Summary and Notes #2

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- Article:
  The neural basis of complex audiovisual objects maintenances in working memory (2019) by Yuan Jun Xiea,b,*, Yan Yan Lia, Bing Xiec, Yuan Yuan Xud, Li Pengd
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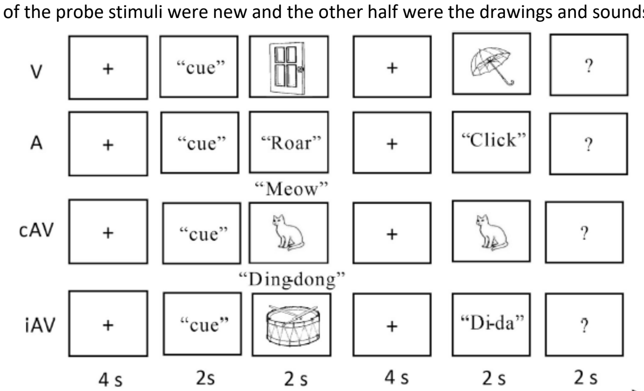
- Summary

  Working memory (WM) is a brain system thought to temporarily and briefly maintain and manipulate limited perceptual information as transient representations even after the stimuli is no longer present. With neuroimaging, the neural mechanisms of WM have been studied with functional magnetic resonance imaging (fMRI). These studies have helped identify how WM utilizes different brain regions during the processing and maintenance of modality-specific information from visual and auditory stimuli. However, rather than focusing on the modality of our senses, this articles explores an "amodal" view of WM to understand how higher-order information is represented from multisensory input. Recent research has indicated a general neural network with the detection of left intraparietal sulcus sensitivity during combined auditory and visual item WM maintenance. Additionally, semantically congruent (e.g., sound and picture of a cat) versus incongruent (e.g., sound of a horn and picture of a violin) auditory-visual stimuli has been shown to result in better encoding and memory recognition. Observations of multisensory processing in humans in various brain regions as well as the congruency effect encouraged the present study to investigate the maintenance of multisensory information in WM using fMRI (3T Siemens TrioTim scanner equipped with a 16-channel head coil) and voxel-based conjunction analysis. These researchers analyzed four types of auditory, visual, congruent, and incongruent audiovisual objects (i.e., visual alone (V), auditory alone (A), semantically congruent (cAV) and incongruent (iAV) audio-visual combinations) with the Sternberg task to investigate whether multisensory information is maintained in modality-specific or modality-independent form.

  A Sternberg-type working memory task is a paradigm of three phrases (encoding of stimuli, maintenance of the stimuli, and retrieval of a single target stimulus by asking participants if the target was previously shown). The present study used this task during MRI scans with four different objects (auditory, visual, congruent, and incongruent audiovisual objects) with standard, naturally occurring black and white line drawings for visual stimuli (e.g., animals, tools, instruments, vehicles, scenes) and sounds from www.findsounds.com modified with Adobe Audition version 5.0 for auditory stimuli. Participants viewed the stimuli with a mirror in the MRI scanner and heard the sounds with MRI-compatible headphones as the stimuli were controlled by E-Prime 2.0 (Psychology Software Tools, Inc. PA). The WM task had three phases of 1) the encoding period (2s cue presentation, word cue of type of stimulus that would be presented, and 2s stimuli encoding) 2) the maintenance period (4s holding of stimuli in mind), and 3) the retrieval/target probe period (2s stimulus retrieval with a 2s response of whether the stimulus matched the previously memorized stimulus). Each trial was followed with a 4-6s resting period. All stimuli were presented no more than twice and in all 4 counterbalanced runs (32 trials each) the trial order was pseudorandomized. Since half of the probe stimuli were new and the other half were the drawings and sounds already presented, participants had to memorize all the presented stimuli.

  - 

  Functional data were obtained with blood oxygen level-dependent (BOLD) sensitive T-2 weight gradient echo-planar images (EPI). The statistical analysis conducted used a random-effect general linear model approach to examine any overlapping activation patterns (i.e., shared processing component of complex multisensory object maintenances) and identify regions of interest (i.e., increases/decreases of regional blood flow at brain site involved in neuronal processing under certain stimuli conditions).

  Responses times for semantically congruent audiovisual conditions was significantly faster than incongruent, single auditory, and single visual conditions. Additionally, common brain activation for congruent conditions were mainly localized in the left hemisphere including the angular gyrus, left supramarginal gyrus, and left precuneus (as well as left parietal cortex and left inferior parietal lobule) and BOLD measures were higher compared to maintenance of single audio and visual objects. These regions are thought to be associated with semantic processing and as cortical multisensory convergence areas. During semantically incongruent audiovisual object maintenance, common brain region activation involved the bilateral angular gyrus, left supramarginal gyrus, left superior parietal lobule, and left middle temporal gyrus. Additionally, BOLD measures were higher for this condition compared to single auditory and visual objects. Interestingly, the left superior parietal lobule contains visual neurons activated by various kinds of visual stimuli (e.g., color), while the left middle temporal cortex is associated with auditory semantic memory and activated during complex sound processing. These findings suggest semantically incongruent audiovisual objects representations are maintained in separate modality-specific systems due to failure unified representation formation. For both semantically related conditions, common brain regions activated included the bilateral angular gyrus and left middle frontal with BOLD levels higher compared to maintenance of single auditory and visual object conditions. These findings indicate that the inferior parietal lobule and angular gyrus are a multisensory hubs with visual and primary auditory pathways.

  Behavioral data showed that compared to single auditory and visual as well as semantically incongruent conditions, semantically congruent audio-visual objects encoding sped up subsequent unisensory memory retrieval. With the conjunction analysis, shared conjoint brain region activation were revealed during the maintenance of semantically congruent and incongruent audiovisual, multisensory objects. This indicates that congruent sensory encoding is enhanced due to multisensory information integrated into a common memory representation whereas incongruent conditions may not form a new coherence representation due to conflicting and inconsistent semantical content. These findings suggest there is a possible "supramodal" storage and attention allocation to help maintain information from various sensory inputs. Rather than the prefrontal cortex storing WM information, researchers now propose it guides the distributive brain network flow and is involved in top-down attention control over all other brain regions where WM information is stored. Thus, the attentional control of the prefrontal cortex guides our focus onto task-related information and inhibits task-irrelevant information to improve the maintenance of WM representations.