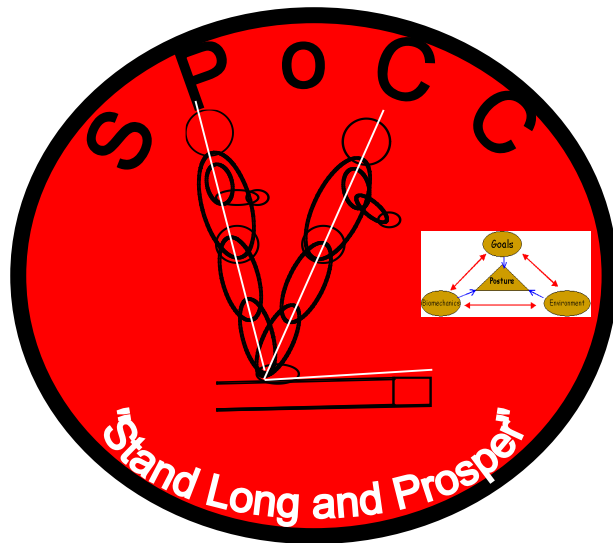


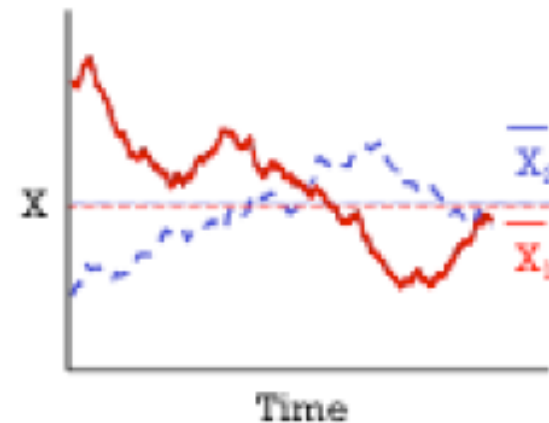
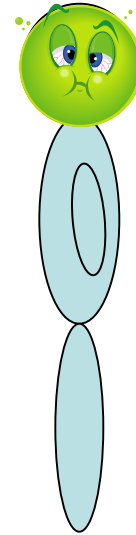
# Perception of Non-Linear Characteristics of Posture



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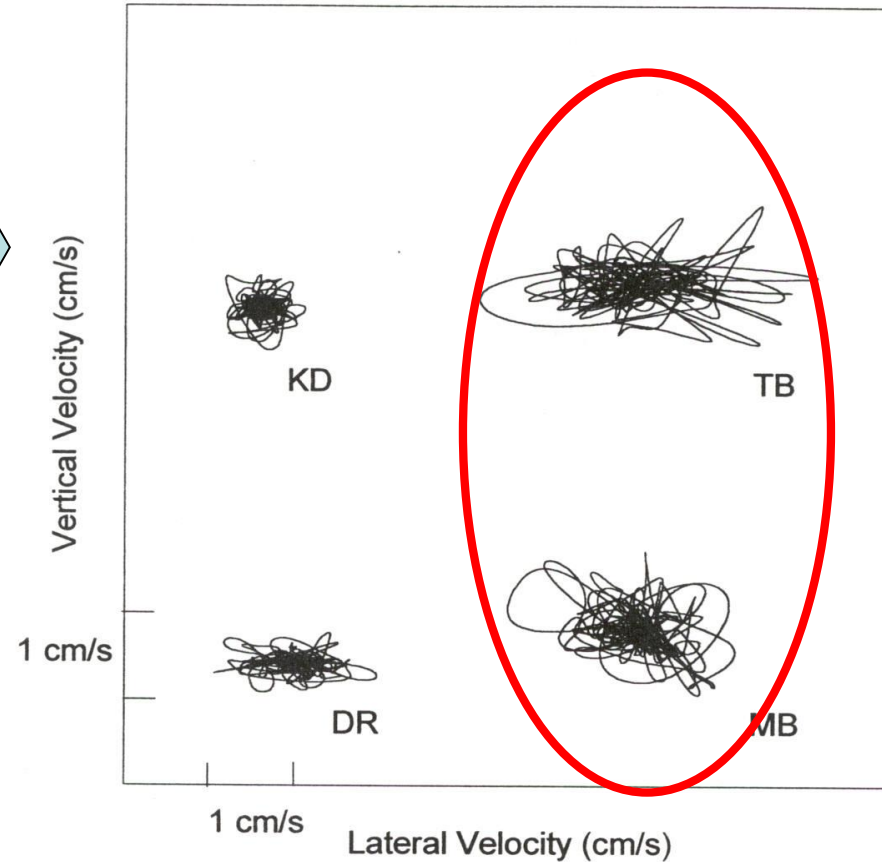
# Moving to sickness

