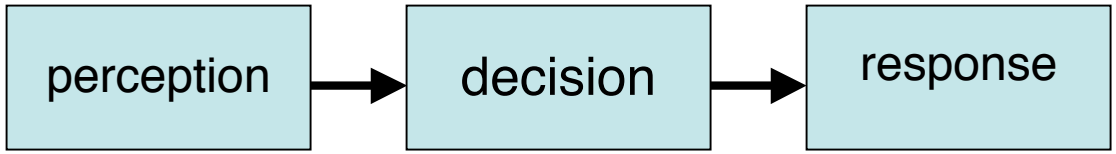
Perception, Cognition, Action



Ken Nakayama
Harvard University

Sperry, R.W. Neurology and the mind brain problem

American Scientist 40, 291-312, 1952

" . . . An approach to the interpretation of higher brain functions is here suggested in which motor adjustment, rather than stimulus patterns or the contents of subjective experience, figures predominantly as a proper frame of reference for understanding the organization, meaning, and significance of brain excitation"

visuo-motor control

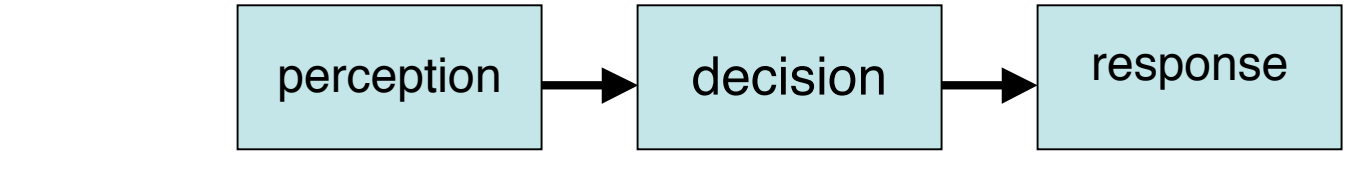
- Flexible behavior afforded by parallel motor plans
- Limits to and possible irrelevance of speed-accuracy trade offs
- Revealing otherwise hidden states
  - dynamics of attentional selection
  - analog number line
  - rapid influence of unseen words

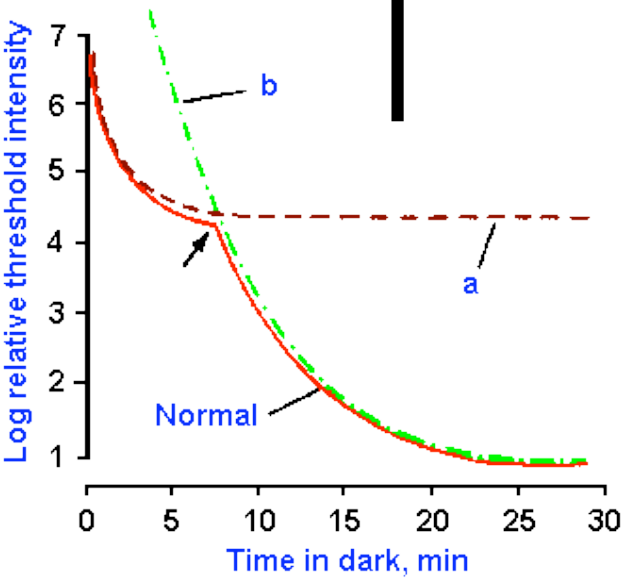
Collaboration with Joo-Hyun Song
Now at Smith Kettlewell
Also Robert McPeek

Underlies psychophysical and many behavioral methods

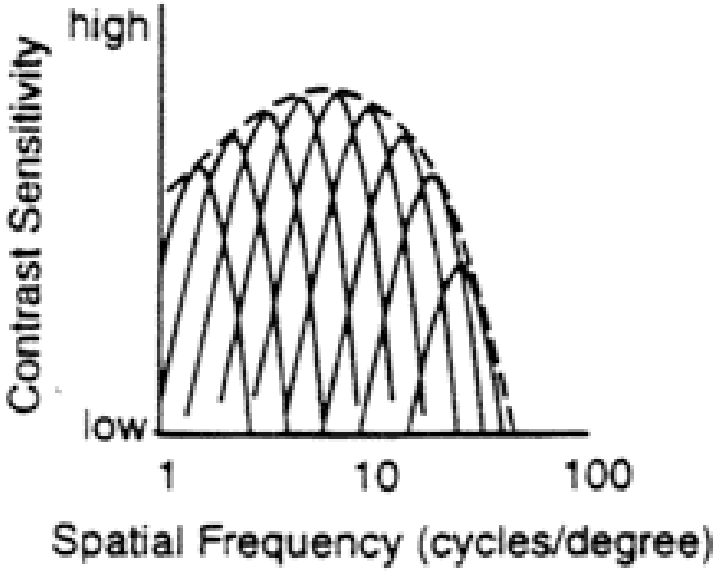
- **Some examples**
- Hecht, Shlaer and Pirenne, 1943
- Julesz 1960s
- Sperling 1960s

Success of serial assumption



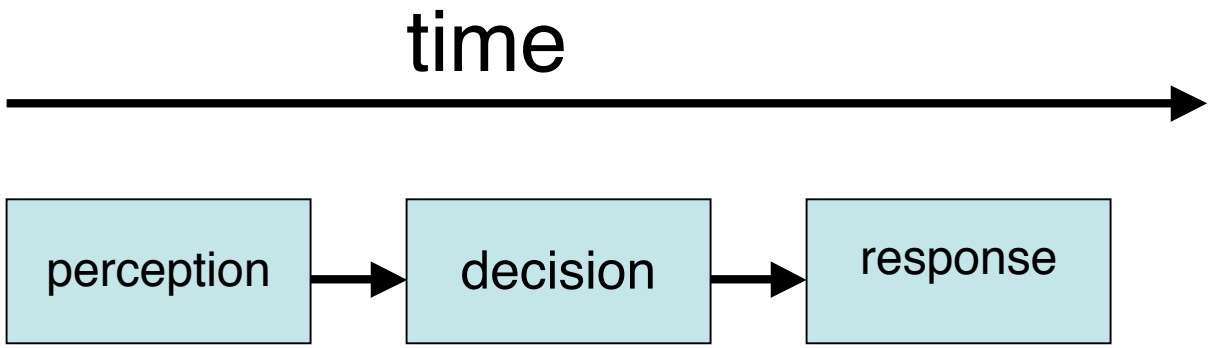


Rods/cones



S.F. channels

Serial assumption- mainstay of cognitive studies



Additive Factors Logic
Mental Chronometry

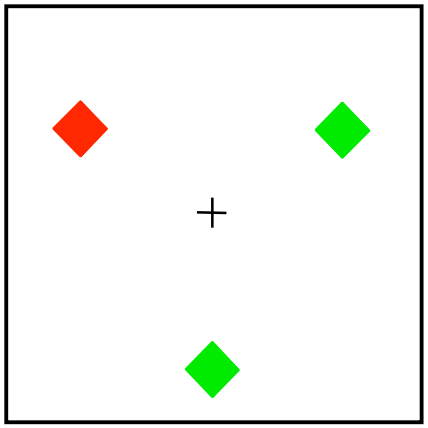
F.C. Donders
S. Sternberg
M. Posner
Woodman, Kang, Thompson, Schall (2008)

Generality of serial processing ??

Maradona

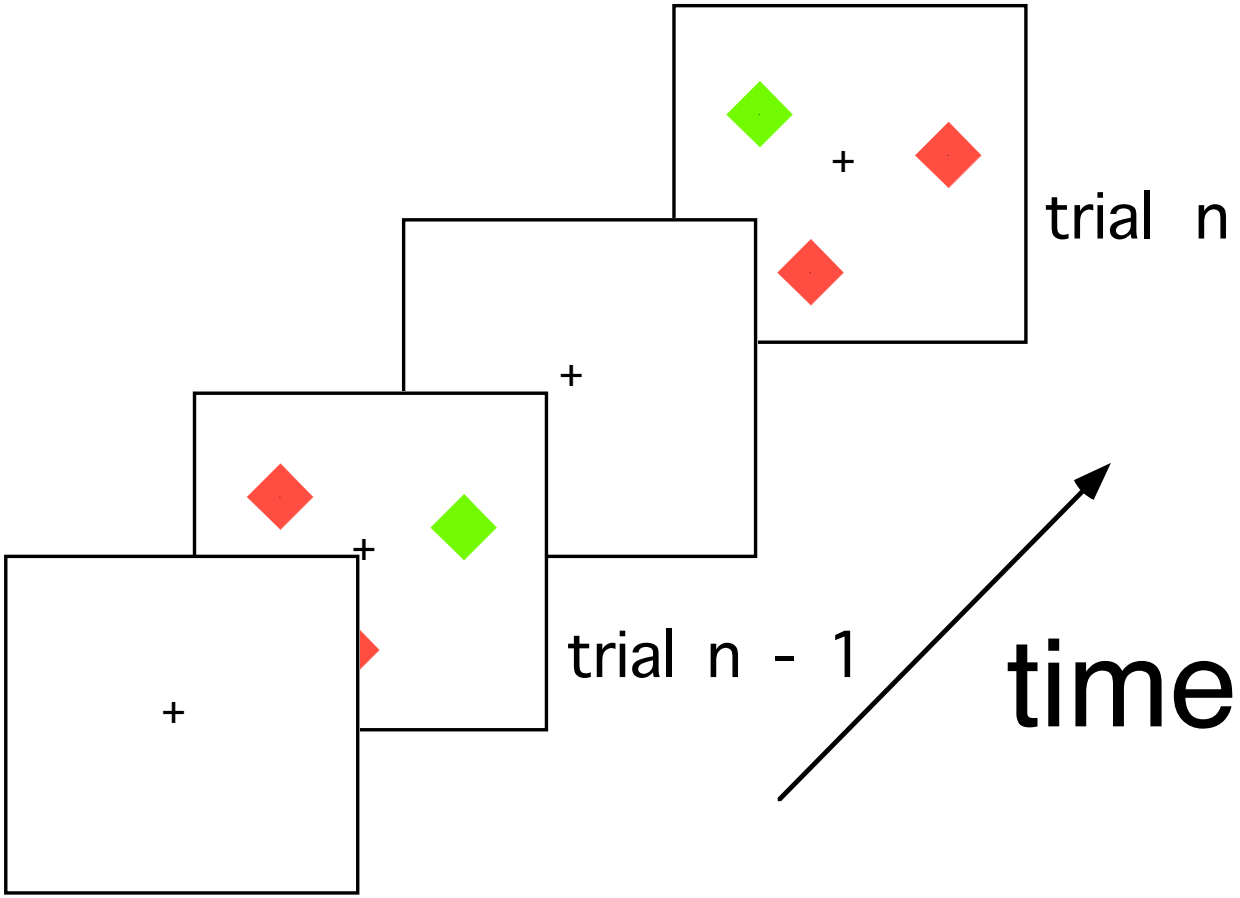
The problem of serial order in behavior. Lashley, K. S. (1951)In Cerebral Mechanisms in Behavior, Wiley, pp. 112-136.

