

Pigeons, Rats, and Humans Show Analogous Misinformation

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In three experiments, we show that pigeons, rats and humans can be influenced by misleading postevent information in ways analogous to findings in the human memory distortion literature. We used a delayed matching to sample analog of the eyewitness testimony procedure from Loftus et al. (1978), and varied the length of the delay between event and exposure to postevent information (PEI). We also varied the nature of PEI so that it was consistent with the event information, inconsistent, or neutral. In Experiment 1, pigeons' memory performance for colored lights was influenced by the presence of another colored light. In Experiment 2, rats' memory performance for lever position was influenced by position-related cue lights. In Experiment 3, we verified the validity of our analog procedure by having human subjects remember kaleidoscope images. Despite differences in species and the nature of the stimuli, all three experiments replicated key findings in the literature: memory accuracy was highest when consistent PEI was presented at the end of a delay, and lowest when inconsistent PEI presented at the end of a delay interval. PEI had no effect when presented at the beginning of a delay.

One of the basic tenets of animal cognition research is that many of the mechanisms that govern human behavior also govern nonhuman behavior. Animals have demonstrated the ability to form concepts (Herrnstein, 1979; Honig & Stewart, 1988), measure the passage of time (Killeen & Fetterman, 1988; Roberts, 1981) and to learn by observation (Heyes, Jaldow, Nokes, & Dawson, 1994). Some have even learned to use human forms of communication (Savage-Rumbaugh, Pate, Lawson, Smith, & Rosenbaum, 1983). But what do we know about animal memory, and how is it like human memory?

Like humans, animals can correctly remember and discriminate large quantities of visual information. Vaughan and Greene (1983, 1984) showed pigeons hundreds of pictures of various scenes, pairing some pictures with reinforcers and others with no reinforcers. Later, the pigeons were more than 90% accurate in recognizing the reinforced pictures. In fact, two years later, they were still more than 70% accurate. We also know that animals display many of the same phenomena that have been demonstrated in the human memory literature, including the ability to show object permanence (Pepperberg & Funk, 1990), retroactive interference effects (Harper & White, 1997; White, 1985), the influence of prior learning on subsequent memory performance (Edhouse & White, 1988), serial position effects (Harper, McLean, & Dalrymple-Alford, 1993; Wright, Santiago, Sands, Kendrick, & Cook, 1985), and are able to make use of mediating behavioral strategies to enhance accuracy (Harper & Bizo, 2000).

Clearly, all animal species display the ability to form accurate memories of relatively simple and even more complex experiences. However, humans are also

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prone to memory distortion, especially when they are exposed to misleading postevent information (PEI). In this distortion, known as the *misinformation effect* (Belli 1989), when subjects are misled about a previously witnessed event they often integrate these misleading suggestions into their accounts of the event. Do animals experience eyewitness memory distortions? The answer is ‘yes’. Recently, we adapted the classic Loftus paradigm (Loftus, Miller, & Burns, 1978) for pigeons. In the standard paradigm, there are three stages. First, subjects watch a visual presentation of an event (such as a simulated crime or accident). Next, after a filler task designed to thwart rehearsal, they are exposed to detailed PEI in a narrative summarizing the original event. Some of the PEI is misleading, while some is not. Finally, subjects are tested about what they saw originally. Decades of research producing hundreds of experiments have demonstrated that inaccurate PEI can bias memory reports in line with the misleading postevent suggestions. (Belli, 1989; Lindsay & Johnson, 1989; Lindsay, 1990; Loftus & Palmer, 1974; McCloskey & Zaragoza, 1985; Mitchell & Zaragoza, 2001). In our research (Harper & Garry, 2000), we showed that pigeons make eyewitness errors that mirror the ones humans make (Loftus et al., 1978). That is, misleading PEI was most likely to lead pigeons to report an incorrect target event when it was presented at the end of a delay. Our results also correspond with those found in the more recent human eyewitness memory literature (Belli, Windschitl, McCarthy, & Winfrey, 1992; Sutherland & Hayne, 2001; Vornik, Sharman, & Garry, , 2003).

