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Inattentional blindness to unexpected events in 8–15-year-olds

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ABSTRACT

If attention is diverted to a specific attention-demanding task, observers often fail to notice an unexpected event even if it is directly fixated, a phenomenon known as inattentional blindness (IB). To investigate the developmental course of this phenomenon, an IB task based on one used by Simons and Chabris (1999, *Perception*, *28*, 1059–1074) was presented to 480 children between the ages 8 and 15. This task tested the ability to perceive an unexpected object while performing a counting task. Older children were more likely to perceive the unexpected event than were younger children, and they almost reached adult performance levels at the age of 11. Children from 8 to 10 years display significantly higher IB levels, suggesting that this age group has lower attention resources to detect unexpected objects than do adolescents or adults. These developmental trends in IB have important implications for parents, educators, and government policy makers with respect to critical practical issues such as traffic safety.

Two children chat and laugh with each other while walking down the sidewalk. As they begin to cross the street, a car suddenly brakes so sharply that the car behind hits it. Both children claim they had looked in both directions. If they are telling the truth, the cause of the children's failure to see the car must lie elsewhere. One possibility is inattentional blindness (IB; Mack & Rock, 1998). If attention is diverted to a specific object, observers may fail to notice any other unexpected object, even if it is

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directly in front of them and visually fixated by the observer (Most, Scholl, Clifford, & Simons, 2005). Although identified in older adults (Graham & Burke, 2011), IB has not been examined systematically in children and adolescents. This is somewhat surprising, given the number of children who die in traffic accidents every year (Beck, Dellinger, & O'Neil, 2007). Road traffic injuries are the leading cause of death in children and youth (Sonkin, Edwards, Roberts, & Green, 2006). Attention is a key factor in road traffic injuries (Kareem, 2003).

The development of attention in children and adolescents has been studied extensively (Plude, Enns, & Brodeur, 1994; Ruff & Lawson, 1990). Age comparisons of performance in different attention tasks (e.g., alerting, shifting, or encoding) have shown improvement in children between the ages of 8 and 13 (Rebok et al., 1997). Mirsky (1996) even speculated that different attentional sub-processes are supported by the development of different kinds of neuroanatomical structures. IB differs from traditional attention dimensions such as attentional breadth (Goode et al., 1998) or sustained attention (Pylyshyn & Storm, 1988) and therefore warrants investigation as a distinct attentional phenomenon (Memmert, Simons, & Grimme, 2009).

Noticing an unexpected object in an IB task is observed in the prefrontal cortex (Thakral, 2011), a region associated with conscious processes (Baars, 2003; Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006). The causal mechanisms involved in IB remain uncertain, with both bottom-up (Most et al., 2005) and top-down mechanisms (Memmert, 2006) discussed. Attentional set figures most prominently in top-down accounts, as enhancing the probability of perceiving unexpected objects (White & Aimola Davies, 2008). It is not certain how many basic cognitive mechanisms are implicated in IB (Memmert & Furley, 2010; Most, 2010; Moran & Brady, 2010), but working memory (Fougnie & Marois, 2007; Todd, Fougnie, & Marois, 2005) and perceptual load (Cartwright-Finch & Lavie, 2007) seem to be closely correlated to the IB detection rates, suggesting that IB can be caused by central information processing limitations. Graham and Burke (2011) found that IB is more pronounced in older adults, supporting this possibility.

In change blindness (Simons & Levin, 1997), a phenomenon like attentional blindnesss, children have difficulty detecting significant changes in visual scenes when these occur during a visual disruption (Fletcher-Watson, Collis, Findlay, & Leekam, 2009). Shore, Burack, Miller, Joseph, and Enns (2006) found age-related improvement in a change-blindness task from age 6 to young adulthood. The authors speculated that the immature attentional system of children may be particularly susceptible to difficulty in detecting major changes in scenes.