Ph.D. work of Rob McPeek

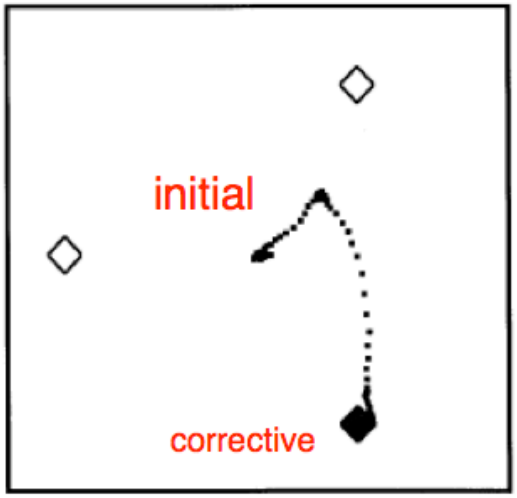


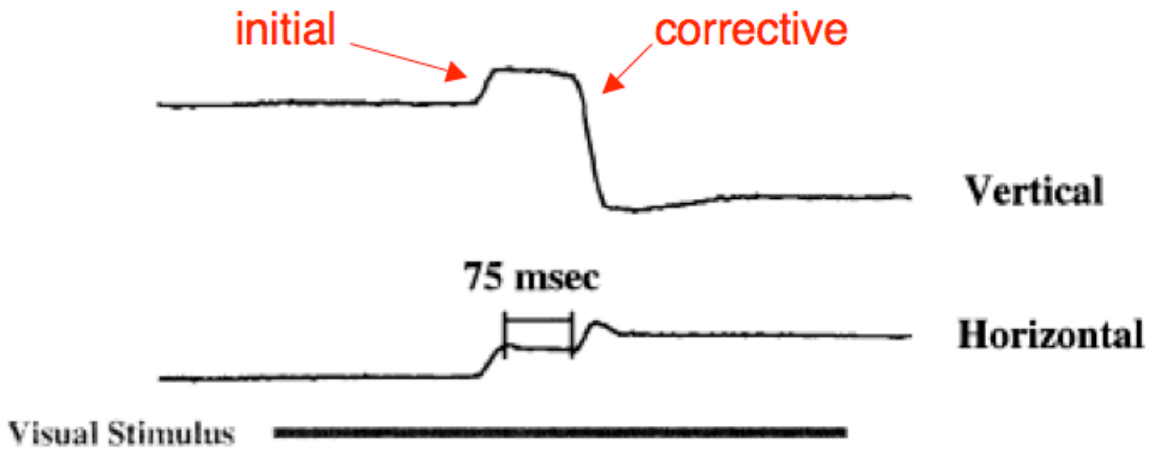
Task:
Make eye movement to odd colored target

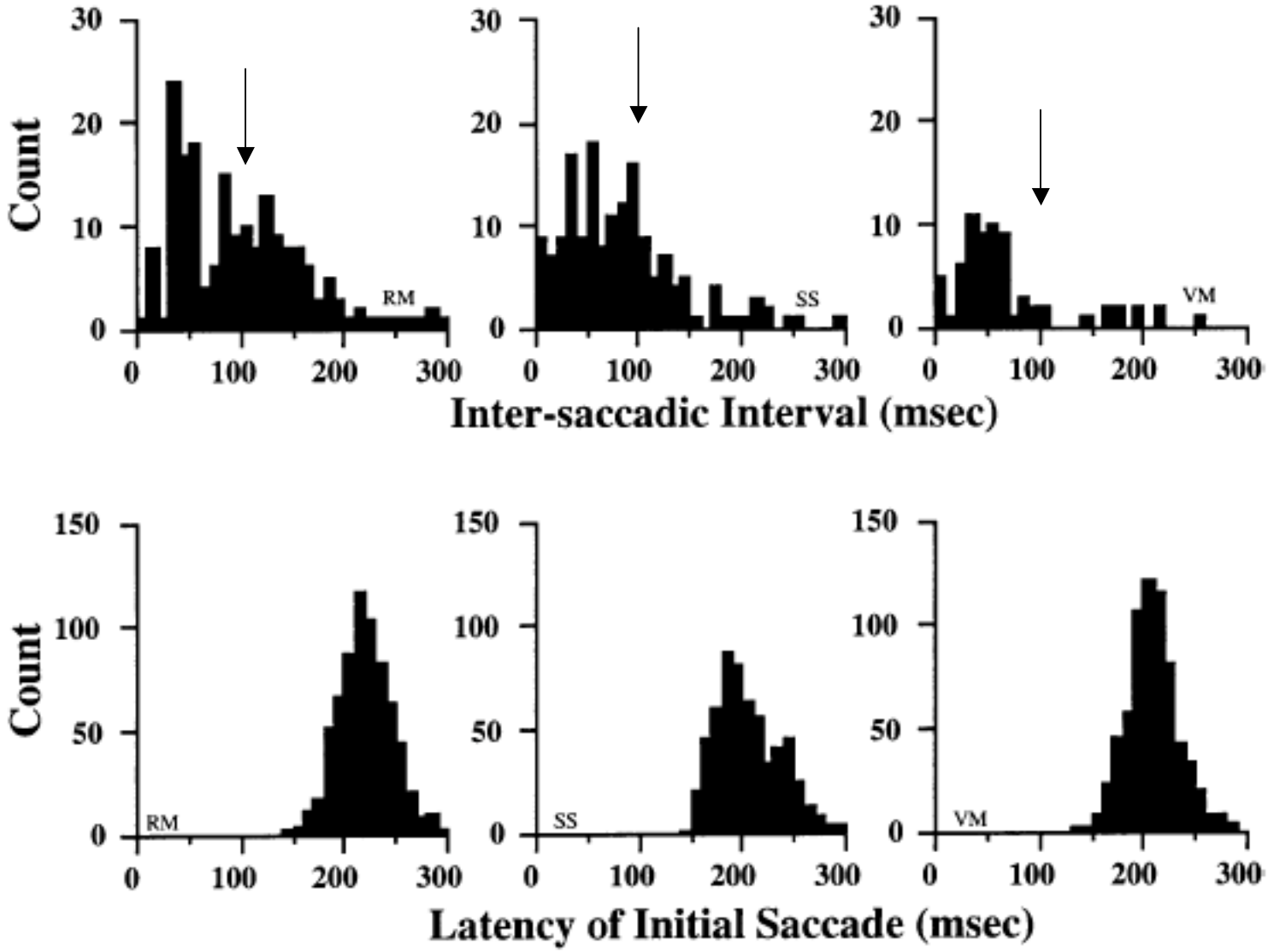
(McPeek, Skavenski, Nakayama,2000)

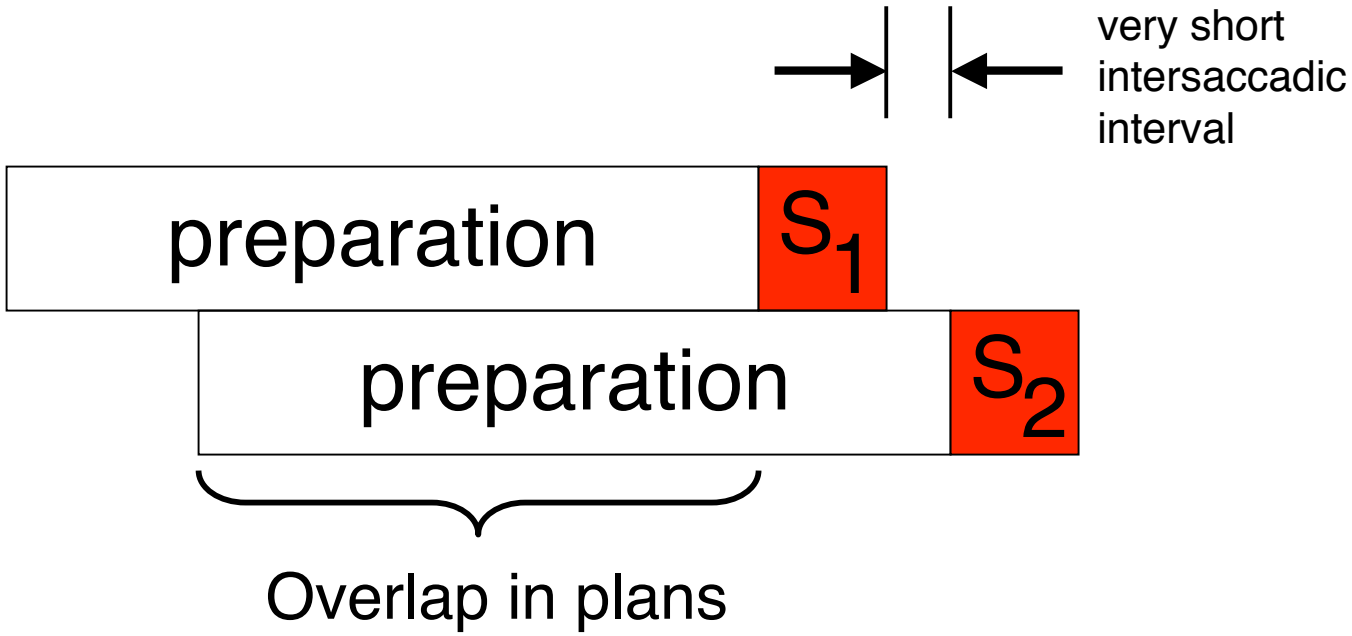


Task: make a saccade to the odd colored target


initial
corrective

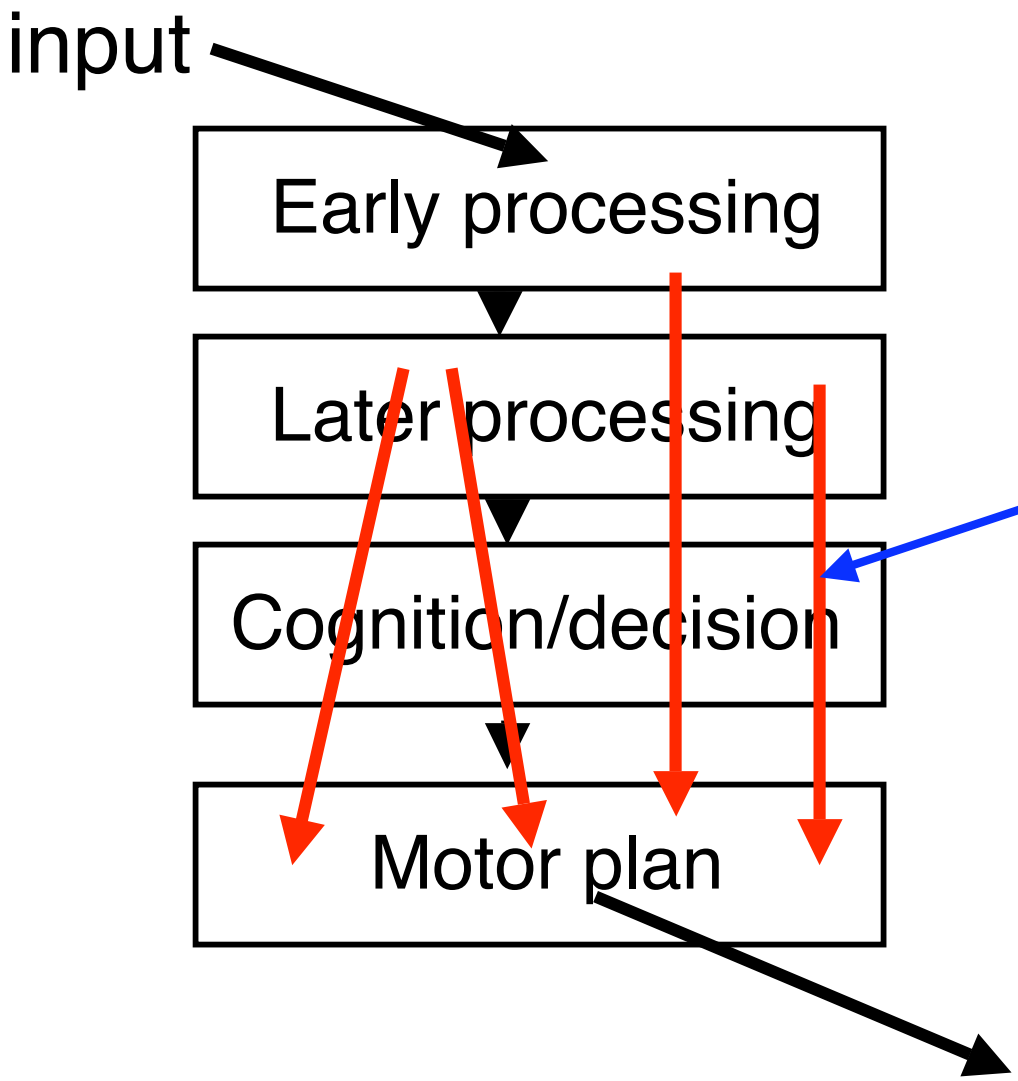

initial
corrective
Vertical
75 msec
Horizontal
Visual Stimulus


Count
30
20
10
0
RM
SS
VM
0
100
200
300
Inter-saccadic Interval (msec)
Count
150
100
50
0
RM
SS
VM
Latency of Initial Saccade (msec)



Concurrent (parallel) processing in motor systems

McPeek et al., superior colliculus study



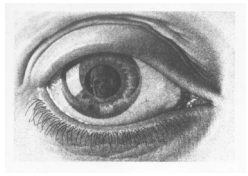
Reaching

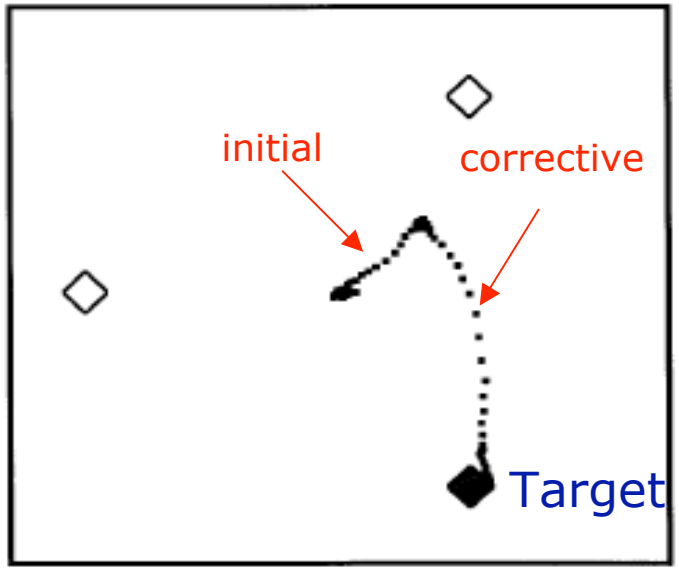
LEAKAGE

Full details of trajectory

Concurrent process for “eyes” but what about larger body movements?

