

The Role of Selective Attention on Academic Foundations: A Cognitive Neuroscience Perspective

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This article reviews hypothesised links between selective attention and processing across three domains important to early academic skills.

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This article reviews hypothesised links between selective attention and processing across three domains important to early academic skills. First, a brief review of the neural bases of selective attention is presented. Second, the developmental time course of selective attention is examined. Third, the processes of selective attention are related to three domains important to academic foundations: language, literacy, and mathematics. Fourth, the possibility of training selective attention is discussed. Fifth, the application of these principles to educationally-focused attention-training programmes for children are examined.

- Academic achievement is determined by a variety of factors including educational opportunity, socio-economic status, social aptitudes, personality traits, and cognitive skills.
- The ability to focus on the current task and ignore distractions (referred to as selective attention) appears to have reverberating effects on several domains important to academic foundations, including language, literacy, and mathematics.

What is selective attention?

- The term selective attention refers to processes that allow an individual to select and focus on particular input for further processing while simultaneously suppressing irrelevant or distracting information.
- Competing information can occur both externally or internally.

Neural bases of selective attention

How does selective attention modulate information processing?

- According to the Hillyard Principle (for example Hillyard et al., 1987), responses should be compared to the same physical stimuli to assess the effects of selective attention, while holding overall arousal levels and task demands constant so that the only difference is the focus of selective attention.
- Several studies report attentional modulation throughout multiple cortical and even subcortical processing areas.
- Attention alters the selectivity of neurons in the hierarchy of visual areas.

Mechanisms by which selective attention is deployed

- Selective attention is guided and controlled by both

bottom-up signals and in a top-down fashion (for example, the intraparietal sulcus, frontal eye fields, and additional regions of the anterior frontal gyrus are important to the endogenous orienting of selective attention).

- While the effects of selective attention are most apparent in the cortical areas associated with the attended stimulus dimension, a fronto-parietal network is used across dimensions to deploy selective attention.

Neural mechanisms that actively manage competition from irrelevant stimuli

- Larger reaction time or differences in accuracy between compatible and incompatible conditions are an index of poorer attentional filtering ability. For example, the anterior cingulate cortex (ACC), thalamus, bilateral frontal regions, and portions of the fusiform gyrus are important. The ACC-frontal network is specifically engaged to manage response conflict.

Development of selective attention

- Many neural structures (including regions of the prefrontal and parietal cortex) demonstrate a protracted period of postnatal structural development lasting into at least the third decade of life. Thus, functional changes in selective attention may occur throughout childhood and adolescence.
- The ability to deploy and control selective attention continues to develop into early adulthood.
- The ability to select from competing stimuli and preferentially process more relevant information are available in very young children; however, the speed and efficiency of these behaviours improve as children develop.
- Selective attention can be recruited (even in young children) if sufficient cues are provided to direct

selective attention.

- Individual differences during development exist in the capacity to deploy selective attention and modulate early neural processing. For example, children from low socio-economic backgrounds are poorer in selective attention.
- The ability to dynamically reallocate attention as task demands change and the ability to handle response conflict may be processes that matures more slowly.

Selective attention and academic performance

Language processing

- When processing speech, listeners learn to identify and predict word initial segments and selectively direct attention to those points in time to aid processing.
- Deploying temporal selective attention strategically may allow the listener to select and amplify processing of the portions of the speech signal most critical for comprehension.
- Early enhancement of word-initial processing is a neural mechanism available to young children and thus is a candidate critical mechanism for parsing and processing the continuous speech stream.

Literacy

- Unlike language processing where auditory selective attention is directed to critical points in time, reading requires visual selective attention to be focused spatially.
- Over the course of literacy acquisition, the brain needs to adapt processing systems to support the fast, accurate identification of written symbol strings.
- The left extra-striate cortex, known as the visual word

form area (VWFA), is believed to respond preferentially during tasks that involve the automatic conversion of a visual to a linguistic form.

- There are developmental shifts in the lateralisation of the N170 (a component of event-related potential (ERP) that reflects the neural processing of faces, familial objects or words) to words during reading acquisition.
- Selective attention may be critical to the development of the VWFA, perhaps through the role of fronto-parietal attention networks, in shifting the focus of selective attention to different unit sizes (words, letters) during literacy acquisition.
- Deficits in selective attention occur among individuals with reading disorders.

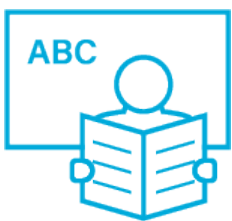
Mathematics

- Working memory skills are particularly important for dealing with word problems. This begins to highlight the interaction between working memory and selective attention.
- It is suggested that there is a link between attention and mathematics word problems skills that is mediated by the effect of selective attention on working memory.
- Selective attention—and distractor suppression in particular—is important for regulating access to working memory and optimising working memory capacity.
- The links between selective attention and mathematics performance are clearly more speculative than those linking selective attention with language and literacy.

How can selective attention be trained?

- Action game play is related to enhancements in various aspects of attention, including selective attention over space, time, or objects.
- Action gamers more efficiently suppress unattended, potentially distracting information.

- Meditation improves attention in a practice-related manner, with the act of meditation engaging neural systems that support selective attention.
- Meditation experience initially enables greater recruitment of attentional control systems as the attentional task becomes more effortful; however, as expertise develops with extra training, meditation expertise may enable a focused state of attentional control to be achieved automatically.
- After training (six weeks of high-intensity training with a computerised intervention programme designed to improve language skills), children demonstrated greater effects of selective attention on neural processing.
- Children receiving Early Reading Intervention (Simmons et al., 2007, 2003) in addition to the regular kindergarten curriculum demonstrated increased effects of selective attention on neural processing.
- Some interventions designed to improve language skills may also train selective attention.
- Interactive adaptive computer games increased children's attention and IQ.



Implications

- It is important to separately assess distractor suppression and signal enhancement. These two aspects of selective attention can operate independently, and each may have unique relationships with particular academic skills.
- Some children may need more cues to support their

selective attention capability. This may involve limiting distractors or presenting more opportunity for orientation so that a child is prepared to deal with distractions.

- Attention skills can be enhanced and distractor suppression may be especially modifiable.
- In a classroom context, there may be significant benefits in incorporating attention-training activities into the school context.
- To the extent that training and support for selective attention is valued, it may be leveraged as a force-multiplier across domains.