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Evaluating Mechanisms of Fatigue Using a Digit Symbol Substitution Task

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Abstract: Participants were asked to encode a target's location relative to 1 to 3 environmental features, based upon a brief (53ms) stimulus presentation. A boundary enclosing the target was the most effective cue, while landmark cues produced less accurate performance. Such encoding forms the basis for complex representations of the environment.

Summary: Evidence for bias, including categorical effects, in perceptual encoding of spatial location is widespread. For instance, Huttenlocher, Hedges, & Duncan (1991) provide a demonstration of such effects in the context of representing a target point within a circle. Simultaneously, there is an extensive literature that has explored the nature of spatial representations in the context of a variety of complex reasoning tasks (e.g., Franklin & Tversky, 1990; Mou & McNamara, 2002; Stevens & Coupe, 1978). What is missing, however, is an explanation of how sequential, retinotopic perceptual information is processed to produce the higher-level spatial representations required for such complex reasoning activities. Our research is targeted at addressing this gap by using methodologies from the attention literature to inform theoretical claims drawn from the literature on spatial reasoning. In this experiment, participants were shown a target at the center of a monitor. While fixating this target, 1 to 3 "environmental features" appeared around this target, providing a context for locating the target. The potential features were (1) an outline of an irregular polygon defining the boundary of a space enclosing the target, (2) a "landmark" feature positioned within the space, and (3) another landmark feature positioned outside the space. These correspond to commonly proposed features that can be used in naturalistic environments for encoding spatial location with respect to a non-egocentric frame of reference. These features were displayed briefly (53 ms) and then masked, preventing the use of eye movements to encode the target's location strategically. Following the mask, a test screen was presented that showed some or all of the reference features from the stimulus, potentially augmented by additional features that were not shown in the stimulus. The locations of these features were translated (coherently – all shifted the same distance and direction), and participants were asked to click on the display to indicate where the stimulus was located relative to available features. Not surprisingly, the results demonstrated that performance improved as more features were shared between the stimulus presentation and the test. More interestingly, this result appears to have been driven by the utility of individual features in identifying the location of the target. Specifically, when the outline of the space was shown both during stimulus presentation and during the response phase, performance was best, and performance was not improved when landmark features were also available during both phases of the trial. When the border was not available, performance was dominated by the presence/absence of the internal landmark, once again independent of the presence/absence of the external landmark. The worst performance was observed when the only feature shared between stimulus presentation and test was the external landmark. The results begin to expose how environmental features provide are used to establish a non-egocentric frame of reference for encoding object location. Future research is targeted at understanding these processes in more naturalistic scenes and how such knowledge can be accumulated over time to create more complex representations, such as those commonly referred to as "cognitive maps."