Eye vs hand

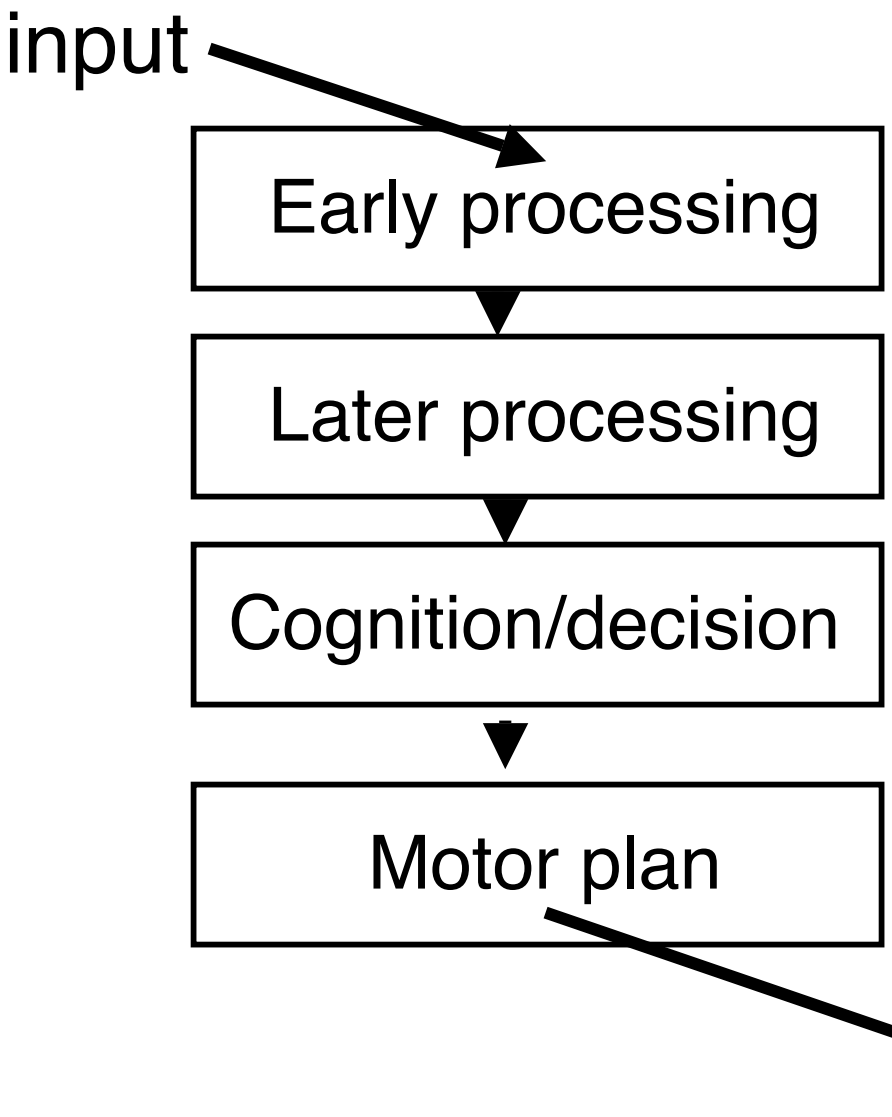




~zero mass (inertia)

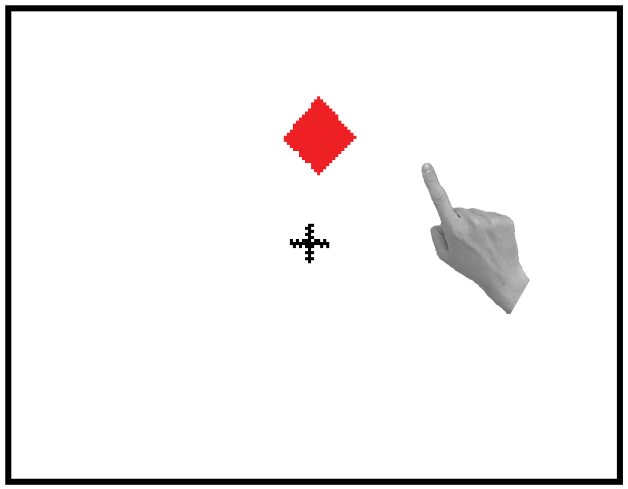
high mass (inertia)

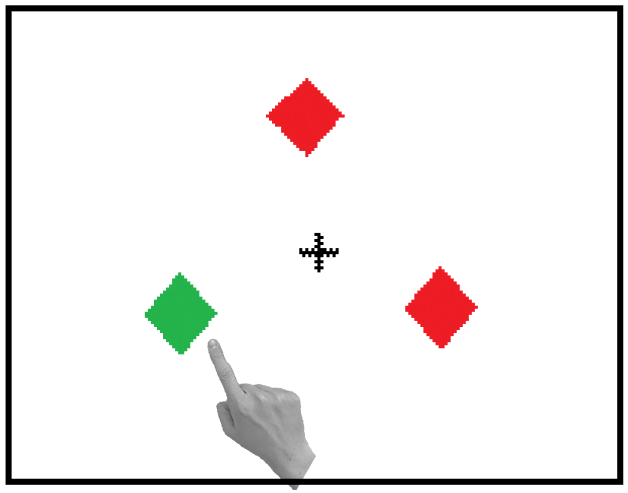
System more “careful” with arm movements ?



