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Who Remembers Best? Individual differences in memory for events that occurred in a science museum

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SUMMARY

Individual differences in memory and suggestibility were assessed in an experiment involving 1989 people who attended the Exploratorium, a science museum located in San Francisco. Subjects watched a brief film clip of an assault and later answered questions about it. Approximately half received misinformation about some critical items. Four demographic variables (gender, educational level, age, and occupation) were examined to determine their impact on memory performance. The principle of discrepancy detection predicts that, compared to individuals with a good memory, people who have poor memory to begin with will be relatively suggestible (that is susceptible to misinformation). Some of our findings were consistent with this principle. For example, children (5–10 years) and elderly (over 65) were relatively inaccurate and also relatively suggestible. Other findings were not consistent with the principle, for example the finding that artists and architects were relatively accurate, but they were also highly suggestible.

When two people experience the same event, their recollections will often differ. Differences will invariably occur in terms of their general level of accuracy, and in terms of the extent to which their recollections can be distorted later. Such wide variability in memory has been noted in reviews of the literature on eyewitness memory (e.g. Shapiro and Penrod, 1986; Wells and Loftus, 1984). Despite the prevalence of interest among cognitive researchers in uncovering basic processes of information acquisition and retrieval, we take for granted the existence of individual differences.

Given that we accept that people differ, just what individual differences do we agree upon? As it happens, most of what we know about memory concerns the memory of college students.

Scores of studies inform us about the memory of male college students versus female college students. These subjects-of-convenience have been referred to as 'psychology's fruit flies', after the observation that even in genetics there is not much research conducted with elephants. Fruit flies are the subject of choice because they have shorter life spans and cost less (Rubenstein, 1982). So, in many fields of science, convenience dictates the choice of subjects.

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But there may be a cost to this choice when it comes to the study of memory. Historically, when the memory of some demographic group (say children) has been of interest, often that group of interest is compared to a group of college students (Dent, 1988). For example, in wondering whether the memories of children differ from those of adults, Cohen and Harnick (1980) compared the ability of 9- and 12-year-olds to that of college students. One finding was that the younger children were less accurate and more suggestible than the college students. As noted below, not all investigators have found this result.

In wondering whether the memories of the elderly differ from younger adults, again investigators often compare performance of elderly individuals with college students (Bartlett and Leslie, 1986; Smith and Winograd, 1978; Yarmey and Kent, 1980). For example, Yarmey and Kent (1980) compared the ability of 40 elderly individuals, whose mean age was 73, to that of college students. Young adults performed better, a common finding in tasks involving episodic memory. In wondering whether the memories of police officers differ from those of non-police, both Yuille (1984) and Ainsworth (1981) compared the memories of police officers to those of college students. As noted below, they obtained different results.

Should the college student be the basis for the bulk of our knowledge of memory? Should the college student be the 'control group' for comparison with other groups of demographic interest? College students are, by definition, relatively educated, and a large proportion of them are middle-class. Moreover, they tend to have higher self-esteem, and score higher on measures of intellectual ability and need for achievement (Rubenstein, 1982). An observation that this group outperforms a group of elderly on some memory measure may lead to an unwarranted conclusion about the effects of age, if the elderly group is also different in many other ways. The present research, utilizing a memory task given to a wide range of people, including college students, provides a basis for pursuing this issue.

Another problem in the bundle of research on individual differences is that questions about some particular individual difference variable have been asked by different researchers, working in different laboratories in different parts of the world, and at different times. This makes meaningful cross-experimental comparisons virtually impossible. While typically highly impractical, it would nonetheless be ideal to conduct a study in which the variety of ages, occupations, educational levels and genders could experience the same event and the same test. Their performances could be compared to one another or to the mean of the group rather than to the ubiquitous college student.

The present research used exactly this plan. Participants were attending a science museum in San Francisco that contained a variety of interactive exhibits. The current experiment was one of the interactive exhibits for subjects, which means that they provided data for the experiment while simultaneously learning from the exhibit. All subjects watched a short film clip and later answered a series of questions about it. Moreover, some subjects were exposed to misleading questions while others were not, so that the impact of misinformation could be assessed. Four demographic questions gathered information about the gender, age, occupation, and educational level of the subject. Statistical analyses then revealed relationships between the demographics and performance (accuracy and suggestibility). Our choice of demographic variables was dictated in part by interests of previous researchers and by questions that have arisen in the literature on eyewitness memory.

As alluded to earlier, age is a demographic variable of great interest to researchers (Baxter, 1990; Davies, Tarrant, and Flin, 1989; Doris, in press; Moston and Engleberg, 1990). In numerous tasks involving episodic memory, children have been found, often but not always, to be less accurate and complete in their reports than adults. They provide fewer details when they must freely recall an event (Dent, 1988). They often perform more poorly than adults in answering specific questions, although under some circumstances they show adult levels of accuracy such as when the remembered detail is particularly interesting to the child (King and Yuille, 1987) or when the context is appropriately reinstated (Wilkinson, 1988).

