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Do interactions between motor and visual codes facilitate visuospatial memory?: The influence of action on memory performance: When does it help you, when does it hurt you

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Abstract for DBER Group Discussion on 2013-10-03

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Title:
The influence of action on memory performance: When does it help you, when does it hurt you

Abstract

One of the hallmarks of human cognition is that we have a limited number of cognitive resources available and successful performance in the environment requires an appropriate number of these resources to be directed towards one's primary task. As such, it is unsurprising that when attention is divided between two tasks simultaneously, performance on each task suffers relative to if each task was done in isolation. At the same time, however, it has also been shown that when individuals process information in multiple ways (e.g. across more than one modality) that performance is enhanced. In the present talk I will discuss two brief papers examining whether the requirement to actively point to to-be-remembered visual information (e.g. remember the spatial locations of items in an array) is helpful or hurtful to memory. On the one hand, pointing to items should lead to a motor trace in memory that could facilitate and compliment the visual trace. On the other hand, the requirement to actively point to something you are trying to visually memorize could impair memory by reducing the number of cognitive resources available for memorization. Pointing turns out to have both beneficial and detrimental effects dependent on a variety of factors. Ramifications for our understanding of multimodal processing will be discussed, as will the potential benefit of these findings for educational settings.

Do interactions between motor and visual codes facilitate visuospatial memory?

Mike Dodd
DBER seminar
October 3rd 2013

My research

- Vision, Attention, Memory, Perception (VAMP lab)
- Eyetracking
- Memory Errors
- Visual Illusions/Perception
- Goal-directed behavior
- http://psych.unl.edu/mdodd/VAMP/index.htm

Today

- Attention, Memory, Motor Behavior
- How does action (e.g., pointing to or grasping an object) influence memory for object location

The catalyst

- Harold Bekkering, University of Nijmegen, The Netherlands
- “Pointing at objects appearing in locations you are attempting to memorize should enhance memory for that spatial location”

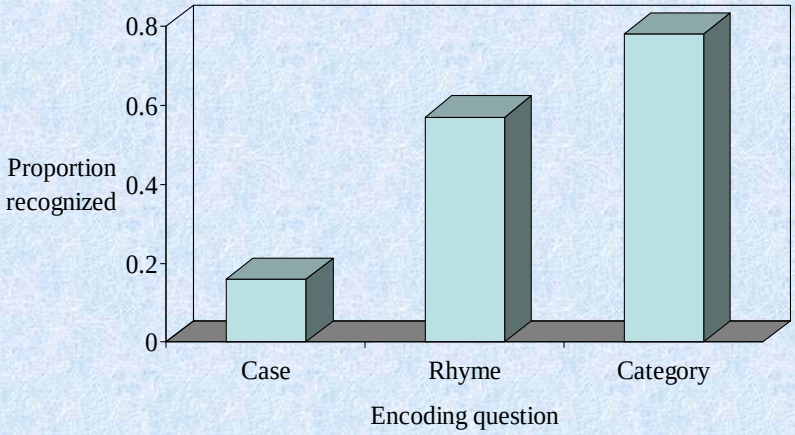
The rationale

- Levels of processing – Relative to passive viewing, pointing should lead to both
  - a) a deeper encoding of object location and
  - b) an additional memory trace (motor) to compliment the original memory trace (visual)

Evidence for Levels of Processing
Craik & Tulving (1975)

Level of Processing		**Example**
Shallow	Physical	Word: TABLE Is the word written in capital letters?
↓	Acoustic	Word: CAT Does the word rhyme with "MAT?"
Deep	Semantic	Word: DAFFODIL Is the word a type of plant?

Evidence for Levels of Processing
Craik & Tulving (1975)