- ▶ Several studies over the past decade have shown that changes in postural motion both precede and can predict motion sickness in participants (Smart et al., 2014; Otten & Smart, 2009; Smart, Otten, & Stoffregen, 2007; Stoffregen & Smart, 1998).
- ▶ However, standard means of quantifying these data (e.g., variability, velocity, range) have yielded inconsistent relations with the behavioral changes observed.
- ▶ Nonlinear measures (e.g., Path length, elliptical area, Normalized Path length) have yielded better consistency, but still make errors in 'categorization'



# This is where we come in...

- ▶ An interesting phenomena that has been observed is that people have little problem distinguishing these behavioral changes.
  - ▶ Which of these postural traces reflects people who became motion sick?
- 
- ▶ If you said the ones on the right, you are correct!
  - ▶ In fact in it has been shown that people's ability to identify "motion sickness" in a sorting task is on par with statistical predictions (86% - c.f., Braun, 2012)
  - ▶ Interestingly **the errors made** by the statistical 'models' and people are **similar**



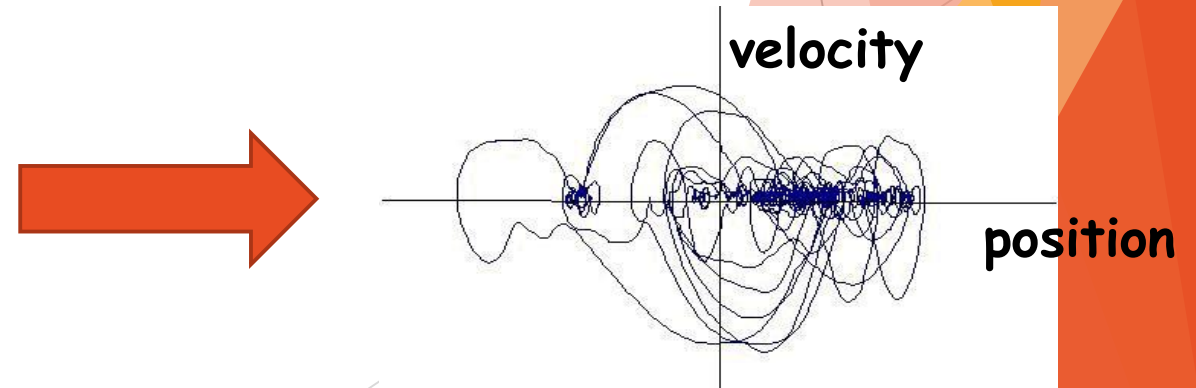
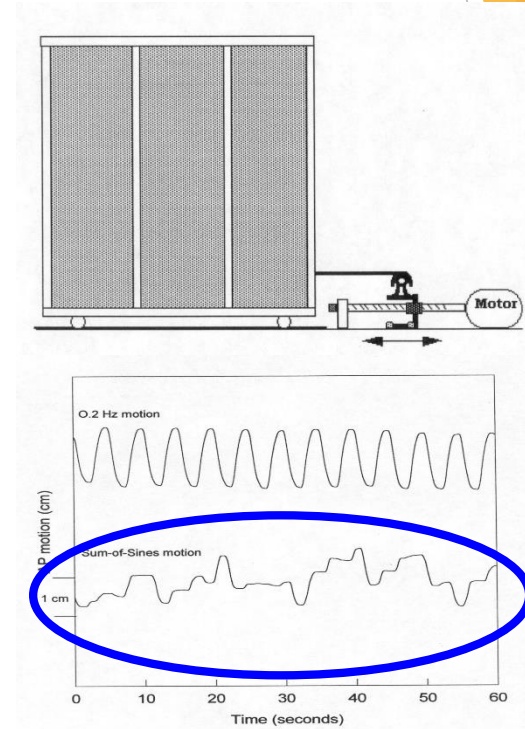
## The Question...