In terms of suggestibility, children often, but not always, demonstrate greater susceptibility to suggestive or leading questions than do adults (e.g. Goodman and Reed, 1986; Ceci, Toglia, and Ross, 1988). Researchers have noted an absence of clear developmental progression in the research findings (Loftus and Davies, 1984), and blamed this absence on the massive differences (e.g. in age, in materials, in delay intervals) from one study to the next.

At the other end of the lifespan, numerous episodic memory studies have revealed that older people performed more poorly than their younger counterparts. For example, Farrimond (1968) presented males between 23 and 79 years scenes recorded on silent film. One scene showed a 4-second shot of a young boy inflating a bicycle tyre. Another showed a man winding up a watch, while a third showed a car crossing a bridge. To conceal the purpose of the experiment subjects were told to try to read the lips of a commentator after each scene was presented. This also ensured that subjects would pay attention to each of the scenes. At the end an unexpected test of memory for the scenes was given. Performance was best for subjects in their mid-40s, and then began to decline, showing noticeable decline after the age of 60 years.

The elderly have also been shown to perform more poorly when they must recognize the faces of strangers seen only once before. In episodic memory studies that involve an 'eyewitness' type of paradigm, the elderly have been shown to perform more poorly than their younger counterparts in free recall of details of the event (List, 1986) and in most categories of event recall (Yarmey and Kent, 1980). Whether this means that the elderly store information more poorly, or whether they have greater difficulty accessing recently experienced events in memory, is still being vigorously debated. In terms of suggestibility, little work has been done with the elderly. It would be expected that if they store a poorer memory in the first place they might demonstrate greater susceptibility to misinformation, although at this stage this is just a hypothesis. Related work with the elderly on visual detail (Pezdek, 1987) and source attribution (McIntyre and Craik, 1987) similarly leads to the prediction that the elderly would be more susceptible to suggestion. In Pezdek's study, older subjects (68–90 years) were less able than younger people to notice changes (e.g. insertion or deletion of details) in complex stimuli. In McIntyre and Craik's study, older people showed greater forgetting of the source of information given to them than younger people. Based on work of this type, it would not be surprising to find that the elderly were more susceptible to misinformation.

There is also a theoretical reason to suspect that the elderly would be more susceptible to misinformation. Hall, Loftus, and Tousignant (1984) proposed a principle—namely the principle of discrepancy detection—for discussing when changes in recollection would occur as a result of misinformation. The principle states that recollec-

tions are more likely to change if a subject does not immediately detect discrepancies between post-event information and memory for an original event (p.135). The author cited indirect support for the principle in the finding that the effect of a misleading message is greater if the interval between the original event and the misleading message is longer rather than shorter. Apparently a misleading post-event message is most effective if memory for the original event has been allowed to fade with time. With the passage of time it is likely that a discrepancy will be noticed when the misinformation is being processed. The first direct support for the discrepancy detection principle came from Tousignant *et al.* (1986). They showed that subjects who scrutinize a misleading post-event message are more likely to notice discrepancies and are more likely to resist misinformation. In fact, the claim has been made that the discrepancy detection principle can be used to discuss a wide variety of situational and individual difference variables. Until now, it has largely been applied only to situational variables.

The relevance of this discussion to the age variable is straightforward. If it is the case that young children, and the elderly, absorb a poorer memory for an event, then these groups ought to be particularly susceptible to misleading post-event information. Such a finding would be consistent with the discrepancy detection principle.

Although past research led us to expect age effects in both accuracy and susceptibility to misinformation, it provided little guidance for generating predictions about other demographic variables. Take gender, for example. The classic review of research on gender differences (Maccoby and Jacklin, 1974) had little to say about differences in memory. It provided no discussion of memory for spatial information, memory for faces, or memory for real-life complex events. Yet many common beliefs about gender differences exist (in the minds of college students). People (i.e. college students) believe that females will remember better than males the face of a previously seen stranger, the details of a conversation with a friend, and the first person they kissed. Males, on the other hand, will better remember where they parked their car and how to reconstruct a complex block pattern. A review of actual memory studies reveals that neither sex can be said to have a better memory *per se*; rather the two sexes differ in terms of what type of information they remember best (Loftus, Banaji, Schooler, and Foster, 1987). But this conclusion rests largely on a comparison of male and female college students, not male and female anything else. The discrepancy detection principle suggests that if females, for example, have a better memory when not misled, then females would be more resistant to suggestion. Of course we have no basis in past research for making this prediction.

We also gathered information on educational level, but the predictions are not straightforward. Since a majority of experiments on adult memory utilize college students as subjects, little is known about the impact of educational level of memory performance. It might be expected that persons who have attained higher levels of education would have better memories; perhaps people with good memories in fact select themselves for advancement in school. Such a finding would be sensible, and hardly surprising. If so, perhaps the more educated individuals would also be more resistant to misinformation—a prediction of the discrepancy detection principle.

As for the impact of occupation, little is known about the relationship between the occupations people pursue and their memory performance. One ancient study of face recognition (Howells, 1938) examined the performance of college students

and then, almost as an afterthought, compared this to the performance of 44 sales people in retail stores and to 32 'adult farm people'. The farmers performed at about the level of the college students, but the sales people apparently did significantly better. Little commentary was made about this result other than a restatement of results: 'It seems clear that the sales people are superior on the identification test' (p. 126).

