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REFERENCE FRAMES OF SOMATOSENSORY AND VISUAL SPACE REPRESENTATIONS IN VENTRAL INTRAPARIETAL (VIP) AREA OF MONKEYS

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Keywords: **Posterior parietal cortex, eye position, macaque**.

The ventral intraparietal (VIP) area receives converging inputs from different sensory modalities, raising the question of a common reference frame for encoding stimulus location. By mapping visual receptive fields (vRF) for different eye positions, Duhamel et al. (1997) have already shown that, in VIP, visual space is encoded either in retinotopic, head-centered, or intermediate coordinates.

Single-cell activity was recorded extracellularly in VIP of one monkey. Tactile receptive fields (tRF) were estimated by using trains of air puffs delivered through needles arranged in an orderly manner on a mask fitting the monkey's face; this procedure was performed while the monkey fixated a spot of light located either centrally, or at 18 deg. left or right on a tangent screen. vRF were also determined for the same three eye positions by using a moving bar of light. Fifteen out of 26 neurons were bimodal and their visual and tactile receptive fields were found roughly aligned. Changes in eye position did not shift the location of tRF on the body surface, i.e. the tRFs remained anchored to a body-centered reference frame. However, in half of the cells, eye position modulated the amplitude of the response to air puff, and defined a "gain field". The reference frame of the matching vRF of these bimodal cells was not exclusively head-centered; it could also be retinotopic or intermediate. Therefore, evidence for the use of a common reference frame for the visual and tactile RF was found only in a subset of VIP bimodal cells (n=6/15). This results stand in contrast with observations made in other brain regions, such as the superior colliculus or the ventral premotor cortex, where multisensory stimuli are systematically encoded in eye and body-centered reference frames, respectively. We therefore suggest that area VIP may represent an intermediate stage in multisensory coordinate transformations.

VISUO-TACTILE BINDING SITES ARE MODULATED BY SPATIAL COHERENCE, ATTENDED MODALITY AND TASK: AN FMRI STUDY

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Keywords: **fMRI, vision, touch, multisensory, integration**

Introduction: Recent human neuroimaging studies have suggested that the inferior parietal lobe may play an important role in the binding of visual and tactile co-ordinate information[1]. The following study aimed to firstly identify sites of visuo-tactile integration using statistical interaction techniques and then test whether manipulating attention to either the visual or tactile modality or the nature of the task (simple detection vs. intensity discrimination) would modulate these binding sites.

Method: A mixed block/event-related design was used in order to present unpredictable sequences of unimodal (visual **or** tactile) and bimodal (visual **and** tactile) single events within blocks where attention could be directed to either the visual or tactile modality. In addition, bimodal events could either be together in space (congruent) or apart (incongruent). Reaction times were simultaneously collected for comparison with imaging results.

Results: Sites of visuo-tactile integration were first identified by looking for bimodal responses that were greater than the algebraic sum of the two unimodal conditions - "multisensory integration"[2]. This strategy identified a core network of regions putatively involved in the crossmodal binding of visual and tactile co-ordinate information including the caudate nucleus, intraparietal sulcus, superior parietal lobule and posterior cingulate gyrus. When bimodal inputs were spatially congruent activation was identified exclusively in the caudate nucleus, parahippocampal gyrus and posterior cingulate gyrus. When attention was directed to vision activation occurred preferentially in the intraparietal sulcus whereas attention to touch activated the caudate nucleus. Finally, discrimination but not detection activated frontal cortex, which is consistent with previous studies implicating this region in crossmodal object binding[3].

Conclusion: An interaction analysis identified a network of regions putatively involved in the binding of visual and tactile co-ordinate information. Further, this network could be modulated by explicitly changing the spatial, attentional and task-related parameters and the relation to task performance. This alludes to a more 'context-related' recruitment of visuo-tactile binding sites than previously suggested.

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MULTISENSORY VISUAL-AUDITORY OBJECT RECOGNITION IN HUMANS: A HIGH-DENSITY ELECTRICAL MAPPING STUDY

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Keywords: **Multisensory, visual, auditory, high density ERPs, object recognition**