- ▶ Are people perceiving the **same structures** or traits that the quantitative analyses are using **to make predictions/classifications?**



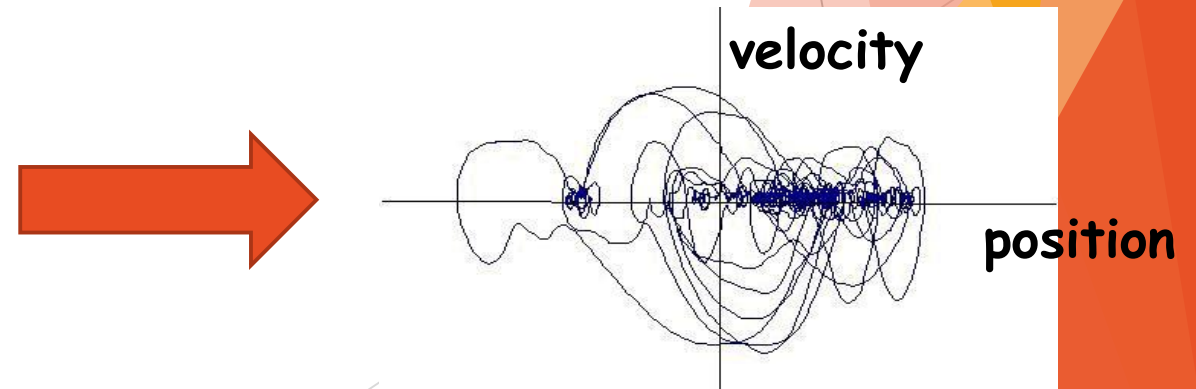
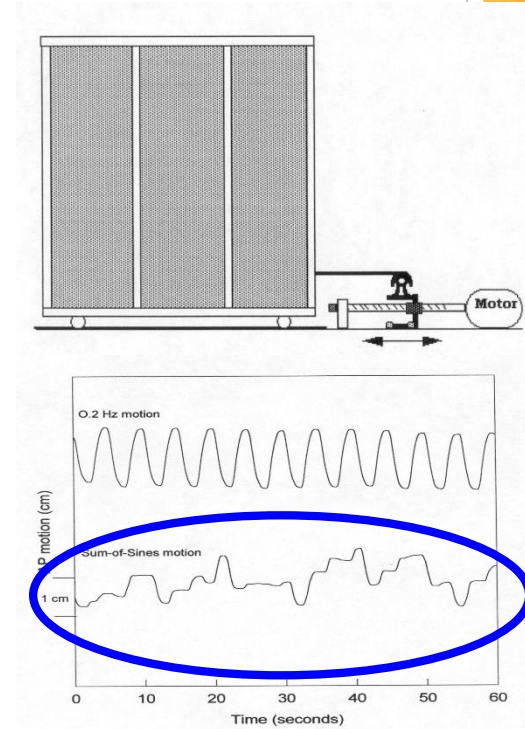
# The task

- ▶ Using data from Stoffregen & Smart (1998) and Smart, Stoffregen, & Bardy (2002):
  - ▶ 74 postural motion phase plots (AP position vs. AP velocity) were created.
  - ▶ Each plot represents 10 min\* of motion data while being exposed to complex optic flow
  - ▶ Participants were not told what the plots represented\* and the axes were not labeled
  - ▶ Phase plots were printed on 3" x 5" index cards
  - ▶ Participants were told to sort cards based on "similarity"\*



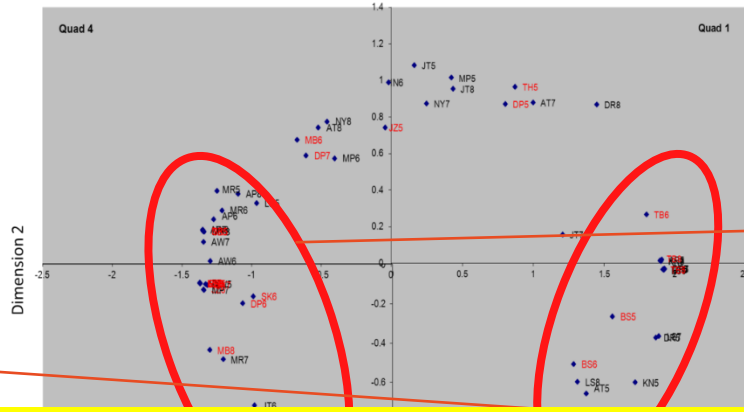
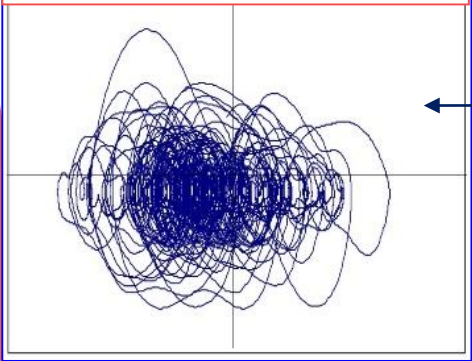
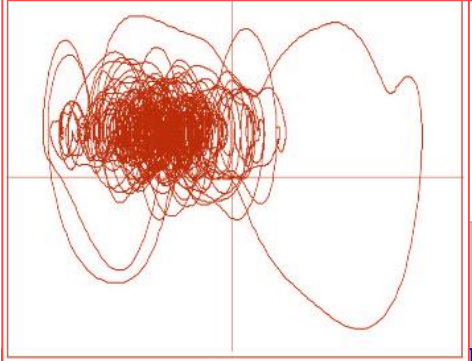
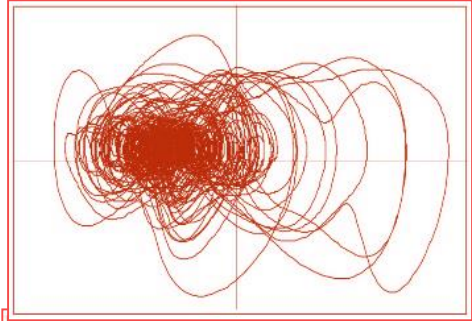
# The Measures

