

Journal Club

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fMRI Adaptation: Stimulus Specific or Processing Load Specific?

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Review of Xu et al. (<http://www.jneurosci.org/cgi/content/full/27/22/5981>)

Repetition suppression, or fMRI-adaptation, refers to decreased neural activity for repeated versus novel stimuli as measured with functional magnetic resonance imaging (fMRI). Recently, this technique has been widely used, especially in probing the plasticity of the nervous system and the functional properties of neural ensembles (Grill-Spector et al., 2006). However, stimulus repetition also leads to performance facilitation [i.e., repetition priming (Schacter and Buckner, 1998)]. Thus, it remains unclear whether fMRI-adaptation is stimulus-specific or simply reflects the stimulus processing that is necessary to reach a task decision (i.e., processing load-specific).

One way to examine the correlation between fMRI-adaptation and visual repetition priming is to dissociate behavioral performance from neural activity. For example, Henson et al. (2000) used familiar and unfamiliar stimuli to manipulate stimulus familiarity. They found attenuated responses to the repetition of familiar stimuli but enhanced responses to the repetition of unfamiliar stimuli, which excludes a sim-

ple one-to-one correspondence between adaptation and repetition priming.

A recent paper by Xu et al. (2007) in *The Journal of Neuroscience* reports a full dissociation between adaptation and repetition priming in the scene-specific region in the ventral visual cortex, the parahippocampal place area (PPA). Observers viewed pairs of very similar and less similar scene photographs [Xu et al. (2007), their Fig. 1A (<http://www.jneurosci.org/cgi/content/full/27/22/5981/F1>)]. Two tasks were used to induce opposite behavioral patterns to identical stimuli. In the scene task, observers judged whether two photographs originated from the same scene and, thus, needed to attend to the photos as a whole. As such, behavioral responses were faster and more accurate when the two photographs were very similar than when they were less similar. In the image task, observers judged whether the two photographs were identical pixel by pixel and, thus, needed to focus on feature analysis. This, however, resulted in faster and more accurate behavioral responses when the two photographs were less similar than when they were very similar [Xu et al. (2007), their Fig. 1B (<http://www.jneurosci.org/cgi/content/full/27/22/5981/F1>)]. Because overall reaction time and accuracy showed no difference between the two tasks, processing load was matched. This was further supported by the lack of difference in peak amplitude and latency of the PPA responses between the two tasks. Although observers might

use different strategies and displayed different eye movement patterns, these parameters did not seem to affect neural and behavioral responses.

Most interestingly, the significant interaction between stimulus similarity and task observed in the behavioral performance was not reflected in the responses in PPA. Rather, PPA responses were greater for the less similar image pairs than for the very similar image pairs, independent of stimulus processing time. This suggests that attenuation in ventral visual areas is stimulus-specific rather than processing load-specific. Using a whole-brain random-effects analysis, rather than region-of-interest (ROI) analysis to localize the PPA, the authors identified two regions that mirrored the behavioral performance, the anterior cingulate cortex (ACC) and left insula [Xu et al. (2007), their Fig. 2A,B (<http://www.jneurosci.org/cgi/content/full/27/22/5981/F2>)]. Both regions are involved in decision making (Wig et al., 2005). As such, both task-independent and task-dependent fMRI responses were identified in ventral visual cortex and prefrontal cortex, respectively.

The strength of this study is the manipulation of task difficulty while keeping the stimuli identical, thus providing evidence that fMRI-adaptation is stimulus specific. However, given the limitations of fMRI, single-cell level evidence is necessary to fully demonstrate the stimulus specificity of fMRI-adaptation. For example, mon-

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keys exhibit repetition suppression and repetition priming, but such correlation disappeared with trial-by-trial analysis (McMahon and Olson, 2007). A combination of imaging and single-cell recordings with closely matched paradigms would help resolve whether dissociation between fMRI-adaptation and behavioral performance can be observed in monkey single-unit responses across trials.

Equally important is the characteristics of the sequential stages of information processing during repetition attenuation. In this study, the task-independent and task-dependent fMRI responses in visual cortex and prefrontal cortex, respectively, reflect different information processing stages related to fMRI-adaptation. Because activity in ventral visual cortex did not correlate with task difficulty, and previous studies suggested that attention and emotion can modulate repetition suppression (Grill-Spector et al., 2006; Yi and Chun, 2005), the dynamics of informa-

tion processing stages involved in fMRI-adaptation is likely one-way, rather than recursive. In other words, bottom-up retinal sensory inputs (e.g., affective properties of the stimuli) and certain top-down factors (e.g., internal attentional state of the observer) can modulate categorical processing in the ventral visual cortex. But this categorical processing may be immune to task-related factors like decision making stage in frontal/prefrontal cortex. However, because fMRI-adaptation is sensitive to experimental conditions and depends on the assumption that a second identical stimulus will tap into the adapted subpopulation whereas a second different stimulus will access an unadapted subpopulation (Krekelberg et al., 2006), this formulation might not apply if tasks or stimulus properties are changed.

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