The fact that pigeons and humans respond the same way to misleading PEI has at least two important theoretical implications for the study of human memory. First, our results suggest that demand characteristics play only a limited role in misinformation effects (see also Belli, 1989). After all, pigeons are somewhat unlikely to be behaving on the basis of what they believe the experimenter wants them to do. Second, our results were similar to those found with other nonverbal creatures: human infants, whose results were in turn similar to those found with children and adults (Rovee-Collier, Adler, & Borza, 1994). The striking consistency across creatures prompted us to recall Rovee-Collier’s (1997) suggestion that when it comes to memory theorizing it is time to simplify our view of the universe. Such a view is similar to that put forth by Wasserman (1993), who—in reviewing a century of comparative cognition and discussing its relevance in the future—concluded that when we gather more evidence on the abilities of animals, we gather more evidence about what mechanisms drive similar abilities in humans.

In this paper, we had two broad goals. First, we wanted to examine whether an animal model of the human misinformation task would produce results consistent with the wider human misinformation literature. Second, having developed an animal analog, we wanted to evaluate the extent to which it is a good analog by subjecting it to “backward translation;” that is, by seeing if human subjects using our animal analog would perform similarly to humans from the Loftus et al. studies.

In this paper, we present three experiments in which we developed a delayed matching to sample (DMTS) analog to a misinformation task. The DMTS we used

is common in the animal memory literature. If we found that the patterns of results in all experiments were similar, and the pattern of results in Experiment 3 were similar to those found in the original Loftus et al. (1978) work from which the three experiments derived, then we would have strong evidence for the cross-species continuity of memory and memory distortions.

Experiment 1

Method

Subjects

Six individually housed adult homing pigeons, who had no prior experience in conditional discrimination tasks, were maintained at 80%-85% of their free-feeding weights. They received supplementary feed after the final session each day to maintain prescribed body weights.

Apparatus

A sound-attenuating chamber, measuring 32 x 34 x 32 cm, contained an interface panel with a centrally mounted grain hopper and three response keys. One response key was mounted directly above the hopper, and the other two keys were mounted above and to either side of the hopper. Each key could be illuminated one of three colors from behind: red, green or yellow. A ventilation fan at the rear of the chamber helped mask extraneous sounds.

Procedure

Training. Pigeons were trained for approximately 3 months before we collected baseline data. In the preliminary training phase, they were first trained to peck when the keys were illuminated, and received access to a wheat reinforcer. Next, pigeons were trained in an abbreviated version of the adapted three stage misinformation procedure in which the postevent information (PEI) stage was omitted. That is, pigeons were trained to witness a target event stimulus and then, after a nominal 0.2 s delay, choose between this original event and another stimulus.

Figure 1 shows our specific two-stage training adaptation of the Loftus et al. (1978) misinformation procedure. The event was a central key, lit from behind by either a green light, or, as Figure 1 shows, a red light. Light color order was randomized across trials. After pigeons pecked the key five times, the light turned off and initiated a delay. During the delay, the chamber was dark and responses were ineffective. Delay intervals were randomized across trials with the constraint that a particular delay did not repeat until the other delays had occurred for a given color.

At the end of the delay, subjects were presented with the two side-key comparison stimuli and had to choose between the original event color (in this example, red) and the non-target color (in this example, green). A single peck at the key corresponding to the correct event color resulted in 3 s access to grain. An incorrect response (a peck to the non-target color) resulted in 3 s time out, in which no food was available, and all keys were darkened. Note that in this phase of training and during the subsequent experimental phase that red and green stimuli were presented equally often on either the left or right during comparison stimulus presentation.

Once subjects displayed at least 70% accuracy for at least 5 consecutive sessions, delays lengthened from 0.2 s to 2.5 s, then to 7.5, and finally to 20.0 s. The actual experiment began after all pigeons displayed consistent performance such that the overall percent correct showed no obvious trends across sessions. Sessions were conducted 7 days per week and comprised 84 trials or lasted 50 min, whichever occurred first.

