Dividing Attention Lowers Children's, but Increases Adults' False Memories

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Abstract

The present study examined the impact of divided attention on children’s and adults’ neutral and negative true and false memories in a standard DRM paradigm. Children (7- and 11-year-olds; *n* = 126) and adults (*n* = 52) received 5 neutral and 5 negative DRM word lists where half of each group received a divided attention task. The results showed that divided attention affected children’s and adults’ false memory levels differently, but did not alter true memory differently. Specifically, our results revealed a developmental shift in that divided attention lowered children’s false memory rates, but increased adults’ false memory rates, regardless of the nature of the material (i.e., neutral or negative). Our study indicates that manipulations that target conscious processing (e.g., divided attention) result in marked qualitative and quantitative differences between children’s and adults’ false memories but not true memories.

Keywords: False memories, Development, Divided attention, Memory

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Memory scholars have become increasingly interested in examining developmental differences in memory, particularly the development of spontaneous memory illusions that reduce overall memory accuracy (e.g., Brainerd, Reyna, & Ceci, 2008; Otgaar & Candel, in press; Wimmer & Howe, 2010). A widely-used memory paradigm to investigate spontaneous memory illusions is the Deese/Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). Here, participants study lists of semantically-related words (e.g., *table, sit, legs, couch*) all of which are related to a non-presented critical lure (e.g., *chair*). When memory is tested for these words (either recall or recognition), a significant proportion of participants falsely remember the non-presented critical lure with rates often comparable to memory for the studied words (Roediger & McDermott, 1995). In developmental studies, a typical finding is that young children are less susceptible to spontaneous memory illusions than older children and adults (e.g., Howe, Wimmer, Gagnon, & Plumpton, 2009).

Several theories have been proffered as explanations of the mechanisms underlying the development of the false memory illusion. Fuzzy-trace theory (FTT; Brainerd et al., 2008) postulates that memories are stored as two opponent traces. Verbatim traces store item-specific surface characteristics (e.g., font of a word) of information while gist traces store meanings of the information being processed. According to FTT, false memories arise mainly due to reliance on gist traces as verbatim traces become weaker and less available in memory. FTT posits that false memories are less robust in children because they are poorer at extracting the overall theme (gist) of DRM lists. Because gist extraction improves with age in childhood, spontaneous false memories increase throughout development.

Alternatively, associative-activation theory (AAT; Howe et al., 2009), which is partly based on activation-monitoring theory (AMT; Roediger, Watson, McDermott, & Gallo, 2001b), stipulates that both true and false memories arise out of automatic associative processes (Roediger, Balota, & Watson, 2001a). The basic premise behind AAT is that the processing of one word results in a spreading activation to corresponding nodes in our mental lexicon. According to this theory, false memories arise because the presented words are all associated with the critical lure that becomes activated when words are processed through spreading activation. AAT contends that false memory creation is based on increases in the number and strength of associative relations as well as the speed and automaticity with which these associations are accessed and activated (Wimmer & Howe, 2009). Children's and adults' false memories differ in the degree of automaticity of associative activation which in turn is driven by developments in children's knowledge base (see Howe, 2005; Howe & Wilkinson, 2011). The knowledge base is composed of networks of interrelated concepts whose structure adapts with development and experience. Specifically, with age, children become more able to automatically activate associative networks and therefore they are better equipped to employ associative relations in much the same manner as adults.

The difference between these theories is that FTT explains age-related increases in false memories in terms of changes in gist extraction whereas AAT explains these same changes in terms of changes in children's knowledge base and the automaticity with which this information is activated. Although both FTT (dual-process theory) and AAT (single-process theory) predict quantitative changes in false memories with age, only AAT anticipates qualitative changes in children's false memories as a consequence of these changes in automaticity (see later discussion and Wimmer & Howe, 2010).

Recently, two lines of research have emerged that examined the precise circumstances under which false memories increase or decrease in adults and children. One of those research lines focused on whether false memories are consciously produced or whether they can also be elicited unconsciously (e.g., Dodd & Macleod, 2004; Wimmer & Howe, 2010). The other research line has concentrated on how emotion (valence-arousal effects) affects the development of false memories (e.g., Brainerd, Holliday, Reyna, Yang, & Toglia, 2010; Howe, Candel, Otgaar, Malone, & Wimmer, 2010; Otgaar, Candel, & Merckelbach, 2008). Up until now, no effort has been made to combine these two research lines in one study and test whether there exist developmental differences in this respect. Hence, the purpose of the present study was to examine the effect of emotionality (valence-arousal) on children's and adults' false memory development under conditions that adversely impact conscious processing (i.e., divided attention).