- ▶ Using measures from Smart, Otten, Strang, Littman, & Cook (2014):
  - ▶ **Hurst Exponent** - measure of ‘self-similarity’ across timescale
  - ▶ **Sample Entropy** - measure of temporal stability
  - ▶ **Path Length** - measure of sway extent
  - ▶ **Path Length Normalized** - measure of spatial complexity
  - ▶ **Elliptical Area** - measure of sway magnitude

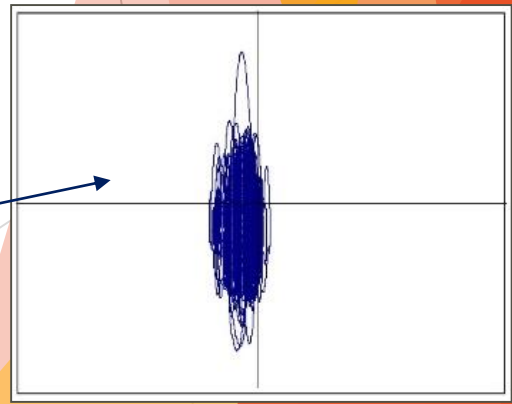
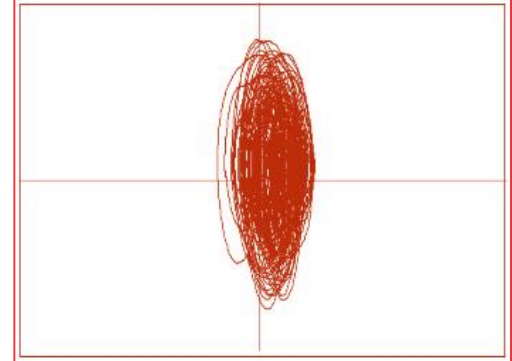
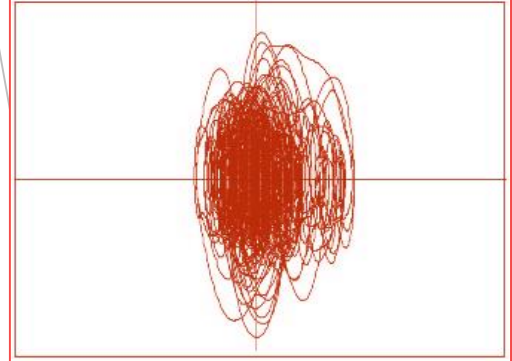
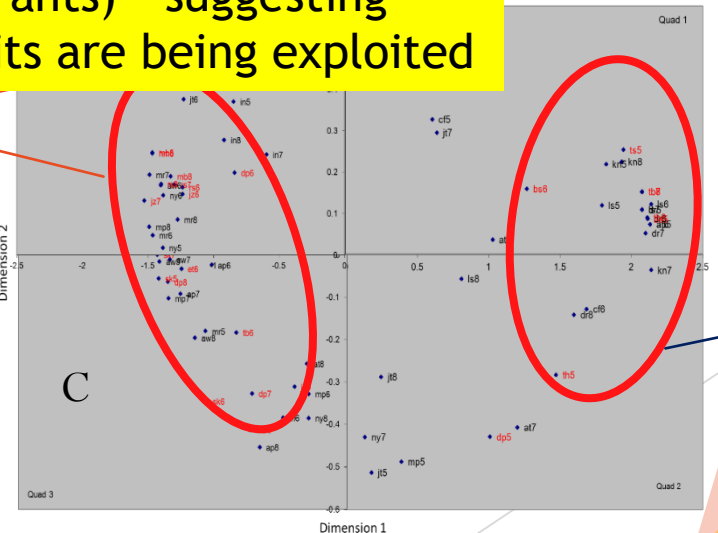
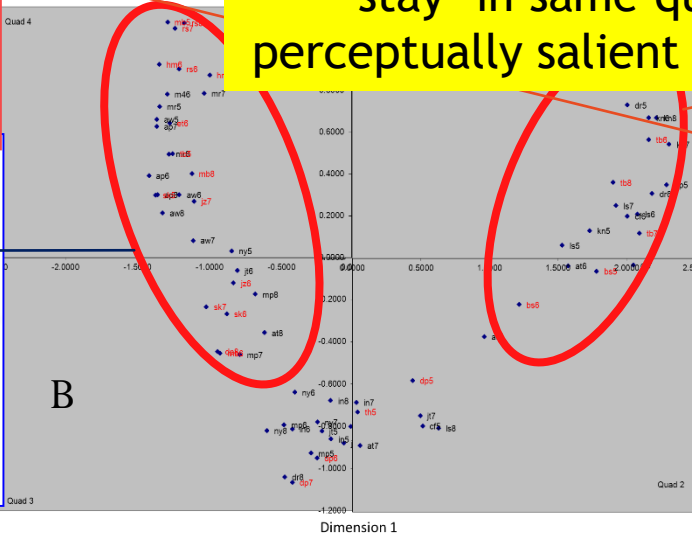




