Investigating the crossmodal spatial cuing of driver attention

Cristy Ho[†], Hong Z. Tan[§], & Charles Spence[†]
[†]Crossmodal Research Laboratory, Oxford University, UK
[§]Haptic Interface Research Laboratory, Purdue University, USA

Introduction

- Empirical research on crossmodal links in spatial attention demonstrates that responses to targets in one sensory modality can be facilitated by the prior presentation of a relevant cue in another modality from the same spatial location (see Spence et al., 2004, for a recent review).

- However, it is unclear whether the facilitatory effects reported in many previous cuing studies (esp. applied studies) should be attributed to attentional facilitation (where the cue leads to a crossmodal shift of spatial attention that enhances perception of the target, and subsequently performance), response priming (where the facilitation of performance occurs without there necessarily being any change in perceptual acuity), or to some unknown combination of these two effects. Note that while both forms of facilitation are important in an applied setting, from a theoretical perspective, it is important to differentiate between them.

- Our research question: How 'early' in information processing do crossmodal cuing effects attributable to the presentation of a warning signal occur? We addressed this question in a simulated driving task.

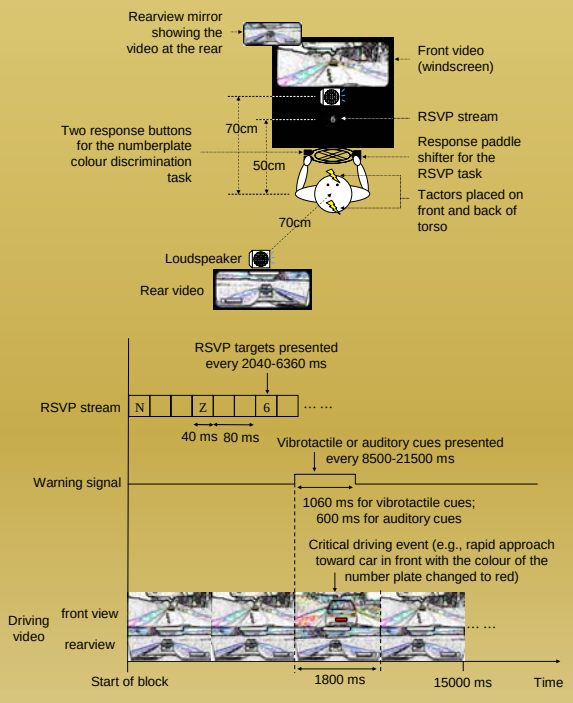
- It is only by gaining a better understanding of the relative contributions of the two effects to performance that we may, in the future, be able to design the most effective warning signals that can facilitate performance by acting at both the perceptual and decisional levels.

Dual-task design

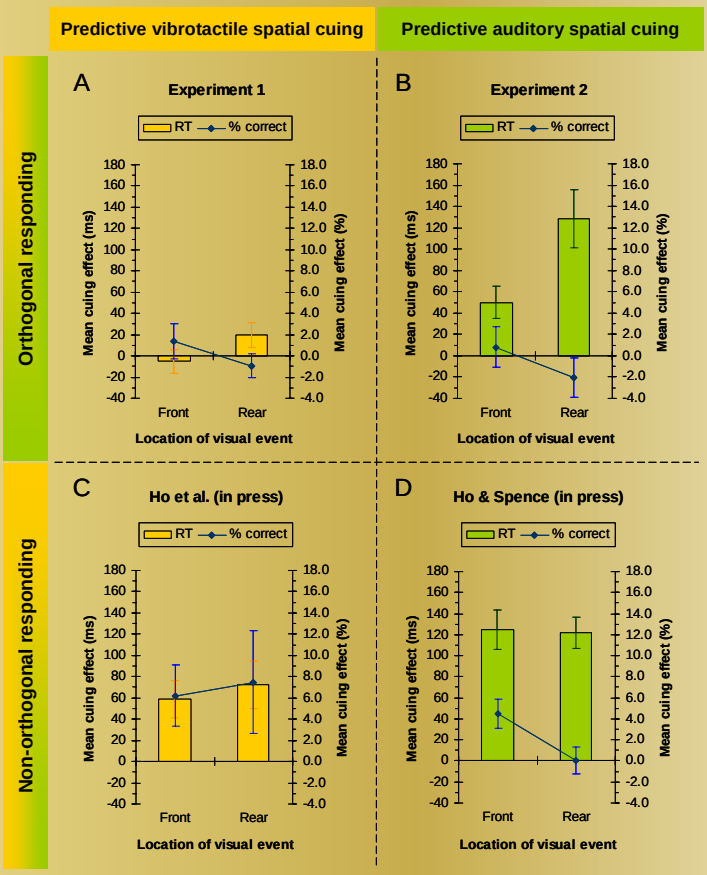
Task 1: Rapid serial visual presentation (RSVP), detecting target digits amongst distractor letters.