Researchers have also been interested in the memory abilities of police officers as a specialized group. Interest in police probably stems from a widely held 'belief' on the part of laypersons that, by virtue of their training or experience, police have better memories than the average citizen. In one survey over 500 registered voters in Dade County, Florida (thus jury eligible) were asked 'Do you think that the memory of law enforcement agents is better than the memory of the average citizen?' Half said yes, 38 per cent said no, and the rest had no opinion (Loftus, 1984). In a survey of Canadians (Yarmey and Jones, 1983), laypeople commonly claimed that the police had better memory ability than a civilian, and rarely claimed the reverse.

Do police have better memories? A few studies have compared the actual ability of police to civilians, with highly equivocal results. In some studies the police performed similarly to non-police (Ainsworth, 1981). In other studies the police made more errors, primarily because they were biased towards 'seeing' crimes happen, even when they did not (Clifford, 1976). For example, Tickner and Poulton (1975), showed a film depicting a street scene to 24 police officers and 156 civilians. Participants watched for particular people in the film and reported instances of crimes being committed. The researchers found that the police reported more alleged thefts than the civilians, but the civilians did just as well as police when it came to detecting actual crimes. Yet other studies, such as those by Yuille (1984), have shown the police reports are more detailed and more accurate than reports of those without police training. Moreover, Yuille also found the police to be somewhat less influenced by post-event suggestion than were non-police. Oddly, this research also showed no difference in performance between police trainees and experienced police officers (average of 8 years of police work), suggesting to Yuille that 'experience is not as critical as training in improving police recall' (1984, p. 18). This is odd, indeed, given Yarmey's (1986) observation that 'very little training is given in police academies specifically on perceptual and memorial concerns' (p. 47). No wonder Yuille claimed that his conclusion could only be tentative pending further research.

We had several reasons for being interested in the memory abilities of various occupational groups. Another test of the ability of police and law enforcement officers seemed in order, at Yuille's suggestion. Our procedure permitted a comparison between this group and an array of other occupational groups, not simply college students. Of additional interest was the performance of one particular group who one might think would have an especially good memory for visual events; namely artists. How well would the artists do? If artists are better than non-artists at reconstructing a past visual image, they may be more accurate when they answer questions about a largely visual event. Would they then be resistant to misinformation, as the discrepancy detection principle would predict? We asked artistically inclined friends to predict our results and many of them made the opposite prediction. The opposing argument went something like this: Since misinformation is 'fed' to artists in the experiment via leading questions (that is verbally), the artists might have

an easier time converting the verbal misinformation to a visual image and would thus be *more* susceptible to the misinformation.

METHOD

Subjects

The subjects were 1989 people who attend the Exploratorium, a museum of science, art and human perception founded in 1969 in San Francisco. The subjects who participated attended a special exhibit on memory that opened on 6 July, 1988. The memory exhibit had three major components: 'Remembering Pontito', a show of paintings and photographs; a new 'Memory' section of interactive exhibits; and a series of lectures, demonstrations, performances, and discussions. The first author provided consultation to museum staff regarding the planning of the museum exhibition—in hopes of gaining the opportunity to collect data. As others have learned (Rabbitt, 1989) planning a museum exhibition is an extremely demanding task, involving 'remorseless and nagging attention to detail', p. 56. One aspect of the task involved determining whether an eyewitness experiment would run smoothly in such a unique setting; piloting determined that it would. The current experiment was one of the interactive exhibits for subjects, which means that they provided data for the experiment while simultaneously learning from the exhibit about memory phenomena.

Materials and procedure

When subjects entered the museum they watched a 1.25 minute film clip taken from the motion picture 'Z', displayed near the museum entrance. The film clip depicted a political rally at which the protagonist walks through a tense, crowded town square. He is threatened by a number of people, and then is rushed by a menacing blue vehicle. In the end, a man at the rear of the vehicle strikes the hero with a night stick and he falls to the ground.

The film was displayed on a large TV screen which was hard to avoid looking at, although subjects could have simply walked right by it without viewing the film. To encourage viewing of the film clip, an informational sign gave subjects a simple rationale for watching the film. The sign told subjects that a new exhibit on memory was in place in the museum, that would explore how people perceive and remember events such as those depicted in the film. Subjects stood in front of the TV as they watched the film clip. They watched either alone or in groups, depending upon museum traffic. No records were kept of this behaviour.

After viewing the film clip, subjects wandered at their own pace towards the memory exhibit, which was at the back of the museum. In the unlikely event that subjects walked directly to our interactive exhibit without stopping in between, it might have taken a couple of minutes. More likely, subjects worked their way towards the memory exhibit, stopping to interact with many other exhibits on the way. Thus the retention interval between when subjects watched the film clip and when they answered questions about it was variable, and for some subjects the retention interval could have been as long as several hours.

