Session Title: Clarifying Attentional Mechanisms and Studying Neurologic Attention Deficits (Using Imaging).
Facilitators: Ayelet Sapir, Branch Coslett
Summarizer: Patricia Arenth

Proposed Discussion Questions:

- What experimental tasks and paradigms are most useful for understanding neural control of attention?
- How well do imaging tasks capture ecologically important phenomena such as sustained performance, performance in unstructured settings, etc.?
- Can modulation of sensory or motor systems be useful in measuring attentional phenomena?
- What are the implications of individual and group differences in task difficulty, skill level, and effort, in understanding attentional systems?

Summary of Discussion:
Initially, facilitators discussed basic definitions/descriptions of attentional processes as follows:

Attention was described as the process through which the mind chooses among various the stimuli striking the senses at any given moment. It was pointed out that we are constantly bombarded with more stimuli than we are able to process, and our attentional systems filter out the most salient information using bottom-up or top-down processes. Brief descriptions of orienting attention, selective attention, divided attention and automaticity were given.

A couple of examples of attentional studies were provided:
In one description, subjects engaged in a visual task where a visually presented arrow provided an anticipatory cue for the upcoming target location. Reaction time was faster for attended vs. unattended targets, suggesting that spatial attention facilitates visual processing.

A second example provided was of dichotic listening tasks, in which individuals have been shown to attend to auditory information coming into one ear, while ignoring additional information coming into the other (i.e., the well known "cocktail party effect").

The facilitators suggested that imaging techniques may be helpful in studying several different aspects of attention. For example, it may be helpful to use imaging to evaluate how individuals shift attention from one set of stimuli to another – i.e., is attention shifting done by enhancing a given target, or by suppressing distractors. Similarly, it may be helpful to use imaging to evaluate how we filter information, and where in the attentional process the filter is located. Imaging may contribute to evaluating how we select relevant targets, whether there is early or late selection, and may help us in evaluating between different types of attentional processes in use during various circumstances (i.e., endogenous vs. exogenous orienting, sustained attention vs. shifts in attention).

At this point in the presentation, there was a discussion among participants regarding at what point filtering occurs. Dr's Seitz and Shomstein discussed early filtering. Dr. Whyte brought in more recent discussions about flexible placement of filters in accordance with task demands. Dr. Shomstein made a point regarding the salience of the stimulus and the interaction of top-down and bottom-up processes and suggested that the goal of attention may shift if more salient information interrupts current processing, and that this could be either a bottom-up or top-down process.

Dr. Coslett indicated that attention has an effect on the BOLD signal, and that imaging studies are warranted to look at this further: He asserted that attentional processes augment/operate on the area(s) of the cortex most relevant to the requirements of any task presented to a subject (i.e., visual, motor etc.). As a result, the relevant cortices will show changes in activation depending on the interaction of the task demands and attention. In looking at the BOLD signal, it is difficult to define what is due to attention and what is not.

Group discussion focused on how difficult it is to define what is attention and what is not. Dr. Detre asked a question about whether there are good ways to control for attentional modulation in sensorimotor tasks (i.e., vary the nature of stimulus parameters in the study) and whether these things should be controlled? (i.e., reduced performance in a person who has never had an fMRI and is distracted by the environment – should you have “practice” for all subjects to control). Dr. Shomstein suggested that it is not possible to get rid of attentional issues, but that by varying vs. keeping attentional demands the same across tasks, it might be possible to control them or use as a covariate. Dr. Detre asserted that a problem is that a measure of attention is always an inference, and that the individual subject’s capacity for attention is also always a factor.

Some additional studies were presented as examples of the effects of attention on performance:

Baker and Sands showed performance differences when subjects completed a finger-tapping task while looking at their finger versus looking away. Similarly, John Bradshaw showed that where one allocates visual attention there is a huge effect on performance.***References?

Dr. Selzer asserted that multiple mechanisms of inattention could be likely: For example, inattention could be due to habituation over time (it is possible that in some instances, individuals my habituate too quickly, reducing attention). In some instances (i.e., individuals with hemiplegia), failure of input may be at play. Fatigue may also be a factor.

Dr. Seitz indicated that even when encouraging normal subjects to attend to electrical stimulation, the threshold had to be increased over time, suggesting that peripheral mechanisms may contribute significantly.

A question about how to differentiate between habituation and inattention was raised. Dr. Cosett asserted that attention occurs at all levels and that habituation could be considered a form of physiological inattention.

Dr. Sapir suggested that one limitation of attentional studies is that in the lab, we attempt to control external stimuli, however in the real world there are more stimuli that we need to suppress. Dr. Shomstein reported an example of a video study that tries to replicate the real world situation in the lab: When subjects were asked to focus on and count the number of times individuals in the video passed a ball back and forth, only 35% of subjects noted that a person dressed in a gorilla suit came into the picture while the ball was being passed. ***reference?

