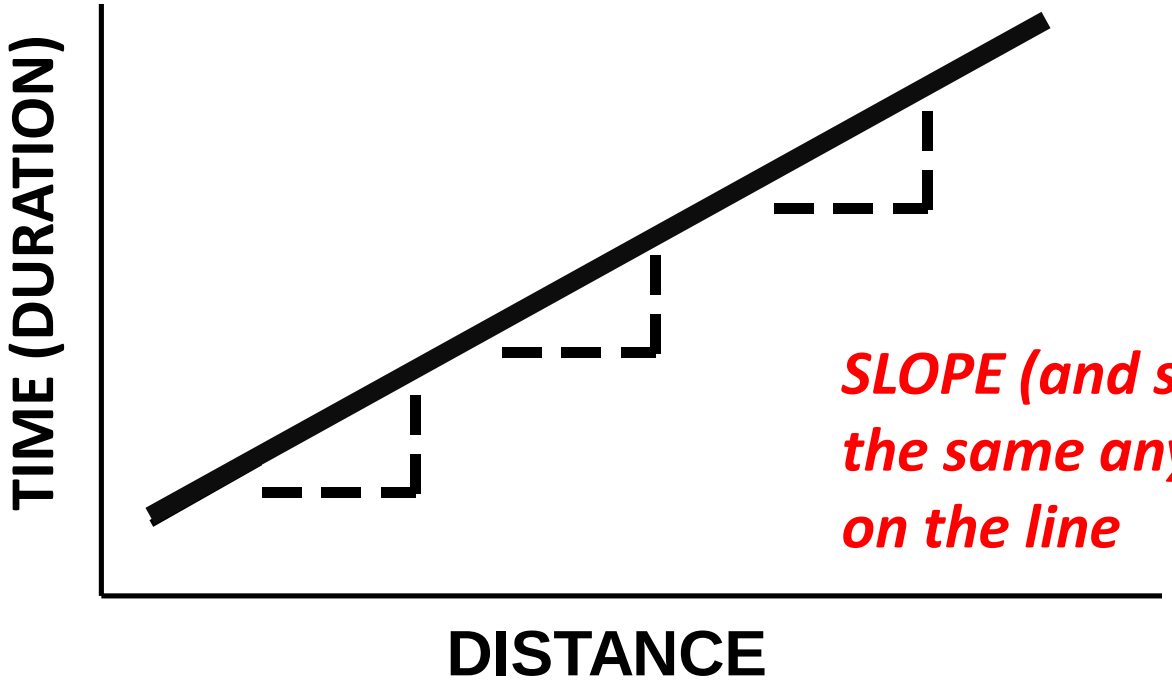
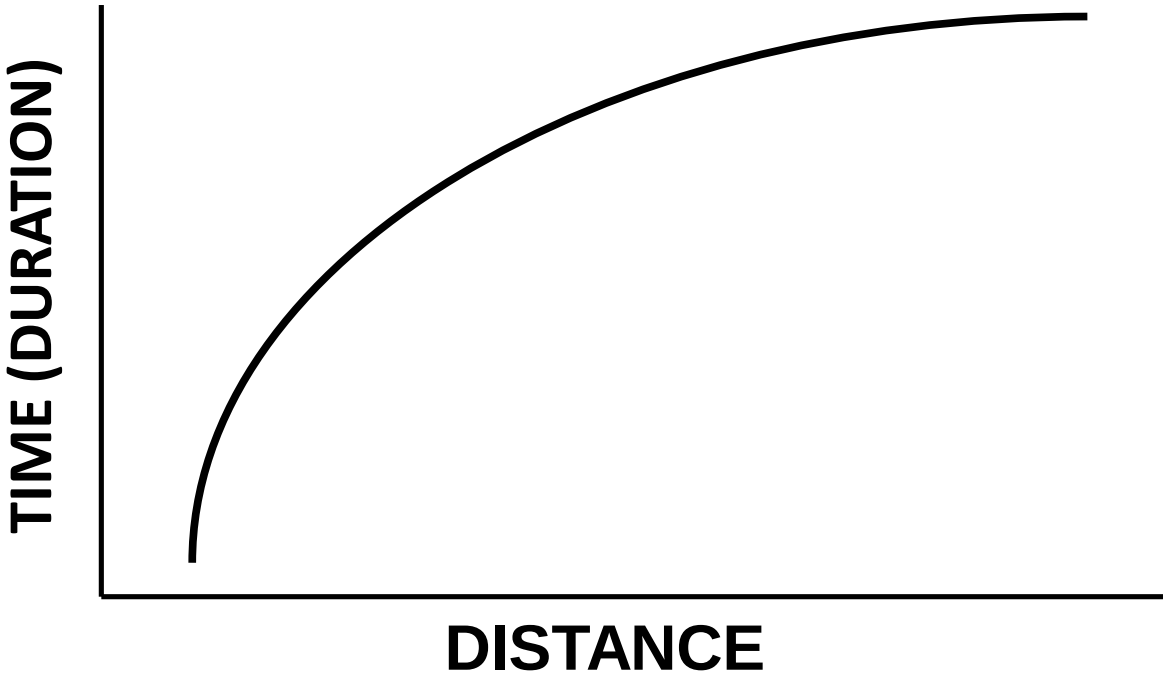