# The Data - Overview



While shifts in absolute position occur - general pattern of sorting persists (cards 'stay' in same quadrants) - suggesting perceptually salient traits are being exploited

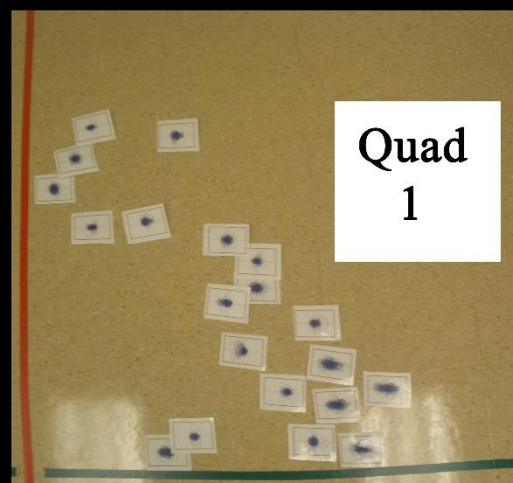
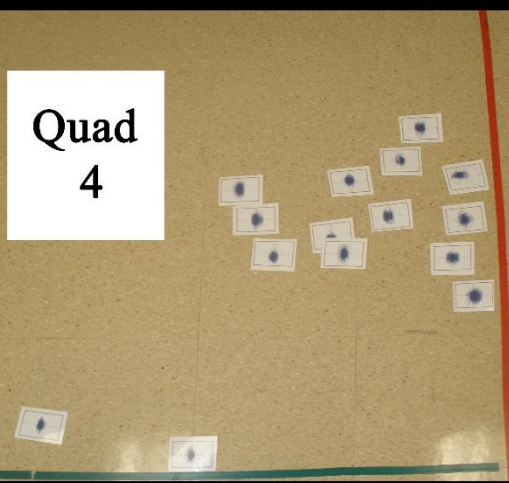


A- Free "choice", B - Scale Choice, C - Binary Choice

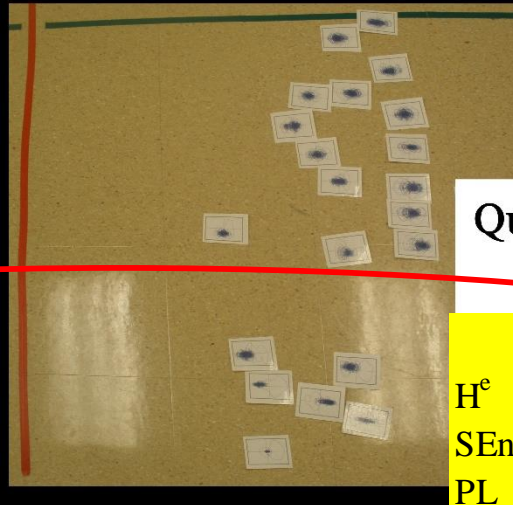
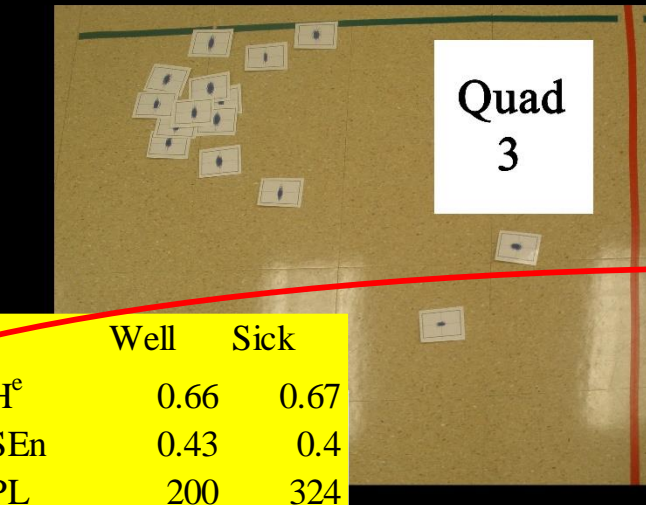