assumption of serial processing

Pointing task



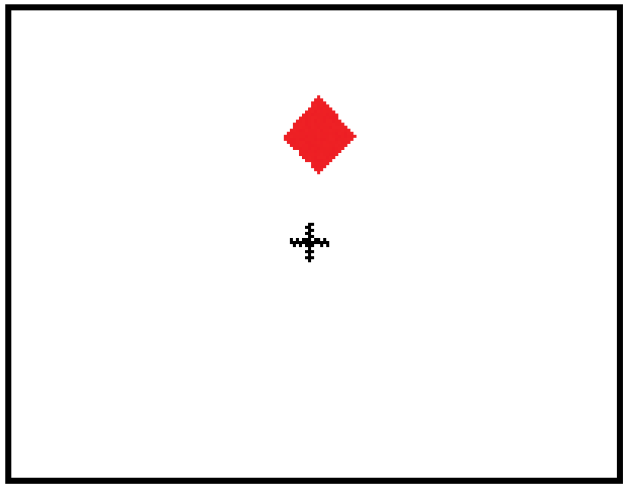


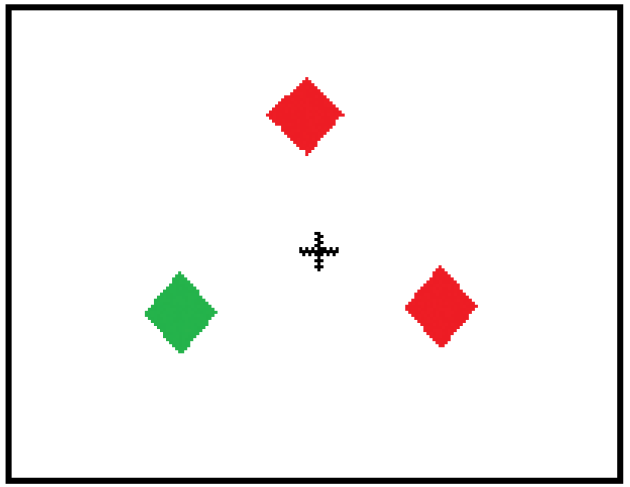
Touch the single target

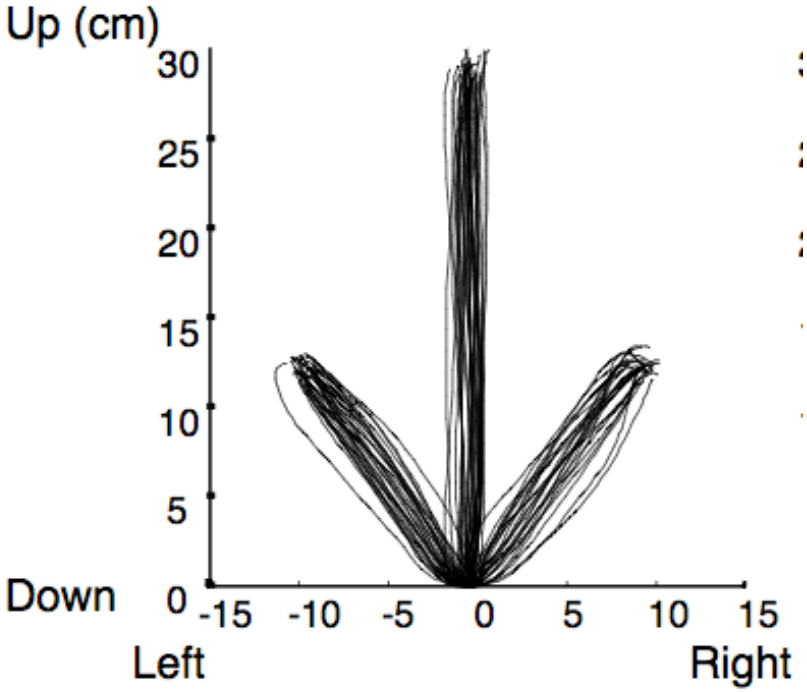
or

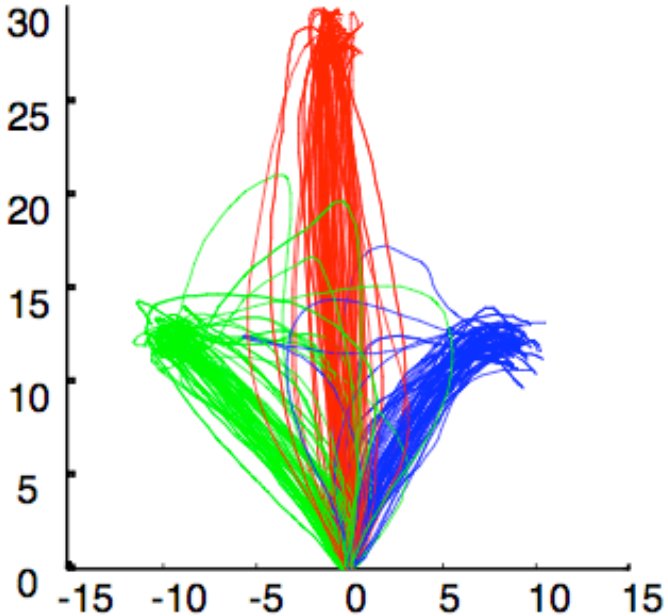
Touch odd colored target

Mixture of two tasks

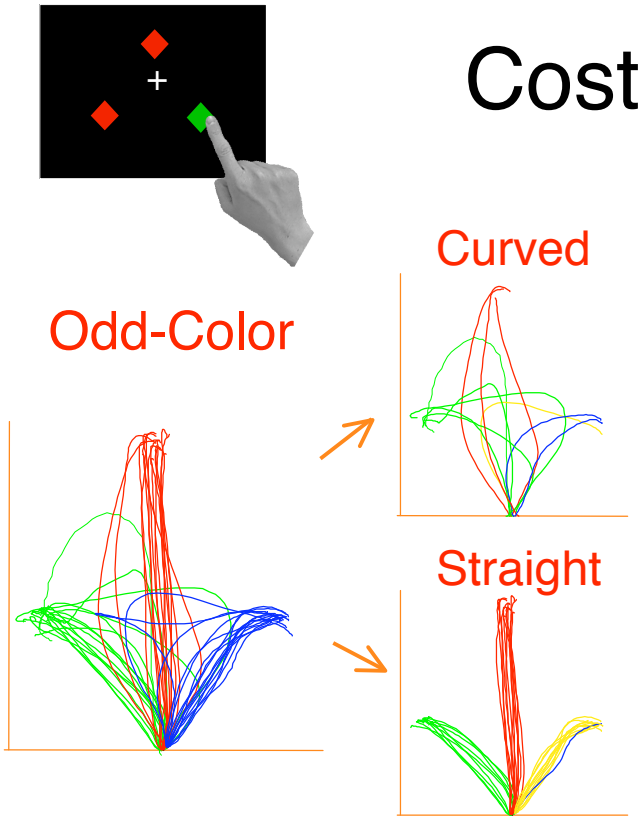


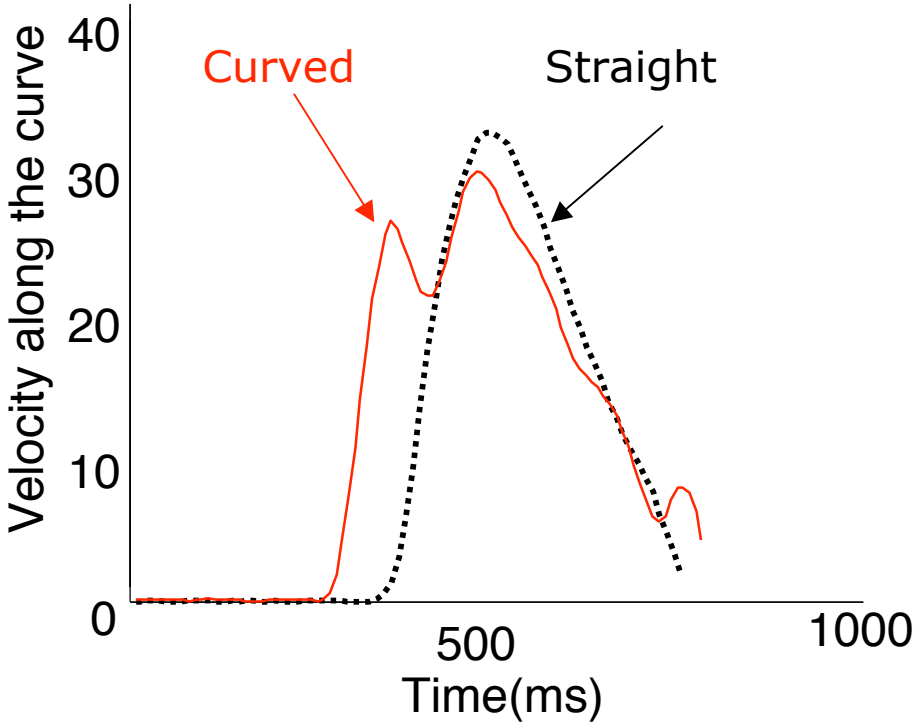






Cost of corrective movements ?

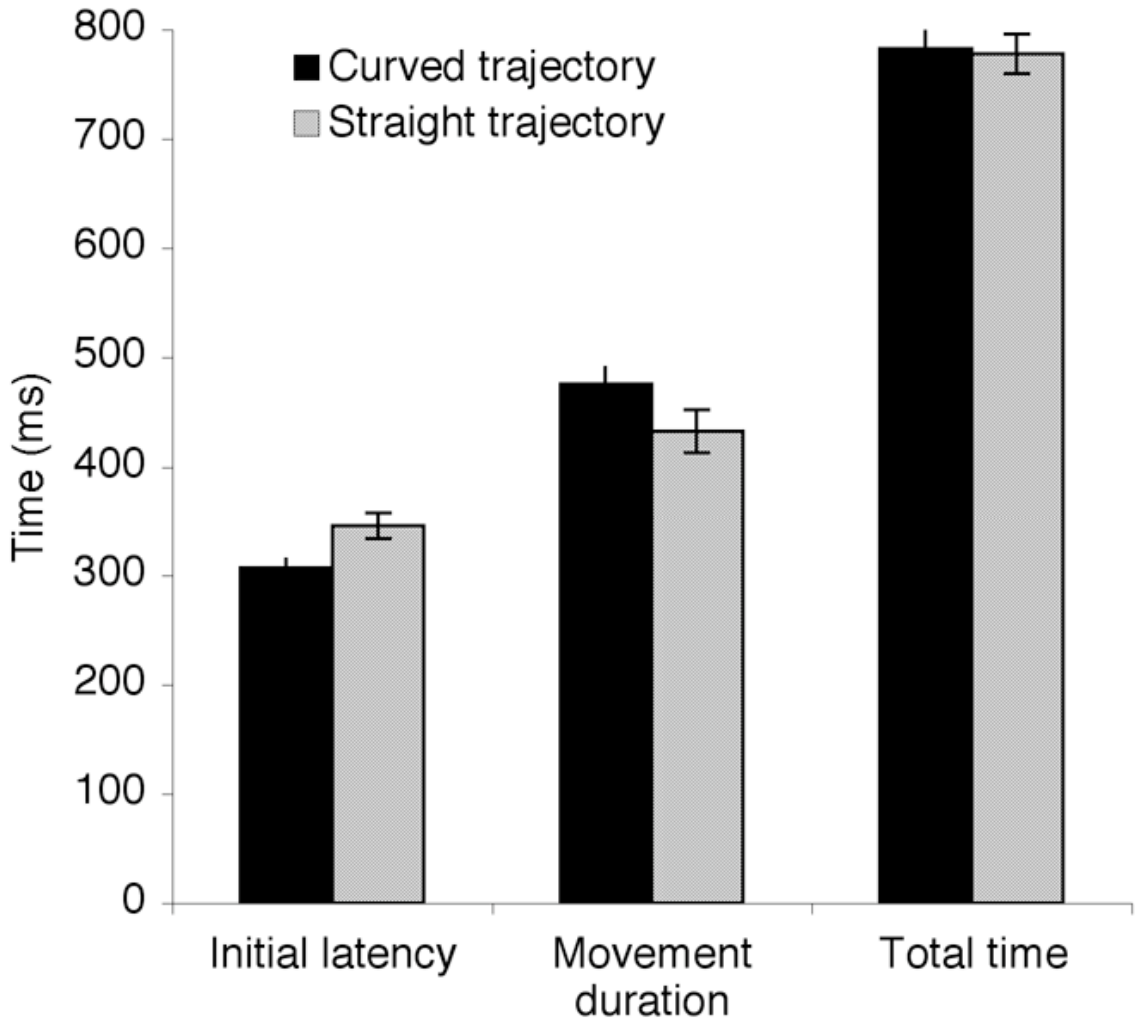




Latency, movement time, total time, accuracy

Optimality vs satisficing

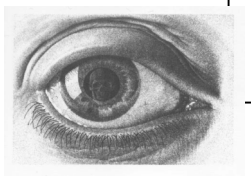
Neglible cost in time and accuracy



Neglible cost in time and accuracy why?

Answer

Concurrent motor planning ?



preparation S_1

preparation S_2

preparation error

preparation correction

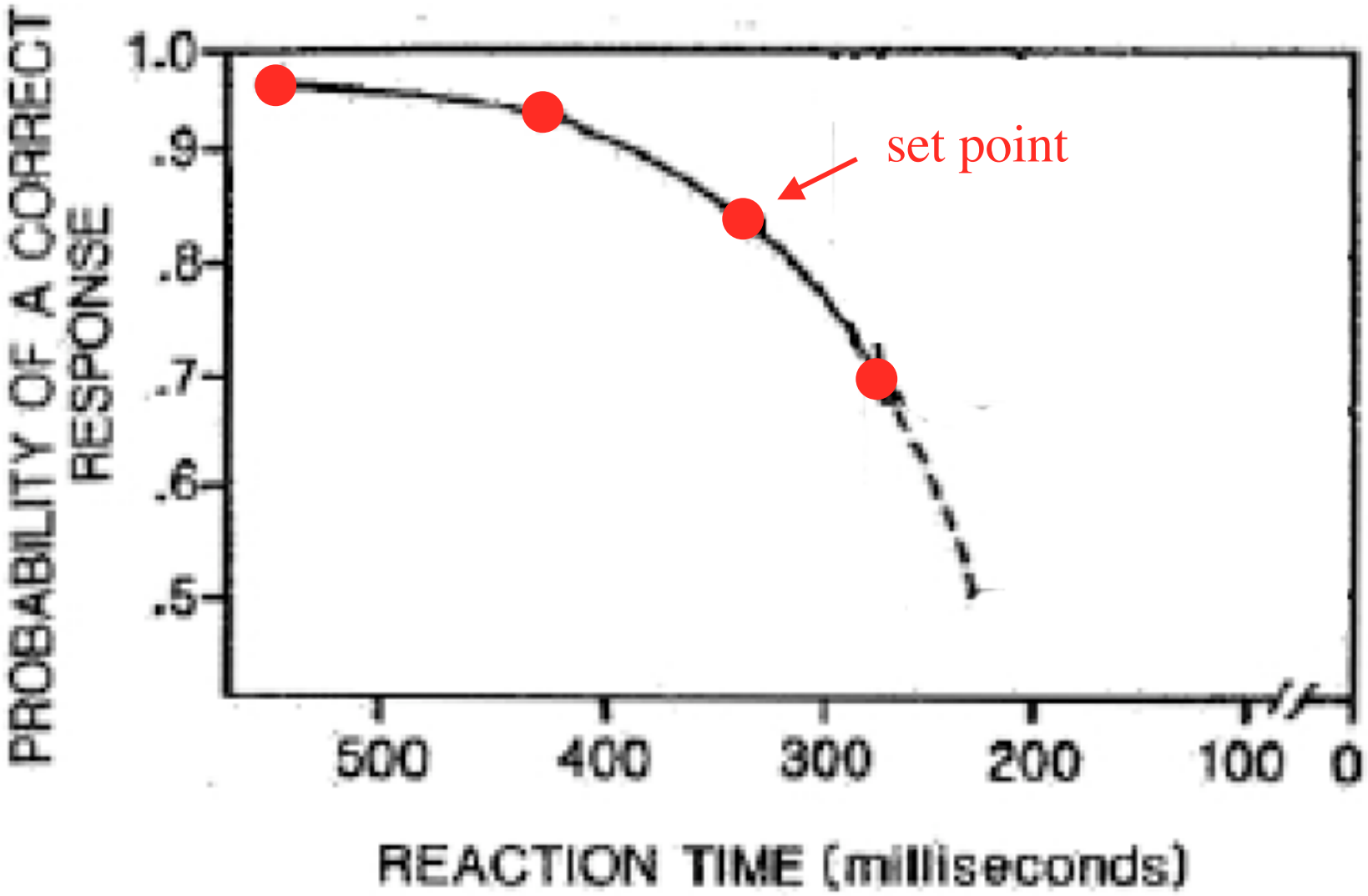
?

Are curved trajectories typical?

Can we control them?

