Attentional Effects of Working Memory Load and Consolidation During Visual Search

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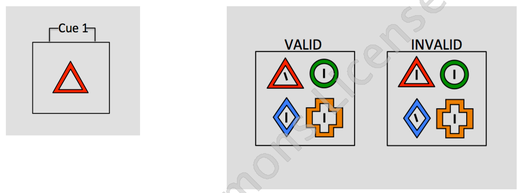
1. INTRODUCTION

- The cued visual search paradigm (Soto *et al.* 2008): a working memory (WM) cue is followed by a visual search stimulus containing the remembered cue.

  The cue can be a *valid* or *invalid* indication of the presence of the search target, here a tilted line amongst vertical distractors:



  - Processing in working memory is known to produce a greater effect on search RT than the mere presentation of an initial cue.
- An item in WM which validly or invalidly cues a search target respectively decreases or increases RT. This is known as the "validity effect".
- Soto and Humphreys (2008) report that increases in task load reduce the validity effect, perhaps by reducing top-down activation from WM. It has also been suggested that effects on search occur particularly when items are being consolidated in WM.
- Here we examined how WM load interacts with the effect of altering the time lag between the memory cue and search displays, separating out effects from different serial positions in WM.

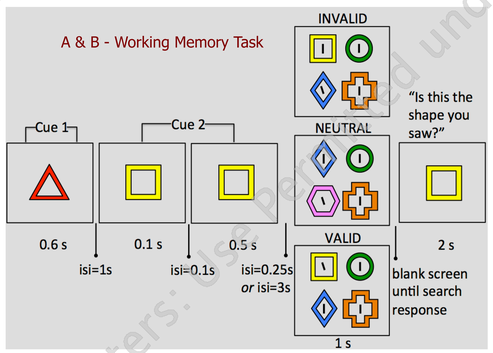
2. METHODS

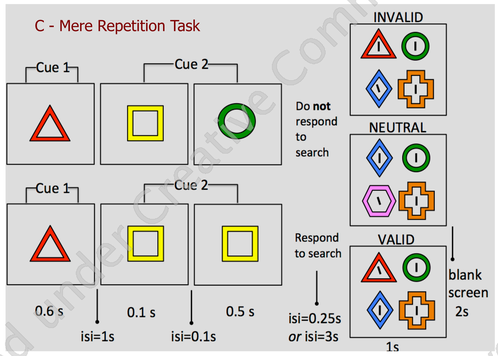
N=13 students (7 female). Mean age = 20.3 years. Stimuli: 7 shapes x 7 different colours, 6cm across.
Three different task types (A-C) were presented in blocks of 48 trials. We increased WM load by requiring participants to memorise two cues in task B.
Cue 1 and Cue 2 appeared in the search for an equal number of trials within each block. We also varied time allowed for WM consolidation.
An equal number of trials contained 0.25s and 3.0s ISI's between Cue 2 and search onset. Participants completed 12 blocks in total.

A. WM low load
1) Ignore cue 1 and memorise the colour and shape of Cue 2
2) Complete visual search by indicating direction of tilted line (left or right up).
3) Complete WM task by indicating whether probe stimulus is identical (both in colour and shape) to the stimulus.

B. WM high load
1) Memorise the colour and shape of Cue 1 AND Cue 2
2) Complete visual search by indicating direction of tilted line (left or right up).
3) Complete WM task by indicating whether probe stimulus is identical (both in colour and shape) to *one* of the stimuli remembered.

C. Mere Presentation/Repetition (MR) task
1) Do not memorise colour or shape of either cue.
2) Instead, note whether stimuli flashed up for Cue 2 are same or different.
3) If different, do not respond to search task
4) If same, respond to search task.





