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The effect of testing on the vulnerability to misinformation in adolescents and adults

Review

False memories are a frequently recurring problem in the courtroom and therefore research on this topic is highly needed. In the present study, 51 adolescents and 50 adults were tested to investigate the effect of testing on the vulnerability to misinformation. The main expectation was that these groups have different levels of susceptibility to misinformation. Using the Fuzzy Trace Theory as a framework, it was hypothesized that the testing effect influences these different levels of susceptibility to misinformation. On the first testing day, after viewing a video of a theft, participants received gist or verbatim questions. On day two, an eyewitness statement, manipulated with misleading information, was presented, after which participants received a final memory test on a verbatim level. It was found that (i) susceptibility to misinformation decreases with age and therefore adolescents were more vulnerable to misinformation than adults and (ii) the testing effect only applied when no misinformation was presented. Limitations might be that participants received forced choice questions and that there was no free recall, which occurs in real-life situations as police interviews.
Keywords: False memory, Fuzzy Trace Theory, Testing effect, Misinformation, Adolescents

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INTRODUCTION

A false memory is a recollection of events or experiences which is distorted or fabricated, and did not actually happen (Loftus, 1980). In general, there are two forms of false memories: spontaneous false memories and implanted false memories (Reyna, 1995). Spontaneous false memories arise endogenously due to cognitive distortions (Reyna & Brainerd, 1998). On the other hand, implanted false memories result from exogenous misinformation. Misinformation after exposure to an event can affect the memory of that event and also memory reporting of details of that particular event.

Loftus, Miller, and Burns (1978) introduced the so-called misinformation paradigm, which now is commonly used in studies where susceptibility of eyewitnesses to misleading post-event information is being investigated. Research suggests that participants are more prone to suggestion if misinformation and misleading suggestions are reported in a memory test, compared to a control condition with no misinformation and misleading suggestions (Loftus, 1978). Regardless of whether post-event information is misleading or consistent, this information is integrated into the event memory of a witness, which is called the misinformation effect (Loftus, 1978).

The storage of event memory can be explained by the *Fuzzy-trace theory* (FTT). The FTT states that individuals who witness an event will derive two independent memory traces or representations of event details – verbatim and gist traces (Brainerd, Reyna & Ceci, 2008; Rivers, Reyna, & Mills, 2008). Verbatim representations store exact surface details of an event or experience (i.e., exact words and details of a story), whereas gist representations consist of meaning-based memory for the event or experience (i.e., the theme of a story) (Howe, Wimmer, Gagnon, & Plumpton, 2009). Gist representations are superior to verbatim representations in memorability and accessibility (Brainerd & Reyna, 2001). More precise, gist processing is a favored retrieval mode over time and at immediate memory testing (Pansky & Koriat, 2004).

A study by Bouwmeester and Verkoeijen (2011) suggests that gist traces strengthen even more when a memory test is conducted. The effect that taking a memory test improves retrieval of information is called the *testing effect* (Roediger, Jacoby & McDermott, 1996; Roediger & Karpicke, 2006a; Roediger & Karpicke 2006b). The relation between the testing effect and the FTT is explained by the theory that the gist traces will strengthen because these traces are used to reconstruct and retrieve information from participants' memory (Bouwmeester and Verkoeijen, 2011). On the other hand, a study phase followed by a restudy phase will strengthen verbatim traces. In line with this argumentation, it is demonstrated that repetition and restudying can lead to a decrease of false memories due to the strengthened verbatim traces (Brainerd, Payne, Wright, & Reyna, 2003). The main question underlying the study of Pansky and Tenenboim (2011) is whether testing

can serve as a buffer for the susceptibility to misleading post-event information. They conclude that strengthened event memory on the verbatim level can inoculate against misinformation. On the other hand strengthening gist level memories did not decrease the effect of misinformation.

The testing effect can have both a beneficial (Warren & Lane, 1995), and a detrimental (Chan, Thomas, & Bulevich, 2009; Chan & Langley, 2011) influence on suggestibility to misinformation. Research has shown that when a test is preceded by misleading post-event information, the misinformation effect increases (Chan, Thomas & Bulevich, 2009). More precisely, although the testing effect enhances memory of a witnessed event, retrieval practice can increase people's suggestibility to manipulated information. This means that even though it has consistently been shown that correct recall improves by repeated testing, this testing could have a reversed effect when misinformation is introduced.