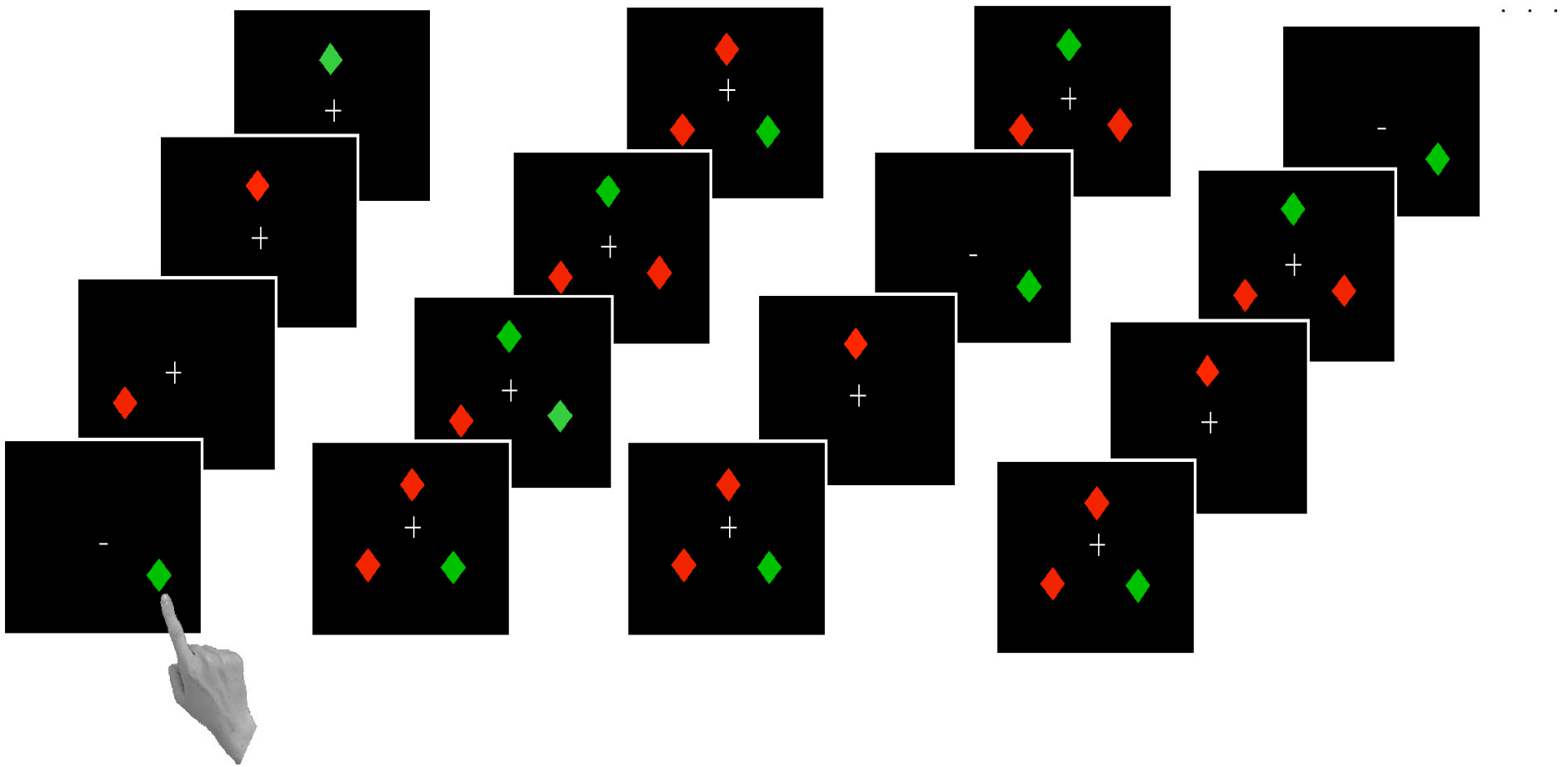
mediator: visuo-motor readiness
(related to speed-accuracy trade-off?)

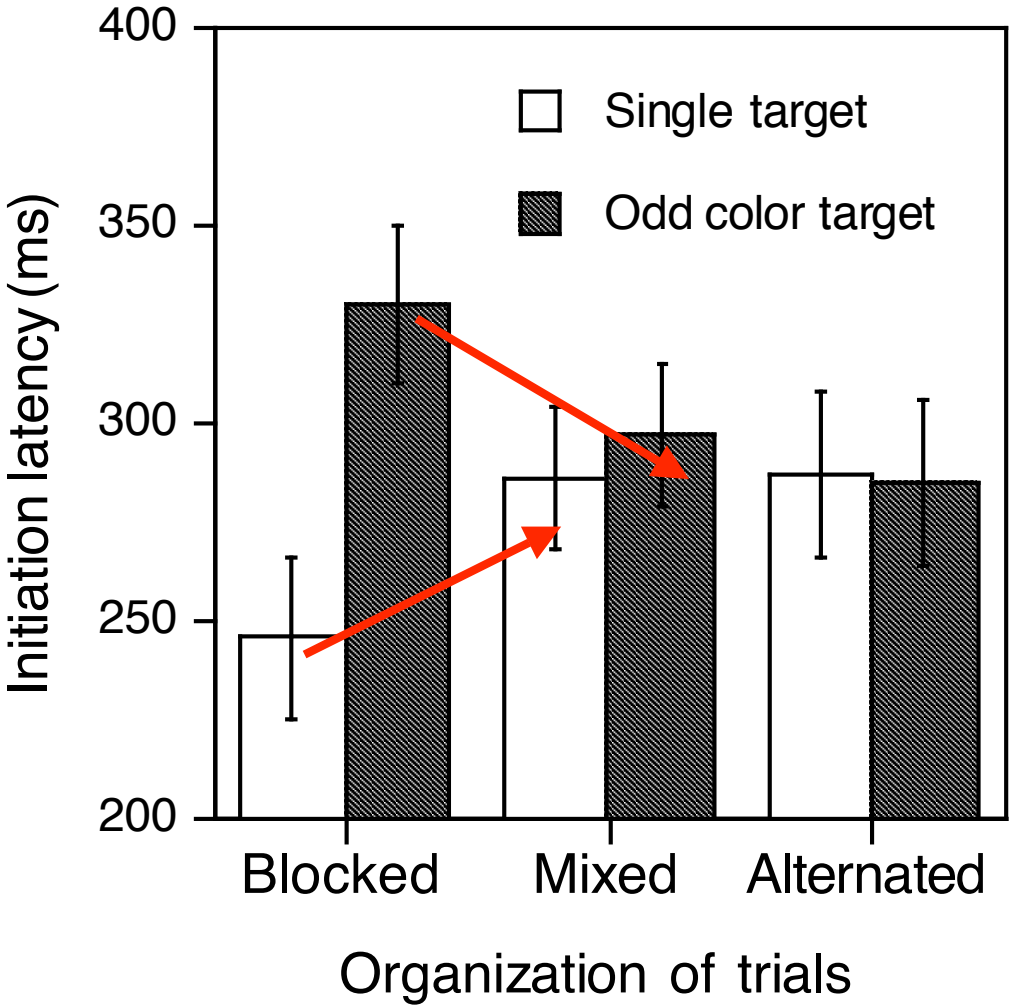
Speed accuracy trade off (SATO)



Pachella and Fisher (1972) redrawn by Sperling & Dosher (1986)