Once at the exhibit, a large sign enticed subjects to sit down in front of a Macintosh

computer. The computer was controlled by a Hypercard stack which presented questions and collected data. The screen display initially read: 'Eyewitness Testimony: When you entered the museum you may have watched a film clip depicting an assault on a man in a crowded town square. If you watched the film, please answer some questions about it.'

Subjects used the mouse to respond. One of the first questions asked them whether they had completed the interview before. Data were only collected from subjects who responded 'no', although subjects were unaware of this feature. All subjects were asked a series of 10 questions about the film, all of which could be answered 'yes' or 'no'. For approximately half of the subjects, questions 3 and 5 presented misleading information about the colours of certain key objects. Question 3 was 'Did you see the two thugs in the black shirts who threatened the victim just before the white vehicle tried to run him over?' when actually the vehicle was blue. Question 5 asked 'Think about the main assailant, the balding man in the back of the charging vehicle who wore a black jacket and carried a big night stick. Did he hit the victim on the head?' when actually the jacket was blue. For the remaining subjects, questions 3 and 5 did not contain misleading information. They referred only to the vehicle and the jacket without mentioning any colours. To be precise, of the 1989 subjects, 1038 subjects received two items of misinformation, and 951 did not. This uneven split resulted from random assignment of respondents to the two conditions.

For all subjects, the last two questions examined whether subjects accepted the misinformation. Question 9 asked whether they had seen that the charging vehicle was white, and Question 10 asked whether they had seen that the assailant's jacket was black. The other questions in the set inquired about miscellaneous recollections about the film.

After answering the questions, subjects were debriefed via computer. The debriefing told subjects they had been part of an experiment on memory, and that half the subjects had received some misleading information. After the debriefing, demographic information was collected. Subjects indicated their occupation by choosing one of the 13 categories: student, artist/architect, teacher, lawyer, law enforcement, medical, business, trade/technical, sales, scientist, homemaker, retired, unemployed. They indicated their education by choosing one of six categories: grammar school, high school, g.e.d., 1–2 years college, 3–4 years college, graduate degree. They indicated their age by choosing one of 11 categories: 5–7, 8–10, 11–12, 13–15, 16–18, 19–25, 26–35, 36–50, 51–65, 66–75, over 75. Their sex was obtained in the obvious way.

RESULTS

This section is divided into four major parts. We first present descriptive performance data collapsed across all demographic variables. We next present data on the relationship between performance and the age of the participant, where we had *a priori* predictions. As we shall see, support was found for the principle of discrepancy detection. Next, we present data on other demographic groups for which we had no *a priori* predictions. As we shall see, some interesting results, emerged, but they were not consistent with the notion of discrepancy detection. Finally, we report data on the 'typical' college student by isolating them from the other respondents.

Overall performance

In analysing the data we obtained several measures from subjects. One measure was an overall accuracy score for non-misled items. To obtain this accuracy score, we used five questions for which no subjects received misinformation. We refer to these items as the 'accuracy items'. These five questions asked subjects about details of the event, such as how long the film lasted, when the assault occurred, and about other concrete details. For each subject the percentage correct for the five items was calculated. Only five items were included in this analysis because two questions (Nos. 3 and 5) were designed to expose misled subjects to the misleading information, and two other questions (9 and 10) were designed to test for misinformation acceptance. Data for item 8 were inadvertently not recorded due to a programming error. Across all 1989 subjects, performance on the five accuracy items was 73.8 per cent.

Two questions were designed to assess whether subjects were influenced by misinformation. Only one of these items revealed a significant misinformation effect, the item about the colour of the vehicle that rushed towards the victim. Recall that the vehicle was blue, but misled subjects received a suggestion that it was white. The blue vehicle was seen in the film for a total of 8 seconds. Yet more than a quarter of the subjects claimed they remembered it as white. Control subjects were less likely than misled subjects to erroneously claim that they saw a white vehicle (26 per cent versus 31 per cent), $z = 2.39, p < .001$.

As mentioned, only one item showed a significant misinformation effect. In other studies involving multiple items of misinformation it is common to find large variations in the size of the misinformation, depending upon the type of item (e.g. Loftus and Banaji, 1989; Sheehan and Tilden, 1983; Tousignant, Hall and Loftus, 1986). Subsequent demographic analyses are based upon performance on the critical item, the blue (not white) vehicle, that did show the significant misinformation effect.

Age and performance

The sample contained subjects varying in age between 5 years and over 75. The relationship between age and performance on the accuracy items is shown in Figure 1. Because of small numbers of subjects in the 66–75 age range, and in the over 75 age range, these groups were combined. Also combined were data from the 5–7 and the 8–10-year-old groups. Figure 1 shows that performance rises as a function of age, up to the 26–35-year-old range, and then begins to fall. The most accurate subjects, the 26–35-year-olds ($n = 566$), performed statistically better than the least accurate subjects, the over 65-year-olds ($n = 43$), (77.3 per cent versus 56.3 per cent, $z = 4.59, p < .001$).