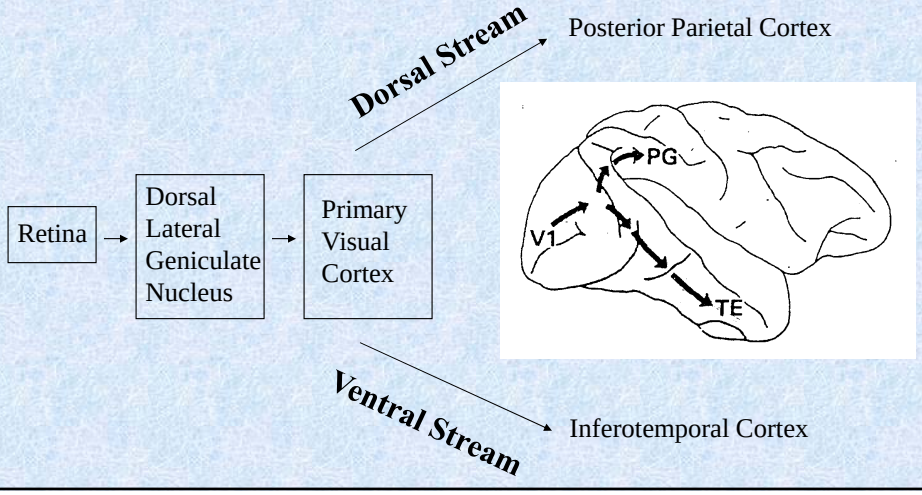
Levels of Processing:

- Emphasis on nature of encoding processes, not stores
  - Active involvement necessary for good memory
- Processes can be characterized in terms of:
  - Depth
  - Elaboration
  - Organization, distinctiveness
  - Compatibility with retrieval processes (test type or test context)

The rationale

- Levels of processing – Relative to passive viewing, pointing should lead to both
  - a) a deeper encoding of object location and
  - b) an additional memory trace (motor) to compliment the original memory trace (visual)
- Related finding: Grasping leads to better memory for object orientation
- Also: Action engages additional perceptual pathways relative to passive perception

There are 2 important neural correlates of perception, and damage to either of these produces very different patterns of results

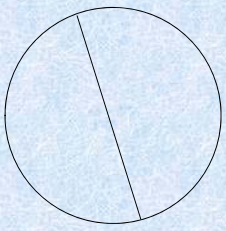


Dorsal/Ventral = what vs. where

- The ventral stream handles “what” information: perception
- The dorsal stream handles “where” information: provides info to the motor system for action

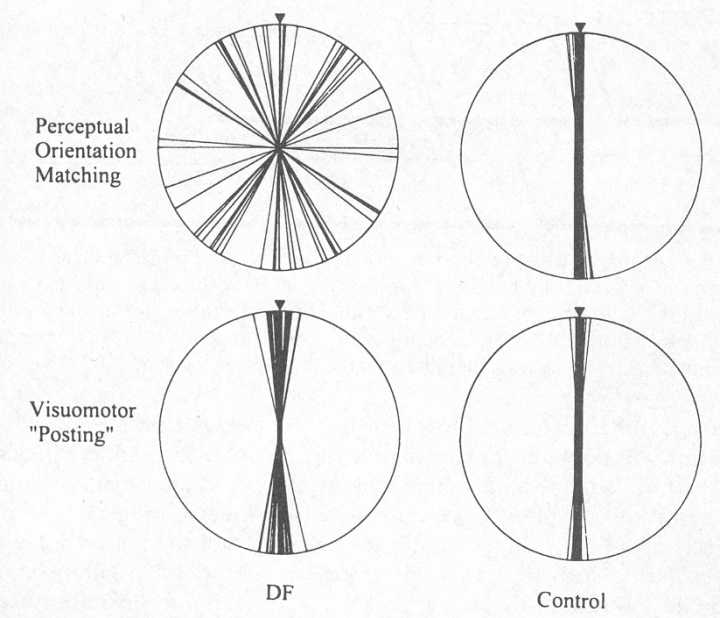
Patient DF

- Patient DF: Lesion to ventral stream, intact motor stream
- Two tasks compared to controls…perception vs. action



Task: Either manually rotate a level until it is at the same orientation as the slot here (perceptual) or place an envelop in the slot (action)

Possible for DF to perform motor task even though perceptual system is getting insufficient information