What does research tell us about the development of false memories under circumstances that make it difficult to consciously study DRM word lists? Overall, research in this area has mainly been carried out with adult participants and is related to work on subliminal semantic priming (Greenwald, Abrams, Naccache, & Dehaene, 2003). Although studies show that in the DRM paradigm, false memories may become consciously activated during study (McDermott, 1997), the general finding is that for adults, false memories occur automatically without conscious awareness (e.g., Dodd & MacLeod, 2004; Kimball & Bjork, 2002). For example, Dodd and MacLeod (2004) showed that false memories can be evoked when words are processed incidentally. Also, other studies have shown that false memories even arise when adults receive forewarning instructions about the possible occurrence of the false memory illusion (Peters et al., 2008).

A more common method used to examine the automaticity of false memories is the divided attention task. In this task, participants have to learn DRM lists while simultaneously paying attention to a second task (e.g., the so-called "oddball" task such as identifying infrequent high tones among frequent low tones). However, studies using divided attention tasks with adult participants have failed to provide a consistent picture with respect to false memory development. Some studies show that divided attention increases false memory illusions in both recall and recognition procedures (e.g., Dewhurst, Barry, Swannell, Holmes, & Bathrust, 2007 (Experiment 1); Pérez-Mata, Read, & Diges, 2002; Peters et al., 2008) while other studies demonstrate that false memory levels are lowered when attention is divided while studying the DRM word lists (e.g., Dewhurst et al., 2007; Experiment 2).

Possible reasons for these conflicting results include the use of different secondary tasks across studies which makes direct comparisons between studies complicated (Seamon et al., 2003). Other reasons include the use of within- or between-subjects designs (e.g., Peters et al., 2008; Wimmer & Howe, 2010) or the use of recall or recognition measures (e.g., Dewhurst et al., 2007). Finally, most studies on the impact of divided attention on false memory rates have been conducted using adult samples only.

As far as we know, there is only one study examining the effect of divided attention on *children's* false recognition (Wimmer & Howe, 2010; Experiment 2). In this study, children (7- and 11-year-olds) and adults were subjected to a divided attention paradigm while receiving six neutral DRM word lists. The study revealed two important findings. First, dividing attention during encoding significantly reduced true, but not false, recognition regardless of age. Second, they found that for children, true and false memory rates were strongly related to each other when attention was divided. However, for adults, true and false memory rates were unrelated when attention was divided. Wimmer and Howe (2010) argued that these results provide evidence for an important *qualitative* developmental difference between children's and adults' false memory production. The current study aimed to extend these findings by also examining the effect of *valence* on children's and adults' false memory formation when attention is divided.

What do we know about the role of valence-arousal on children's and adults' false memories? Overall, studies show a fairly consistent picture with respect to this issue. That is, results demonstrate that children and adults falsely recognize more negative than neutral critical lures, while false recall is higher for neutral than for negative lures (e.g., Brainerd et al., 2010; Howe et al., 2010). To date, however, no study has investigated whether the effects of valence-arousal on false memory differ developmentally when conscious processing of DRM lists is interfered with: that is, when participants are involved in a divided-attention task.

To the best of our knowledge, there are no published studies that have investigated the effect of divided attention on children's and adults' neutral and negative memory accuracy. We selected 7- and 11-year-old children and adults in the present study as previous research has shown that within these age categories, there is a significant developmental increase in the number of false memories (e.g., Howe et al., 2009). In our study, children and adults received neutral and negative DRM word lists with half of them also receiving a divided attention task (i.e., oddball task). After each word list presentation, participants were instructed to report all the words they could remember (i.e., free recall).

