The Frankenbear Experiment: Looking for part-based similarity effects on search guidance with complex objects

THE EYE MOVEMENTS AND VISUAL COGNITON LAB

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Introduction

Similarity is a key concept in many theories of visual search, but the effects of similarity on search are largely unknown for realistic objects. Using simple stimuli, Duncan and Humphreys (1989) found an interaction between target-distractor (T-D) similarity and distractor-distractor (D-D) similarity; target-similar distractors take long to reject and distractor-distractor grouping reduces the number of these time-consuming rejections. In this study we ask:

- Will the relationships between similarity and search established using simple stimuli generalize to real-world objects?
- Can we better specify the nature of this interaction using eye movement measures?

Methods

The similarity manipulation used here transplanted target features to the distractors on a part-by-part and pixel-by-pixel basis (see also Wolfe & Bennett, 1996). In this experiment, the heads, arms, legs or torsos of distractor teddy bears were replaced with the equivalent parts from a target teddy bear.

- Task: Find a previewed target in a present/absent search display consisting of random, unaltered bears or bears that were manipulated to have one, two or three parts matched to the target.
- Within-subjects variables:
  - Target-distractor similarity (0 part, 1 part, 2 parts, 3 parts)
  - Present/Absent
- Between-subjects variables:
  - Set size (4 or 8)
  - Distractor-distractor similarity: homogenous or heterogenous
- 48 Subjects total (12 per condition)

References

Duncan, J., & Humphreys, G. (1989). Visual search and stimulus similarity. *Psychological Review*, *96* (3), 433-458.

Wolfe, J., & Bennett, S. (1996). Preattentive object files: Shapeless bundles of basic features. *Vision Research, 37* (1), 25-43.

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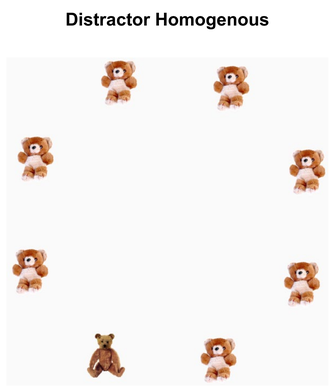
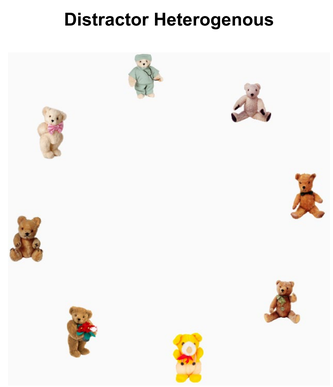
Alexander, R., & Zelinsky, G. (2009). The Frankenbear experiment: Looking for part-based similarity effects on search guidance with complex objects. *Journal of Vision, 9*(8), 1184-1184.

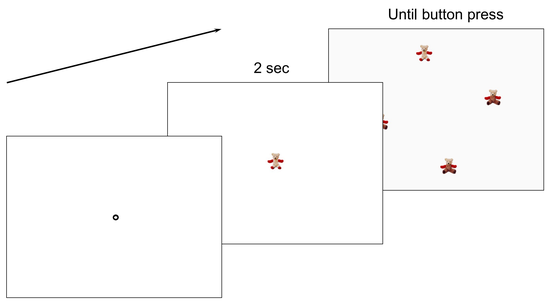
For the paper resulting from this work, see:

Alexander, R. G., & Zelinsky, G. J. (2012). Effects of part-based similarity on visual search: The Frankenbear experiment. *Vision research, 54*, 20-30. doi:10.1016/j.visres.2011.12.004





Procedure



Predictions

- If the similarity between realistic objects affects visual search in the same way as the similarity between simple stimuli, we predict:
  - More false alarms with greater T-D similarity and with heterogenous displays
  - Longer RTs with greater T-D similarity and with heterogenous displays
- Duncan and Humphreys (1989) predict an interaction between T-D similarity and D-D similarity in search guidance but not in target verification . This interaction should be apparent in initial saccade direction and the time it takes subjects to fixate the target (measures of guidance), but not in time from target fixation to response (a measure of verification).

