# Attentional Blink Differences in Dyslexia from Children to Adult: A Meta-Review

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**Abstract:** *People with dyslexia show time delay in attention transition, which has been widely concerned by researchers in the past decade. An attentional blink is an ideal tool for studying how visual attention allocates resources during reading, but there are differences between the results. This study used meta-analysis to find significant differences in an attentional blink between people with dyslexia and regular reading groups. Children with dyslexia may significant difference between the study, suggest that dyslexic persons who may have developmental and structural defects coexist; a correlation between attentional blink with some reading ability, suggest attentional blink detachment may be predictive; at the same time, it said that the start time of stimulation flow is significantly correlated with the attention of individual attention. The longer the start-up time, the lower the transient release effect, suggesting that this distribution mechanism can be further concerned in the future.*

**Keywords:** Dyslexia, Rapid Serial Visual Presentation Stimulus, Attentional Blink, Meta-Review

## 1. Introduction

Reading ability is one of the most important skills in modern society, from picture books to reading stories to social news browsing, we need to understand written material. However, dyslexia may have occurred when individual reading scores were far below the expectations of individual age, intelligence testing, and age-appropriate education [1]. Many factors may be associated with dyslexia, and these factors can be divided into two categories, one is pure language difficulties, the most important reason is defective speech processing; the second category includes dealing with delicate perception, which contains the time processing deficit [2]. These factors may occur simultaneously or independently of the individual.

Temporal processing is defined as any processing in any two or/and a plurality of stimulation sequence presented [3]. Farmer and Klein (1995) illustrate this definition by dividing time processing into three components: stimuli individualization, chronological judgment, and sequence identification [4]. When Broadbent (1987) in rapid serial visual presentation experiments, it was found were asked to identify a target stimulus, subjects can be correctly reported, but if the first target stimulus (T1) after the second exhibit a concise period of time target stimuli (T2), then the test is to identify the second target (T2｜T1) capacity decreases [5]. Raymond, Shair, and Arnell (1992) named this phenomenon as Attentional Blink (hereinafter referred to as AB), then to this, many studies have explored using single time processing capability AB paradigm [6].

The relationship between Blink and dyslexia is first by Hari, Valta, and Uutela (1999)inspection, they compare the characteristic AB in adults with dyslexia and persons of regular reading, found that although both groups exhibited a strong AB, but the AB of the dyslexia group was significantly longer than the control group (700 ms vs. 540 ms) [7]. They believe that visual recognition stimulation in adults with dyslexia takes longer. Although there are some studies later confirmed the study of Hari [8] [9] [10] [11], there are also some studies that do not get consistent conclusions [12] [13] [14]. For Lacroxi (2005), who found that dyslexic adolescents show AB lighter than average readers [12]. According to the study by Badcock (2008), they found that if only focus on the accuracy of target discrimination, the dyslexia patients attentional blink amplitude was significantly longer than that of the control group, but if the AB para-metrically fitted, AB differences are not significant between the dyslexia patient and the regular reader [13].

The concern about AB phenomenon in patients with dyslexia is due to that some researchers believe that the clinical manifestations of patients with dyslexia, such as poor speech decoding skills, backward word recognition, are all connected with the cascade effect of low-level cognitive processing abilities [15]. The insufficient due to individual perception or cognition, thus hindering long time phonemes and shape characterization of memory [16], AB research can help to investigate the processing mechanism. On the other hand, AB mode provides for the allocation of attention mechanism to check an ideal tool, imaging and electrophysiological studies show that AB information processing bottleneck phenomenon is not revealed by the visual cortex, but mainly in the previous In the frontal-parietal region network involving visual-spatial attention [17] and these regions are closely related to language processing ability, the study of AB characteristics may help to reveal some language processing characteristics of patients with dyslexia.