An object can often be identified based on information from several sensory modalities. Clearly, the sight of a common animal immediately reveals its identity. Similarly, with one's eyes closed, most animals are readily identified by their vocalizations and this would also be the case should one feel the animal for a few moments. Yet the joint influence of information from multiple senses on object recognition has not been extensively examined. The present study tested the effect of visual and auditory information on object recognition. High density evoked potentials (from 128 scalp electrodes) were recorded while subjects performed an object recognition task in which they pressed a key to the occurrence of a target animal. On each trial one of four stimulus types was presented: animal pictures alone; animal sounds alone; paired pictures and sounds of the same animal (congruent pairs); and paired pictures of one animal and sounds of another (incongruent pairs). Five types of targets were derived from the four stimulus types: auditory-alone targets, visual-alone targets, auditory incongruent targets, visual incongruent targets, and congruent targets. There were 8 animals, and each served as the target for two runs. Reaction times to the congruent targets were significantly faster than reaction times to any of the other target conditions. Miller's test of the race model was violated over the early portion of the RT distribution, providing evidence for the contribution of the interaction of the multisensory target information to RT facilitation. The evoked potentials elicited by the targets showed a significantly larger and extended visual N1 to congruent pairs compared to the incongruent pairs, suggesting that auditory information influences early visual object recognition processes.

DECONSTRUCTING TEMPORAL VENTRILOQUISM: HOW DO SOUNDS CAPTURE THE PERCEIVED OCCURENCE OF LIGHTS?

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Keywords: Temporal perception, audition dominance, appropriateness hypothesis

Several experiments examined how the temporal positioning of irrelevant sounds influenced performance in a visual temporal order judgement (TOJ) task. The first two experiments established the finding that sounds occurring before and after two successive lights improved visual TOJ performance compared to when sounds appeared simultaneously with the lights. Additional experiments examined the role of the first and second sounds independently, revealing that the effect was due to the second sound lagging after the second light. In a final experiment it was found that the second sound improved performance to the greatest extent when the first sound was present. This suggests that the integration of lights and sounds depends on the overall context. These experiments illustrate a temporal ventriloquism whereby the perceived temporal occurrence of lights is biased by the timing of sounds.

CONVERGENCE OF AFFECTIVE INFORMATION IN MULTIMODAL REGIONS OF THE HUMAN BRAIN

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Keywords: Multisensory, affect, PET, middle temporal gyrus.

A PET study investigated whether convergence brain regions were activated during the perception of affective audio-visual events. Happy or fearful stimuli were presented to eight subjects in three conditions (visual only, auditory only and audio-visual). A convergence region situated in the left lateral temporal cortex (-52x, -30y, -12x) was selectively more activated by affective bimodal stimuli than affective unimodal stimuli (whether visual or auditory). Distinguishing positive and negative emotions, supplementary convergence areas situated mainly anteriorly in the left hemisphere for happiness and in the right hemisphere for fear were activated. Right amygdala activation was observed equally for visual fearful and audio-visual fearful stimulations. These results are consistent with previous fMRI data (Dolan, Morris & de Gelder, 2001) suggesting that facial expression and auditory fragment are concurrently processed in convergence regions rather than in modality-specific cortex.

Dolan, R.J., Morris, J.S., & de Gelder, B. (2001). Crossmodal binding of fear in voice and face. *Proc Natl Acad Sci USA* **98:** 10006-10.

THE CEREBRAL REORGANIZATION OF LANGUAGE FUNCTIONS IN LATE BLIND ADULTS AS AN EXAMPLE OF CROSS-MODAL PLASTICITY IN ADULTHOOD

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Keywords: **language, fMRI, late blindness, plasticity**.

It has been shown that the nature and timing of language input significantly influence the neuro-anatomical implementation of language functions. For example, a recruitment of right hemispheric areas for language has been observed in users of American Sign Language (ASL). However, an activation of the right homologous perisylvian areas was less pronounced and only partly in late learners of ASL. Similarly, a bilateral rather than strongly left-lateralized brain activation during speech processing has been observed in congenitally blind adults both with event-related brain potentials (ERPs) and functional magnetic resonance imaging (fMRI). Moreover, evidence for a language-related activation of visual cortex in the blind was reported. It is not known yet, if the more efficient processing of speech and / or the altered neural representation of language in the blind are linked to 'critical' or 'sensitive' periods during development or if similar changes occur when visual deprivation starts after puberty. These questions were addressed using fMRI. Nine late blind adults listened to meaningful or pseudo-word sentences which had an easy or difficult syntactic structure. Task of the participants was to detect rare sentences with an incorrect word order. The data showed a left-lateralized activation of perisylvian brain regions in the sighted controls but a bilateral activation pattern in the late blind participants. Furthermore, the language related activation extended into visual cortex areas in the late blind but in none of the sighted controls. The observed changes of language functions in the late blind group are similar to those observed for congenitally blind adults although they were partly not as pronounced after late than early onset of blindness. The present study demonstrates cross-modal plasticity of auditory language functions in adulthood.