Task 2: Numberplate colour discrimination (red vs. blue).

- Spatial vibrotactile (Expt 1) or spatial auditory (Expt 2) warning signals predicted location of critical visual targets (on 80% of trials).
- Targets just as likely in front windscreen as in rearview mirror.
- Orthogonal speeded responses (to spatial dimension of interest): red vs. blue (green numberplate catch trials, 16.7% of total).
- Note that in our previous research (Ho & Spence, in press; Ho et al., in press), the required response to the critical visual driving events (rapid approach of car toward front or from behind) was to brake or accelerate, respectively (i.e., a non-orthogonal response).



Results



- No facilitatory crossmodal spatial attentional cuing effect observed following the presentation of spatially-predictive vibrotactile warning signals (Panel A; Expt 1); Contrast this with the significant crossmodal spatial facilitation effect demonstrated in our previous study (Panel C).

- Significant crossmodal spatial facilitation reported following presentation of spatially-predictive auditory warning signals (Panel B; Expt 2), consistent with our previous findings (Panel D).

Possible explanations for the differential effects of vibrotactile & auditory cues on performance

- Given the slower transduction of tactile information at the receptor surface (i.e., skin) than auditory stimuli at the basilar membrane (Spence & Squire, 2003), participants in Experiment 1 may not have had sufficient time to localize the vibrations prior to their attention being captured by the colour change target driving event.

- The brain represents stimuli occurring in peripersonal space somewhat differently from those occurring in extrapersonal space (Rizzolatti et al., 1997; Spence & Driver, 2004). The remapping of a front / back directional cue on the torso (i.e., in peripersonal space) to a target visual event occurring at a location farther away in extrapersonal space may be less efficient than when the auditory cue and visual target both occur within the same 'functional' region of space (i.e., both in extrapersonal space).

- In short, our findings demonstrate that response compatibility is an important factor in multisensory interface design (see also Proctor et al., in press), and may facilitate performance whenever the cue and target are presented from the same direction. However, additional benefits attributable to attentional facilitation may only occur when the cue and target are spatially co-localized.

- We are currently investigating the relative efficacy of auditory warning signals presented in peripersonal vs. extrapersonal space (cf. Kitagawa et al., in press).

Acknowledgements

This research was supported in part by scholarships from the Clarendon Fund, Oxford UK, and from the Overseas Research Student Awards Scheme to C.H., and a Network Grant from the Oxford McDonnell-Pew Centre for Cognitive Neuroscience to H.Z.T. and C.S.

For further information concerning this research contact: *cristy.ho@psy.ox.ac.uk*

References

- Ho, C., & Spence, C. (in press). Assessing the effectiveness of various auditory cues in capturing a driver's visual attention. *Journal of Experimental Psychology: Applied.*
- Ho, C., Tan, H. Z., & Spence, C. (in press). Using spatial vibrotactile cues to direct visual attention in driving scenes. *Transportation Research Part F: Traffic Psychology and Behaviour.*
- Kitagawa, N., Zampini, M., & Spence, C. (in press). Audiotactile interactions in near and far space. *Experimental Brain Research.*
- Proctor, R. W., Tan, H. Z., Vu, K. -P. L., Gray, R., & Spence, C. (in press). Implications of compatibility and cuing effects for multimodal interfaces. *Proceedings of the HCI International 2005.*
- Rizzolatti, G., Fadiga, L., Fogassi, L., & Gallese, V. (1997). The space around us. *Science, 277*, 190-191.
- Spence, C., & Driver, J. (2004). *Crossmodal space and crossmodal attention*. Oxford, UK: Oxford University Press.
- Spence, C., McDonald, J., & Driver, J. (2004). Exogenous spatial cuing studies of human crossmodal attention and multisensory integration. In C. Spence & J. Driver (Eds.), *Crossmodal space and crossmodal attention* (pp. 277-320). Oxford, UK: Oxford University Press.
- Spence, C., & Squire, S. (2003). Multisensory integration: Maintaining the perception of synchrony. *Current Biology, 13*, R519-R521.