Blocked trials Mixed Alternated

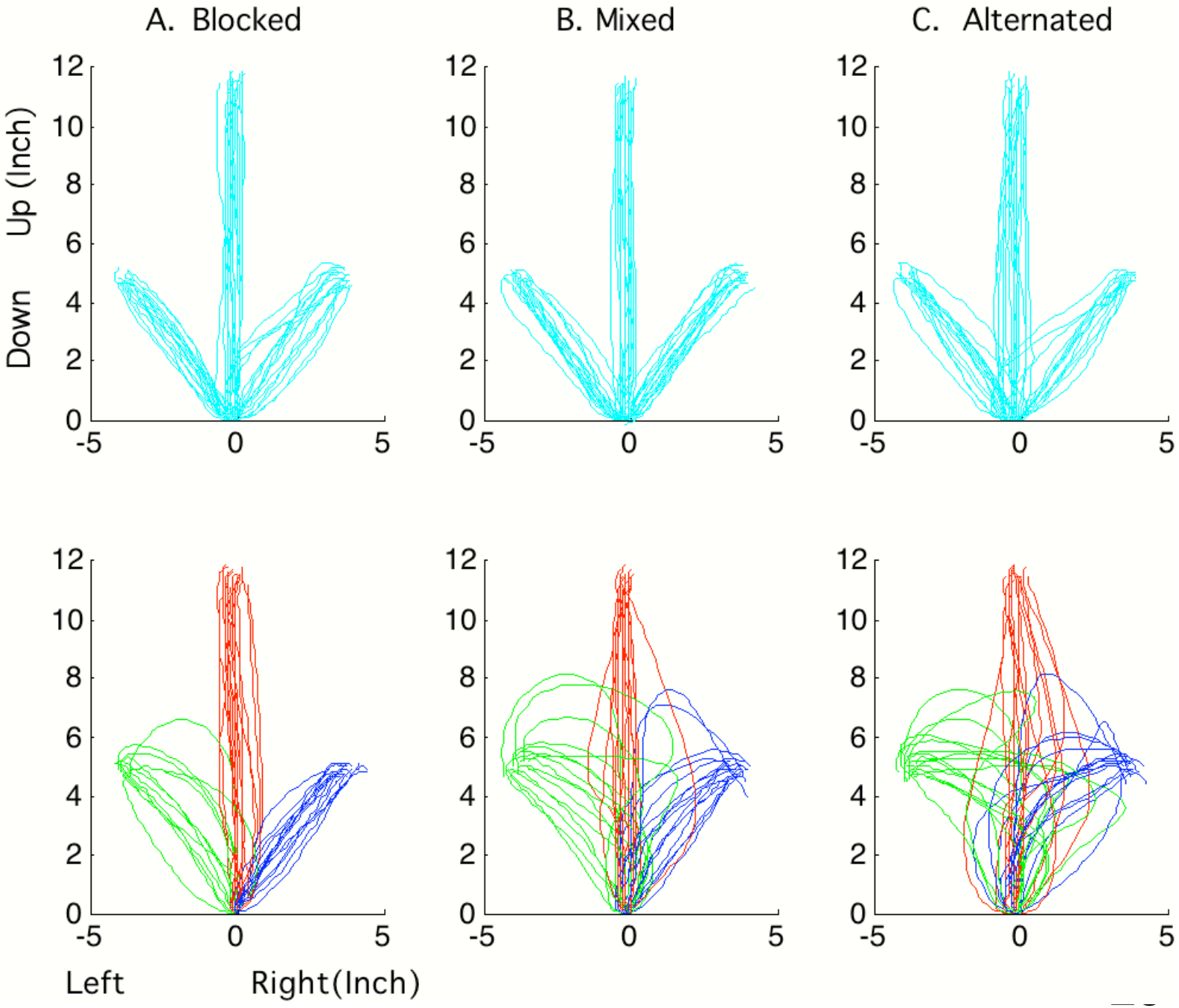




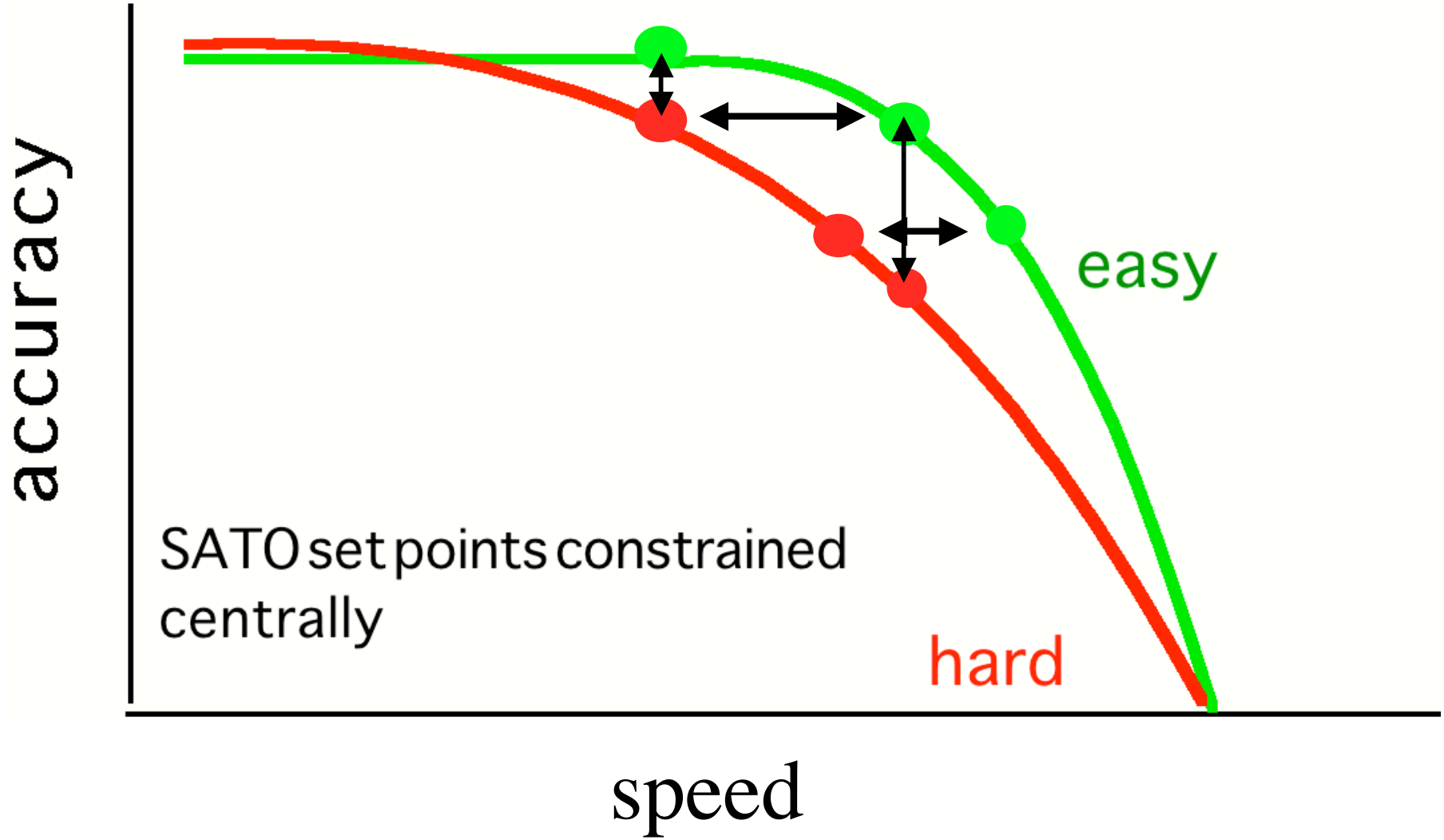
homogenization

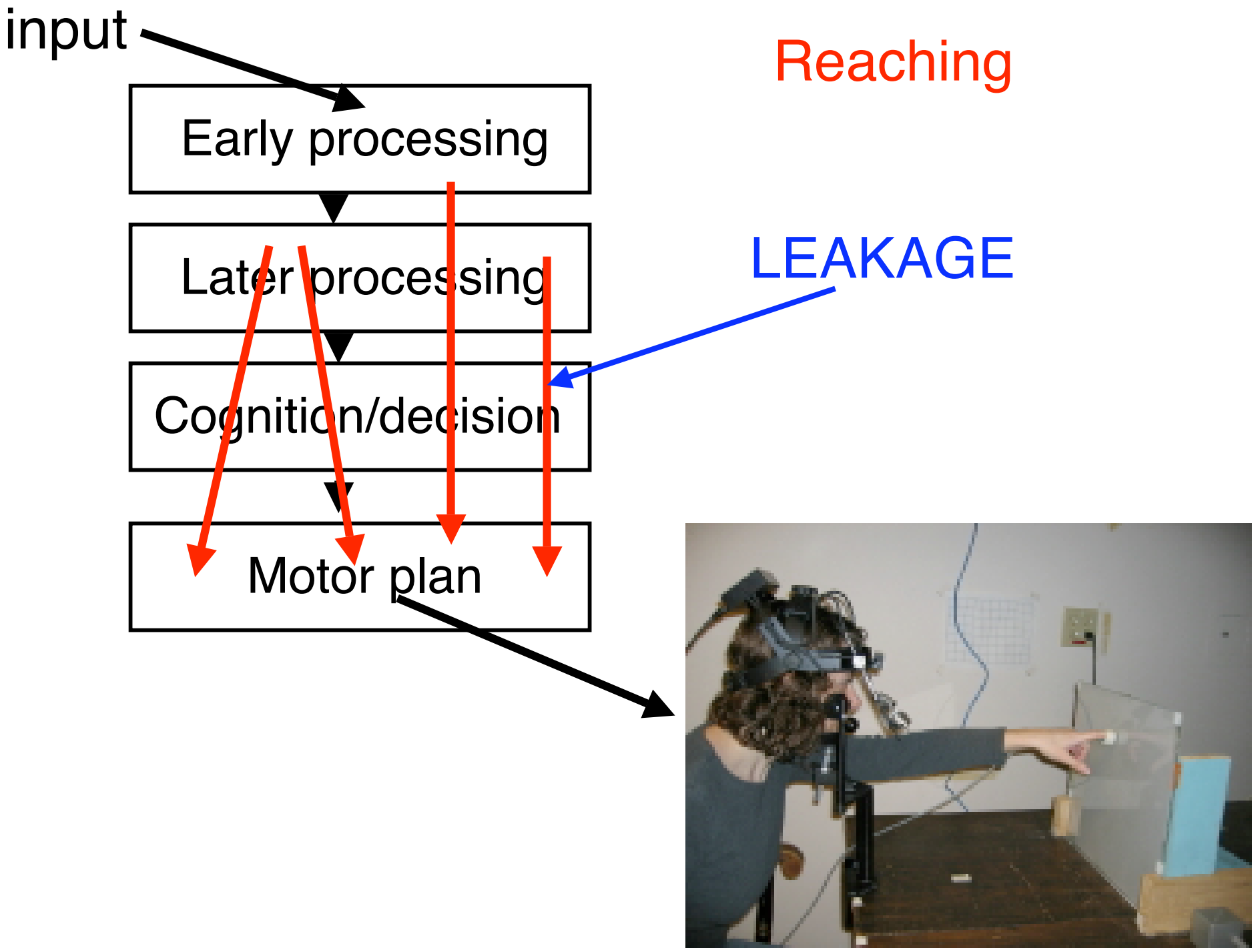
Hard gets faster

Easy gets slower


A. Blocked
B. Mixed
C. Alternated
Down Up (Inch)
12
10
8
6
4
2
0
-5
0
5
Left
Right(Inch)

Conjecture : Can't set up separate speed accuracy set points for Different tasks



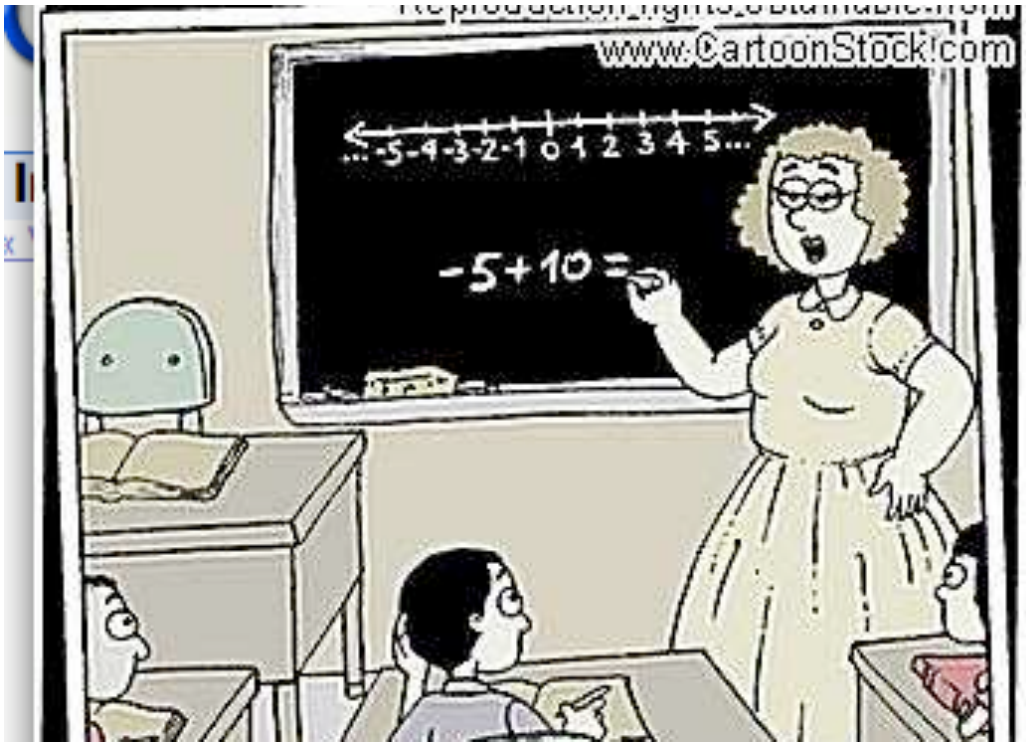

input
Early processing
Later processing
Cognition/decision
Motor plan
Reaching
LEAKAGE

Two examples of “leakage”

- I. Early hand trajectories reflect an underlying number representation
  - *Song and Nakayama, Cognition (2008)*

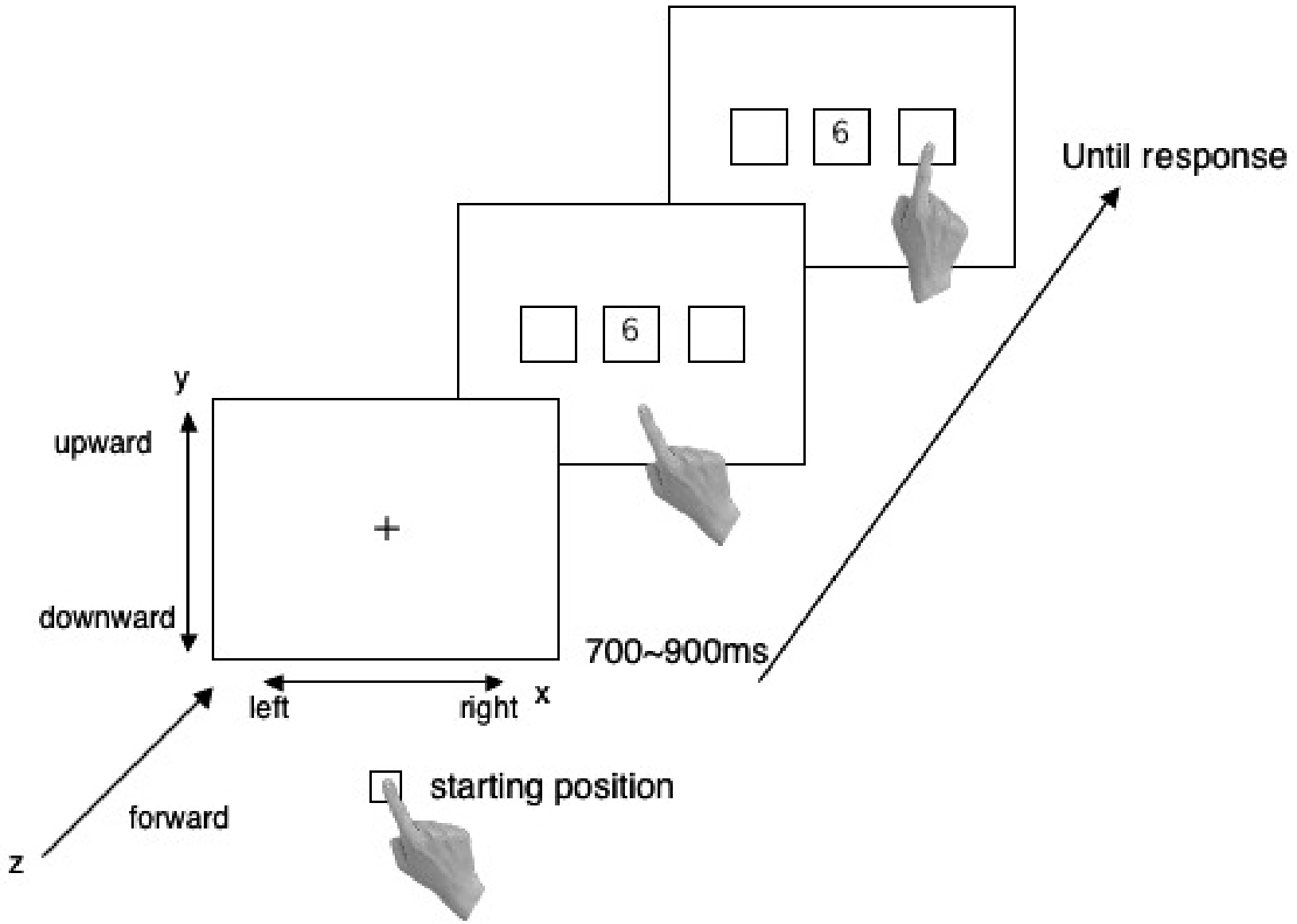
- II. pointing trajectories reveal influence of unseen words
  - *Finkbeiner, Song, Nakayama, and Caramazza, Visual Cognition (2008)*