Based on previous studies (e.g., Howe et al., 2010), we expected all participants to falsely recall more neutral false memories than negative ones. We predicted that divided attention would affect children's and adults' false memories differently. Specifically, dividing attention should decrease children's false memories as it would either impede gist extraction (FTT) or hinder spreading activation (AAT). Because adults' knowledge base is better developed and can be accessed more automatically (outside conscious awareness) than children's (AAT), dividing attention will not lead to decreased false memory rates for adults'. In fact, false memory production might even increase for adults' if divided attention leads adults to rely more on the themes that were activated during list presentation (AAT; Howe & Wilkinson, 2011) or on gist rather than verbatim traces (FTT).

Method

Participants

Hundred-seventy-eight children and young adults (45% male) took part in the present study with 78 7-year-olds (mean age = 7.41 years, *SD* = 0.55), 48 11-year-olds (mean age = 11.69, *SD* = 0.51), and 52 young adults (mean age = 21.19 years, *SD* = 2.25). All children had parental consent and received a small present for their participation. Adults received course credit for their participation. This study was ethically approved.

Materials

Five neutral (*bread, window, sweet, smoke*, and *foot*) and five negative (*murder, pain, punishment, death*, and *cry*) word lists were used in the present study with each containing 10 words. These lists have already proven their effectiveness in eliciting a substantial amount of DRM-related false memories (Howe et al., 2010). List items were selected from the Dutch word association norms (Van Loon-Vervoorn & Van Bekkum, 1991) and were presented in order of backward associative strength, from strongest to weakest in line with Howe et al. (2010) and Otgaar and Candel (in press) (but see other DRM-false memories studies in which words are presented in order of forward associative strength; McEvoy et al., 1999). Using the Celex lexical database (Baayen, Piepenbrock, & Gulikers, 1995), we ensured that the mean word frequency of the neutral and emotional critical lures did not differ ($t(8) = 0.22$, *ns*). Furthermore, the mean backward associative strength between the neutral list items and their critical lure and the mean backward associative strength between the negative list items and their critical lures did not differ ($t(8) = 1.69$, *ns*). To examine the properties of our lists more deeply, we also tabulated the mean arousal and valence values of the lists and the critical lures using the ANEW norms (Bradley & Lang, 1999; Appendix A) and also report the mean values of the following semantic properties: concreteness, familiarity, and meaningfulness using norms from different databases (Gilhooly & Logie, 1980; Toglia & Battig, 1978; see Appendix A). The lists were presented in a fixed random order. Words were presented in an auditory manner at a 2 s rate on a computer using E-Prime software.

For the divided attention task, we used an adapted version of the oddball paradigm used by Peters and colleagues (2008). In a standard oddball task, participants are instructed to identify infrequent “target” stimuli within a series of rapidly presented “standard” stimuli. We modified the oddball task with E-Prime to make the task more child-friendly. In our adapted version, participants received a visual oddball task in which red and green smileys were shown. These smileys were presented for 250 ms during the presentation of the DRM word lists on a 17-inch computer screen. A smiley was shown before and after the presentation of a word. A fixation cross appeared on the screen for 500 ms preceding each smiley that was presented before word presentation. During each word list, a total of 20 smileys were presented with one smiley before and after each word. The number of red smileys per word list ranged between 2 and 6 (approximately 10-30% of the smileys) to prevent the impact of guessing and predictability. After each word list, participants who received the divided attention task were asked to indicate the number of red smileys they had seen. In the control condition, the exact same task occurred except no smileys were presented.

Design and Procedure

This experiment employed a 3 (Age: 7-year-olds vs. 11-year-olds vs. adults) x 2 (Condition: Full attention vs. divided attention) x 2 (Valence-Arousal: Negative vs. neutral) split-plot design with the latter factor being a within-subject variable. Children and adults were randomly allocated to the full attention ($n = 92$) or divided attention condition ($n = 86$).

Participants in the full attention condition received 10 DRM word lists with the instruction to remember the words presented in these lists. The DRM word lists were presented in a fixed random order. After each word list, participants had 1.5 min to recall all the words they could recollect. Participants in the divided attention task first received information about the oddball task to make sure that they understood the exact procedure. Specifically, they received pictures of red and green smileys and were told that these smileys would be presented during the word presentation and that they simultaneously had to remember words and count the number of red smileys that they encountered. Like the full attention condition, word lists were presented in a fixed random order. In the divided attention condition, after each word list, participants first had to indicate verbally how many red smileys they had seen. Next, they were instructed to recall all the words they could remember. This recall phase lasted for 1.5 min.