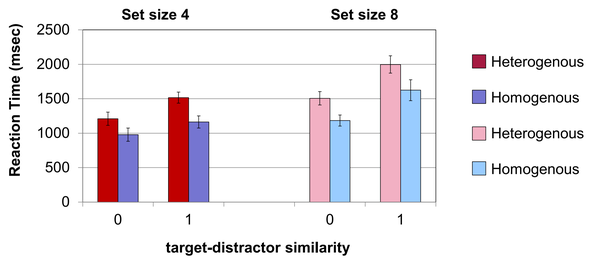
Accuracy

Error rates		Absent				Present			
	Target-distractor similarity	0	1	2	3	0	1	2	3
Set size 4	Heterogenous	2	5	26	35	3	4	17	11
	Homogenous	1	4	20	21	4	4	12	10
Set size 8	Heterogenous	1	11	27	**51**	5	19	12	12
	Homogenous	1	2	17	33	2	4	6	13

- Very high false alarm rates on high T-D similarity trials.
- More errors overall with higher T-D similarity ($p < .001$) and on heterogenous trials ($p < .001$).

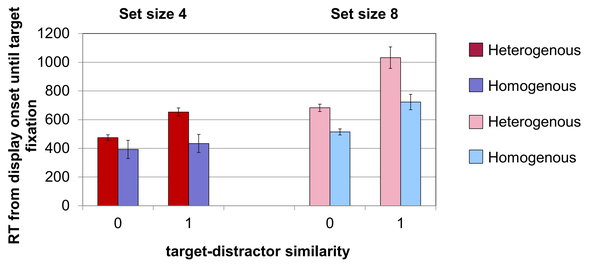
Reaction Times

(correct target present trials)



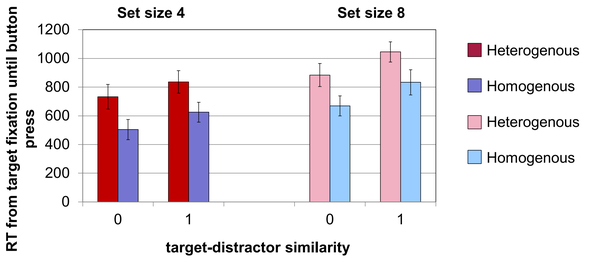
- RTs increased with T-D similarity ($p < .01$) and were longer on distractor heterogenous trials ($p < .01$).
- Consistent with Duncan and Humphreys (1989), there was also an interaction between T-D and D-D similarity when only 0-part and 1-part conditions were considered ($p < .05$).
  - However, no interaction if all similarity levels are included ($p > .18$), probably due to chance levels of guidance in the 2- and 3-part conditions.

Search Guidance



- More time was needed to fixate the target as T-D similarity increased ($p < .01$) and on heterogenous trials ($p < .01$), and T-D similarity and D-D similarity INTERACTED ($p < .01$).

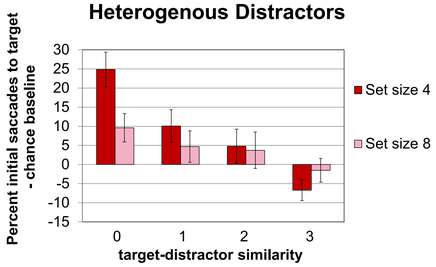
Target Verification



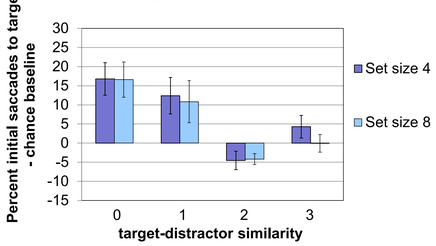
- Time from target fixation until the subject responded increased with T-D similarity ($p < .01$) and was longer on heterogenous trials ($p < .01$), but there was NO INTERACTION between T-D and D-D similarity ($p = .83$; $p = .31$ if 2-part and 3-part conditions are included).

Initial Saccade Direction

Heterogenous Distractors



Homogenous Distractors



- As T-D similarity increased, FEWER initial saccades were made in the direction of the target ($p < .01$); as D-D similarity increased, MORE initial saccades were made in the direction of the target ($p < .01$).
- These effects of T-D and D-D similarity interacted ($p < .01$); there was a greater decline in initial saccades to the target in heterogenous trials as T-D similarity increased.
- Guidance was at or below chance when two or more parts of the distractors matched the target.

Conclusions

- Duncan and Humphreys (1989) found that errors and RTs increased with T-D similarity and decreased with D-D similarity. We replicated these findings in the context of real-world objects by manipulating similarity in terms of shared parts between targets and distractors.
- However, when T-D similarity was too high (2-3 parts matching) targets could not be distinguished from distractors, resulting in a break down of grouping and ultimately high errors rates and chance guidance.
- We also found that T-D and D-D similarity interacted only in measures of search guidance, not in measures of target verification. This is consistent with the relationship between similarity and search as originally outlined by Duncan and Humphreys; increasing D-D similarity lessens the effect of T-D similarity on RT by reducing the number of search comparisons, not by speeding the comparison process.

Sponsorship

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