Mental number line

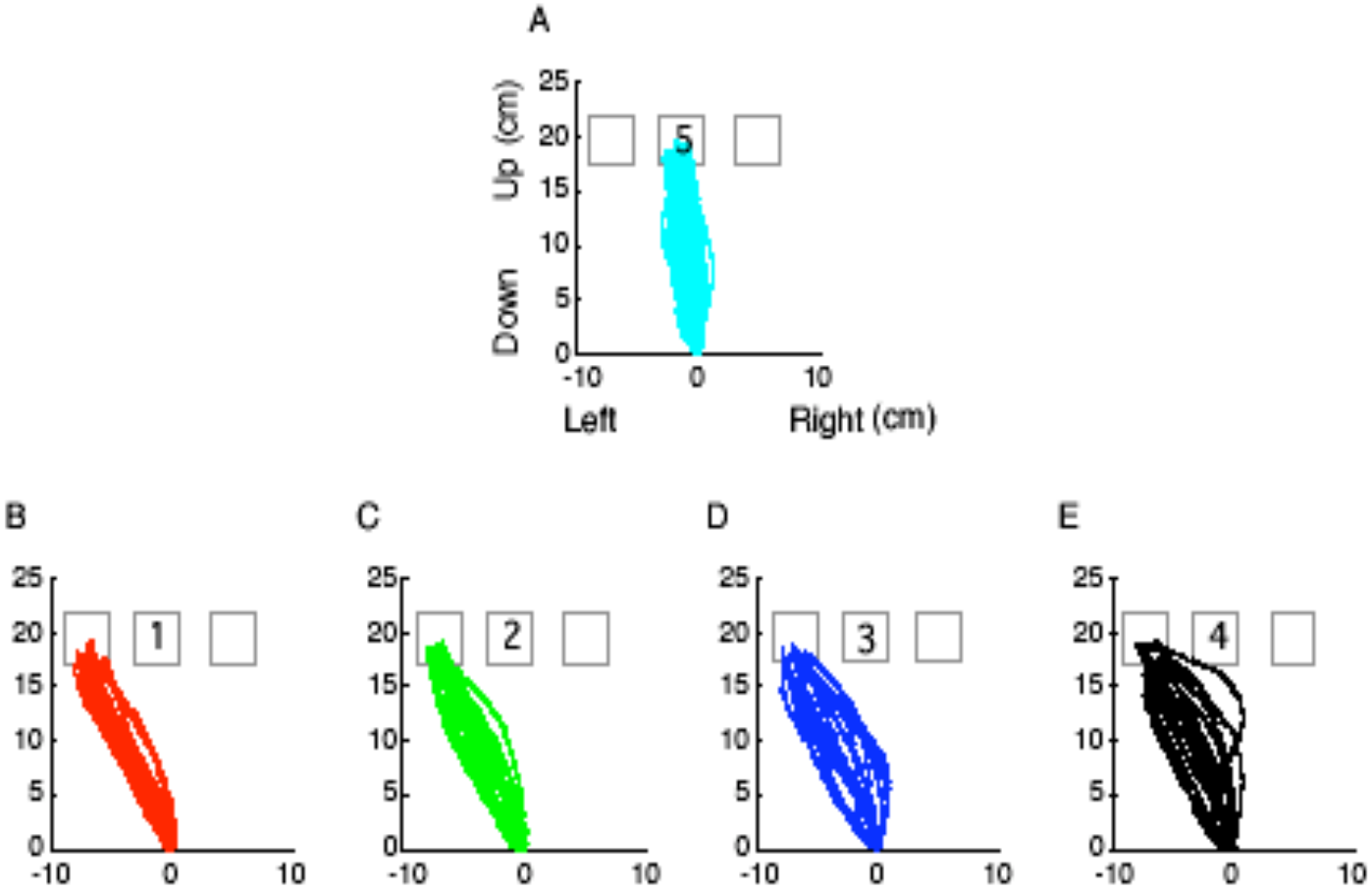


• Characteristics of number representations are mainly examined with discrete responses such as reaction time and accuracy.

• In the current study, to map *invisible* internal cognitive processes of numeric comparison in spatial domain over time, we measured trajectories.


6
6
Until response
y
upward
downward
700~900ms
left
right
x
z
forward
starting position

X-Y trajectories



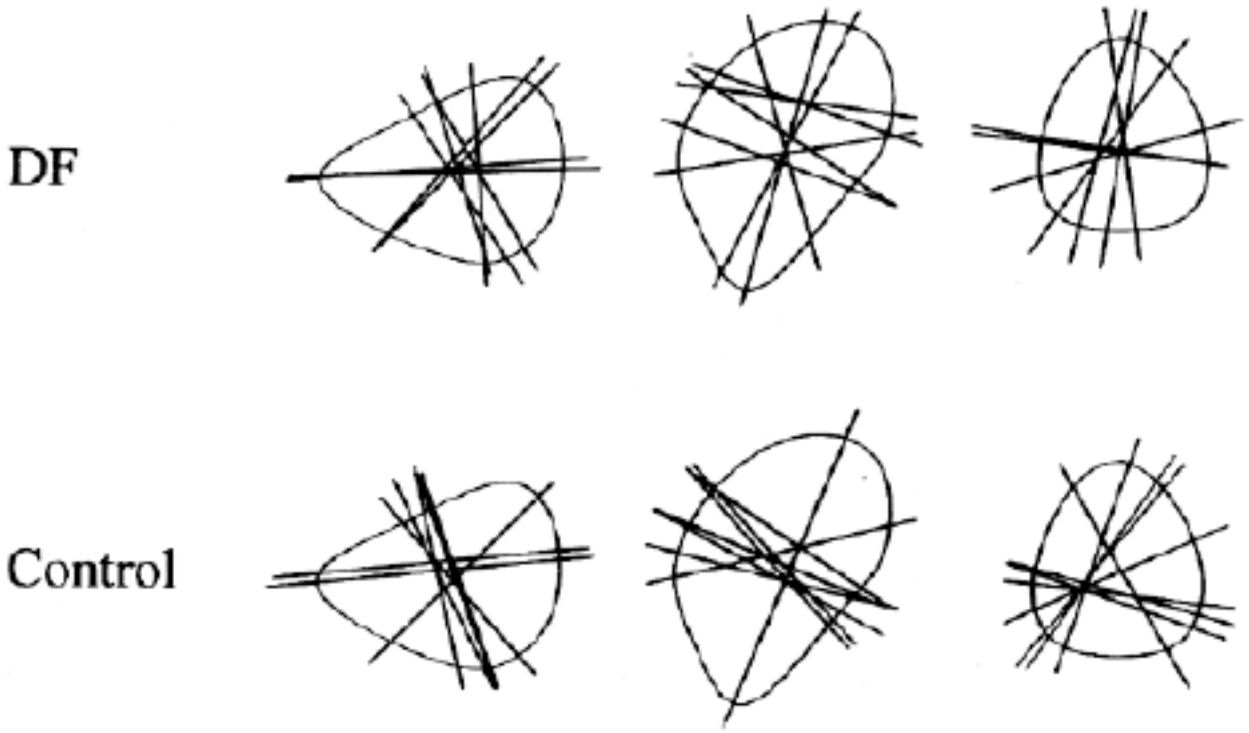
• ***Systematic shift*** of initial trajectories towards a hypothetical position on a number line intermediate between the numeral 1 and 5 positions

- I. Early hand trajectories reflect an underlying number representation
  - *Song and Nakayama, Cognition (2008)*

- II. Pointing trajectories reveal influence of unseen words
  - *Finkbeiner, Song, Nakayama, and Caramazza, Visual Cognition (2008)*

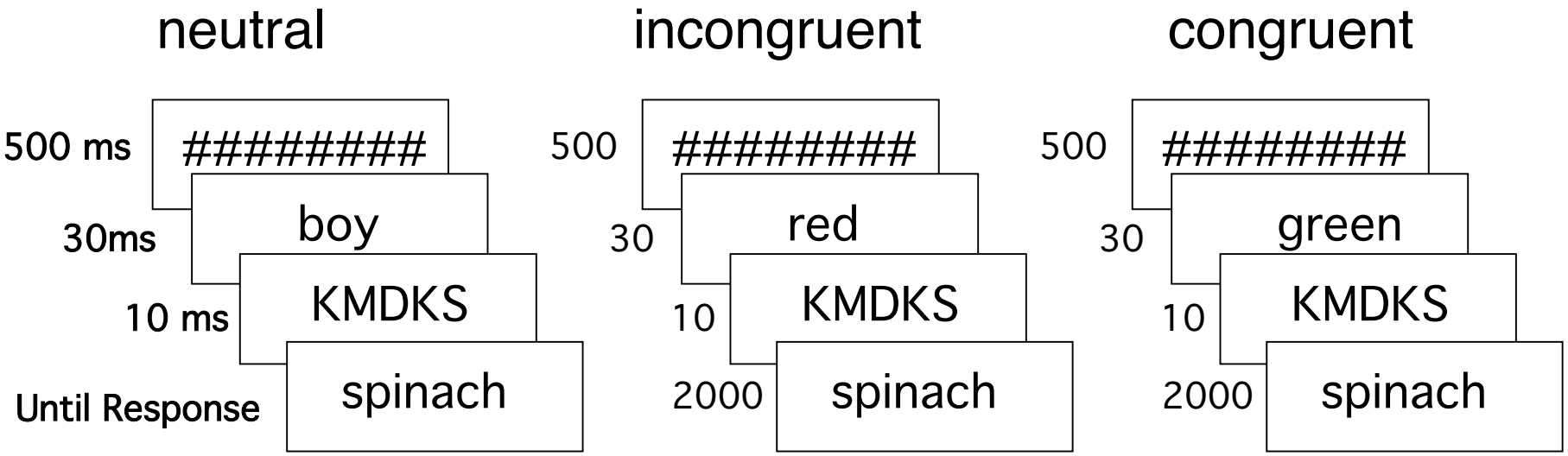
linkage between invisible text and actions?