It was suggested that the way in which we process visual and auditory information may be allocated to different spatial locations in healthy individuals, and that deficits in spatial orienting in individuals with mild TBI could account for some attention issues found in this group.

The Posner task of visual attention was discussed.
Discussions regarding spatial orienting using exogenous (reflexive/bottom-up) versus endogenous (top-down) processes followed.
Dr. Mayer presented a study where subjects were presented with identical tasks in both visual and auditory formats. By instructing subjects to selectively attend to the visual or auditory stimuli (i.e., finger tap to visual input vs. tap to auditory), it was possible to look at differentiated activation patterns using neuroimaging. ***reference?
Others in the group suggested the possibility of using a numerical Stroop task, or using parametric manipulation of difficulty.

It was asserted that frontal/parietal areas are known to be involved in attention, working memory, and spatial attention. A question was asked about whether spatial working memory and spatial attention could be considered to be the same thing. It was suggested through the discussion that both utilize a similar scheme – holding something online to cognitively process information. Whether these processes are exactly the same was uncertain.

The discussion then returned to the question about attention versus habituation: It was suggested that habituation requires an initial presentation/attention to stimuli, and then habituation occurs, however inattention may not require the initial presentation. At this point, there was a discussion about how processes such as priming, gating, and other “unconscious” processes fit into the model of attention. It was decided that, from a patient standpoint, keeping the focus of discussion on the study of attentional processes that involve conscious awareness may be most beneficial for the purposes of this discussion.

The focus of the discussion moved to a discussion of patients with visual neglect, which usually occurs after a right hemispheric stroke. Neglect refers to the inattention to contralateral visual information. Additional symptoms of right hemispheric stroke often also include a lateral rightward bias, as well as deficits in arousal/vigilance and spatial working memory. A neuroimaging study was presented in which a group of 11 stroke patients were followed. The design of the study was as follows:***Reference?

Subjects were first seen at 3-4 weeks post stroke. At that time, they completed a neuropsych battery, a computerized battery (orienting, motor and vigilance tasks) and a Posner cueing paradigm in the fMRI scanner with an event related design. At approximately 39 weeks, these tasks were repeated and a high resolution anatomical scan was obtained.

Based on behavior– subjects recovered in terms of reaction time and ability to respond when an invalid target cue was presented.

FMRI results:
Acute neglect: results suggested that the whole brain shuts down: neuroimaging showed a lesion on the right, with very little activation, suggesting reduced whole brain activation. High activity was found in the left parietal cortex of acute patients.
Chronic neglect: neuroimaging results suggested activity levels were returning, even on the lesioned side.

Acute vs. Chronic voxel wise ANOVA results: higher activity at chronic versus acute stage. In the left superior parietal lobule, acute patients actually had hyperactivity as compared to chronic patients. Activity on the Left SPL was correlated with neglect severity. The BOLD % signal change increased positively with more severe neglect in the chronic phase. There was not enough power in this study to see correlations at the acute phases (not able to predict neglect at the chronic phase from acute BOLD change).
A suggestion was made about using voxelwise ANOVA versus regions of interest for study of these types of issues.

Participants brought up several potentially relevant studies and models: Nets and Turtain paper, Herald Model, Cabezza Model (uncertain of proper spellings and years for each of these).***Check names and provide references?

Dr. Coslett mentioned a 2006 study by Smith, Taylor, Bramme, Toon et al. in which individuals with ADHD compared to healthy controls.***Reference? Participants participated in a “go-no go task as well as a motor Stroop task with congruent and incongruent cues as well as an oddball task in which they were asked to do nothing. They were also presented with a “switch task”. Behavioral data was comparable. Neuroimaging data was similar for the go-no go task and Stroop (which were considered to be matched tasks), but were significantly different with a more complex task (the “Switch Task”). Findings indicated that seemingly similar tasks could produce significantly different neuroimaging results.

Synthesis/Recommendations:
Models and theories of attention were discussed, and behavioral and neuroimaging studies of attention were presented. Consistent with much of the discussion throughout the symposium, there was not always consensus on the theories and definitions of attention or on the best methods for studying the processes of attention. It was suggested that neuroimaging techniques may be helpful in differentiating between various attentional processes, however it was also asserted that attention is a difficult construct to define and study. It was asserted that control of attention is difficult to maintain in experimental design, and is often inferred, but difficult to measure as there is still much to learn in this area. Previous studies have indicated that attention does have an effect on task performance and on neuroimaging results. There is still much to be done in understanding the complexity of

cognitive processes, as well as in understanding the reliability and results gained through our use of neuroimaging tools. Additional complexity is added by studying patient as well as healthy populations. Overall, the discussion seemed to indicate that there are many challenges, but also great potential for learning more about attentional processes through the use of neuroimaging techniques.