Therefore, this study aimed to a uses meta-analysis of behavioral studies from the period 1999-2017 dyslexia with AB phenomena were analyzed to explore the causes of dyslexia patients was significantly longer in the AB feature of the phenomenon and attempt between explaining group differences origin.

## 2. Method

### 2.1 Inclusion criteria

We use the following inclusion criteria for research selection: 1) The experimental report of the AB phenomenon needs to include comparison of dyslexia with the average reader; 2) the dual-target task in the document that needs to identify and/or detect the two targets ; 3) the use of visual stimuli .4) Using English as the writing language.

### 2.2 Experiment selection

This study searched from 1995 to December 30, 2018, published updated data was January 31, 2019. Using "Attentional blink" and "reading disability or dyslexia" as keywords, get 16 English reports from the Web of Science database. We returned the same data from PubMed and PsycInfo using the same search criteria. According to the inclusion criteria, repeated deletions, and review of titles, abstracts, and full texts, the final ten articles in the study meet all the criteria for inclusion in the study, one of which is a reanalysis of the original study, so exclude one of the study analysis. McLean et al. have two research reports from 2010 to 2011 [14] [18]. We reviewed the two reports and found that the 2011 report was an extension of 2010, doubling the sample size. So we chose the 2011 report excludes 2010 one, this review of study eventually enter the case as shown in Table 1 [19], where Visser (2004) and Buchholz et al. (2007) are used in two AB related experiments.

**Table 1:** Basic information of the studies

| Authors (Years) | Exp. | Average age | | Pre-RSVP | Targetstimulation/ Interference stimulus | SOA | T1 Time Difference | T2 Time Difference | RSVP Time | Total Item | Task No. | T2\|T1 Accuracy | | Group Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Dyslexia | Control | | | | | | | | | Dyslexia | Control | |
| Hari et al. （1999） | 1 | 33.6 | 29.7 | 0 | White Letter/Black Letter | 106.5 | 958.5 | 1171.5 | 958.5 | 25 | 3 | 63.75 | 74.08 | -0.39 |
| Visser et al. （2004） | 1 | 12.7 | 12.9 | Key Press | Shape / Spot | 100 | 300 | 1300 | 1600 | 6 | 0 | 85.15 | 87.6 | -1.00 |
| Visser et al. （2004） | 2 | 12.7 | 12.9 | Key Press | Shape / Spot | 100 | 300 | 1300 | 1600 | 6 | 1 | 78.66 | 85.13 | -1.32 |
| Lacroix et al. （2005） | 1 | teenager | teenager | 1000 | Red Number/White Number | 100 | 400 | 700 | 0 | 10 | 1 | 55.12 | 42.53 | 1.10 |
| Buchholz et al. （2007） | 1 | 34.40 | 31.18 | 1000 | Red Number/White Number | 100 | 400 | 600 | 0 | 17 | 0 | 71.53 | 85.79 | -0.81 |
| Buchholz et al. （2007） | 2 | 34.40 | 31.18 | 1000 | Red Letter/Black Letter | 100 | 400 | 600 | 0 | 9 | 1 | 87.35 | 94.85 | -1.47 |
| Badcock et al. （2008） | 1 | 40.83 | 40.42 | 500 | T1White Letter, T2 Black Letter/Black Letter | 100 | 900 | 1100 | 1600 | 20 | 3 | 55.51 | 67.86 | -0.67 |
| Facoetti et al. （2008） | 1 | 12.5 | 11.83 | 600 | Letter / Number 8 | 100 | 125 | 900 | 925 | 9 | 0 | 68.00 | 79.00 | -1.33 |
| Lallier et al. （2011） | 1 | 11.28 | 10.7 | 600 | T1 Red Number, T2Black 0/Black other numbers | 116 | 928 | 696 | 928 | 12 | 3 | 74.46 | 82.61 | -1.27 |
| McLean et al. （2011） | 1 | 9.5 | 9.6 | 500 | Image/ No-rules image | 106.6 | 424 | 639.6 | 1492.4 | 11 | 1 | 71.54 | 78.68 | -1.29 |
| Laasonen et al. （2012） | 1 | 36.11 | 37.51 | Key Press | T1 White Letter, T2Black X/Black Letter | 133.3 | 1066.4 | 1333 | 3065.9 | 25 | 3 | 70.31 | 76.98 | -0.49 |
| Barry et al. （2015） | 1 | 10.37 | 10.66 | 1000 | Letter /Number | 110 | 330 | 660 | 1550 | 12 | 2 | 61.87 | 69.84 | -0.72 |