No systematic developmental investigation of the IB phenomenon exists that includes different age groups in a single study. Only four studies have included children or adolescents. Neisser and Rooney (reported in Neisser, 1979) found that younger children showed more IB than older ones. Preliminary evidence by Memmert (2006) also indicated that IB is more pronounced in younger children using the Simons and Chabris (1999) opaque IB task in which a person wears a gorilla costume. Eight-year-olds did not perceive the unexpected gorilla at all (0% noticing); 13-year-olds had a detection rate of 35%. In another study by Memmert (2009) using a computer-based IB task (Most, Simons, Scholl, & Chabris, 2000a; Most et al., 2000b), participants had to count the number of times that a set of four moving white L and T shapes touched a horizontal line in the middle of the screen, ignoring the four moving black L and T shapes. After five seconds of a critical trial, a light grey cross unexpectedly entered the screen from the right, moving horizontally on a linear path 2.4 cm above fixation. Eighty percent of 7-year-olds perceived the unexpected cross. It is difficult to compare results (0 to 80% detection rate) given the multiple factors that may contribute to variation—for example, the video (opaque vs. transparent vs. computer based), nature of the unexpected object (umbrella-woman vs. gorilla costume vs. cross), duration of the unexpected object (6 to 9 s), or level of attention needed in the primary task (watching/counting players in white vs. black).

In sum, IB has not been studied systematically from a developmental perspective, and therefore it remains unclear to what extent IB exists as a function of age. The aim of the present investigation is to address this question. According to previous developmental attention research (e.g., Rebok et al., 1997; Ruff & Lawson, 1990; Shore, Burack, Miller, Joseph, & Enns, 2006) and to the IB findings involving children discussed above (Memmert, 2006; Neisser, 1979), we hypothesize that IB is more pronounced in children than in adolescents or adults and that the ability to perceive unexpected objects will improve with age. Evidence of children's greater distractibility compared to adolescents or adults (Kannass, Colombo, & Wyss, 2010; Wetzel & Schröger, 2007) is consistent with such a hypothesis.

1. Method

1.1. Participants

Four hundred and eighty children participated in the experiment (235 females). Participants were between the ages of 8 and 15 (mean age 143 months, SD = 28 months, range 98–192 months), with 60 of each age and approximately evenly divided by gender at each age. Because of the expertise effect regarding IB found by Memmert (2006), we assessed sports experience of participants. One hundred forty-five children had practiced in team sports (e.g., basketball), 153 in individual sports (e.g., swimming), and 81 in a mixture of team and individual sports, while others had no specific experience in team or racket sports at all ($n = 101$). With several classes being examined at the same time, we made sure that no communication was possible between participants during the study. Those with need for optical aids wore their normal correction while participating.

1.2. Materials and procedure

The IB paradigm ("gorilla video") developed by Simons and Chabris (1999) was used. Participants were seated in front of the computer screen at a distance of 45 cm. The size of the stimulus field was 27.1° of the visual angle in the vertical dimension and 33.7° of the visual angle in the horizontal dimension. An experimenter read instructions. It was ensured that all participants, in particular the youngest children, understood the instructions. Participants completed two 30 s trials in which they had to watch a basketball game involving six players, three wearing white shirts and three wearing black shirts. In a third trial, after 14 s, a seventh person wearing a gorilla costume unexpectedly entered the scene from the right, walked through the action, and disappeared on the opposing side after 23 s. Thus, the unexpected object was fully visible for 9 s.

In both non-critical trials and in the critical trial, the counting instruction for the attention-demanding task was set at a medium level of difficulty to allow us to test participants of varying age levels. Participants were instructed, "Watch only the players in white in the video clip and count the number of passes made by them." After watching the video and stating the number of passes, participants answered four questions (following Simons & Chabris, 1999): (1) While you were counting, did you perceive anything unusual on the video? (2) Did you perceive anything other than the six players? (3) Did you see anyone else (besides the six players) appear on the video? (4) Did you notice a gorilla walk across the screen? After any "yes" reply, children were asked to provide details of what they noticed. If at any point a child mentioned the unexpected event, the remaining questions were omitted.

In the final full-attention trial, participants viewed the video again without performing the attention-demanding primary task. This was done to verify that they could perceive the gorilla when it was no longer unexpected and when attention was not otherwise engaged. Here, they were simply instructed to watch the video.

2. Results

Following Simons and Chabris (1999), data from 60 participants were deleted from the analysis for one of three reasons: 20 participants stopped counting in the middle of the video; 23 claimed to know the phenomenon and mentioned this during the video or afterwards; 17 did not perceive the unexpected object in the full-attention trial[1]. Neither gender nor sports activity emerged as significant predictors and are not considered further.

[1] We did not have to exclude children based on their counting performance (cut-off criterion: error rate > 3 SD).