The effect of misinformation on children is a recurrent point of discussion in the legal field. However, little research is available on this effect on adolescents. The current study focuses on the effect of misinformation in this age group. Still, it is important to consider children as a comparison group (Brackmann, in prep.). Recent research has shown that false memories increase between early childhood and young adulthood under certain circumstances (e.g., Brainerd, 2013; Ceci & Bruck, 1993). Brainerd (2013) states that the risk to develop false memories increases drastically with age. Therefore, it is no longer justifiable to use the assumption that children's testimonies, compared to adults' testimonies, should in general be more infected with false memories. With regard to the developmental reversal it is important to note that this phenomenon only exists when adults have higher knowledge of meaning connections than children (Sutherland & Hayne, 2001).

In the present study adolescents and adults were tested to investigate the effect of testing in combination with misinformation on false memories. It is a well-established finding that children's memory relies less on gist representation compared to adults, and therefore children are expected to be less vulnerable to the production of false memories (Reyna & Kiernan, 1994). It can be expected that memory processes and therefore production of false memories works differently in adolescents, than in adults. Decision-making (i.e., the cognitive process that results in the selection of a course of action out of alternatives) in adolescents is more intuitive and less computational compared to adults (Rivers, Reyna & Mills, 2008). Adolescents find themselves between relying on verbatim analysis and relying on gist-based intuition (Reyna & Brainerd, 1995). In this study, the focus is on adolescents as nearly no study on this subject has been conducted that takes this age group into account (Jack, Leov, & Zajac, 2014). The research question is therefore: to what extent does testing have an effect on adolescents' vulnerability to misinformation compared to adults?

It was hypothesized that (i) adolescents will be less vulnerable to misinformation compared to the adult sample in this study, due to less reliance on gist representation; (ii) according to the testing effect, performance should be improved on the items of the final memory test, that were tested (Roediger, & Karpicke, 2006); and (iii) that the misinformation effect is expected to manifest itself in an impaired performance on items with misinformation in the final memory test, compared to items with no misinformation in the misinformation account.

METHOD

Participants

In total there were 101 participants (45 male participants), which is a subsample of the participants in the study of Brackmann (in prep.). 51 adolescents (M=15.04, SD=.52, age range from 13.69 to 16.59) and 50 adults with (M=22.32, SD=1.99, age range from 18.91 to 27.33) were tested. The different age groups were adjusted in order to make the different stages of development easy distinguishable. The verbatim condition included 26 adolescents and 27 adults, and the gist condition 24 adolescents and 24 adults. Participants were recruited from secondary schools in the surroundings of Maastricht (The Netherlands), and Maastricht University. Adults were compensated for participation by receiving either one subject point or an Iris Cheque with a value of €7.50. The adolescent participants were tested at their secondary schools during class time. The adult group was tested in a lab at Maastricht University. Informed consents were obtained from students, and from parents or legal guardians, in case of under-age participants. In both age groups the division of participants in the gist-testing or verbatim-testing group was counterbalanced.

Materials and procedure

Participants were tested individually on two consecutive days. On both days, test sessions lasted about fifteen minutes. At the start of each session, participants were told to concentrate and pay close attention as at the end of the session questions would be asked about the video. The first day, participants were presented with a video about an electrician entering a house to do chores and repair a list of electrical objects (see Takarangi, Parker, & Garry (2006) for a detailed description of the stimulus film). After a nonverbal filler task of approximately 3 minutes, the interpolated cued-recall task was presented to the participants. This task consisted of eight items with two questions each, one general question and one group specific question which was either gist- or verbatim-based.