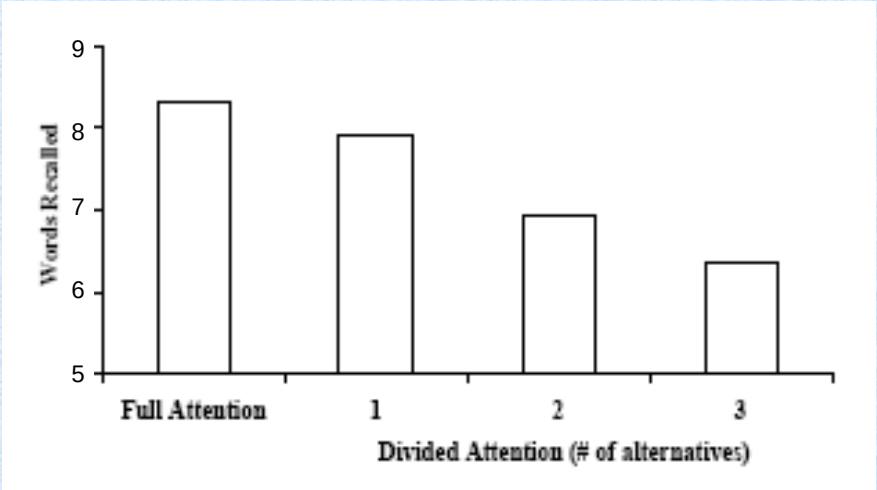
So, action should always enhance attention/memory?

- Not so fast: What about divided attention?
- Dividing attention between tasks at encoding generally leads to a reduction in overall memory

Attention and memory
Anderson & Craik, 1974

- Full attention
  – study list of 12 words
- Divided attention
  – study list PLUS reaction time task
  – tones of different pitch, press appropriate key
  – vary difficulty: 1, 2 or 3 alternatives
- Free recall

Divided attention
Anderson & Craik (1974)



Interference

Posner & Rossman (1965)

Study phase: 8 3 4 4 2 5 9 1

transform final 2 digits

write (91)

OR add (10)

OR count back by 3s (91, 88, 85)

OR classify as < or > 50 (>)

Test: Recall first three digits

Interference

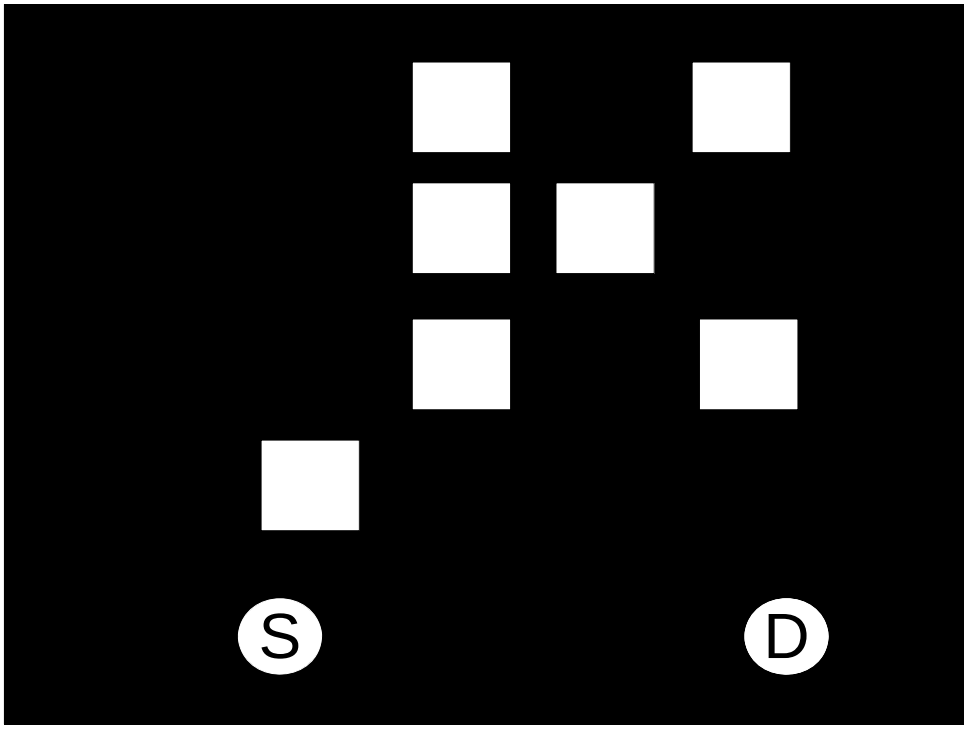
Posner & Rossman (1965)

The nature of secondary tasks

- Performing a secondary task can either greatly aid attention/memory or lead to substantial decrements in attention/memory
- How do we reconcile these two opposing findings?
- When trying to memorize spatial location, should pointing to a location in space aid subsequent memory, or impair it?