One interesting result emerged when the age groups were examined separately for males and females. The most striking result occurred in the 'over-65' group, where the elderly females significantly outperformed their male counterparts. In the over-65 group the mean accuracy score for 22 females was 69.1 per cent, versus 42.9 per cent for 21 males, $z = 1.73, p < .05$. Thus, relative to the males, the accuracy for females was much closer to the accuracy score for the entire sample (73.8 per cent).

We next examined the misinformation effect for different age ranges. A number of the age groups showed a significant misinformation effect, as can be seen in Table 1. For example, the youngest group (ages 5–10) showed a 19 per cent misinformation

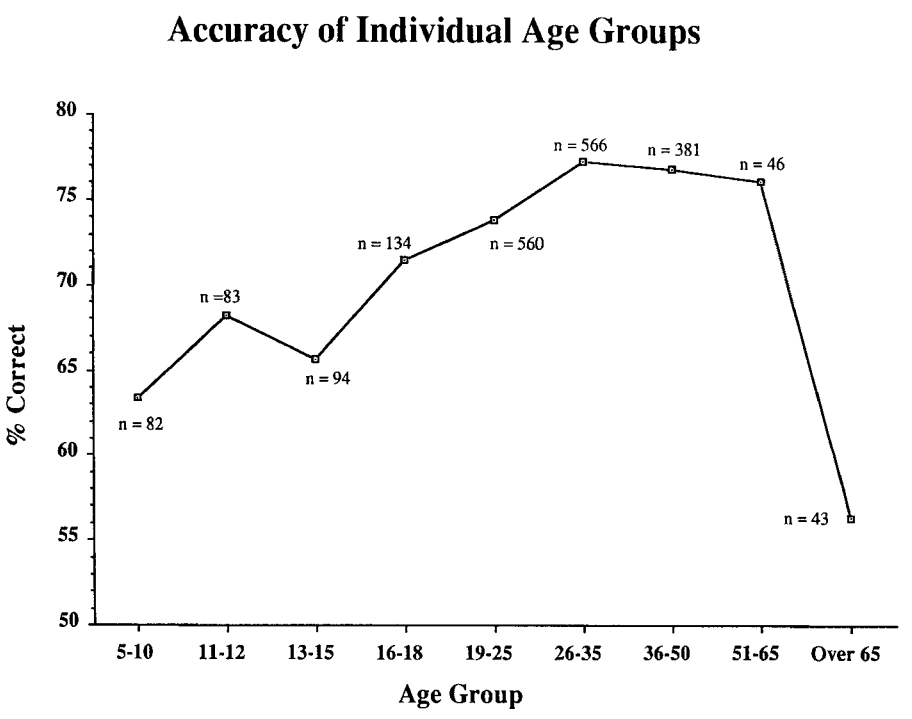

Figure 1. Accuracy of individual age groups

effect, and the oldest group (over 65) showed a 32 per cent misinformation effect. Sizeable misinformation effects were also seen in the 19–25-year-old group (14 per cent) and in the 26–35-year-old group (11 per cent). The misled subjects performed significantly more poorly than controls for the 5–10-year-olds, $z = 1.87$, $p < .05$; for the over 65-year-olds, $z = 1.94$, $p < .05$; for the 19–25-year-olds, $z = 3.68$, $p < .001$; and the 26–35-year-old subjects, $z = 2.65$, $p < .01$. Inexplicably the 46 subjects in the 51–65-year-old group showed a significant reverse effect.

Table 1. Percentage of subjects giving misinformation answer

Age group	Control		Misinformed	
5–10	18.9	(37)*	37.8	(45)
11–12	48.7	(39)	29.6	(44)
13–15	26.1	(46)	22.9	(48)
16–18	36.8	(76)	25.9	(58)
19–25	20.9	(254)	35.0	(306)
26–35	19.3	(264)	30.1	(302)
36–50	29.7	(199)	22.5	(182)
51–65	60.9	(23)	21.7	(23)
Over 65	38.5	(52)	70.0	(30)

* Figures in parentheses denote number for that cell.

In sum, the youngest and oldest subjects performed relatively poorly and were also relatively suggestible. This is consistent with the principle of discrepancy detec-

tion, that claims that relatively poor memory should be associated with greater suggestibility.

Education, occupation, and gender

The sample contained subjects who varied from having little educational background (i.e. grammar school) to extensive educational background (i.e. graduate school). Educational level influenced performance, in a positive direction. To demonstrate this relationship statistically, we grouped the three lowest educational levels together, and the proportion correct for this group was 70.0% ($n = 480$). The three highest educational levels were similarly combined, producing a percentage correct score of 75.7 per cent ($n = 1509$), which was statistically different, $z = 4.36$, $p < .001$.

Educational level did not significantly influence the size of the misinformation effect. For purposes of analysis we grouped the three lowest educational levels together and the three highest. The misinformation effect was roughly equivalent, about 4 per cent for the lower education subjects and about 6 per cent for the higher educated, a non-significant difference.

