Flexible top-down control in the interaction between working memory and perception

Chunyue Teng1, Jacqueline M. Fulvio1, Jiefeng Jiang2, Bradley R. Postle1

1 University of Wisconsin–Madison, 2 University of Iowa

Working memory (WM) and perception are highly intertwined and interactive processes (e.g., Awh and Jonides, 2001; Chun, Golomb, Turk-Browne, 2011), and a considerable amount of research supports the idea that these two functions may rely on a common representational substrate (e.g., Teng & Kravitz, 2019; Teng & Postle, 2021). Here we examined how the interaction between WM and ongoing perception is controlled, by testing human performance on a dual task that varied conflict between WM and perceptual representations. Subjects first viewed an orientation-grating memorandum, then performed an orientation discrimination on a second item (the discriminandum), and then recalled the orientation of the memorandum. Congruity between memorandum and discriminandum was manipulated, and incongruent trials generated hallmarks of both proactive and reactive control in performance on the subsequent trial: The response-time cost of incongruity was reduced for the discrimination task (indicating increased proactive control) and the sign of the serial bias of the discriminandum on recall flipped, from attractive following congruent trials to repulsive following incongruent trials (a consequence of reactive control). A separate control experiment confirmed that the repulsive serial bias reflected top-down control (rather than, e.g., passive perceptual adaptation), because it was absent when the orientation of the discriminandum was made task-irrelevant. To formalize these observations, we fit the data using the Flexible Control Model (FCM; Jiang et al., 2014, 2015) and two model parameters were sensitive to trial-by-trial variation in conflict: fluctuation in “predicted conflict” quantified adjustments in the level of proactive control; and the value of the “control prediction error” captured the strength of reactive control recruited in response to memorandum-discriminandum congruity. Furthermore, the magnitude of the repulsive serial bias triggered by an incongruent trial was predicted by the magnitude of that trial’s “control prediction error” (solidifying the link between repulsive bias and reactive control). Overall, these results illustrate that conflict between the current contents of WM and perception is governed by the flexible recruitment of two types of top-down control, proactive and reactive control. Model-based analysis of the results from a follow-up EEG experiment will investigate neural correlates of these two distinct forms of cognitive control.