### 2.3 Statistical methods

We calculated Cohen's d values using the mean and standard deviation of the two sets (process and control). If the mean and standard deviation were not reported in the study, we used WebPlotDigitize to estimate the data in the published data [20]. In addition to differences between groups, we also compiled the following documents for all relevant variables: age, time in advance RSVP (RSVP in advance if there is no time, indicate the method); target stimulus/interference stimulus presentation content; Stimulus onset asynchrony (SOA); T1-T2 time difference; total target in the stimulus flow and task complexity. Table 1 shows the characteristics of all included studies. Review Manager 5.3 using the amount of effect of each experiment were compared.

## 3. AB studies of people with dyslexia

### 3.1 Group differences AB in dyslexia and typical readers

Between groups of 10 articles into a Discussion of 12 studies of experimental results difference, using for

Review Manager, 5.3 Meta be analyzed to obtain the results shown in Figure 1. An overall difference of -0.82, p = 0.0001, indicating that 12 experiments, dyslexia's T2 | T1 accuracy is more reduced, take longer response time.
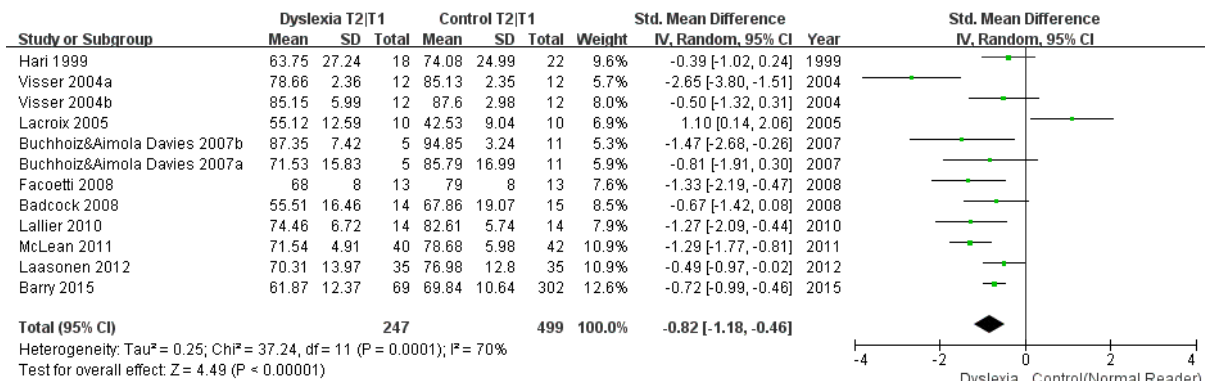


**Figure 1:** Forest plot of the group difference in overall T2|T1 accuracy by experiments. T2|T1 denotes T2 accuracy calculated for those trials in which T1 was correctly reported.