Results

True recall

Analyses of variance (ANOVA) were conducted to examine the effect of divided attention on children’s and adults’ neutral and negative true and false memories. Post-hoc comparisons were performed using Bonferroni tests. A 3 (Age: 7-year-olds vs. 11-year-olds vs. adults) x 2 (Condition: Full attention vs. divided attention) x 2 (Valence-Arousal: Negative vs. neutral) ANOVA on the mean proportion true recall revealed a significant Age x Condition x Valence-Arousal interaction, $F(2,172) = 5.31$, $p < .01$, $?^2_p = .06$. Simple effect analyses showed the following results. First, dividing attention during study significantly reduced true recall for all age groups ($p < .001$; see Table 1). Second, we found that in the divided attention condition, neutral words were significantly better remembered than negative words in all age groups (F(1,83) = 11.72, $p < .001$, ?^2_p = .12). However, this was not the case for participants in the full attention condition. Here, our data revealed that for the 11-year-olds (F(1,23) = 13.36, $p < .01$, ?^2_p = .35), neutral words were better recollected than negative words while young adults (F(1,25) = 5.67, $p < .05$, ?^2_p = .19) remembered more negative than neutral words. For the 7-year-old group, this difference was not significant ($p > .05$).

False recall

When we conducted a similar ANOVA on the false recall data, we found two important results. First, our analysis revealed a significant main effect of valence-arousal (F(1,172) = 44.68, $p < .001$, ?^2_p = .21; see Table 2) with neutral critical lures being more easily recollected than negative critical lures. Second, we found a significant Age x Condition interaction (F(2,172) = 7.45, $p < .001$, ?^2_p = .08). Simple effects tests showed that divided attention significantly reduced younger and older children's false memory levels (F(1,122) = 4.98, $p < .05$, ?^2_p = .04), but increased adults' false memories (F(1,50) = 8.07, $p < .01$, ?^2_p = .14). When we ran analyses separate for the effect of divided attention on younger *and* older children's false memory levels, we found that although dividing attention reduced both children's false memory levels, this effect was only significant for the older children (F(1,46) = 3.89, $p < .05$, ?^2_p = .08) and not for the younger children (F(1,76) = 0.86, *ns*). This latter finding likely reflects a floor effect since although divided attention decreased younger children's false memory levels (full attention: M = .15, divided attention, M = .12), false memory levels in this age group were very low (see Table 2).

We also found an age-related increase in false memories with 11-year-old children having more false memories than 7-year-old children in both the full and divided attention conditions (*ps* < .05). However, adults' false memory rates were relatively low and these were not higher than the 11-year-olds' false memory rates in the full attention condition but were higher than the 7-year-olds' false memory rates in the divided attention condition ($p < .01$).

Net accuracy

To investigate whether divided attention would impact children's and adults' net accuracy, we computed net accuracy scores (true recall/true recall + false recall; see Table 3). We found a significant main effect of valence (F(1,172) = 28.75, $p < .001$, ?^2_p = .14) with negative net accuracy scores being higher than neutral net accuracy scores (see Table 3). Furthermore, our analysis showed a significant Age x Condition interaction (F(2,172) = 3.61, $p < .05$, ?^2_p = .04) with simple effects indicating that adults' net accuracy were significantly reduced when attention was divided (F(1,50) = 11.06, $p < .01$, ?^2_p = .18), yet divided attention did not affect children's accuracy scores ($p > .05$).

Discussion

The present study was designed to examine the impact of divided attention on children's and adults' neutral and negative true and false recall. Our most important finding was that divided attention significantly affected children's and adults' false recall in opposite ways. Specifically, when attention was divided in children, false memory rates were significantly reduced whereas the reverse was true for adults. That is, for adults, dividing attention increased false memory levels. What this finding implies is that there is a developmental shift in the effects of divided attention on children's and adults' false memory production. To our knowledge, we are the first to report such developmental shift, a shift that has considerable ramifications for our understanding of the development of children's and adults' false memory.