After a 24-hour time interval, on day 2, participants received an audio version of an eyewitness account about the video which they viewed on day 1. In this eyewitness statement eight items were manipulated with misleading information (see Table 1). Four of these items were tested earlier in the interpolated cued-recall task on day 1 and four items were not tested earlier. Afterwards there was a nonverbal filler task that served as a pause between the eyewitness account and the cued recall task. The cued recall task consisted of 18 questions on the verbatim level about the video of Eric the Electrician. Besides the eight misinformation items, this final memory task included items that were not manipulated in the eyewitness account which were either neutral or verbatim. Neutral items were mentioned in the eyewitness account on a basic level and verbatim items were mentioned on a more detailed level. The questions in this cued recall task were presented in the same order for every participant, but were previously randomized by Takarangi et

al. (2006). Lastly, the participant was asked not to tell details of the study to their classmates or other students until the study had finished and thanked for his or her participation.

It should be noted that in this particular study a forced-choice report was applied, which implies that participants cannot choose the level at which they report their memories. All questions were accompanied by two possible answers, which participants had to choose from. Both these cases of forced choice could have an effect on participants' performance and therefore they should be taken into account when analyzing the data (Payne, Elie, Blackwell and Neuschatz, 1996).

Table 1. Misinformation items in the cued-recall task on day 2.

Correct item displayed in the video on day 1	Misinformation item in the eyewitness account on day 2	Testing condition in interpolated cued-recall task on day 1
Magazine Time	Magazine Newsweek	Tested
Photo of the Tower of Pisa	Photo of the Eiffel Tower	Untested
Made bed	Unmade bed	Tested
Black cap	Blue cap	Untested
RJ's Electrician	AJ's Electrician	Untested
Wristwatch	Wall clock	Untested
White cup	Yellow cup	Tested
Coca-Cola	Pepsi	Tested

Design

Two age groups were compared: adolescents and adults. Age was considered as a between subjects factor. Participants engaged in an interpolated cued-recall task where half of the participants in each age group received questions on the gist level, and the other half received questions on the verbatim level. A between subjects comparison was made between gist representations and verbatim representations. A within subjects design was used to compare the influence of misinformation or no misinformation and the effect of tested and untested items on memory of participants in the final memory test. The within subject items of the final memory test consisted of four levels: tested misinformation x tested no misinformation x untested misinformation x untested no misinformation. The dependent variable of this study was the correct or incorrect answers participants gave on the final memory test. Concluding, this resulted in a 2 (age: 14-15, adults) x 2 (testing group: gist testing, verbatim testing) x 2 (testing condition: tested, untested) x 2 (misinformation condition: misinformation, no misinformation) mixed model design, with age and testing group as between-subject factors and testing and misinformation condition as within-subject factors.

Results

As in this study, both a between subjects design and a within subjects design were used, the collected data were analyzed with the use of a four-way mixed-model ANOVA. The between-subjects factors were represented by the interpolated-testing mode and age. The within-subjects factor was the misinformation condition and the test-condition. This resulted in a 2 (age: 14-15, adults) x 2 (testing group: gist testing, verbatim testing) x 2 (testing condition: tested, untested) x 2 (misinformation condition: misinformation, no misinformation) mixed model design.

First, the responses of participants on the final memory test were compared by a function of age group, testing group, testing condition and misinformation condition. Table 2 presents the proportion of incorrect answers on the final memory test in each age group and condition. These data are used for the following analyses with a four-way mixed-model ANOVA.

A significant main effect of testing condition was found, $F(1, 204) = 72.489$, $p < .001$, $\eta^2 = .262$ indicating an effect of tested versus untested items on performance on the final memory test. There was also a significant main effect of misinformation condition, $F(1, 204) = 251.465$, $p < .001$, $\eta^2 = .552$. Participants displayed impaired performance on items with misinformation in the eyewitness account compared to items with no misinformation.

Table 2. Mean (M) and standard deviation (SD) of the proportion of incorrect answers on the final memory test as a function of age, testing group, testing condition and misinformation condition.