The sample contained subjects who varied in occupation. The performance score for each occupational group is shown in Table 2. Proportion correct ranged from a low of 65.3 per cent for the unemployed to a high of 76.5 per cent for those who classified themselves as 'trade/technical', $z = 2.40$, $p < .02$. Relatively poor performance was also exhibited by the lawyers (66.5 per cent). Of particular interest is the performance of the law enforcement group (68 per cent). No evidence exists here for the hypothesis that they have better memories than the average citizen (recall that overall performance was 73.8 per cent). To the contrary, a test combining the 105 lawyers and law enforcement persons showed that they performed less well than the rest of the population, $z = 2.64$, $p < .01$. Relatively good performance was exhibited by teachers (75.8 per cent) and by the artist/architect group (74.1 per cent); both groups performed slightly better than the average, but not statistically better.

In terms of the misinformation effect, for several occupational groups the number of subjects was too low to permit a meaningful interpretation of data. For example,

Table 2. Performance on the five accuracy items as a function of occupation

Occupation	Number of subjects	Percentage correct
Unemployed	60	65.3
Lawyer	80	66.5
Law enforcement	25	68.0
Retired	14	70.0
Student	786	73.6
Homemaker	53	74
Artist/architect	126	74.1
Scientist	109	74.7
Medical	126	75.1
Business	281	75.4
Teacher	118	75.8
Sales	67	76.4
Trade/technical	144	76.5

only five control subjects indicated that their occupation was 'law enforcement', and another five control subjects classified themselves as 'retired'. The remaining occupational groups are listed in Table 3, along with the misinformation effect for each group. The largest misinformation effect occurred for the 'artist/architects' (control = 16.7 per cent versus misled = 53.9 per cent, a difference of 37.2 per cent, $z = 4.14$, $p < .001$). While some other occupational groups showed a misinformation effect, only the 'medical' subjects showed a statistically significant effect in the direction of greater error for misled subjects, $z = 1.97$, $p < .05$. Inexplicably, the homemakers showed a reverse effect that reached statistical significance, $z = 2.82$, $p < .005$.

Table 3. Percentage of subjects giving misinformation answer

Occupation	Control		Misinformed	
Student	24.9	(394)*	28.1	(392)
Artist/architect	16.7	(48)	53.9	(78)
Teacher	32.7	(52)	34.9	(66)
Lawyer	29.2	(48)	25.0	(32)
Medical	16.7	(60)	31.8	(66)
Business	26.4	(140)	27.7	(141)
Trade/technical	25.6	(78)	19.7	(66)
Sales	21.4	(14)	35.9	(53)
Scientist	30.8	(52)	35.1	(57)
Homemaker	50.0	(30)	13.0	(23)
Unemployed	28.0	(25)	40.0	(35)

* Figures in parentheses denote number for that cell.

The gender of the subject did not affect accuracy. The sample contained 1162 males whose overall percentage correct was 73.4. For the 827 females the figure was 74.5 per cent, a non-significant difference, $z = 1.49$, $p > .10$.

When we examined the misinformation effect as a function of gender we found that males, but not females, were significantly misinformed. Male control subjects erroneously claimed that they saw a white vehicle less often than male misled subjects (25.5 per cent versus 33.4 per cent), $z = 2.95$, $p < .002$. On the other hand, female controls did not perform differently than female misled subjects (27.0 per cent versus 27.4 per cent), $z = .15$, n.s. Given that the critical suggestibility item was a vehicle, and males have been previously shown to be more interested and more accurate about vehicles (Powers, Andriks, and Loftus, 1979), we did not expect a gender difference in favour of females.

The college student and the rest of the world

Historically, researchers have wondered whether college students (or the proverbial college sophomores), the subjects of most psychological studies, are inherently different from the population at large. This demographic sample affords a unique opportunity to address this issue. To identify 'typical' college students from our sample, we examined the performance of subjects who were jointly members of three categories: They listed 'student' as their current occupation, they were in the 19–25-year-old

range, and they had 1–2 years of college. We found 115 such persons. For this set of subjects, performance on the accuracy items was 78.8 per cent, higher than all other occupational groups. To assess the significance of this level of performance, we compared college students (mean of 78.8 per cent) to all other participants in our sample (mean of 73.5 per cent) and found them to perform significantly better, $t(1987) = 2.73, p < .01$.

Of the 'typical college students', 57 were misinformed and 58 were not. One-third of the misled subjects (33.3 per cent) erroneously claimed they saw the white vehicle whereas 25.9 per cent of the control subjects erroneously did so, a difference of about 7 per cent, which is close to the figure obtained for the total sample. Thus, compared to the rest of the world, the typical college student tended to be more accurate, but comparably suggestible.

DISCUSSION

This unique opportunity to examine memory performance in a vastly heterogeneous group of subjects revealed a number of individual differences to relate to memory performance. Some of these variables influenced accuracy; others influenced suggestibility.

The principle of discrepancy detection provided us with *a priori* predictions. Prior research suggested the hypothesis that individuals who are generally less accurate about an event would be more likely to be influenced by misleading post-event suggestions. This would occur if those with initial low accuracy (for whatever reason) were less likely to detect a discrepancy as they were processing post-event inputs between those inputs and what was previously stored in memory. Our present results found that young children and the elderly were less accurate than their middle-aged counterparts. Moreover, they were highly influenced by the misleading suggestion. Thus the impact of age on memory performance fits well with the predictions of the principle of discrepancy detection.