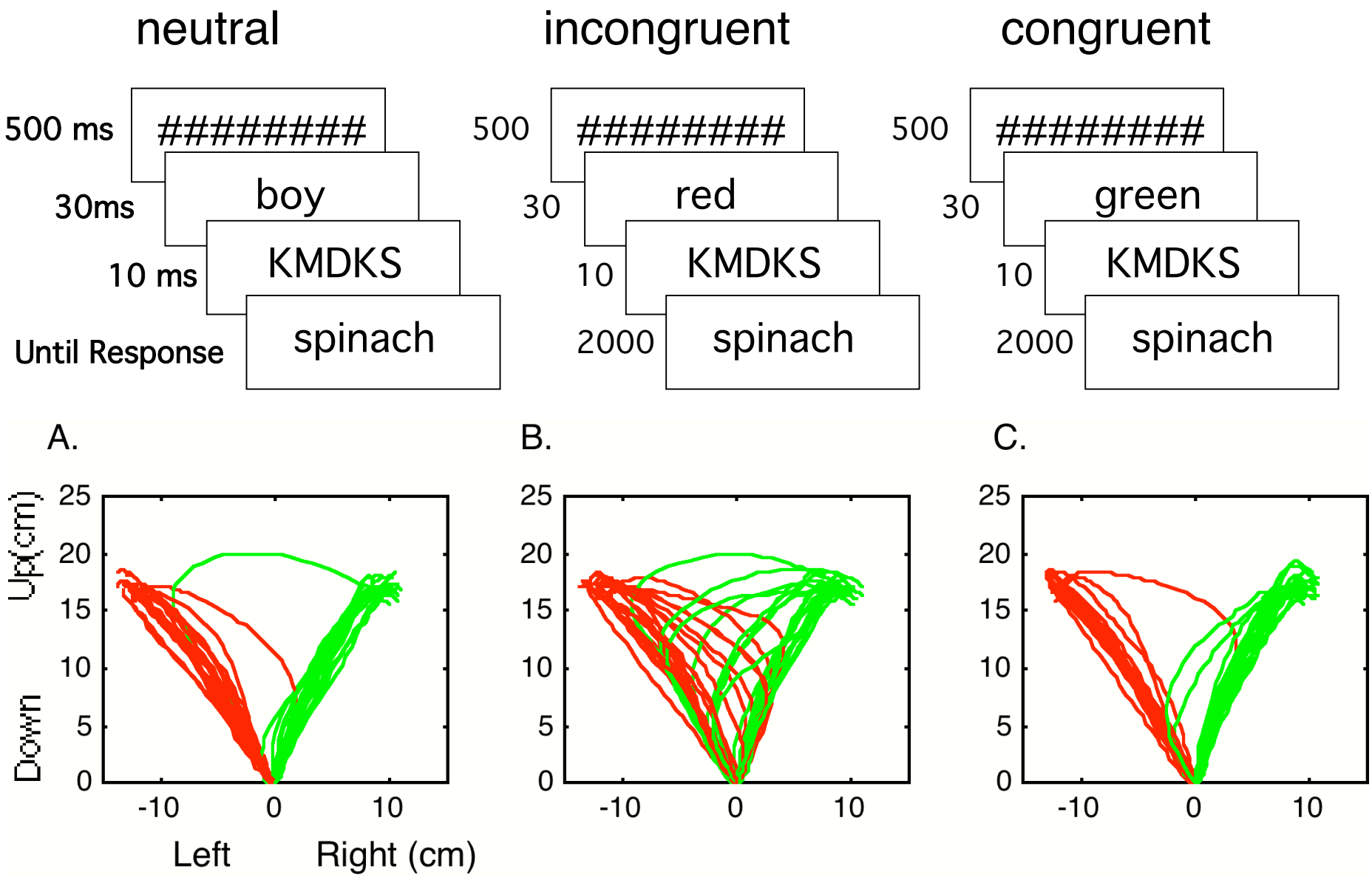
Goodale and Milner

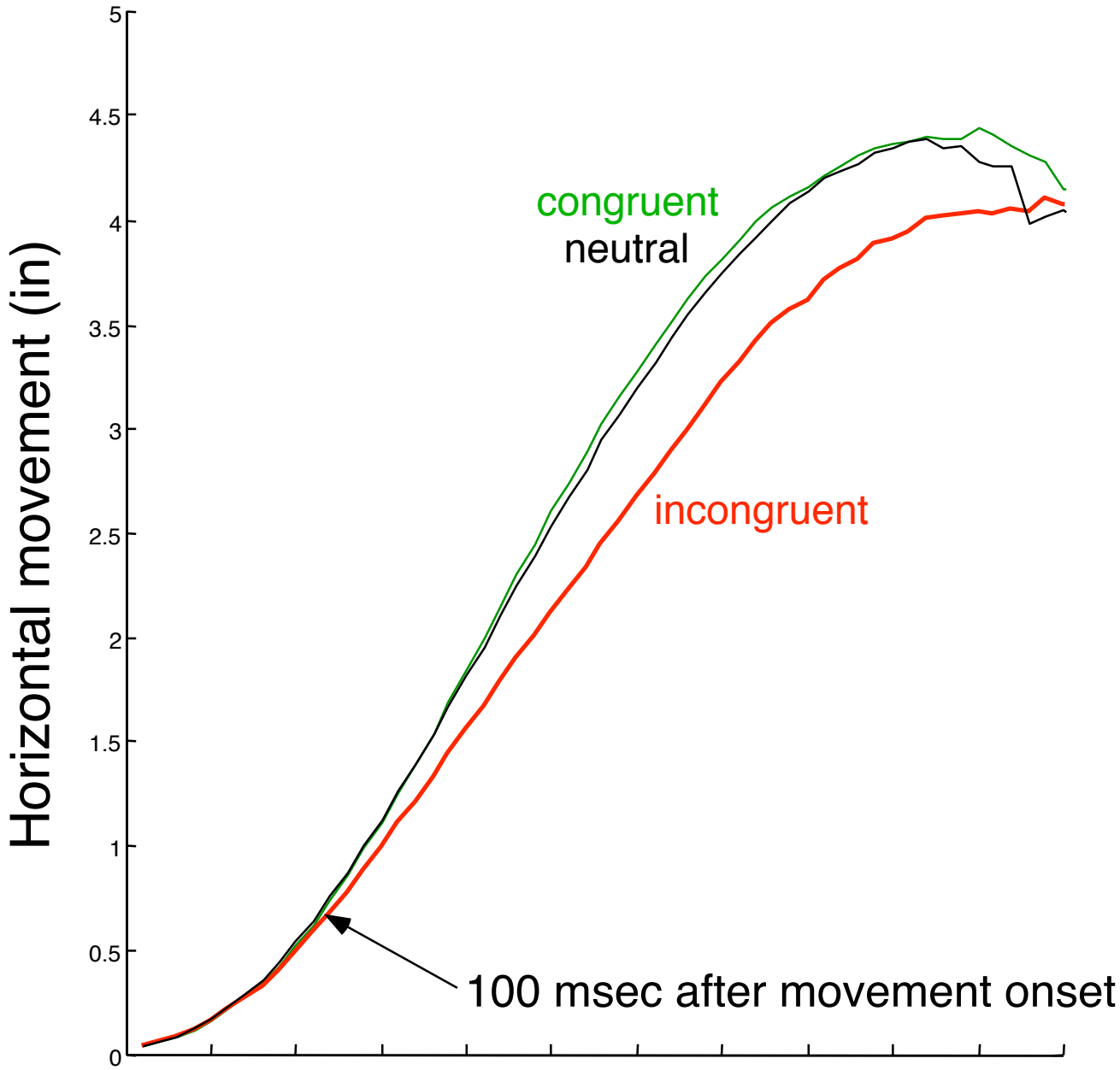


Dorsal
Vs
Ventral

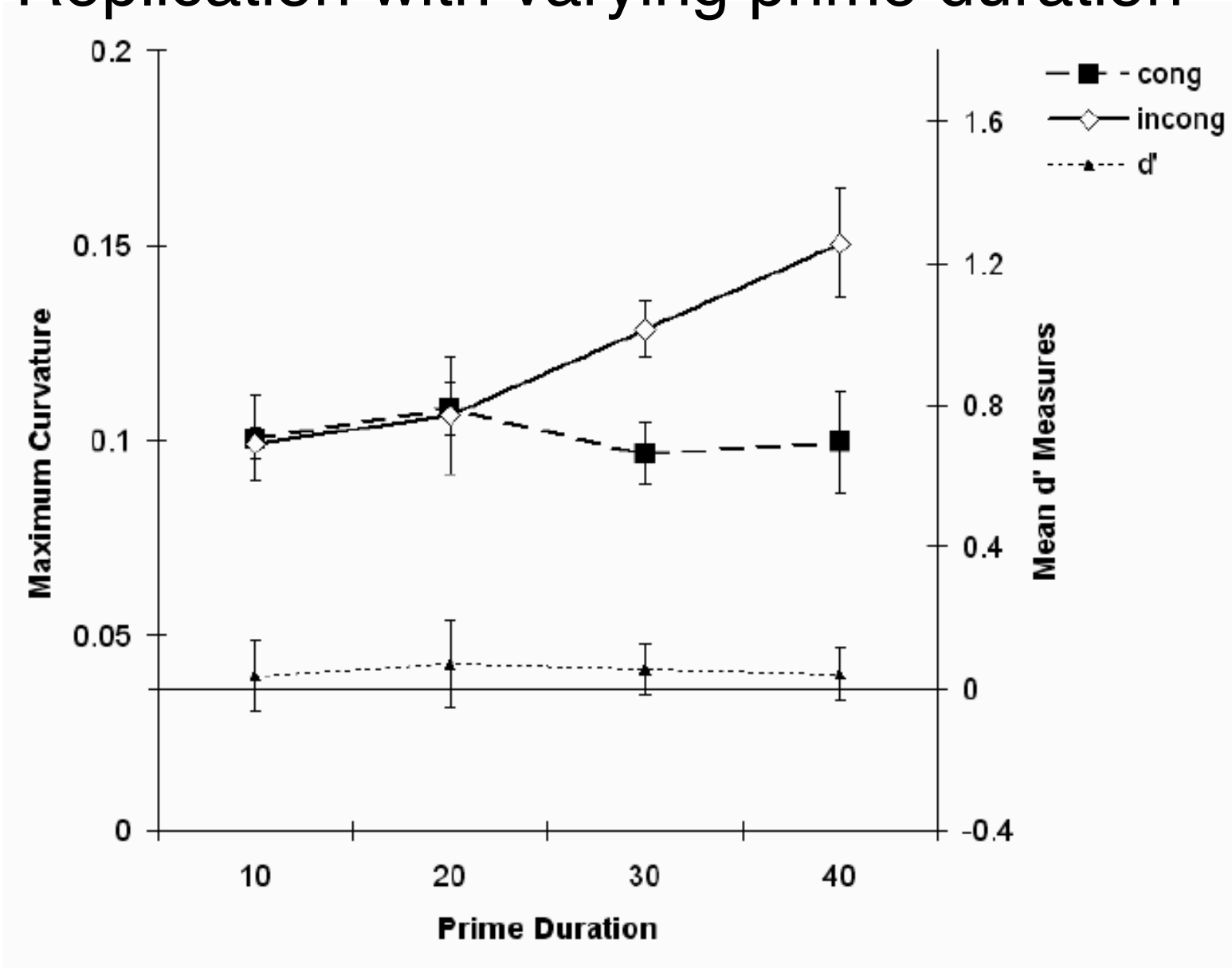
Point to color of the word




neutral
incongruent
congruent
500 ms
30ms
10 ms
Until Response
500
30
10
2000
#########
boy
red
green
KMDKS
spinach
A.
B.
C.
Up(cm)
Down
25
20
15
10
5
0
-10
0
10
Left
Right (cm)


Horizontal movement (in)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
congruent
neutral
incongruent
100 msec after movement onset
Time after movement initiation

Replication with varying prime duration

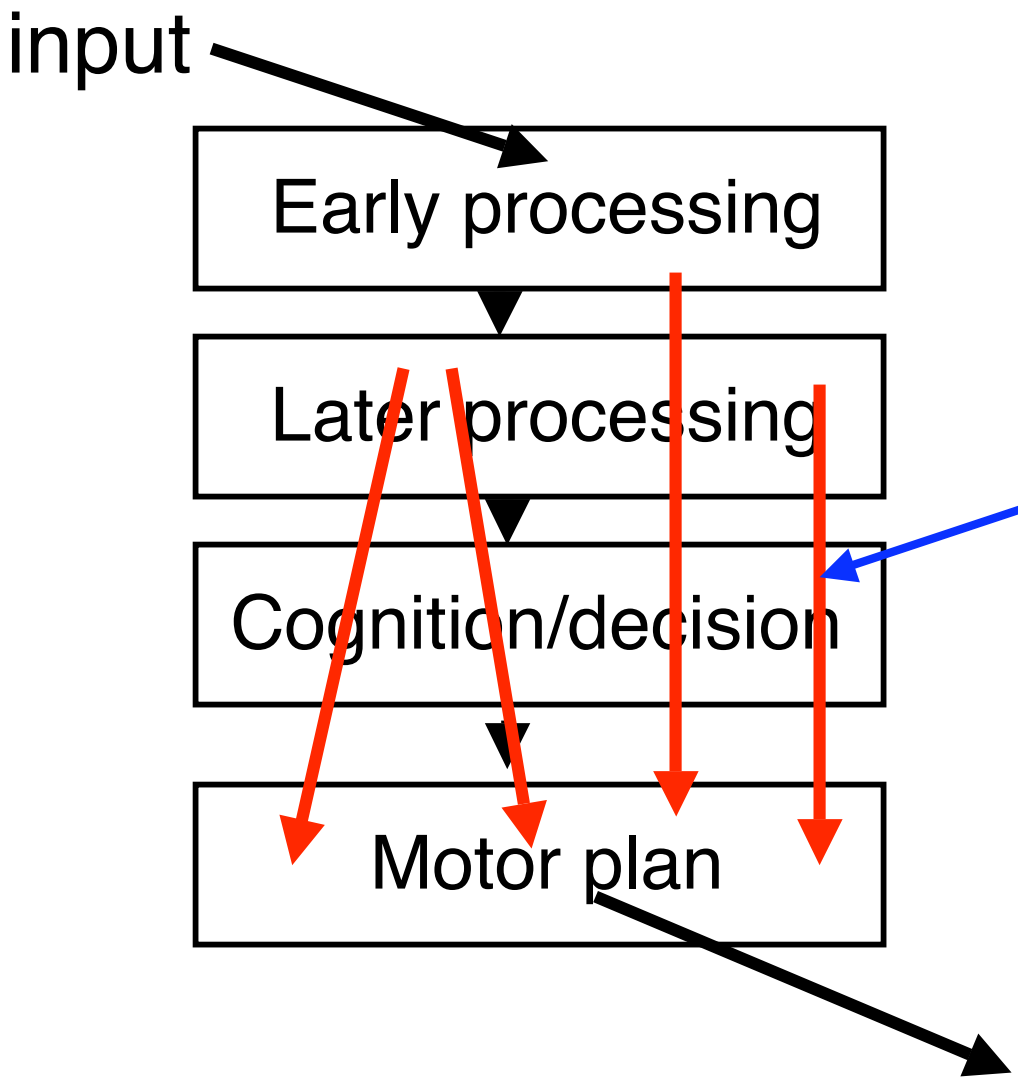


• Despite the unavailability of the invisible stimulus to visual awareness, the congruity of the prime stimulus with the target stimulus had a significant effect on participants' pointing trajectories.

• Masked unseen word processing extends down to include the formulation of overt motor responses

•Word form area (ventral)

Visuo motor area (dorsal)



Reaching

LEAKAGE

Full details of trajectory

visuo-motor control

- Flexible behavior afforded by parallel motor plans
- Limits to and possible irrelevance of speed-accuracy trade offs
- Revealing otherwise hidden states
  - dynamics of attentional selection
  - analog number line
  - rapid influence of unseen words

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