# Free Choice (based on similarity)

	Well	Sick
H <sup>c</sup>	0.59	0.62
SEn	0.42	0.44
PL	200	218
PL <sub>N</sub>	251	242
EA	7	10



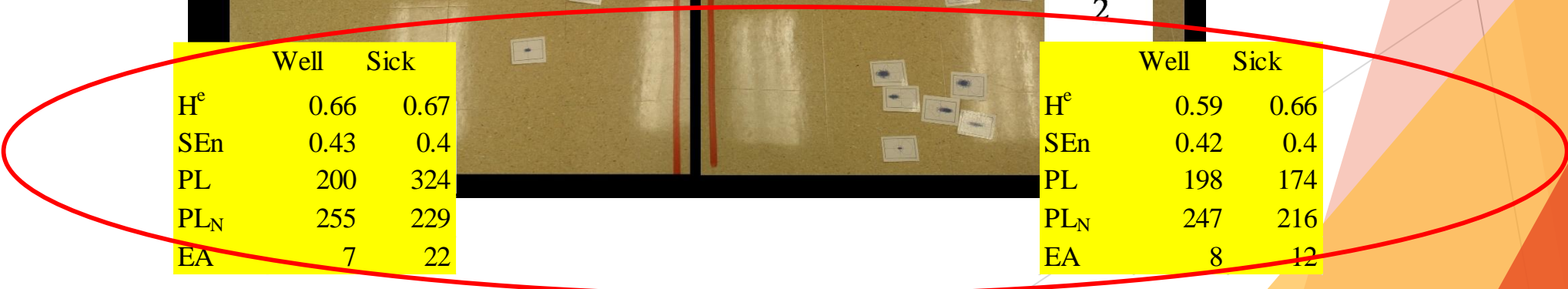
	Well	Sick
H <sup>c</sup>	0.63	0.62
SEn	0.46	0.4
PL	192	269
PL <sub>N</sub>	268	227
EA	6	18



	Well	Sick
H <sup>c</sup>	0.66	0.67
SEn	0.43	0.4
PL	200	324
PL <sub>N</sub>	255	229
EA	7	22

	Well	Sick
H <sup>c</sup>	0.59	0.66
SEn	0.42	0.4
PL	198	174
PL <sub>N</sub>	247	216
EA	8	12

While we see differing patterns for Well/Sick in general, characteristics are consistent across quadrants