Our finding suggests that manipulations that target conscious processing (e.g., divided attention) result in marked quantitative and qualitative differences in children's and adults' false memories. For children, divided attention likely affected the understanding of the true items such that detailed understanding of those items was impaired. This possibly prevented the process of spreading activation (AAT/AMT) and gist extraction (FTT) thereby lowering false memories relative to the full attention condition. For adults, divided attention made them rely more on themes that were activated during presentation (AAT) or on gist traces that were extracted (FTT), leading to an increase in false memory levels. Although these findings are broadly consistent with the expectations of most theories of false memory development, only AAT predicted the qualitative differences between children's and adults' false memories (e.g., differences in automaticity).

Alternatively, the rise in adults' false recall during divided attention might partly be explained by participants' difficulty monitoring the occurrence of critical lures (Perez-Mata et al., 2002) or by a shift in response criterion (Dewhurst et al., 2007). It is likely that divided attention prevented adults from encoding and identifying the cognitive processes and phenomenological characteristics related to false memories. This could have resulted in the fact that adults were unaware that they produced false memories during divided attention. This interpretation is consistent with AMT's prediction that divided attention during encoding makes adults less able to monitor their memory accuracy, resulting in more inferential processing (Roediger et al., 2001b). This increased inferential processing leads to more activation of related items (critical lures) in an associative network. Because in adults, these critical lures were strongly activated during encoding under divided attention conditions, they contained features similar to those of actual list items. Hence, during retrieval, adults in the divided attention condition were more likely to recollect critical items than adults in the full attention condition. Of course, the increase in adults' false recall may be the result of a criterion shift in which adults are aware that their memory is impaired during divided attention and then compensate by falsely recalling related but incorrect items. Despite the fact that our data are silent to which explanation offers the best fit, our recall findings concur well with those found by others (Dewhurst et al., 2007; Perez-Mata et al., 2002; Peters et al., 2008).

Interestingly, developmental shifts are rarely seen in memory development research and therefore highlight the need to examine developmental trends and reversals in false memories. For example, Brainerd et al. (2008) showed that under certain circumstances (e.g., when studying spontaneous false memories), the traditional view of false memories (i.e., fewer false memories as children get older) is entirely reversed with children having fewer false memories than adults. Our finding that children's and adults' false recall react oppositely when attention is divided adds to the growing body of evidence showing that there exist quantitative as well as qualitative differences in the processes that drive children's and adults' false memories (Wimmer & Howe, 2010).

Reliable support for our developmental effect comes from three sources. First, we showed that across all age groups, divided attention significantly reduced true recall, a finding that is consistent with previous research (Dewhurst et al., 2007). This means that our manipulation affected both children's and adults' true memory in a similar and uniform manner. Second, we found an age-related increase in false memories for the 7- and 11-year-old children. This result is in line with a host of studies showing a developmental increase in the number of false memories for younger (7/8-year-olds) and older children (11/12-year-olds) (Brainerd et al., 2008; Howe et al., 2010; but see below). Third, a developmental reversal was obtained for the divided attention manipulation for false recall. That is, whereas divided attention decreased children's false memories, divided attention increased adults' false memories. However, our results also showed that although divided attention reduced younger children's false memory levels, this effect was not significant. Obviously, this is likely due to floor effects as younger children's false memory rates were already very low in the full attention condition, a finding observed before in the literature (Brainerd et al., 2008).

Although we found an age-related increase in false memories for the 7- and 11-year-olds, this increase did not monotonically continue to adults. That is, we failed to find the standard developmental pattern in false memories in which adults develop more false memories than older children who in turn have higher false memory rates than younger children (Brainerd et al., 2008). The reason for this may be the relatively low levels of false memories for adults in the full attention condition. This finding has also been reported by Wimmer and Howe (2010) who also demonstrated that false recognition was very low for adults under full attention. Although speculative, one possible explanation for this might be differences in populations and individual variations in false memory vulnerability (Bouwmeester & Verkoeijen, 2010).

In the present study, we also showed that neutral and negative false memories were similarly affected by divided attention. That is, in the full and divided attention condition, neutral false memories were more easily elicited than negative false memories in both adults and children. This result corresponds to previous developmental research (Howe et al., 2010) and is related with work showing that negative emotion leads to fewer memory errors than positive emotion (Kensinger & Schachter, 2006). Our finding suggests that emotion plays an important role in false memory creation and that valence effects might be developmentally invariant.