SLOPE (and speed) is the same anywhere on the line

$$\text{SLOPE} = \frac{\triangle D}{\triangle T} = \textit{SPEED}$$

2) If *sign <u>durations</u> are relatively constant*, then for signs that travel farther, the hand needs to SPEED UP, and for signs traveling a shorter distance, speed slows down. This keeps duration constant.

= **non-linear**



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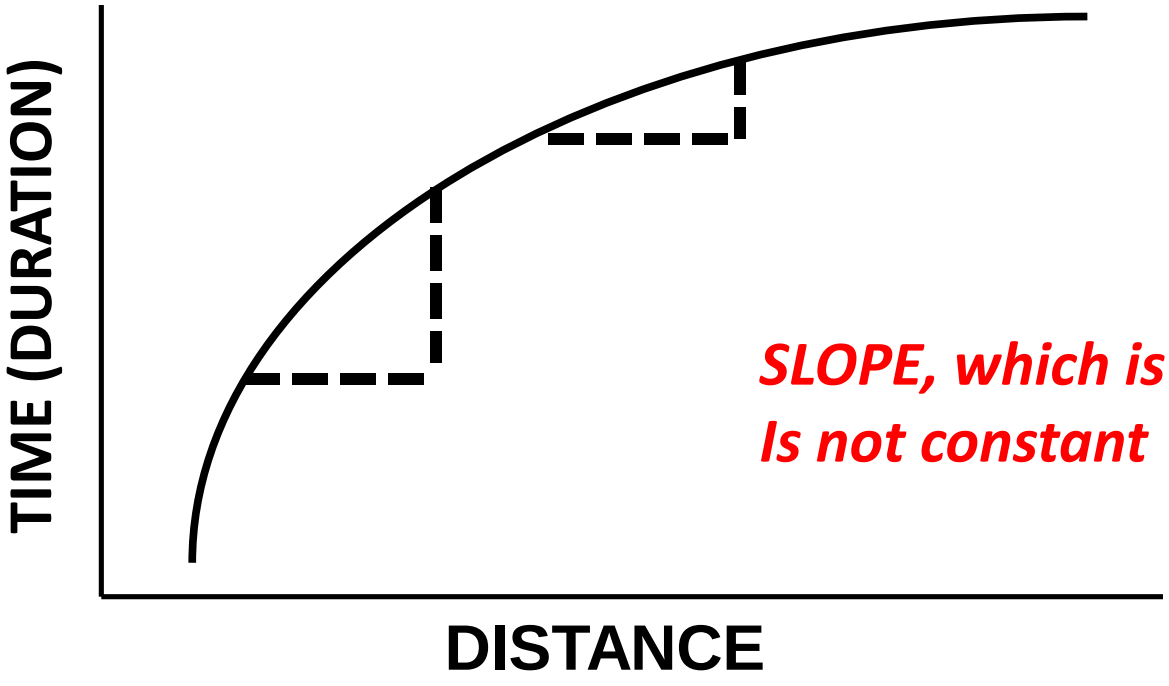
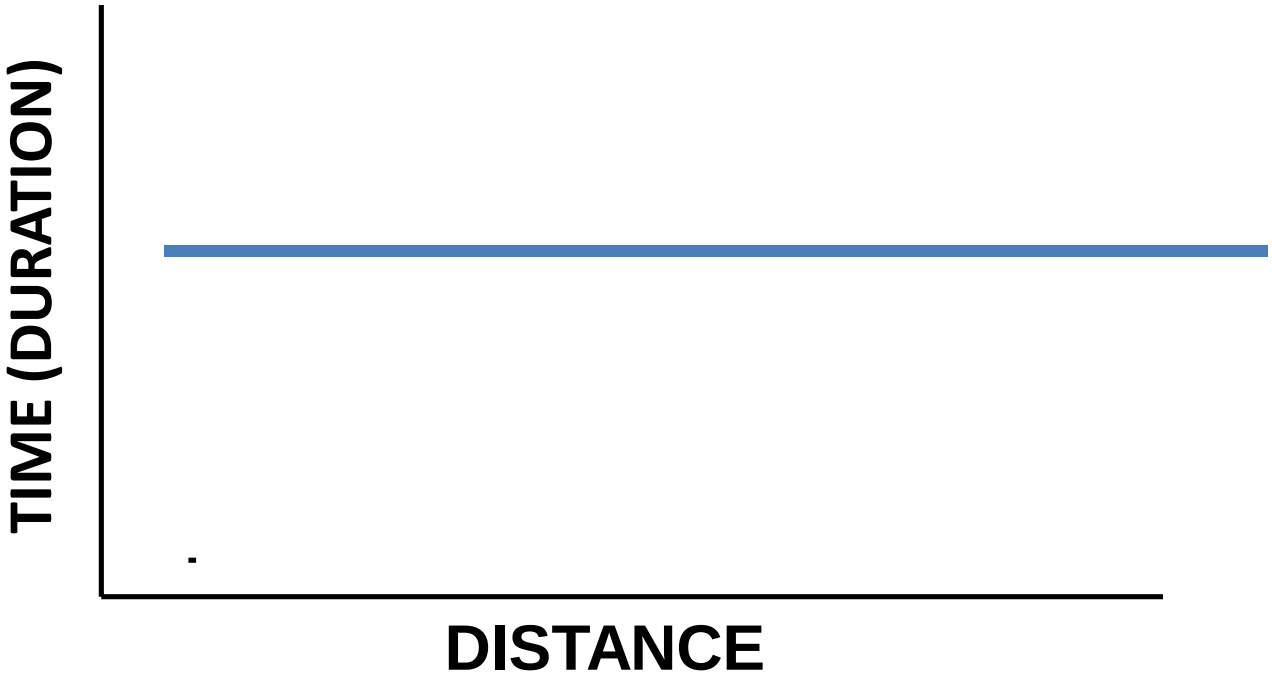


