Location but not direction incongruency evokes slower reaction times in an anti-reach task: Evidence for arm-movement planning in gaze-centered frame of reference

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Consistent with behavioral findings it has been shown that neuronal motor-goal representations in the parietal reach region (PRR) occur earlier in pro- than in anti-reaches. In the standard anti-reach task pro-reaches target the same direction (relative to gaze direction) and the same location (absolute position) as the spatial cue, anti-reaches the opposite direction and a different location. We asked whether targeting the opposite direction or a different location explains slower reaction times (RT) in anti-reaches. Slower RTs in location incongruent compared to location congruent reaches would be in accordance with neuronal findings for PRR, which suggest that motor-goals are first defined in a gaze-centered frame of reference. In this case direction congruency should not affect RTs. On the other hand, many psychophysical studies show that direction incongruency can lead to slower reaction times. Phenomenologically the latter is explained be a higher 'dimensional overlap' between high-level features of cue and response in pro- compared to anti-reaches.

We designed a generalized anti-reach task in which direction and location congruency could be dissociated by using disjoined eye- and hand fixation positions. Pro-/anti-reaches were defined by a reach movement to the same/opposite direction (relative to hand fixation) as the direction of the spatial cue (relative to gaze). Variation of the transformation rule (pro-/anti-reach), eye-hand congruency (joined/disjoined fixation spots), fixation laterality (left/right of midline) and cue laterality (left/right of gaze) resulted in 16 conditions. A four-way ANOVA showed a main effect of eye-hand congruency, but no effect of either direction (pro-/anti-), fixation laterality or cue laterality. An interaction between fixation laterality and cue laterality could be explained by an effect of reach eccentricity. Therefore, for further analyis, we used only the eight conditions characterized by identical physical movements, i.e. without variation of reach eccentricity. The remaining variance could be explained by main effects of location and eye-hand congruency without any interaction. Location-congruent trials were faster than location-incongruent trials; eye-hand-congruent trials were faster than eye-hand-incongruent trials.

Our results are consistent with the assumption of motor-goal encoding in a gaze-center frame of reference. We hypothesize that the location congruency effect indicates a preferential mapping of visual cue locations in retinotopic coordinates onto spatially congruent motor-goal locations in gaze-centered coordinates. The eye-hand congruency effect, on the other hand, could indicate a benefit for mapping motor-goals in gaze-centered coordinates onto visual extrinsic hand-centered coordinates, when both frames of reference are identical.