Testing group	Testing condition	Misinformation condition	Age			
			14 – 15 years old		Adults	
			M	SD	M	SD
Gist	Tested	Misinformation	.47	.32	.20	.22
		No misinformation	.03	.08	.05	.12
	Untested	Misinformation	.53	.20	.26	.23
		No misinformation	.24	.20	.23	.20
Verbatim	Tested	Misinformation	.41	.28	.20	.18
		No misinformation	.04	.08	.07	.11
	Untested	Misinformation	.38	.20	.36	.20
		No misinformation	.25	.18	.18	.16

An interaction effect was found between the factors misinformation condition and age group, $F(3, 204) = 7{,}870$, $p < .001$, $\eta^2 = .104$. This indicated that the influence of misinformation in the eyewitness account on performance in the final memory test differs per age group. It was found that the effect of misinformation decreased with age, as illustrated in figure 1. Thus, performance on the final memory test of adolescents (14 to 15 years old) was more influenced by misinformation in the eyewitness account, compared to performance of adults (figure 1). The mean misinformation effect (y-axis) was higher as performance on the final memory test decreased. Analyzing the simple effects, it was indicated that within both age groups misinformation had a significant effect. When comparing age group 14 to 15 year-olds ($F(1, 208) = 85.86$, $p < .001$, $\eta^2 = .219$) with adults ($F(1, 208) = 14.89$, $p < .001$, $\eta^2 = .038$) it could be concluded that adolescents were more influenced by the misinformation in the eyewitness account.

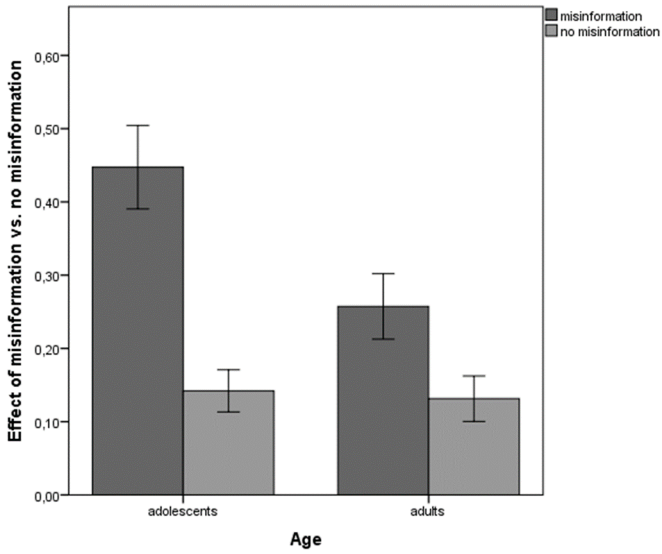

Figure 1. The effect of misinformation compared to no misinformation per age group on the proportion of incorrect answers on the final memory test. The effect of misinformation was significant (p < .001) in both age groups. Error bars: 95% CI.

There was also an interaction effect for testing condition (tested vs. untested items) and misinformation condition (misinformation vs. no-misinformation items), $F(1, 204) = 27.682$, $p < .001$, $\eta^2 = .119$. This effect of within subject manipulation showed that the misinformation in the eyewitness account influenced the effect of testing on performance on the final memory test (see also figure 2). The simple main effects show that when an item consists of misinformation, no testing effect is found in the performance on the final memory test ($F(1, 207) = 3.04$), $p = .083$, $\eta^2 = .014$). In other words, there was no significant effect for testing and misinformation. But when no misinformation was applied, an effect of testing was found ($F(1, 207) = 130.32$, $p < .001$, $\eta^2 = .380$). Thus, the testing effect was only present when there was no misinformation presented in the eyewitness account.

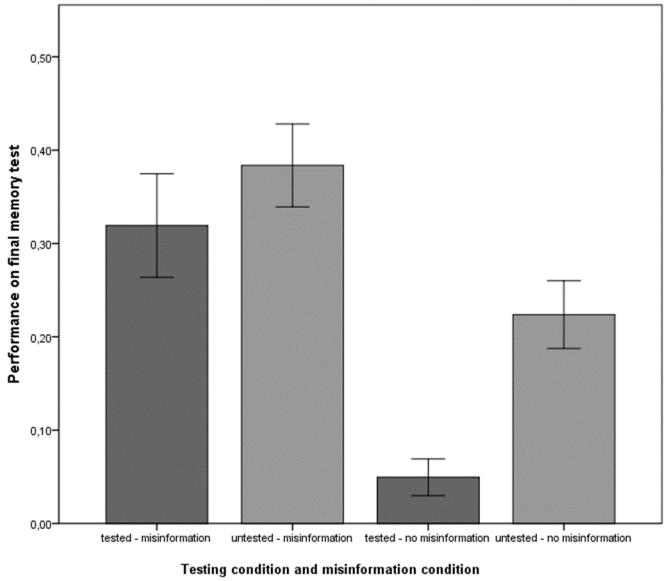

Figure 2. The effect of testing and misinformation on performance on the final memory test. A higher level of performance on the test means more errors. A significant effect of testing was only found on items with no misinformation, when misinformation was presented no testing effect was found. Errors bars: 95% CI.