The task

- Experiment 1 (Dodd & Shumborski)
- 16 possible target locations on a 4 x 4 grid (invisible to participants)
- 3 possible array sizes (5, 7, or 9)
- Items appear one at a time (1000 ms per item), participants are told to memorize them for an upcoming memory task
- Two blocks: Touch each item as it appears vs. passive viewing
- Memory test: All items appear in the same location or one item has changed location (same/different judgment)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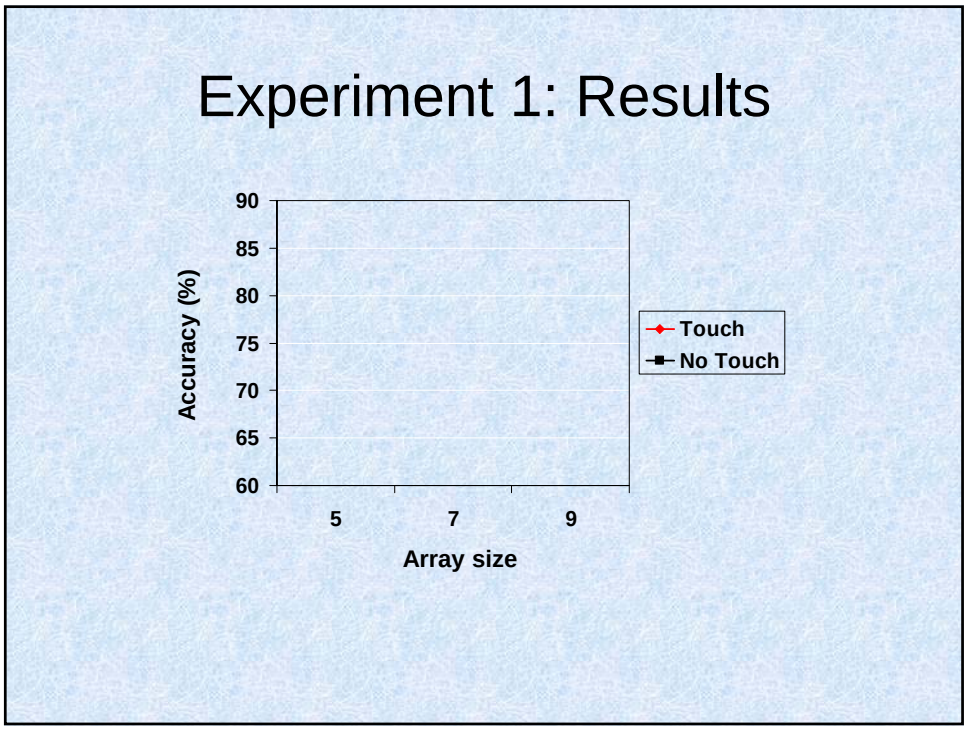
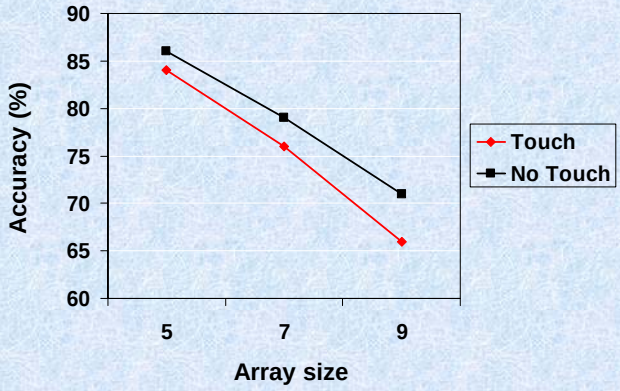
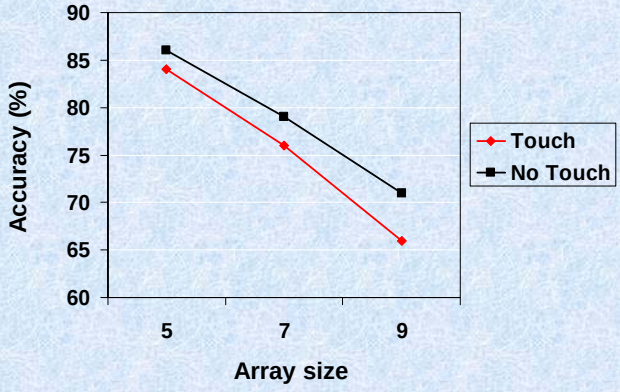

