Review Article

The Attentional Blink and ADHD: A New Interpretation

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Abstract

Objective: The phenomenon of attentional blink (AB) has been explained with the help of different theories based on empirical work. AB refers to period of impairment in rapid presentation of stimuli where the participants are unable to identify a target. This period follows the identification of the first target in the presentation stream and lasts for 400-600 milliseconds. The AB theories do not seem to work well when it comes to explaining the deficits which the Attention Deficit Hyperactivity Disorder (ADHD) population, show on the AB task. The use of the AB paradigm with the ADHD population can shed light on the nature of problems, which this group has and thus would be useful for the purpose of rehabilitation. Data Selection: What follows is a review of work done with ADHD and the theories of AB. Data Synthesis: The review suggests that the underlying problems in the disorder might be faulty top-down control of attention rather than a shortage of attentional capacity. In addition, the brain areas implicated in the problem are also discussed. Conclusions: A new cognitive model which includes both top-down and bottom up processes that better accounts for the deficits in the disorder is also suggested. The framework of the model gives a new perspective to understand the deficits and interventions for ADHDs (German J Psychiatry 2007;10: 122-125).

Keywords: ADHD; attention blink; to-down control

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Introduction

The attentional blink (AB) paradigm is a phenomenon in which stimuli are presented in a rapid serial order at the same location. In a typical AB study, stimuli may be presented at a rate of 10 items per second; and the observers are required to detect or discriminate 2 targets on each trial. This paradigm is described as the rapid serial visual presentation (RSVP). For example, the target may be a colored letter in a list of white letters and the probe may be a letter from a predefined set. The 2 targets are called T1 and T2, and the lag between them is varied randomly across trials. The correct detection of T1 is followed by a period of time during which the observers frequently fail to detect T2, and this period of impaired T2 detection is called ‘attentional blink’. Specifically, T2 detection accuracy drops to its lowest point at a T1-T2 lag of 3 items and then recovers by a lag of 6-8 items. Much of the recent interest in time-based attention derives from a phenomenon that was independently discovered by Broadbent and Broadbent (1987) and by Sperling and colleagues and was named ‘attentional blink’ by Raymond, Shapiro and Arnell (1992).

AB Theories

The different views of how the AB is generated are of three classes: perceptual, memorial, and retrieval. All invoke at least two stages of processing and assume that the first stage
is able to keep pace with the rapid series of stimuli used in
the AB paradigm. A second, higher-order stage of processing
is assumed to be slower than the stimulus series and limited
in capacity, leading to the AB. The theories differ in how
much processing is seen as being completed at each stage.

The perceptual theories, posit that the AB is a consequence
of binding problems experienced when T1 is too closely
followed by another stimulus (Raymond et al., 1992).

A memorial basis for the AB was first proposed by Chun
and Potter (1995), who suggested that every item in the
RSVP stream is raised to a conceptual level and that the AB
is caused by an extremely limited-capacity mechanism that is
needed to make the representation durable, enabling report.
Thus, time and resources are required to consolidate in vis-
ual short-term memory (VSTM) a representation of the first
target. When resources are committed to this process, few
resources are available to encode the probe into VSTM.
They proposed that until this late-stage mechanism has fin-
ished processing T1, T2 cannot be consolidated sufficiently
to enable report. A third explanation for the AB is that it
results from interference in selecting items for report from
VSTM (Raymond, Shapiro, & Arnell, 1995). In this account,
T1 and T2 plus the item following each target enter VSTM
via a template-matching process and compete for report.
A recent explanation for AB has been given by Raymond
(2003), according to this explanation AB reflects a process-
ing bottleneck in perceptual processes required specifically
to create durable new object representations for T2 when it
appears very close to T1.

The blink phenomenon requires attention and hence dys-
function of attention should exacerbate the AB. The AB
paradigm has been used to study attentional capacities in
ADHD children. ADHDs display developmentally inappropriate levels of distractibility, impulsivity,
sustained attention and difficulties focusing on activities
such as school-work (Diagnostic and Statistical Manual-4,
American Psychological Association, 1994). Several studies
have been conducted using AB in ADHD and normal popu-
lation of different age groups with conflicting results.

**AB in Children**

A recent study by Mason et al. (2005) employed ADHD and
normal children aged 8 years 9 months and 14 years 5
months. Eighteen (86%) were male and three (14%) were
female. Of these, 16 (76%) were combined type, 1 (5%) was
inattentive subtype and 4 (19%) were hyperactive-impulsive
subtype. ADHD analyses were repeated with subtype as a
between-subjects factor. There was no main effect of sub-
type and this did not interact with any other variable. In
terms of comorbidity, 9 (42%) were comorbid for opposi-
tional defiant disorder and 2 (9%) were comorbid for con-
duct disorder (removal of these children’s data did not affect
the results). The results showed no major differences in the
duration of attentional blink between the groups. The rate of
recovery from the attentional blink effect was the same in
the ADHD and control children. This in turn suggests that
the overall mechanisms of selection are intact in the ADHD
group relative to controls. This account is consistent with
prior reports in the literature. Several previous studies have
indicated that selective attention in ADHD children is un-
impaired (Karatekin & Asarow, 1998; Hazell et al., 1999),
including the ability to use time to select visual stimuli (Ma-
sen et al., 2003). Nevertheless, the ADHD children did show
a larger attentional blink effect overall, relative to the control
children. The explanation advanced for this result by the
authors is the memorial basis for AB given by Chun and
Potter (1995). The authors state that ADHD children may
require more resources than controls to consolidate the
target into VSTM, leading to a greater overall attentional
blink. However, the reallocation of resources to the probe,
as the target is consolidated over time, operates normally
hence the ‘blink’ recovers at the same rate.