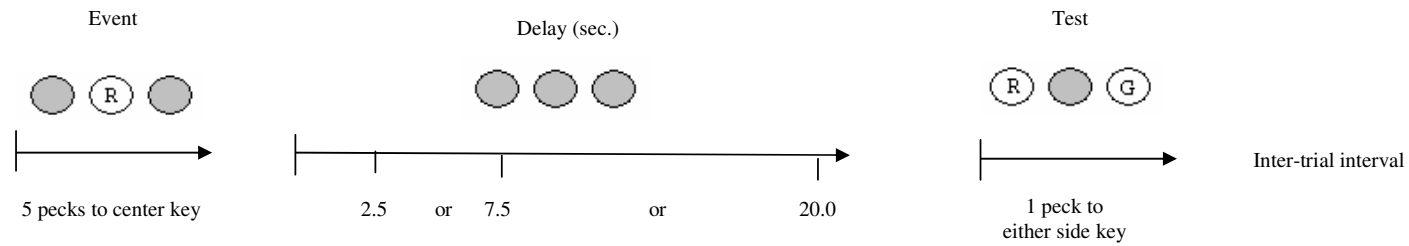


Figure 1. Sequence of events comprising a trial in the basic DMTS recognition task used with pigeons in Experiment 1. Pigeons were trained in this task prior to examining effect of PEI as illustrated in Figure 2. Each circular disc represents a key on the front wall of a response chamber. 'R' and 'G' indicate that the key was illuminated 'red' or 'green' respectively; otherwise a given key remained unlit.

Experiment. In the experimental phase, we examined the effect of PEI by adding that stage to our adapted two-stage procedure by introducing a colored stimulus light either at the start or end of the delay interval. Figure 2 shows a hypothetical trial in which the to-be-remembered sample stimulus is red. Trials comprised the following sequence of events:

1. **Sample presentation.** First, the event stimulus was presented via the central sample key: it was illuminated either red or green. The subject's 5 peck response initiated the delay interval.
2. **Delay Interval.** During the delay interval, there were two conditions presented. Subjects in the *end-of-delay* condition, shown along the upper branch of Figure 2, were exposed to PEI after 2.5, 7.5, or 20.0 s. Subjects in the *beginning-of-delay* condition, shown on the bottom branch of Figure 2, were exposed to PEI was presented immediately after the fifth peck, followed by a delay of either 2.5, 7.5, or 20.0 s. In both delay conditions, a single peck was required on the center key displaying the PEI before the trial proceeded any further.
3. **Forced-Choice Test.** The two side comparison lights were illuminated (one red and the other green) for the forced-choice test after the delay interval had been completed and the subject had responded to the key with the PEI. To gain access to 3 s of grain, pigeons were required to peck once at the key corresponding to the original to-be-remembered color stimulus. An incorrect choice resulted in 3 s of time out. Both correct and incorrect responses were followed by a 27 s interval before the next trial began.

Three pigeons received the end-of-delay condition first, and the other three pigeons received the beginning-of-delay condition first. Each condition contained all three types of trials (described below); each pigeon received both conditions, and each condition lasted for 30 sessions.

In both delay conditions, we varied the relationship between event and PEI in one of three ways (cf. Loftus et al., 1978). In a *Consistent* trial, the event stimulus and the PEI were the same color. In an *Inconsistent* trial, the event and PEI were different colors. Finally, in a *Neutral* trial, the PEI was yellow, regardless of the event color (recall that yellow was never used in the event or test phases). An approximately equal number of *Consistent*, *Inconsistent* and *Neutral* trials were conducted per session in a randomized order with the constraint that no more than four consecutive trials were of the same type.

Results and Discussion

For these analyses, we used percent correct responses made over the last 5 sessions of each condition, separated according to trial type (*Consistent*, *Inconsistent*, or *Neutral*) and delay (2.5, 7.5, or 20.0 s). Recall that the major question in this experiment was whether pigeons would be influenced by misleading PEI when assessed with a modified test. As the top of Figure 3 shows, they were. The top graph indicates a general decrease in accuracy as the delay increased, regardless of trial type. More to the point, subjects were most accurate when exposed to consistent PEI, but least accurate when exposed to misleading PEI. A repeated measures analysis of variance (ANOVA) comparing trial type by delay showed a main effect for trial type, $F(2,10) = 240.5$, $p < 0.01$, and delay, $F(2,10) = 11.8$, $p < 0.01$, on accuracy.

Although PEI at the end of a delay produced a misinformation effect, research suggests that PEI should have much less of an effect at the start of a delay (Loftus et al., 1974). Indeed, the bottom graph in Figure 3 shows only a general decrease in accuracy as delay length increased. A repeated measures ANOVA comparing trial type by delay showed a main effect for delay, $F(2,10) = 14.9$, $p < 0.01$, on accuracy, but no effect for trial type, $F(2,10) = 1.8$, $p > 0.05$.