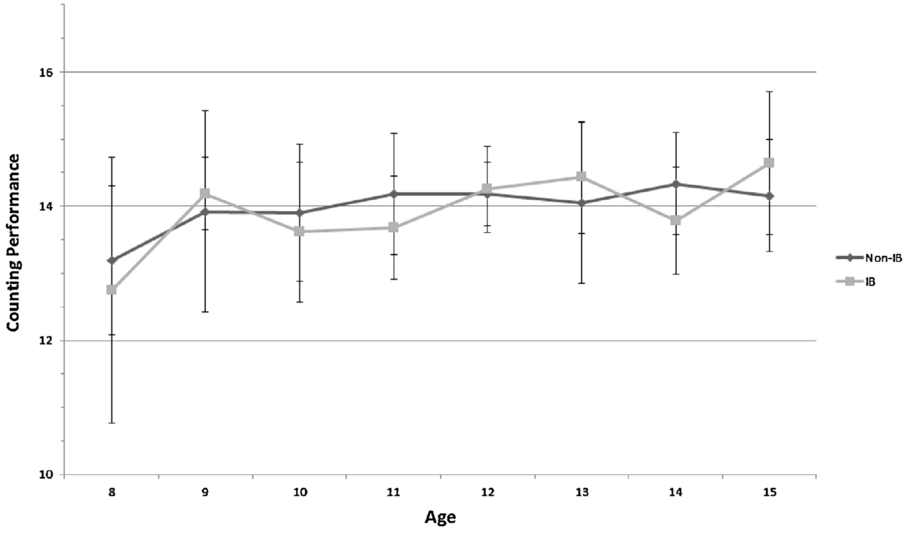

Fig. 1. Mean values of counting performance in the attention-demanding primary task in the IB task by Simons and Chabris (1999) as a function of age and IB; the error bars specify the respective standard deviations. Fourteen is the correct result of the counting task.

To assess whether there were differences in the counting performance of the 420 children in the attention-demanding primary task (see Fig. 1), the accuracy of the number of passes counted was compared between participants who perceived the gorilla and those who failed to see it. An 8 (age group) × 2 (notification rate: observed vs. not observed) analysis of variance (ANOVA) indicated no effect of notification rate ($F < 1.0$,ns.), but a main effect of age, $F(1,7) = 6.571$, $p < .001$, $\eta^2 = .102$, as well as a significant age × notification rate interaction, $F(1,7) = 2.164$, $p < .05$, $\eta^2 = .036$. Post hoc Scheffé tests indicated that only 8-year-olds counted significantly fewer passes than other age groups; no other age group differences appeared. Thus all participants showed fairly good performance in regard to the attention-demanding primary task. Importantly, there was no significant difference in the counting performance between noticers and missers for any of the other age groups.

A total of 43.1% of the participants noticed the unexpected object, revealing a considerable overall level of IB, consistent with the results of Simons and Chabris. Equally important, as shown in Fig. 2, results indicated significant age differences, $\chi^2_{(7)} = 36.72$; $p < .001$, $n = 420$. Most remarkable, only 15% of 8 year-olds perceived the unexpected event.

Both 9-and-10-year olds showed detection rates of only 31% and 32%, respectively. They did not differ significantly from 8-year-olds, $\chi^2_{(2)} < 2.422$. However, they differed significantly from all older age groups, which suggests that IB is more pronounced in younger children until the approximate age of 11. There were no further differences after age 11 (for all age comparison between 11 and 15, $\chi^2_{(1)} < .536$). Nevertheless, about half of the children between 11 and 15 were oblivious to the unexpected object.

3. Discussion

Our findings replicate a number of studies (Mack & Rock, 1998; Most et al., 2005) by showing that IB is a robust phenomenon. More importantly and for the first time, we demonstrate within a large sample that IB is significantly influenced by age. Crucially, 8-, 9-, and 10-year-olds show more IB than older children, and there are no differences between 11 and 15 years; the latter age groups also do not differ from adults. First, these findings are in line with research that shows non-linear developmental change (Fischer, 2008; Wilson, 1989). Second, our results are consistent with developmental evidence (Rebok et al., 1997) that attentional abilities improve with age. In addition, the results