We also found that divided attention significantly reduced adults', but not children's, net accuracy. Although children's false memory rates were significantly affected by divided attention, their net accuracy was not. This finding implies that children's memory accuracy is resistant to manipulations that impact conscious processing and, like our false memory findings, suggest that there are important differences between children's and adults' memory functioning.

To recap, the present study showed that divided attention differentially affected children's and adults' false memories. Specifically, our study showed that children's false memory levels, like their true recall, were lowered when attention was divided. In contrast for adults, although their true recall was also lowered in divided attention conditions, false memory levels were enhanced. This result is consistent with the idea that false memories are automatically activated in associative memory during encoding for adults and to a lesser extent in children but are not so automatically activated at retrieval for children (Howe, 2005; Howe & Wilkinson, 2011). Equally important, our study is the first showing a developmental shift concerning the effect of divided attention on false memories, a shift that occurred irrespective of valence-arousal. Our results suggest that besides qualitative differences (see Wimmer & Howe, 2010), there also exist quantitative differences between children's and adults' false memories.

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Appendix A. Mean values of valence, arousal, concreteness, familiarity, and meaningfulness of critical lures (CL) and wordlists (WL) [1]

	Valence	Arousal	Concreteness	Familiarity	Meaningfulness
Bread-CL	-*	-	622	611	484
Bread-WL	3.62	5.80	550	558	474
Window-CL	5.91	3.97	609	621	507
Window-WL	5.74	4.01	512	535	456
Sweet-CL	-	-	463	570	495
Sweet-WL	6.48	4.37	487	575	490
Smoke-CL	-	-	541	596	534
Smoke-WL	4.70	5.24	671	548	480
Foot-CL	5.02	3.27	558	583	435
Foot-WL	5.52	4.05	568	574	458
Murder-CL	-	-	445	528	536
Murder-WL	2.47	6.64	457	490	490
Pain-CL	2.13	6.50	426	569	557
Pain-WL	4.55	5.24	533	570	512
Punishment-CL	2.22	5.93	358	515	-
Punishment-WL	4.16	5.26	489	534	458
Dead-CL	1.61	4.59	429	581	497
Dead-WL	3.57	4.94	491	516	447
Cry-CL	-	-	436	566	444
Cry-WL	6.85	6.44	448	530	509

*Since we used English equivalents of our Dutch words, some ratings were not available

Footnote

[1]For some words of the lists, there were no ratings available. Hence, the reported values should be interpreted with extreme caution. Furthermore, the reported values have the following ranges: Valence (1 = unpleasant, 9 = pleasant), arousal (1 = calm, 9 = excited), concreteness (100-700 with higher values indicating more concreteness), familiarity (100-700 with higher values referring to more familiarity), and meaningfulness (100-700 with higher values denoting more meaningfulness)

Table 1

Mean proportions and standard deviations (between parentheses) of true recall as a function of age (7-year-olds, 11-year-olds, and adults) and condition (full attention and divided attention)

	Full attention		Divided attention	
Age	Neutral	Negative	Neutral	Negative
7-year-olds	.43 (.11)	.42 (.11)	.33 (.08)	.30 (.08)
11-year-olds	.64 (.09)	.58 (.09)	.52 (.08)	.50 (.10)
Adults	.80 (.09)	.83 (.09)	.71 (.07)	.69 (.07)

Table 2
Mean proportions and standard deviations (between parentheses) of false recall as a function of age (7-year-olds, 11-year-olds, and adults) and condition (full attention and divided attention)

	Full attention		Divided attention	
Age	Neutral	Negative	Neutral	Negative
7-year-olds	.21 (.20)	.09 (.13)	.15 (.19)	.09 (.12)
11-year-olds	.42 (.19)	.24 (.23)	.32 (.22)	.17 (.17)
Adults	.17 (.19)	.10 (.12)	.32 (.27)	.21 (.17)

Table 3

Mean proportions and standard deviations (between parentheses) of net accuracy as a function of age (7-year-olds, 11-year-olds, and adults) and condition (full attention and divided attention)

	Full attention		Divided attention	
Age	Neutral	Negative	Neutral	Negative
7-year-olds	.73 (.21)	.86 (.19)	.77 (.21)	.83 (.22)
11-year-olds	.62 (.14)	.75 (.21)	.66 (.18)	.79 (.20)
Adults	.85 (.15)	.91 (.11)	.73 (.17)	.80 (.15)