Experiment 1: Results
90
85
80
75
70
65
60
Accuracy (%)
5
7
9
Array size
Touch
No Touch

Experiment 1: Results

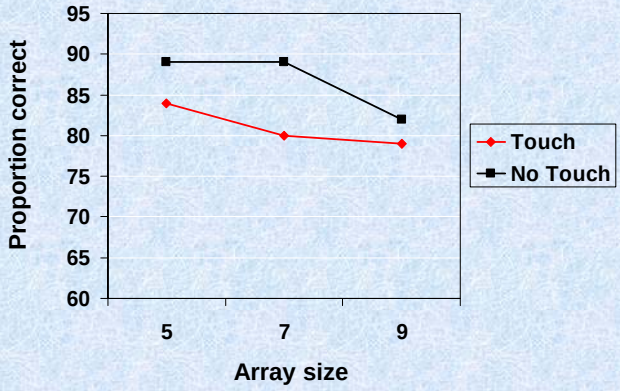


Experiment 1: Results



Complaint: Not enough time to touch each item
Experiment 2: 2000 ms presentation for each array item

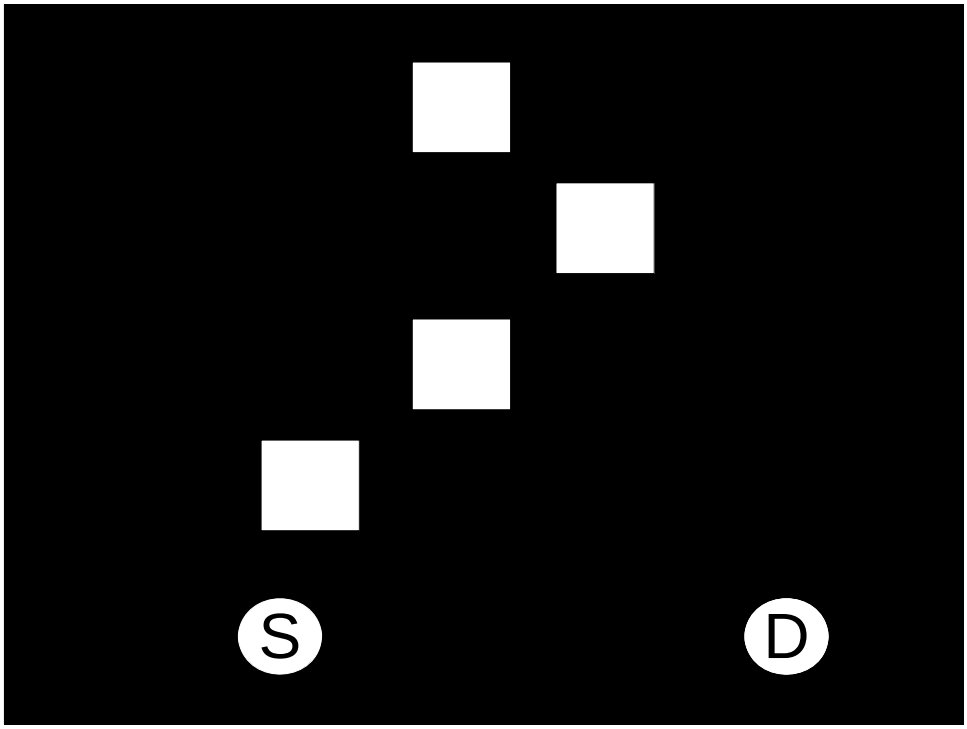
Experiment 2: Results



Increasing item display time improves memory overall, but touching still hurts memory performance