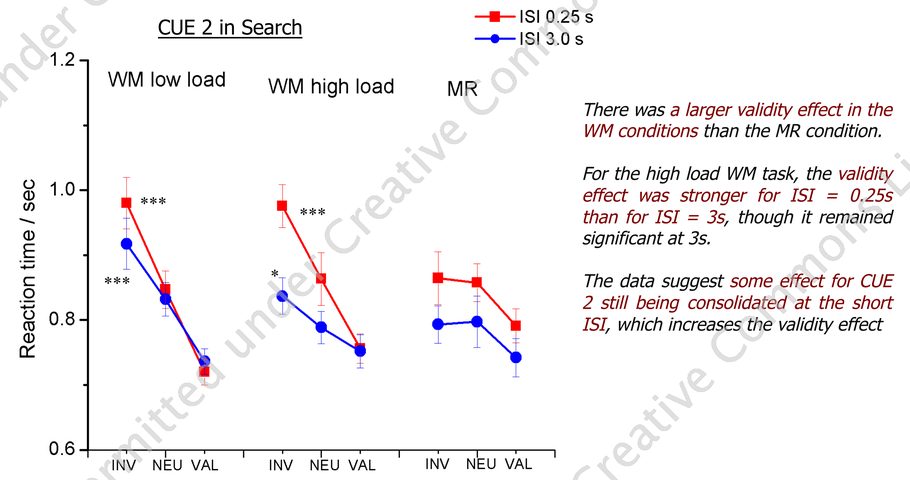
3. RESULTS

- We performed a **4-way ANOVA on all data**.
- There were Significant Main Effects of:
  Validity [F(2,24)=29.7, p<0.001] and ISI [F(1,12)=47.7, p<0.001]
- Cue Position appeared in a number of significant interactions:
  with Validity; Task and Validity; ISI and Validity.

- We thus proceeded to analyse **Cue 1 and Cue 2 data separately**.
- In both cases there was a significant interaction for Task x Validity.
- The Task x ISI interaction was significant for Cue 2.
- For Cue 1 there was a main effect of validity and no interaction with ISI.

- We performed t-tests comparing invalid vs valid conditions, for all different tasks, cue positions and ISI's. Significant validity effect is indicated by
  *** (p<0.001), ** (p<0.01), or * (p<0.02)

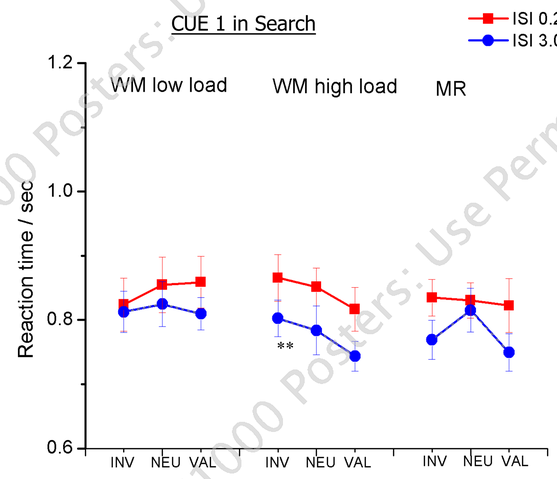
- We also analysed **Cue 1 & 2 data, WM-high task only.** We found main effects of ISI and Validity, and significant interactions for Cue x Validity and Cue x ISI x Validity. *These indicate that validity effect is larger for CUE 2 than for CUE 1 since consolidation is still operating for CUE 2, but is complete for CUE 1.*



There was a larger validity effect in the WM conditions than the MR condition.

For the high load WM task, the validity effect was stronger for ISI = 0.25s than for ISI = 3s, though it remained significant at 3s.

The data suggest some effect for CUE 2 still being consolidated at the short ISI, which increases the validity effect



The low load WM condition behaved similarly to the MR condition and neither showed an effect of validity.

For high load WM, there was a reliable effect of validity but this did not vary across the ISIs.
Cue 1 seems to have been consolidated at both ISIs, but still modulates subsequent attention.

4. CONCLUSIONS

✧As the WM load increases, see decreasing effects of WM influence on search, at long ISI if Cue 2 appears in search, and for both ISI's if Cue 1 appears in search.
✧This reflects the reduced activation of early items in a WM list relative to recent items (Olivers, 2009).
✧The final items in a list take time to consolidate but influence performance irrespective of the load.
✧Results suggest there is differential activation in WM as a function of the serial position of stimuli, that search is most strongly modulated when WM is being consolidated but that substantial WM effects remain even after consolidation has taken place.

ACKNOWLEDGEMENTS

MC was supported by a Value in People award from the Wellcome Trust

KT and GH were funded by the Biotechnology and Biology Research Council, UK

REFERENCES

Olivers, C. N. L. (2009) *J. Expt. Psych: Human Perception and Performance* 35(5) 1275-1291

Soto, D. and Humphreys, G. W. (2008) *Perception & Psychophysics* 70(5) 924-934

Soto, D., Hodsoll, J., Rotshtein, P. and Humphreys, G. W. (2008) *Trends in Cog. Sci.* 12(9) 342-348