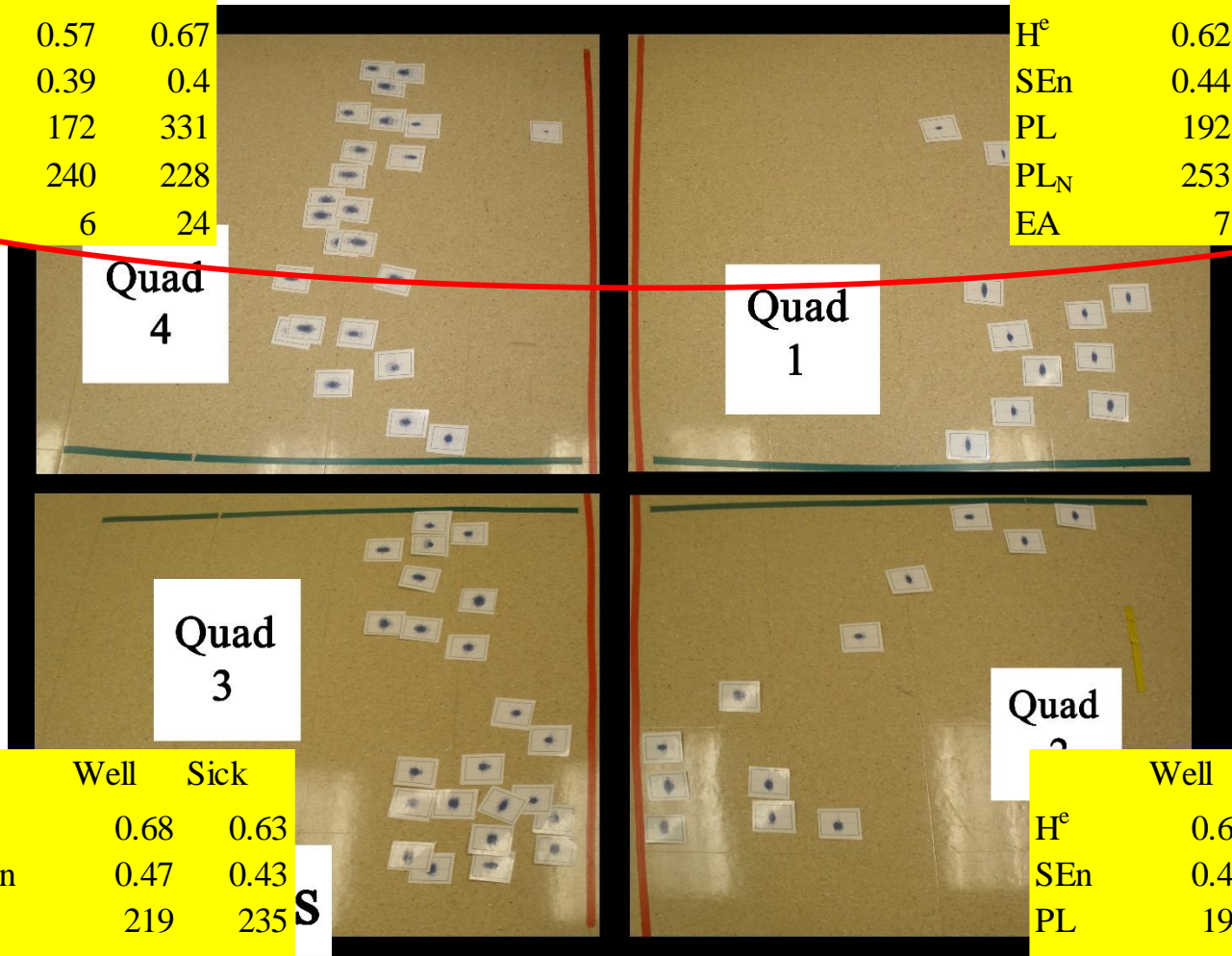




# Scale choice (healthy (10) - unhealthy (1))

	Well	Sick
H <sup>e</sup>	0.57	0.67
SEn	0.39	0.4
PL	172	331
PL <sub>N</sub>	240	228
EA	6	24

	Well	Sick
H <sup>e</sup>	0.62	0.7
SEn	0.44	0.37
PL	192	288
PL <sub>N</sub>	253	205
EA	7	25



Quad 4

Quad 1

Quad 3

Quad 2

	Well	Sick
H <sup>e</sup>	0.68	0.63
SEn	0.47	0.43
PL	219	235
PL <sub>N</sub>	268	239
EA	7	12

	Well	Sick
H <sup>e</sup>	0.62	0.7
SEn	0.44	0.37
PL	192	288
PL <sub>N</sub>	253	205
EA	7	25

