

# Anticipation of action effects — comparison of brain activation by visual and by audiovisual stimulation

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**Summary**— Tennis players use the sound of racket–ball contact (RBC) when anticipating the opponent’s actions. The RBC was not visible in the movements of a reduced stick-figure; it was either marked by a sound or by a flashing of the whole figure. This information was presented in a complementary or conflicting fashion. Behavioral data showed no effect of this conflict. For the visual task, fMRI data showed higher activation for complementary stimulation than for conflicting stimulation (i.e., before the veracious RBC time) bilaterally in the superior temporal sulcus, the right primary auditory cortex and the right inferior frontal gyrus. The audiovisual task showed higher activation for complementary than for conflicting stimulation (i.e., after the veracious time) bilaterally in the middle temporal gyrus. Visual anticipation possibly recruits crossmodal representations of biomotion. The middle temporal gyrus seems to be sensitive to the time lag of auditory stimulation after the inferred event.

## INTRODUCTION

To anticipate the course of the ball when preparing their motor responses, tennis players not only observe their opponents striking the ball but also listen to events such as the sound of racket–ball contact (RBC). We investigated how visual perception of kinematics is processed for sports-related anticipation when the RBC was not visible in the movements of a reduced stick-figure. The RBC was either marked by a sound (audiovisual task) or by a flashing of the whole figure (unimodal task); ball and racket were not displayed. This information was either presented in a complementary or conflicting fashion. Complementary stimuli were presented at the veracious time of RBC (VER). Conflicting stimuli were presented at a time deviant to RBC, i.e., either before (PRE) or after (POS) the veracious time. Participants were asked to anticipate the resultant ball flight.

## RESULTS AND DISCUSSION

Behavioral data showed no effect for complementary versus conflicting stimuli.

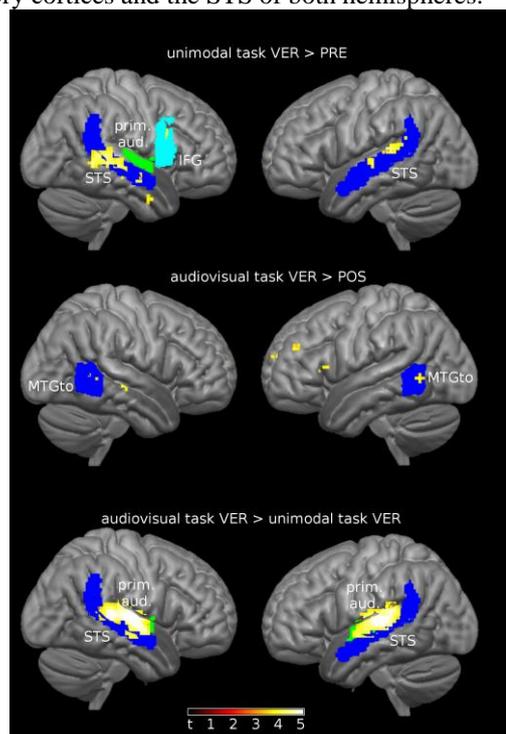
Using a region-of-interest approach, fMRI data showed that the visual and the audiovisual task elicited higher activation for complementary than for conflicting stimuli.

Activation in the visual task was higher for VER

compared to PRE in the superior temporal sulcus (STS) of both hemispheres, in the right primary auditory cortex and in the right inferior frontal gyrus, BA 44. The comparison of VER with POS showed no difference.

In the audiovisual task, higher activation was found for VER than for POS in the temporo-occipital part of the middle temporal gyrus (MTGto) of both hemispheres. The comparison of VER with PRE showed no difference.

Comparing the audiovisual VER with the visual VER stimulation showed higher activation in the primary auditory cortices and the STS of both hemispheres.



**Figure 1** Statistical parametric maps of whole-brain activation (including voxels with  $p < .001$  uncorrected, of clusters with  $k > 0$ ) with color-coded  $t$  values (min = 0.5, max = 5.0). Small correction volumes (ROI masks) are also projected onto the MNI-152-T1 template brain.

We suggest that anticipation based on visual perception possibly recruits crossmodal representations of biomotion when an audiovisual event is inferred. In a natural setting, the sound cannot occur before the event. During anticipation, the multisensory integration area in the middle temporal gyrus seems to be sensitive to the time lag of auditory stimulation after the inferred event.