But wait…

- Halfway across the country, a different experiment is being run
- Experiment 3 (Chum, Bekkering, Dodd, & Pratt)
- 25 possible target locations on a 5 x 5 grid (invisible to participants)
- 2 different arrays per trial (one consisting of squares, one consisting of circles), 3 possible array sizes (5, 7, or 9)
- Participants are instructed to touch the shapes in one of the arrays (e.g., squares) while passively viewing the other (e.g., circles)
- Memory test consists of items from only one of the arrays (though prior to test, participants do not know which array will be tested)
- Either all of the items appear at the same location as during study, or one item has changed location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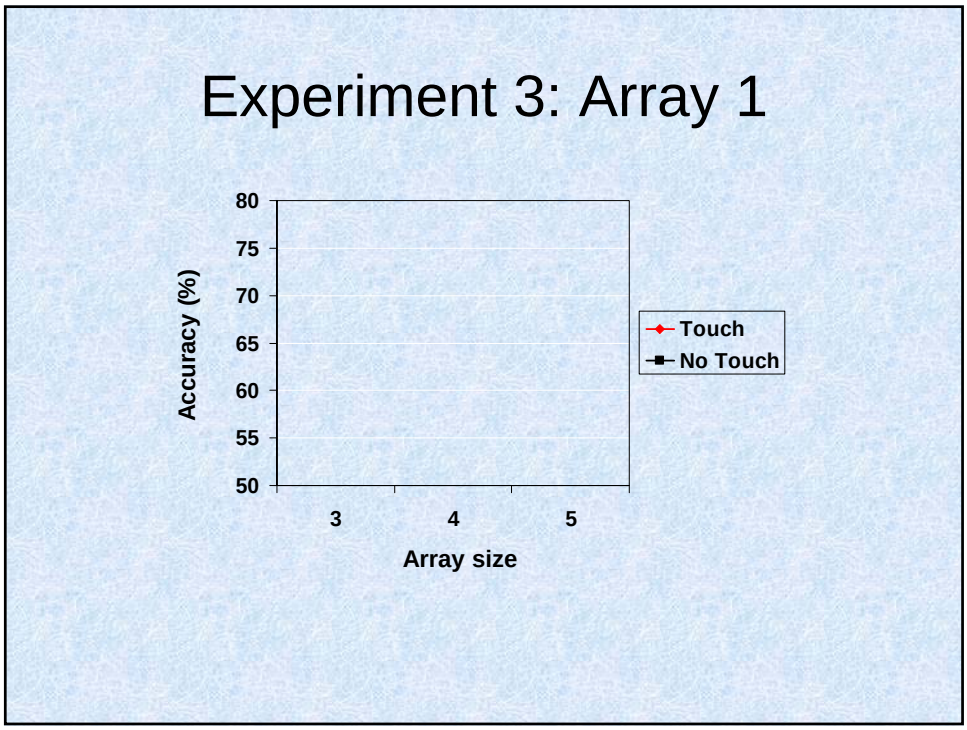
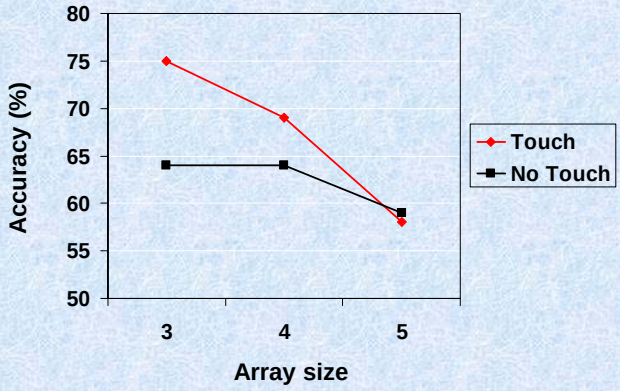
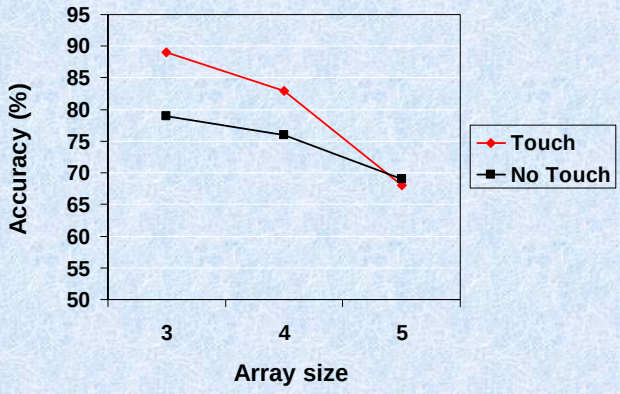

Experiment 3: Array 1
80
75
70
65
60
55
50
Accuracy (%)
3
4
5
Array size
Touch
No Touch