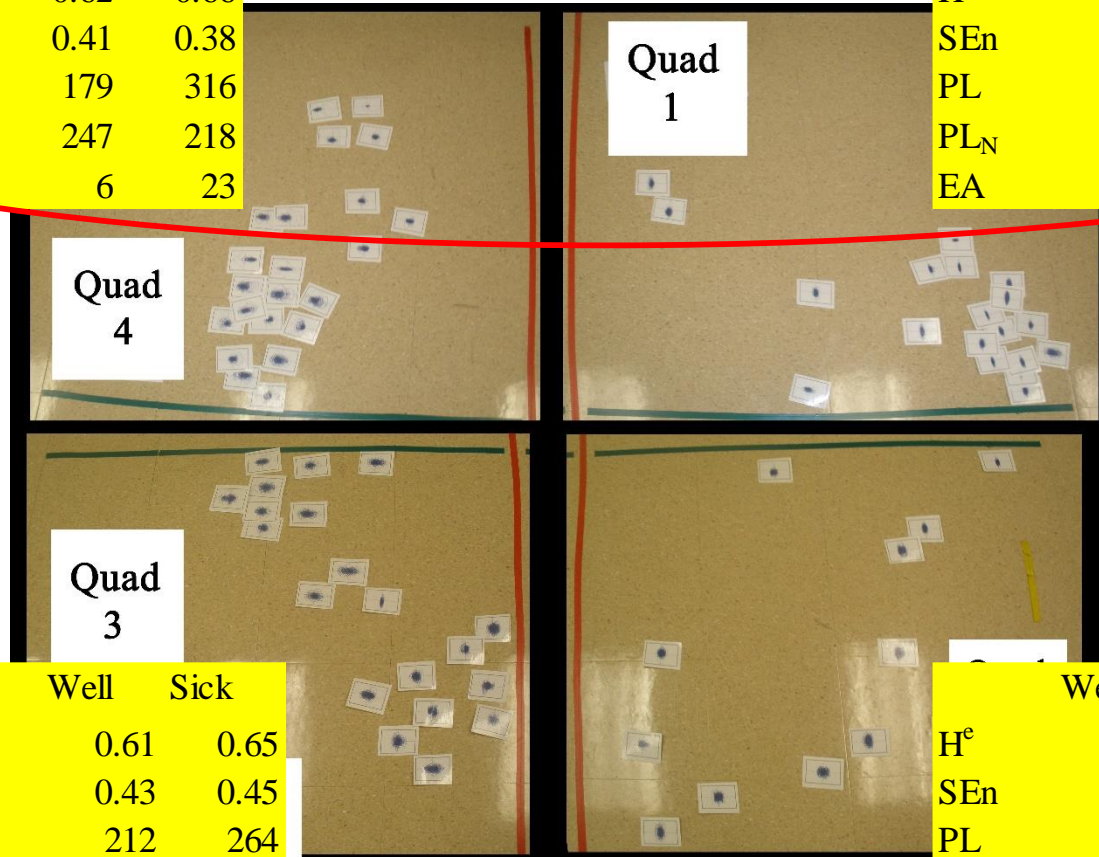
With the change in question, See differential patterns for Well and Sick as well as for key quadrants



# Binary choice (healthy/unhealthy)

	Well	Sick
H <sup>c</sup>	0.62	0.66
SEn	0.41	0.38
PL	179	316
PL <sub>N</sub>	247	218
EA	6	23

	Well	Sick
H <sup>c</sup>	0.59	0.66
SEn	0.44	0.37
PL	192	229
PL <sub>N</sub>	254	211
EA	7	17



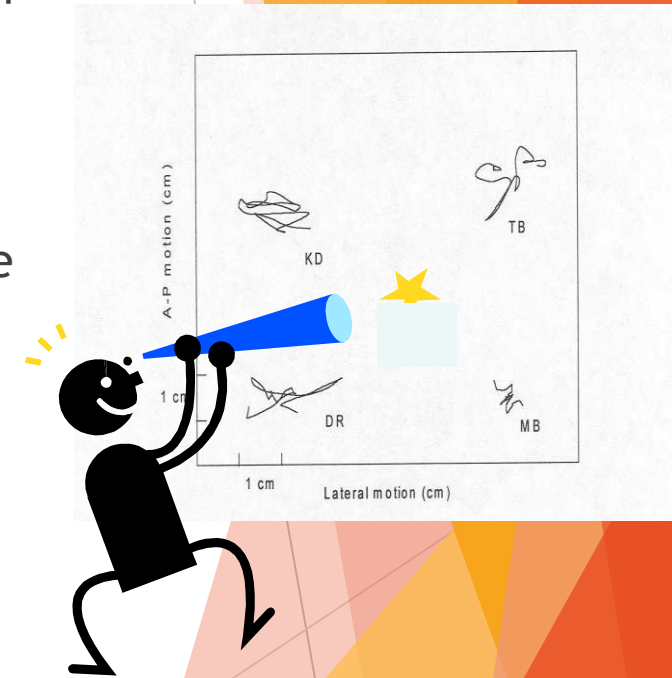
	Well	Sick
H <sup>c</sup>	0.61	0.65
SEn	0.43	0.45
PL	212	264
PL <sub>N</sub>	260	251
EA	7	13

	Well	Sick
H <sup>c</sup>	0.65	0.66
SEn	0.44	0.47
PL	209	201
PL <sub>N</sub>	260	253
EA	8	8

With the forced choice, we see further differentiation between Well/Sick and key quadrants

## So what can we say...

- ▶ Across three samples of participants and different sorting instructions, people were fairly consistent in how they categorized the stimuli.
- ▶ At the tails of the distributions, the stimuli had **high magnitude** (PL, EA) motion coupled with **persistent strategies** ( $H^e$ , SEn)
- ▶ What seemed to determine which extreme the stimuli were placed was the **spatial complexity** ( $PL_N$ )
- ▶ In short, while complex, these non-linear changes across stimuli are both perceivable and usable.
- ▶ Our next step is to try to develop a model incorporating the perceptual measure with the quantitative measures.





thank you!