As the research study, only Lacroix's study, who showed no significant differences between dyslexic and normal readers groups, so first removed Larcoix's study, the test for heterogeneity, the results shown in Figure 2. Q (10) = 21.93, P = 0.02 . The main study showed that variation is due to Lacroix's study. Therefore, the overall AB characteristics of patients with dyslexia are significantly lower than those of the normal reading population. The inconsistent findings of Lacroix's, there may be too little because of the number of test problems (10 people in the control group). In general, a person with dyslexia takes longer to switch to attention. Studies from electrophysiology have shown that attention selection occurs after the target evokes early perception and semantic characterization [21]. So studies suggested that it is because of this delay in conversion that patients with dyslexia are more likely to lose textual information as to this loss. The neural mechanism remains to be further studied.
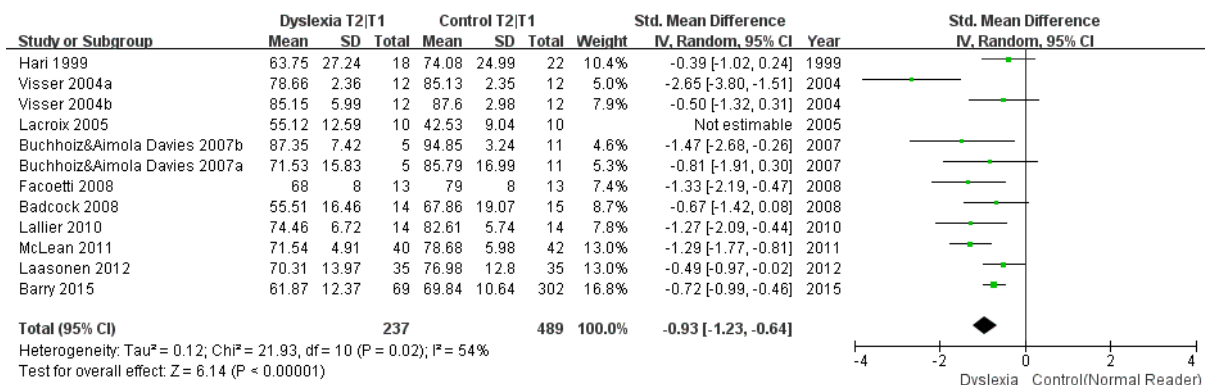


**Figure 2:** heterogeneity test chart (Without Larcoix's study), Q (10) = 21.93, P = 0.02.

## 3.2A comparative study between AB features different ages dyslexia

Excluded Lacroix's experiment from the studies, the remaining ten experiments had four experiments is for adults, while the other six experiments are targeting children. Our 18-year-old age limit, the actual on seven experiments targeting children, the average age of no more than 13 years, the adult group were divided into two groups and subgroups of children, and heterogeneity analysis results are shown in Figure 3. The results showed no significant difference between the adult group and the child group, Q (1) =1.29, p =0.28. However, interestingly, in the children's subgroup, we found that there was a significant difference in heterogeneity between experiments, Q (5) = 18.85, p = 0.002. Tory Visser (2004)studies, age-matched control group in addition to the group, also selected from a group reading capability matching group, the matching group while reading younger than dyslexia groups found Dyslexia group AB and Reading matched set There is no significant difference in characteristics, and the AB characteristics of patients with dyslexia may be a manifestation of stunting. Compared to adult persons with print disabilities AB about 700ms remission, dyslexic children need about remission nearly 1400ms, so Tory Visser thought that reading disorders AB more significant phenomenon might be due to developmental effects, rather than base the impact of limited cognitive processing capabilities. Donnadieu (2015) and other studies in children with ADHD found that the average age of AB phenomenon in children with ADHD group of 11-year-old was significantly higher than age-matched group, but the performance characteristics of children group with eight years of age usually no significant difference, tip AB significant phenomenon in specific populations may be due to developmental delay,

cognitive function rather than structural defects [22]. However, due to the current lack of research on the age-