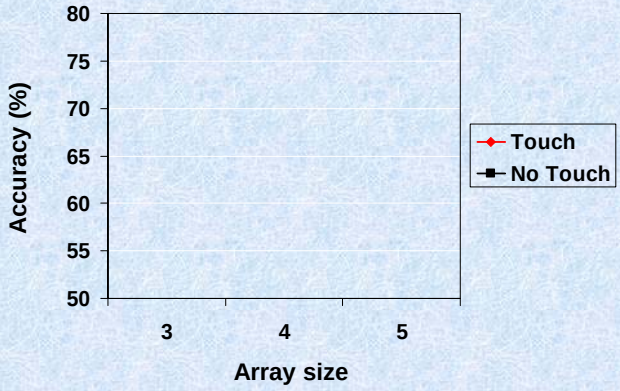
Experiment 3: Array 1



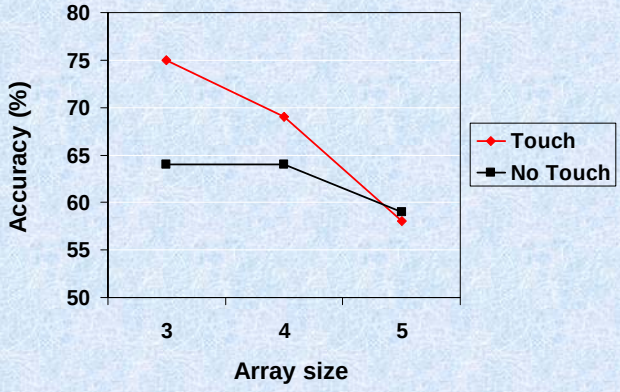
Experiment 3: Array 2



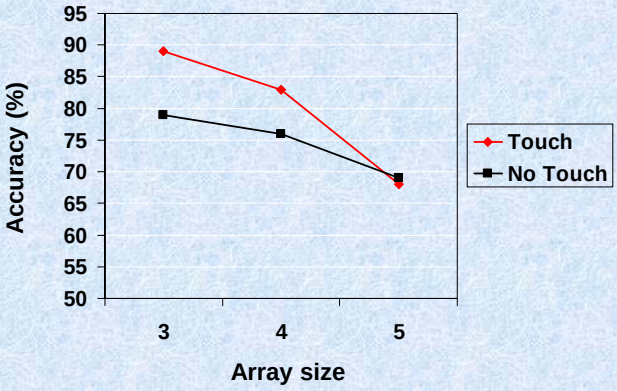
Experiment 4: Array 1



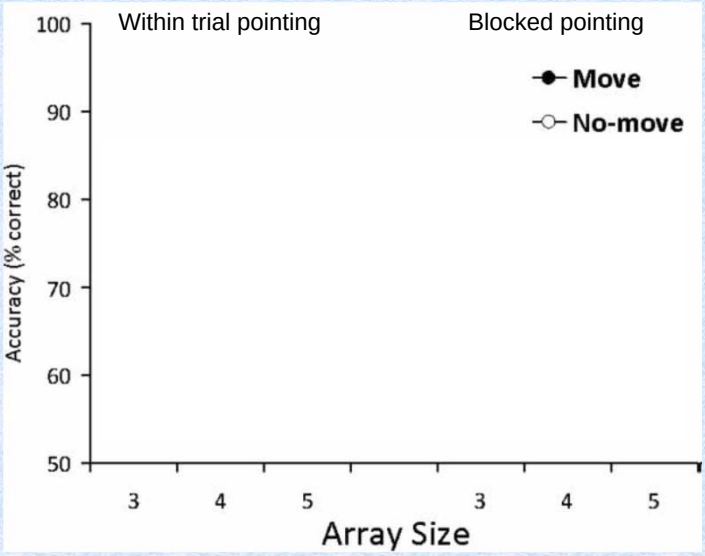
Experiment 4: Array 1



Experiment 4: Array 2



Our replication of Chum et al.