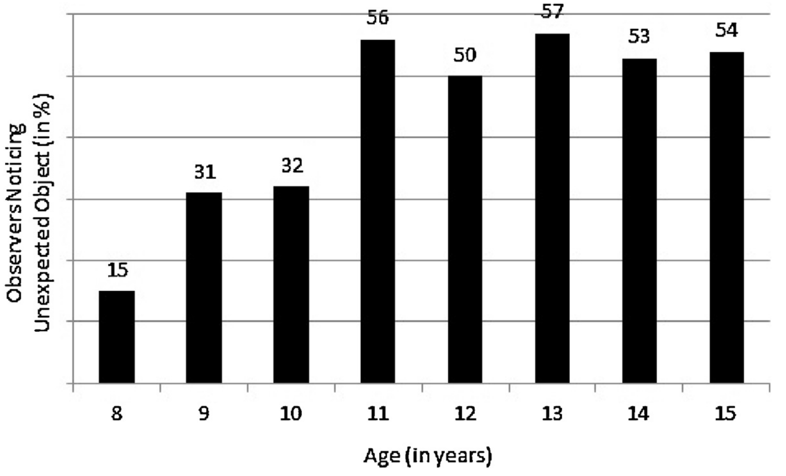

Fig. 2. Percentage of recognitions of the unexpected object using the IB task by Simons and Chabris (1999) as a function of age.

reinforce the work of Fletcher-Watson et al. (2009) who, using a similar paradigm, show a developmental trend towards decreased change blindness; reaching adult levels by 10–12 years. Thus, we show that children have significant problems perceiving unexpected objects while focusing their attention elsewhere. Therefore, it seems that many distinct aspects of attention, including vulnerability to IB, improve developmentally. Connecting the present results to the results from studies of elderly people (Graham & Burke, 2011), it becomes clear that the age of the participants has a significant influence on IB.

The inferior performance of 8–10-year-olds suggests that young children have less skill enabling them to direct their attention towards stimuli that initially appear to be irrelevant. Because attention capacity in children develops rapidly (Rebok et al., 1997), it could be argued that attention capacity seems a better explanation for the development shift in our data than a change in inhibitory control. This interpretation is in line with that made by Graham and Burke (2011) in their study with elderly people (see also Tsushima, Sasaki, & Watanabe, 2006). Nevertheless, further experimental research is needed to address this question adequately. One objective would be to rule out moderator variables like maximum attention capacity. Also, alternative subjective motives of participants may play a role. One possibility would be to measure the maximal breadth of attention by the observers (Hüttermann, Simons, & Memmert, 2014), for example by using the Useful Field of View Task (UFOV) by Green and Bavelier (2003), the Multiple Object Tracking Test (MOT) by Cavanagh and Alvarez (2005), or the Attention-Window Task (AWT) by Hüttermann, Memmert, Simons, and Bock (2013).

It is not yet clear which exact mechanisms cause the development shift in IB performance around the age of 10 and which other factors play a role, e.g., attentional capacity, mental workload or working memory. One potential factor could be working memory (Sander, Lindenberger, & Werkle-Bergner, 2012; Yordanova & Kolev, 1997; Müller, Gruber, Klimesch, & Lindenberger, 2009). Hannon and Richards (2010) and Richards, Hannon, and Derakshan (2010) found a correlation between working memory capacity and noticing rates using an IB task with adults.

Although our cross-sectional developmental data do not allow us to directly address the issue of mechanisms, our results point to the need for a deeper analysis of the neuropsychological and cognitive mechanisms that are responsible for the development of children's attention resources. The change at age 10–11 does not necessarily have to do with maturing of the brain or of cognitive ressources, but may also be related to transfer to secondary school (Fischer & Bullock, 1984; Morrison, Smith, & Dow-Ehrensberger, 1995), with the greater independence and self responsibility that come with it (Rutter, 1985).

Findings by Most et al. (2005) demonstrate that a more eloborate and deliberate attentional setting can reduce IB. All in all, the findings indicate that IB is a risk that is greatest in young children, and therefore these results have important practical implications for parents, educators, and governmental policy makers. Findings of children's low detection rate for unexpected events should encourage new research programs addressing real-world conditions (Chabris, Weinberger, Fontaine, & Simons, 2011; Haines, 1991; Furley, Memmert, & Heller, 2010; Most & Astur, 2007), as well as development of attention training programs for children.

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