Other findings did not fit well. Consider education: subjects with high levels of education were more accurate than those with low education, a result that was not surprising. The causal relationship between these variable is unknown. Whether those with good memories have enhanced opportunity for advanced education, or whether education improves memory skills, or whether some third variable (i.e. intelligence) is responsible for both good memory performance and advances in education cannot be known from the present research. In terms of suggestibility, the higher-educated respondents did not show greater resistance, although we might have predicted that they would have if they had stored a better initial memory in the first place.

The data on occupation similarly did not conform to the predictions of discrepancy detection. The college students were significantly more accurate than the rest of the population, but they were not less suggestible. Even more unexpected was the performance of the artists and architects. These respondents were accurate when not misled, but highly suggestible in the face of misleading information. Why? We can only speculate that this finding may have something to do with a preference for imagery or an ability to image vividly. Imagery is known to play a powerful role in memory, particularly in the encoding and representation of visual information. People who are good visualizers may be better at maintaining or reinstating a visual memory. One would have thought, then, that they would be better able to resist

misleading information. But perhaps their visual skills enable them to convert verbal misinformation into a visual image, thereby rendering it confusable with an actual perception. Their visual ability could then explain their good performance in the absence of misleading information, and their relatively poor performance when they have been exposed to misinformation. These notions derive support from earlier findings of Tousignant (1984) that female college students with vivid imagery were more susceptible to misleading suggestions than females with poor visual imagery.

In sum, we have conducted one of the largest studies of individual differences in memory to be found in the recent literature. Moreover, to our knowledge, it is the largest study of individual differences in memory distortion. Despite the potential contribution of these data to the vast literature on individual differences, we must acknowledge some flaws in the present study. We were enthusiastic about conducting our research in a setting that would provide access to a vastly heterogeneous sample of people, namely attendees at a science museum. (By the way, we were not the first psychologists to think of gathering data from this type of setting. Back in 1884 Sir Francis Galton, the British pioneer experimental psychologist, was also interested in individual differences—albeit in another domain. He set up his Anthropometric Laboratory at the International Health Exhibition and later transferred to the South Kensington Museum in London. During the life of his 'laboratory' he collected data from 9337 people—Boring, 1950; Johnson, McClearn, Yuen, Nagoshi, Ahern, and Cole, 1985; Pearson, 1924).[1]

One problem with the science museum as a vehicle for data collection is that many variables are uncontrolled. In this piece of museum research we had no control over how close the participants stood to the television screen, how long the retention interval between the film and the test was, and how much interaction between participants took place. Participants could have taken the test several times, for all we knew. We tried to remove their data from the analysis by asking them to indicate if they had been through the 'test' before, and only including those who said 'no'. But a subject may have falsely answered 'no', so we cannot guarantee that a person did not get counted twice. It is conceivable that person 1 watched person 2 take the test, and then sat down to be tested himself. He could have seen the debriefing statement, and thus been more vigilant about the misinformation. This would partially explain the relatively small misinformation effect that was obtained here relative to most misinformation studies in the literature. With all the uncontrolled variables with which we contended, it is in some ways remarkable that such orderly data were produced.

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[1] Galton's subjects paid threepence to participate in his research. Unfortunately, this method of grant funding never occurred to us.

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REFERENCES

Ainsworth P.B. (1981). Incident perception by British police officers. *Law and Human Behavior*, **5**, 231–236.

Bartlett, J. C. and Leslie, J. E. (1986). Aging and memory for faces versus single views of faces. *Memory and Cognition*, **14**, 371–381.

Baxter, J. (1990). The suggestibility of child witnesses: A review. *Applied Cognitive Psychology*. (Impress).

Boring, E. G. (1950). *A history of experimental psychology*, (2nd edn.) New York: Appleton-Century Crofts.

Ceci, S. J., Toglia, M. P. and Ross, D. F. (1988). On remembering ... more or less: a trace strength interpretation of developmental differences in suggestibility. *Journal of Experimental Psychology; General*, **117**, 201–203.

Clifford, B. R. (1976). Police as eyewitnesses. *New Society*, **36**, 176–77.

Cohen, R. L. and Harnick, M. A. (1980). The susceptibility of child witnesses to suggestion: an empirical study. *Law and Human Behavior*, **4**, 201–210.

Davies, G. M., Tarrant, A. and Flin, R. (1989). Close encounters of a witness kind: children's memory for a simulated health inspection. *British Journal of Psychology*, **80**, 415–429.

Dent, H. R. (1988). Children's eyewitness evidence: a brief review. In M. M. Gruneberg, P. E. Morris, and R. N. Sykes (eds), *Practical aspects of memory: current research and issues*, Vol 1. (pp. 101–106). Chichester: Wiley.

Doris, J. (ed.) (in press). *The Cornell Conference on Children's Suggestibility*. Washington, DC: APA.

Farrimond, T. (1968). Retention and recall: incident learning of visual and auditory material. *Journal of Genetic Psychology*, **113**, 155–165.