SLOPE, which is speed, Is not constant

$$\text{SLOPE} = \frac{\triangle D}{\triangle T} = \textit{SPEED}$$

3) If *sign durations and sign distances are not related*

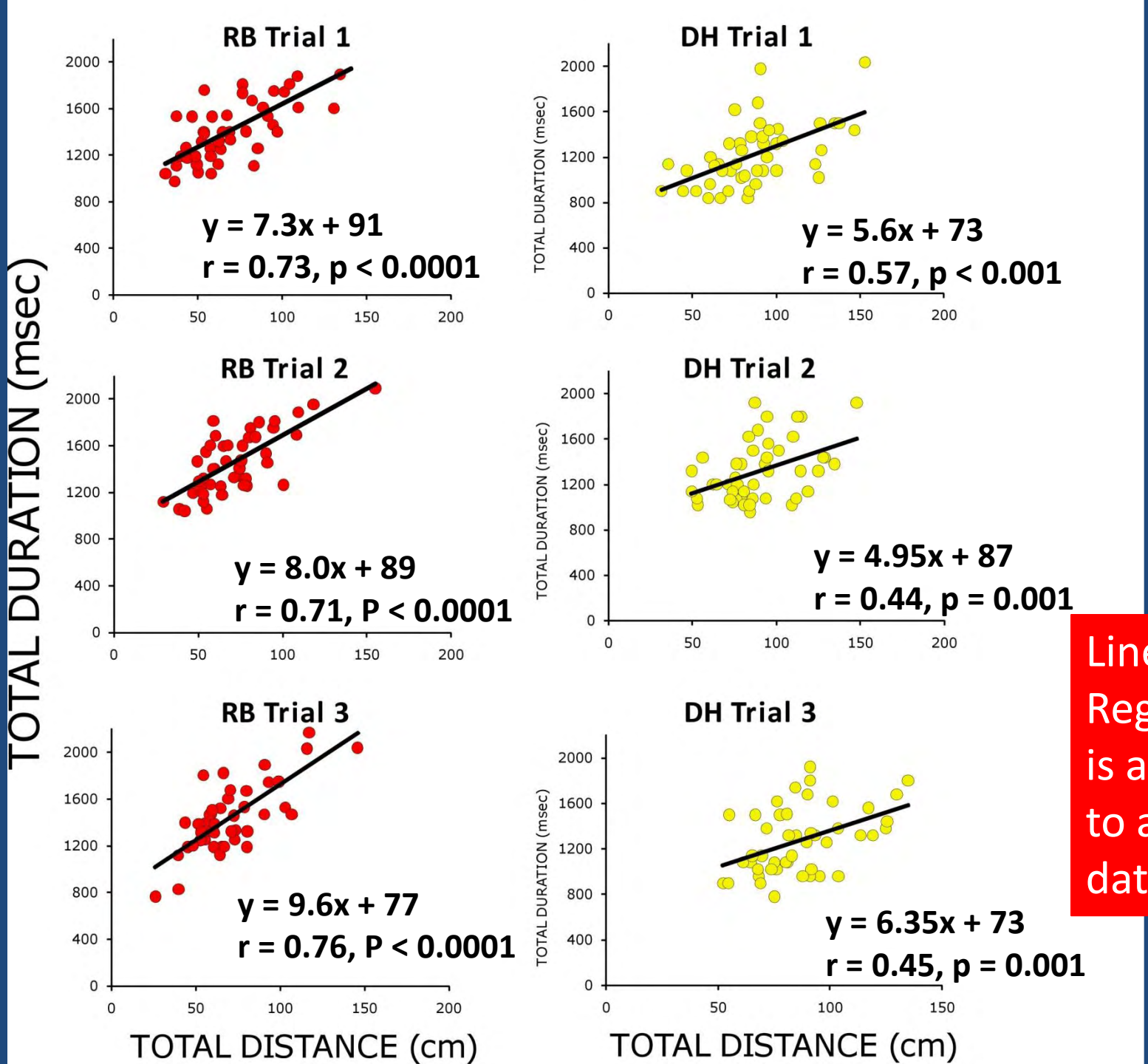
= **no relationship**



RESULTS:

Which relationship does the data show???

… drum roll…



Linear Regression is a good fit to all datasets

CONCLUSIONS:

• Signs that *travel farther* are produced *longer*, and *the* ***relative speed is kept constant.***

• In our motion analyses, we found a specific range of speeds across signs, centered around 40 cm/sec and max speeds between 100 and 280 cm/sec.

• Signs are fastest for narratives than elicited sentences, and these are faster than single signs.

FUTURE DIRECTIONS:

-Need to compare dominant vs. non-dominant hands, *across* sign languages, *more* signers, and ***more data***

-Knowing visual parameters of sign languages permits us to address hypotheses about *changes in visual perception*

-Apply to prosody, stress, and changes in articulation rate (following Wilbur and colleagues' work).

-New method to study "phonetics" and phonology of sign language

Perception in Deaf: Finney & Dobkins 2001:

-Measured deaf signers' and hearing nonsigners' contrast sensitivity for moving stimuli across a range of speeds.

-No differences between subject groups were found, over a range of speeds from 0.1 to 64 deg/sec.

-The task involved merely detecting the presence of the stimulus rather than discriminating its direction or speed.

-Future studies will be conducted in order to determine whether group differences arise when subjects attend to the speed, direction, or orientation of the moving stimulus.