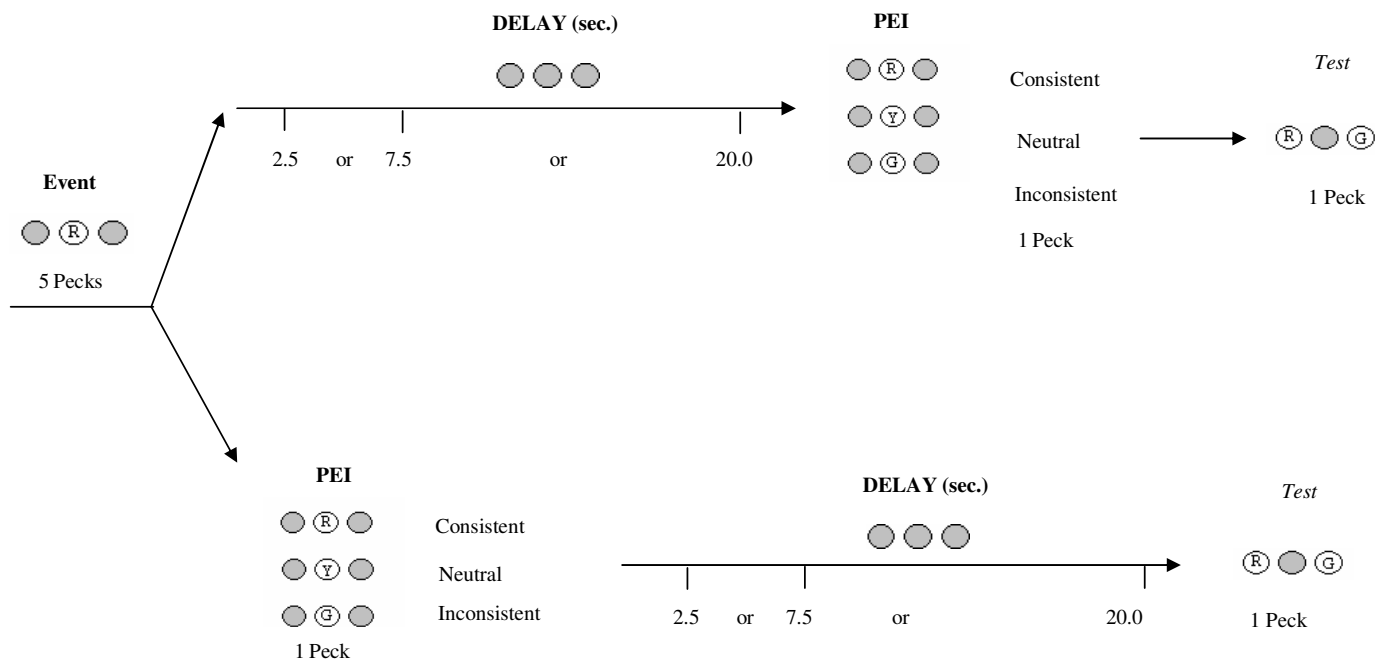


Figure 2. Sequence of events comprising a trial in the adapted DMTS task used to examine the effects of PEI on pigeon recognition performance. Each circular disc represents a key on the front wall of a response chamber. 'R', 'G', and 'Y' indicate that the key was illuminated 'red', 'green', or 'yellow' respectively. The top pathway indicates the sequence of events when PEI was presented at the end of the delay interval, and the lower pathway indicates the sequence of events when PEI was presented at the beginning of the delay interval.