Goodman, G. S. and Reed, R. S. (1986). Age differences in eyewitness testimony. *Law and Human Behavior*, **10**, 317–332.

Hall, D. F., Loftus, E. F. and Tousignant, J. P. (1984). Postevent information and changes in recollection for a natural event. In G. Wells and E. Loftus (eds), *Eyewitnesses testimony: psychological perspectives*, (pp. 124–141). Cambridge: Cambridge University Press.

Howells, T. H. (1938). A study of ability to recognize faces. *Journal of Abnormal and Social Psychology*, **33**, 124–127.

Johnson, R. C., McClearn, G. E., Yuen, S., Nagoshi, C. T., Ahern, F. M. and Cole, R. E. (1985). Galton's data a century later. *American Psychologist*, **40**, 875–892.

King, M. S. and Yuille, J. C. (1987). Suggestibility and the child witness. In S. J. Ceci, M. P. Toglia, and D. F. Ross (eds), *Children's eyewitness memory*, (pp. 24–35). New York: Springer-Verlag.

List, J. (1986). Age and schematic differences in the reliability of eyewitness testimony. *Developmental Psychology*, **22**, 50–57.

Loftus, E. F. (1984). Eyewitness: essential but unreliable. *Psychology Today*, February, pp. 22–26.

Loftus, E. F. and Banaji, M. R. (1989). Memory modification and the role of the media. In V. A. Gheorghiu, P. Netter, J. J. Eysenck, and R. Rosenthal (eds), *Suggestibility: theory and research*, (pp. 279–294). Berlin: Springer-Verlag.

Loftus E. F. and Davies, G. M. (1984). Distortions in the memory of children. *Journal of Social Issues*, **40**, 51–67.

Loftus, E. F., Banaji, M. R., Schooler, J. W. and Foster, R. A. (1987). Who remembers what? Gender differences in memory. *Michigan Quarterly Review*, **XXVI**, 64–85.

Maccoby, E. E. and Jacklin, C. N. (1974). *The psychology of sex differences*. Palo Alto: Stanford University Press.

McIntyre, J. S. and Craik, F. I. M. (1987). Age differences in memory for item and source information. *Canadian Journal of Psychology*, **41**, 175–192.

Moston, S. and Engleberg, T. (1990). The effects of social support on children's eyewitness memory. *Applied Cognitive Psychology*, (In press).

Pearson, K. (1924). *The life, letters, and labours of Francis Galton*: Vol 2: *Researches of middle life*. London: Cambridge University Press.

Pezdek, K. (1987). Memory for pictures: A life-span study of the role of visual detail. *Child Development*, **58**, 807–815.

Powers, P. A., Andriks, J. L. and Loftus, E. F. (1979). The eyewitness accounts of females and males. *Journal of Applied Psychology*, **64**, 339–347.

Rabbitt, P. (1989). Learning to make an exhibition of ourselves. *Psychologist*, **2**, 56–57.

Rubenstein, C. (1982). Psychology's fruit flies. *Psychology Today, July*, pp. 83–84.

Shapiro, P. N. and Penrod, S. (1986). Meta-analysis of facial identification studies. *Psychological Bulletin*, **100**, 139–156.

Sheehan, P. W. and Tilden, J. (1983). Effects of suggestibility and hypnosis on accurate and distorted retrieval from memory. *Journal of Experimental Psychology: Learning, Memory and Cognition*, **9**, 283–293.

Smith, A. D. and Winograd, E. (1978). Adult age differences in remembering faces. *Developmental Psychology*, **14**, 443–444.

Tickner, A. H. and Poulton, E. C. (1975). Watching for people and actions. *Ergonomics*, **18**, 35–51.

Tousignant, J. P. (1984). Individual differences in response bias and recall: A characterization of the effects of misleading post-event information. Doctoral dissertation, University of Washington.

Tousignant, J. P., Hall, D. and Loftus, E. F. (1986). Discrepancy detection and vulnerability to misleading post-event information. *Memory and Cognition*, **14**, 329–338.

Wells, G. L. and Loftus, E. F. (eds) (1984). *Eyewitness testimony: psychological perspectives*. Cambridge: Cambridge University Press.

Wilkinson, J. (1988). Context effects in children's event memory. In M. M. Gruneberg, P. E. Morris, and R. N. Sykes (eds), *Practical aspects of memory: Current research and issues*. Vol. 1 (p. 107–111). Chichester: Wiley.

Yarmey, A. D. (1986). Perceived expertness and credibility of police officers as eyewitnesses. *Canadian Police College Journal*, **10**, 31–52.

Yarmey, A. D. and Jones, H. P. T. (1983). Is the psychology of eyewitness identification a matter of common sense? In S. M. A. Lloyd-Bostock and B. R. Clifford (eds) *Evaluating witness evidence*, (pp. 13–40). Chichester: Wiley.

Yarmey, A. D. and Kent, J. (1980). Eyewitness identification by elderly and young adults. *Law and Human Behavior*, **4** 359–371.

Yuille, J. C. (1984). Research and teaching with police: a Canadian example. *International Review of Applied Psychology*, **33**, 5–24.