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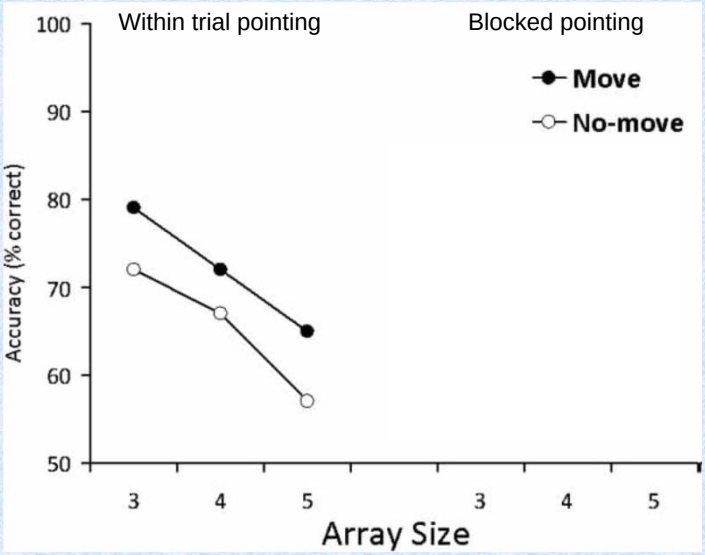

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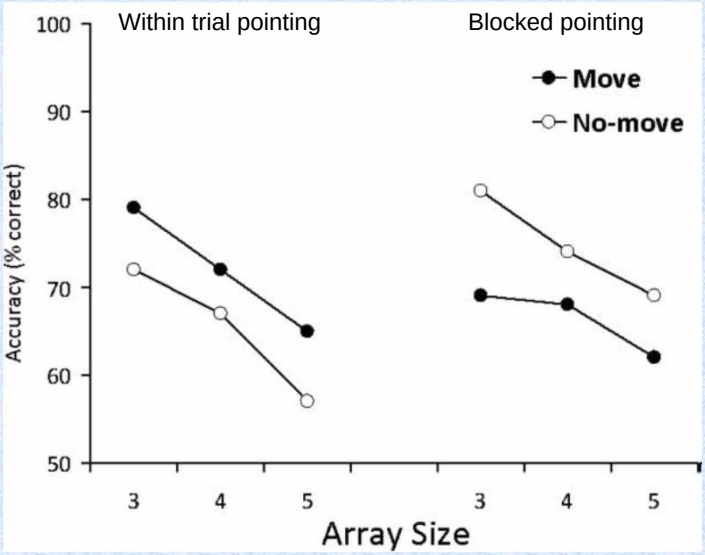

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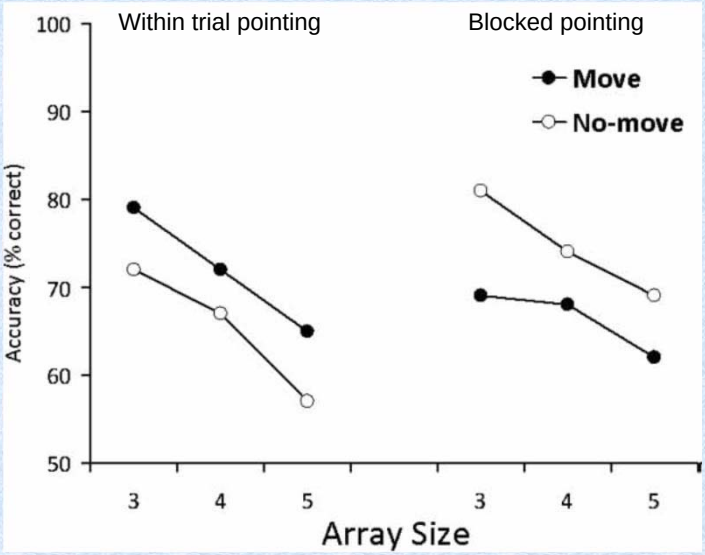

What's up with that?!?

- Interesting point: In the first two experiments, the difference between the touch and no-touch conditions are significant for arrays of size 7 and 9, but not 5
- In the third experiment, the difference between the touch and no-touch conditions are significant for array sizes 3 and 4, but not for size 5
- Is there a magic number here (e.g., touching helps you up until a point, after which it hurts you?)

Critical question

- What is the critical manipulation leading to these contrasting results?
  - Touching within trials/blocks vs. between trials/blocks (inhibition of pointing for no-touch array hurts memory?)
  - Array size manipulations (VSTM?)
  - Touching type (slanted in front or straight in front)
  - Other (what are we missing?)

What does this tell us as it relates to education/learning

- The influence of action on behavior is not straightforward
- Number of items seems important
- Selectivity seems important (e.g. highlighting text)
- Memory enhancement for some material is accompanied by deficits for other materials
- How can this be reconciled with teaching methods