From perception to action: specific role of the Parietal Reach Region (PRR)

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The PRR of the Posterior Parietal Cortex (PPC) seems to play a role in gating the nervous system to either adjust an old motor program under a new context, or bypass the learning. Prior to movement onset a given cell in this region responds very differently when the pending reach is new from when is automatic (observed in 33/35 cells). We describe two distinct types of cells (in 140 cells from 2 monkeys), useful to form a gating mechanism to correctly select the initiation of the action. This gating signal must be linked to the geometry of the space-time for action initiation, i.e. in what direction of space to start moving, and how far and for how long to follow that direction before starting to stop. This information is in place prior to the onset of movement and the availability of sensory motor feedback. It is relevant as soon as an object in space is perceived as a target for action. As the hand approaches that object the initial time to reach the peak velocity changes as a function of the action’s context. Yet in monkeys and humans reaching the same spatial location through very different trajectories and different τ’s does not alter a geometric symmetry. Across differently curved trajectories and the straight lines joining their starting and ending points two ratios are kept invariant. The partial length of the curve up to the point of maximum bending summed with the corresponding straight line length (perimeter) divided by the total sum of the curve’s and the line’s lengths spans a distribution with maximum always centered at ½. Likewise the ratio of their enclosed partial to total area is about ½. Normally the difference between these 2 ratios is very small. Across different contexts the slope and the intercept of the regression line best fitting these distributions are similar within monkeys and humans. This is the case whether the action is new or already a motor program. It would seem that this is just a mechanical constraint or some inevitable byproduct of the arm’s geometry. Yet we show that this measure is under neural control as not only does it break down when the parietal system is compromised but also it gets fixed when the appropriate feedback is provided. For this geometric symmetry an important parameter to know a priori is τ. In parietal patient S.W. the abnormally high variability of τ (as compared to 9 age-matched normal subjects) leads to large initiation errors that result in excess trajectory bending when he points forward in the dark. This in turn increases the initial perimeter (length) component in the ratio thus breaking the symmetry. When an allocentric cue (vision of the target location) is provided his system binds τ to the space for action, repairs the initiation of the motion and recovers the symmetry. In contrast when an egocentric cue (vision of his moving hand only) is provided τ is not fixed, and neither is the symmetry. His egocentric frame of reference is severely impaired. This work highlights the role of the parietal system in the initiation and guidance of voluntary reaches, and a specific way in which the early perceptual system sets the stage for the later motor system.