DISCUSSION

The aim of this study was to examine the influence of the testing effect on the vulnerability to misinformation in adolescents and adults. Emphasis was put on adolescents as most studies have focused on children and adults. It was hypothesized, in line with FTT (Rivers, Reyna, & Mills, 2008), that adolescents are more vulnerable to misinformation than adults. The vulnerability of different age groups depends on the paradigm being used in a study. Children are more prone to suggestive information, while adults are more prone to spontaneous false memories (Otgaar, 2013).

The current study shows that adolescent participants are more susceptible to misinformation than adults. When misinformation was introduced both groups showed impaired performance, although adolescents' performance on the final memory test was more impaired than the performance of the adults. The study of Brackmann (in prep.), which is related to the present study, showed that children are more susceptible to misinformation than adults. Those findings are in controversy with the recent developmental reversal, but it should be noted that a developmental reversal is only present when adults have higher knowledge of meaning connections than children. This assumption could be an explanation for the increased effect of misinformation in children (Brackmann, in prep) and in adolescents, in this study,

compared to adults. When combining the results of both studies, it is indicated that adolescents can be located between children and adults on a continuum of susceptibility to misinformation. Further research could focus on including a greater extent of age groups, which should give a more complete picture on the distribution of different age groups with respect to susceptibility to misinformation.

Another important finding of this study is that, when age is held constant, the testing effect is dependent on the misinformation condition. It shows that an effect of interpolated testing on performance on a memory test only exists when no misinformation is presented. It is remarkable that when misinformation is presented, no testing effect is observed. This implies that the testing effect does not occur when someone is influenced by misinformation. In relation to this it can also be stated that, regardless of the testing effect, participants' performance on the final memory test was negatively influenced by misinformation as the error rate increased with the application of misinformation.

As the FTT states that the suggestibility to misinformation increases when relying more on gist representations compared to verbatim representations (Rivers, Reyna & Mills, 2008), an interaction between misinformation and testing group was expected. However, no support for this hypothesis was found in the present study. The interaction effect of testing group and misinformation did not appear to have an influence. It was expected that the difference between gist and verbatim testing on the first day would influence the performance on the final memory test after the misleading post-event information. This can also be linked to age, because children rely less on gist representations compared to adults and are therefore, in line with the developmental reversal, considered to be less suggestible to false memories (e.g., Brainerd, Reyna, & Ceci, 2008; Reyna & Kiernan, 1994). Although the FTT sets out that children rely less on gist representations, the results of the overarching study (Brackmann, in prep.) point out that children are more vulnerable to the misinformation effect. It is therefore assumed that the hypothesized effect of gist and verbatim testing on the vulnerability to misinformation might not apply.

A limitation of the current study is that participants were forced to report their answers on either gist or verbatim level. In real-life situations, such as a police interview, respondents have the option to choose the level on which they report information (Payne, Elie, Blackwell, & Neuschatz, 1996). As discussed by Payne et al. (1996) the forced-choice answer format could affect the performance on a memory test, because a forced-choice report could lead to an increased proportion of errors. In addition to the fact that participants were divided into separate conditions of report, they were prompted to choose one of the two answer options that accompanied the questions. The absence of the possibility for free-recall of memories could have influenced participants' performance, or at least might differentiate participants' performance from performance in an interview setting.

The conclusion of this study is that susceptibility to misinformation increases with age, and adolescents are more susceptible to misinformation than adults. Furthermore, the testing effect only applied when there was no misinformation. When misinformation comes into play, the testing effect cannot be found. A suggestion for additional research is to more extensively examine the relation between misinformation and testing. By including an adolescent age group, this

study raises an important area of development in the research on false memories, as there is only limited research on this age group. It is important to expand studies on the effect of misinformation on adolescents.

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