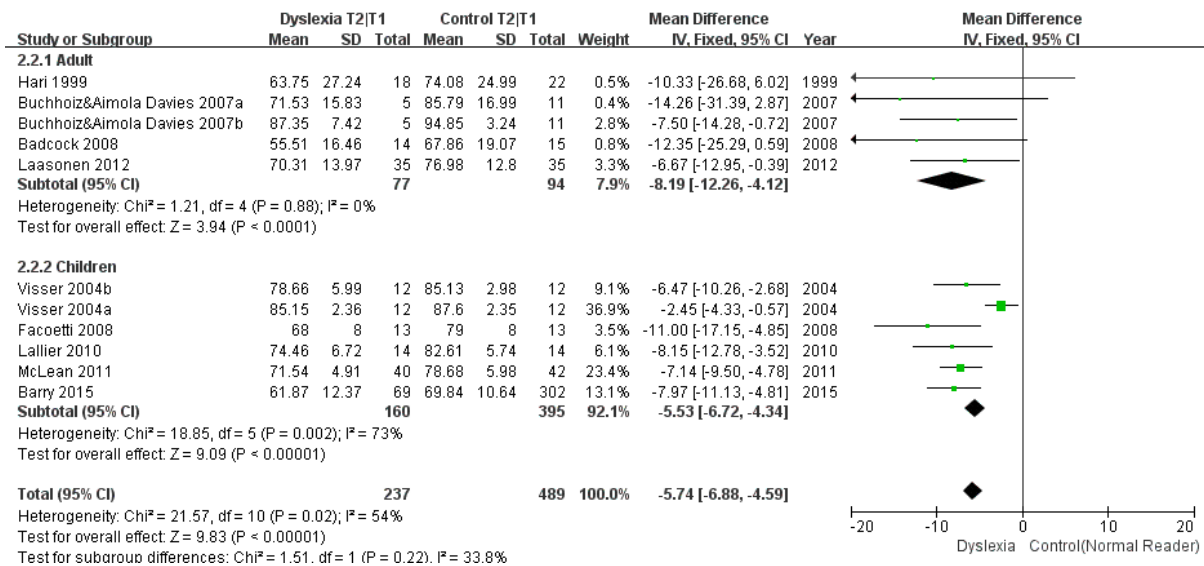related aspects of patients with dyslexia, this conclusion remains to be demonstrated.



**Figure 3:** Forest Map of subgroup analysis results

## 3.3 Correlation between reading characteristics and AB in patients with dyslexia

Dyslexia is a complicated learning difficulty. Aaron (1991) and others suggest that individuals with dyslexia may have different sub-types, such as simple decoding disabilities, simple language understanding disorders, and mixed dyslexia [23]. No studies on the temporary AB individual characteristics of different sub-types of reports in the study currently adopted in the present study. However, some studies have found that AB is associated with rapid naming ability and phoneme awareness [24] [25] [26]. Although the fast naming task is more dependent on visual stimuli, and the typical phoneme conscious task is more dependent on the voice speech signal, they are very different. For this reason, Hari (2001) thinks that the AB phenomenon of patients with dyslexia is a slow shift of attention called sluggish attention shifting (SAS) defects, and believe that the nature of rapid stimulation sequences is rhythmic, and theoretically, it is possible to observe the sensory channel difficulties of rapid continuous processing tasks [27]. Visser and Ohan (2012) provide another possible explanation, and they believe that faster and faster naming capabilities leave additional resources for subsequent tasks [28]. However, some studies suggest that phonemic awareness and rapid naming ability are not the same; the correlation between phonemic awareness and AB task for being part of working memory and a conventional interpretation. Besides, Cao Hongwen (2014) and others studied the phenomenon of the attention of ordinary Chinese readers and found that the relationship between Chinese characters in terms of vocabulary, semantics, morphology, and speech will affect the AB effect of individuals [29]. As for how the AB interacts with the reading ability of patients with dyslexia, further research is needed.

## 4. The influence of the AB paradigm on research differences in patients with dyslexia

Although the overall performance of patients with dyslexia was lower than that of the average reader group, the effect of the difference between groups was observed. However, since the discovery of the AB phenomenon, the AB paradigm has also been deduced. Many variables in the paradigm affect the individual's recognition of the target. These variables also affect the performance of patients with dyslexia.

