Conceptual similarity between targets and distractors influences visually-guided reaching

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Introduction

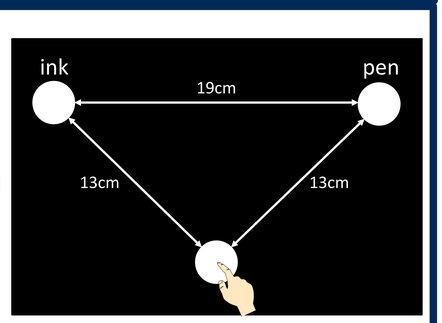
- Previous research has shown that target probability affects real-time decision making reflected in reaching trajectories[1].
- In this study, we tested whether reaching trajectory is influenced by high-level visual and conceptual similarities between object concepts.

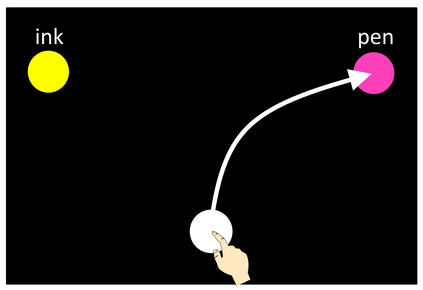
Hypothesis

- **If the similarities between objects influences reaching, then bias toward a competing distractor should be proportional to the degree of similarity with the target.**

Visually-guided reaching task

1. Trials began only after participants held finger on the home position for 500ms
2. Words appeared above potential target locations and participant reads them aloud
3. Target was cued and participants swiped finger to the correct location





Good Trials (Automatic)

Reach initiated between 100-550ms after cue and completed < 700ms after cue

Timeout Trials (Controlled)

Reach initiated more than 550ms after cue

Training Procedure

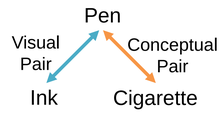
- "Left" and "Right" were displayed above potential target locations
- Training ended after 80% error-free performance quantified using a 10-trial sliding window

Testing Procedure

- 288 trials
- Degree of similarity was randomized across trials
- Trials were repeated if participant missed or reached to distractor

Quantification of Similarity

- Stimuli were selected to create similarity triads
- Word 1 visually similar to word 2
- Word 1 conceptually similar to word 3
- Word 2 not similar to word 3 on either dimension



- Degree of visual and conceptual similarity was equated across stimuli within a given triad
- Similarity levels were divided into low, medium and high

Visual Similarity

- Pairwise similarity ratings obtained using Mechanical Turk
- Participants were asked to rate the visual similarity of the object concepts to which the words referred
- 5-point ratings were normalized to range 0-1

Conceptual Similarity

- Estimated using a corpus-based (Google News) approach implemented with Google's word2vec natural language algorithm
- Cosine similarity calculated based on the angular distance between word vectors in the word2vec model
- 5-word window used to assess co-occurrence

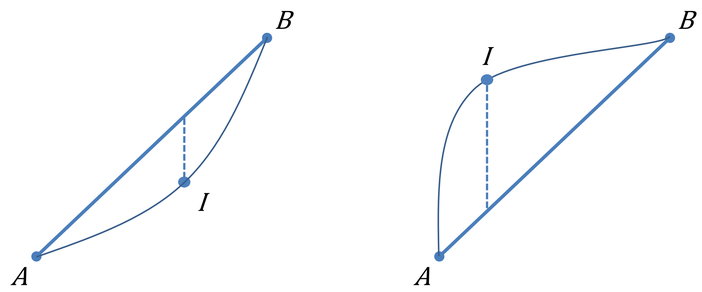
"This pen is no ordinary pen – it's ink can be erased"

Quantification of Reach Bias

- Disparity characterized the curvature of a reaching trajectory
- Positive – biased toward distractor
- Negative – biased away from distractor
- Magnitude in either direction captures degree of curvilinearity
- Calculated as the sum of distance to a perfect line

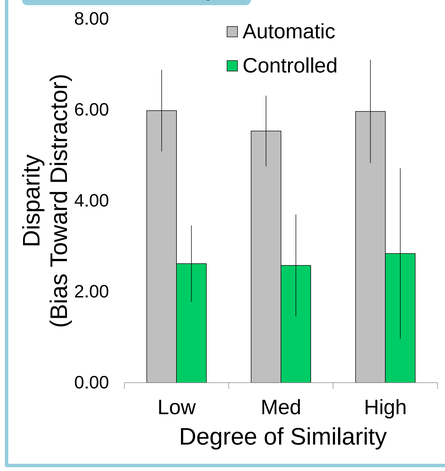
$$\sum (y_i - y_a) - \frac{y_b - y_a}{x_b - x_a}(x_i - x_a)$$

Where *A* is the starting point, *B* is the end point, and *I* are discrete measurements obtained during continuous reach



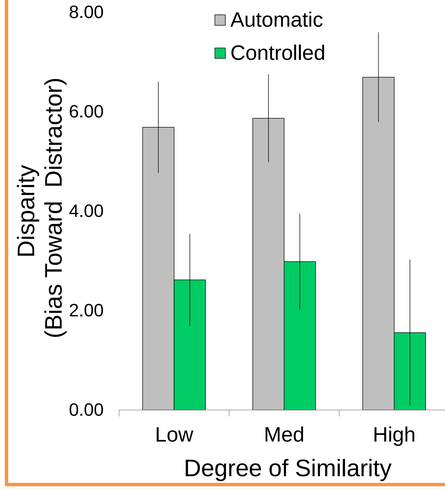
Results

Visual Similarity



- Main effect of control ($F_{1,11} = 22.32$, $p < .001$)
- Reaching trajectory not influenced by degree of visual similarity when words used as stimuli

Conceptual Similarity



- Interaction between control and degree of similarity ($F_{2,22} = 15.19$, $p = .059$)
- Main effect of control ($F_{1,11} = 36.97$, $p < .001$)
- Significant linear trend (upward) for automatic reaching ($F_{1,11} = 12.93$, $p < .01$)

Conclusions

- Reaching trajectory is not influenced by degree of visual similarity between target and distractor words
- Reaching trajectory is influenced by degree of conceptual similarity between a target and a distractor
- When participants rapidly initiated reaches to a cued target (i.e., automatic), bias toward a distractor increased linearly with degree of conceptual similarity
- When movement was initiated more slowly (i.e., controlled), bias toward a distractor decreased with degree of conceptual similarity

[1]Chapman et al. (2010). Reaching for the unknown: Multiple target encoding and real-time decision-making in a rapid reach task. Cognition. [2]Mikolov, T. et al. (2013). Efficient estimation of word representations in vector space. *arXiv preprint https://arXiv.org/abs/1301.3781.*