The question, which arises over here, is why do ADHD
children require more resources than normal children? Ei-
ther they lack the required resources or they lack the re-
quired capacity to allocate these resources properly among
tasks. This is answered by a study done by Schacher and
Logan (1990), which employed a dual task to study three
groups of 6-12 years old boys; ADHD, ADHD plus conduct
disorder and normal children. Their study used a primary
choice reaction time task under two conditions: one with and
one without a secondary task that also required a response.
In the condition that included a secondary task, there were
several time delays between primary and secondary task
stimuli that influenced their overlap. The assumption was
that more capacity would be required with increasing over-
lap. The hypothesis was that if ADHD subjects are deficient
in attentional capacity, when compared with normal con-
trols, their reaction times (RTs) to the secondary stimuli
would increase more with increasing temporal overlaps of
the primary and secondary task stimuli. This hypothesis
was not supported by the data. The RTs of ADHD subjects on
the primary task increased more after the introduction of the
secondary task than did those for normal controls; this find-
ing was an indication of a different allocation policy (faulty
top-down control of attention) but there was no capacity
shortage because the increase in primary task RT after intro-
duction of the secondary task was not influenced by the
overlap of primary and secondary task stimuli.

**AB in Adults**

A study conducted by Armstrong and Munoz (2003) em-
ployed non-medicated 15 ADHD male adults (mean age +
SD: 29±12 years) and 15 age and sex matched controls
(33±10 years) and measured accuracy and gaze stability
during the AB task. ADHD participants reported fewer
targets and probes, showed no major differences in the dura-
ton of attentional blink from the controls; but they did show
a larger attentional blink effect overall relative to the control,
made more eye movements and made identification errors
consistent with non-perception of the letter list. In contrast,
errors made by control participants were consistent with
guessing (report of a letter immediately preceding or follow-
ing the correct letter). Two reasons were advanced for this result: a) ADHD participants were not vigilant; a common diagnostic indicator of ADHD is poor performance on vigilance task (Barkley, 1990); b) inefficient gaze control. They cannot fixate a location for long time periods; they shift their gaze away from the list of letters during its presentation and therefore do not perceive and cannot identify targets or probes. In this account, resource consistency and allocation are not an issue and resources may be applied appropriately.

In their study excessive eye movements resulted in poorer performance for all participants. The question which arises over here is if resource consistency and allocation are not an issue in adults with ADHD then does the capacity to allocate attention improves with age in ADHD population? The answer to this question lies in a paper by Munoz et al (2000) in which they state that “planning of volitional saccades and suppression of reflexive saccades is under the control of frontal cortex and basal ganglia, which also project to the superior colliculus and brain stem premotor circuit.” The dorsolateral prefrontal cortex (DLPFC) and substantia nigra send control signals to frontal eye fields (FEF) and superior colliculus for saccadic suppression. Neurons in both of these structures are modulated by voluntary tasks; does this not hint at the primary problem being that of faulty top down control of attention. The best way to tackle this problem would be to do a dual task with ADHD adults as performed Schacher and Logan (1990) along with an AB task with eye movement monitoring and then see how much the performance on one task correlates with that on the other task.

**AB Models Explaining the Performance of ADHD**

The above-mentioned AB models are not enough to explain the performance of ADHD population. A new model, which would very well explain the results obtained, is a model by Nelson and Narens (1990) which has 2 interrelated levels:

a) Meta level

b) Object level

The meta level contains a cognitive model of the object level and provides top down control (cognitive control) to the object level. The top down processes includes conflict resolution, error correction, inhibitory control, planning and resource allocation. The meta level is continuously updated by bottom up information from the object level (cognitive monitoring), this level includes bottom up processes like error detection, source monitoring in memory retrieval.

In AB the problem occurs when the ADHD participants have to exercise top down control over the RSVP stream looking for T2, where they are unable to allocate resources properly between T1 and T2. The ADHD subjects devote more resources (identification and consolidation) to T1 and hence their performance does not suffer when the RSVP stream contains only T1 but the accuracy to report T2 goes down when it is included in the stream.

The model proposed holds implications for the already mentioned models of AB. If the performance of ADHD is explained by the model of Chun and Potter then ADHD subjects inefficiently employ more resources for the consolidation of T1 in a durable form as compared to normal participants of the same age, so that it is reported but fewer resources are employed for consolidation of T2. The explanation of AB in terms of interference in selecting items for report from VSTM can also be explained in reference to the new model. According to the Nelson & Narens model, the ADHD children will have problems in reporting T2 as there will be more interference for this item. The ADHD population might allocate the available resources to all the items in the VSTM and thus would be unable to devote proper resources for the report of T2. The model proposed by Raymond (2003) can also be understood in reference to the new model. In her model, AB reflects a processing bottleneck in perceptual processes required in the creation of new object representations. The new model would propose that ADHD subjects seem unable to create a durable object representation of T2 as more resources are devoted for the creation of a durable object representation of T1.

**Conclusion**

The review shows that it is necessary to employ different methods of investigation to have more knowledge about the nature of top-down control in ADHD and this knowledge might eventually lead to a comprehensive theory or model which explains the nature of deficits in ADHD or to help build on the existing model like that of Nelson and Narens. This kind of work would be helpful for the rehabilitation of the group with the right kind of methods.

**References**


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