### 4.1 Target influence the content of the presentation characteristics of patients with dyslexia AB

AB was first discovered by Broadbent (1987), the experimental study of T1, T2 of the target using the letters, while the presence of the interference term stimulus color differences. When Hari (1999)and other reading disabilities AB adult characteristics studied, it is also used letters. However, after some scholars suspect that dyslexia themselves is impaired language functions', using a letter signal, the difference is not caused by the delay due to the attention mechanism, or due to language-specific functionality. Subsequent Vierss et al. (2004) studied, using graphics, also the same conclusion. However, Lacroix (2005), by setting targets, were red numerical targets, interference incentives for black digital experiments, found that developmental reading right overall performance disorders in children (under 15 years), and no significant difference with the ordinary reader.

Moreover, Study Buchholz and Aimola Davies (2007), and in adults, using the same paradigm also found significant differences. Researchers believe that reducing the two-goal accuracy of reading disorders may be treated with a goal difference of depth of development to explain, probably because it than other types of identification, such as

graphics, such as letters, numbers, identifying the required resources may be less attention Some. Therefore, in order to explore the consistency between the conclusions of the study, a standardized approach to the paradigm adopted by the study may be more helpful in understanding the attention allocation mechanisms of different groups.

## 4.2 The effect of stimulation sequence initiation on AB characteristics in patients with dyslexia

All published papers, the description of the experimental stimuli are flow sequence start time (P re -RSVP). In the study of Backdoc (2015), this mode of initiation was significantly associated with the AB effect of individuals [30]. Researchers believe Pre-RSVP longer the time, the higher the accuracy of the differences between groups. Nobre, Correa, and Coull (2007) pointed out that when attention is focused on a specific point in time, the decision on the target is more accurate [31]. Visser (2014)found a similar situation, i.e., before time T1 appeared were individually adjusted to reduce the effects of individual AB [32]; In addition to this, multiple experiments AB practice, the time will increase the desired target position. References cited in this study there are three laboratories keypad control means controlled by the subjects themselves stimulation start time-series stream, the additional request is again looking at the computer screen at a computer screen, 0, 500, 600, or The stimulation sequence is automatically started after 1000ms. Different start-up mode is also thought to be a source not get the same result of differences between different studies, in view of this, in advance RSVP time has important implications for the individual is ready to perform the task. However, exciting, the research also indicates that dyslexia patients can learn a long time, reduce the AB effect, and improve the status of the time delay.

## 5. Summary

Survey of the researches of the past nearly 19 years, found that the magnitude of AB dyslexia group was significantly longer than the control group, their visual identification stimulus takes longer; correlation study between AB and reading ability was found, indicating that there is AB Maybe an indicator of the occurrence of predictive dyslexia. However, the attention detachment characteristics of patients with dyslexia still need further study, including: (1) Is the AB phenomenon in patients with dyslexia a developmental delay or a structural cognitive deficit? Suggestions can be verified through a comprehensive understanding of the relationship between the different ages of reading disorder and AB. (2) experimental stimuli flow between (P re -RSVP) when the start sequence was significantly associated with AB individual phenomenon, but also indicates that dyslexia patients can learn a long time, reduce the AB effect, but if you can improve individual Read Capacity should be demonstrated through relevant research. (3) the most current research paradigm major problem is different, and no uniform standard is not conducive to the operation of personal recommendations if at 1992 Raymond, who unified the standard paradigm of research experiments, may be more conducive to different research Comparison

and analysis. (4) At the same time, due to the different subtypes of dyslexia, the future can analyze the relationship between different sub-types and AB, but also help to understand the correlation between AB and to read ability for dyslexia early intervention and intervention Provide evidence and strategy. (5) At present, there is no research on the attention of patients with dyslexia in China. There is only one study of the attention of students with learning difficulties, and relevant research needs to be carried out as soon as possible.

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