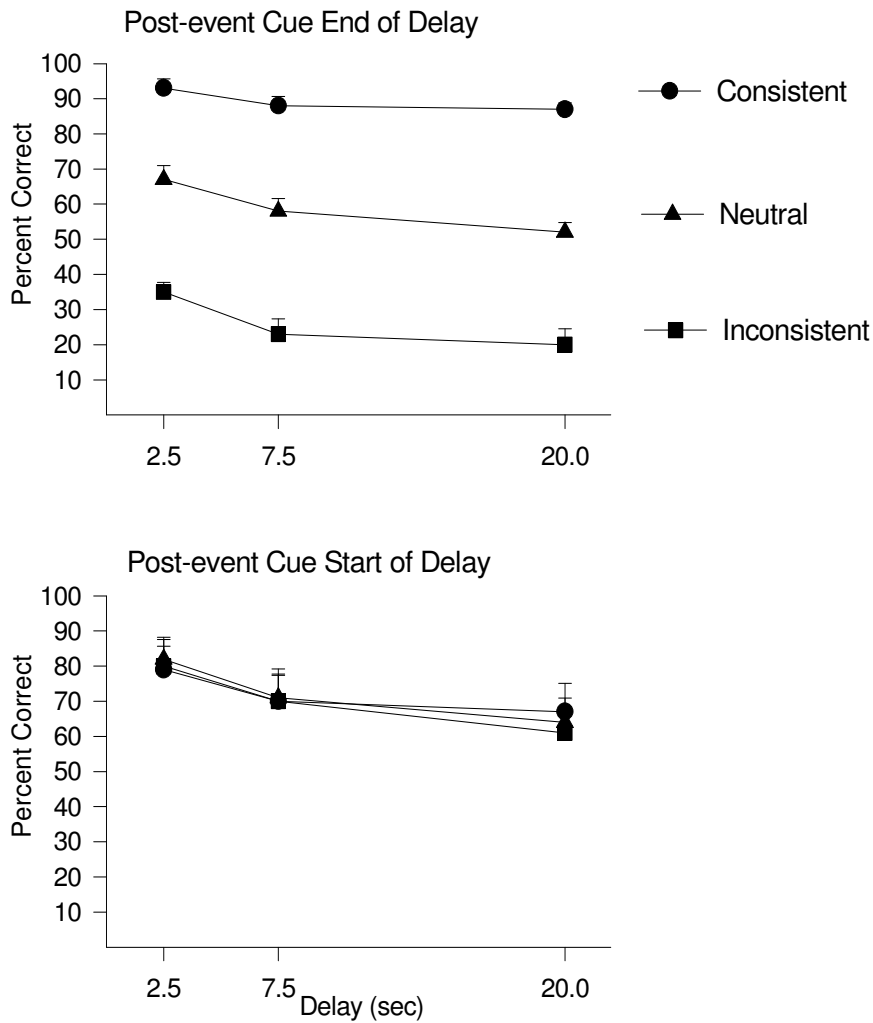


Figure 3. Mean percent correct as a function of delay in Experiment 1 when the PEI was presented at the end of the delay (top graph) or start of the delay (lower graph). Accuracy is shown separately for *Consistent*, *Neutral*, and *Inconsistent* trials. Error bars show standard error of the mean.

Overall, in both conditions, accuracy systematically decreased as the delay between the sample stimulus and subsequent recognition increased. The rate of this decrease in accuracy across delays was not affected by the different types of PEI presented either at the beginning or the end of the delay period (there was no interaction between the effect of delay and trial type on accuracy, $F(4,20) = 0.8, p > 0.05$; $F(4,20) = 1.2, p > 0.05$, respectively). Whether PEI had an effect on overall

accuracy (regardless of delay) depended on whether it occurred at the beginning or end of the delay interval. That is, PEI had no effect on accuracy when presented at the beginning of the delay, but it had a large effect when presented at the end of the delay interval.

In short, Experiment 1 demonstrated that recognition performance in pigeons could be biased by exposure to PEI, suggesting that not only humans show a misinformation effect using a modified test. However, one criticism of Experiment 1 is that it relied on the visual mode only, whereas human misinformation effects occur when memory for event information presented in one modality (such as images) is influenced by PEI presented in another modality (such as text). Additionally, in Experiment 1, we changed the entire stimulus (in other words, the entire event), not just aspects of the stimulus array, as is the case in human misinformation research. These two aspects of the procedure used in Experiment 1 also may lead us to wonder whether the misinformation effect observed here is truly analogous to the effect observed with humans.

Another procedural concern is whether the presence of the PEI at the beginning versus end of the delay period effectively produces an alteration in other structural elements of the task beyond the intended simple alteration in temporal location of the PEI stimulus. For example, the PEI may have had no effect when presented at the beginning of the delay because the PEI was overshadowed by the target stimulus. In other words, the subject may effectively have treated the PEI as a continuation of the target stimulus, rather than as a distinct new stimulus event. Given that the target stimulus was present for 5 pecks, and the PEI only present for one peck, then we would expect the target stimulus to have a stronger representation in memory than the PEI, and cause the results we observed. By contrast, when the PEI occurred at the end of the delay, subjects may simply have treated it as the start of a new trial; that is, treated the PEI as a new target stimulus. Thus, because the PEI and target stimuli share so many characteristics, pigeons may simply not have noticed the PEI, or treated it as the start of a new trial. Despite these potential concerns it should be noted that in the 'neutral' condition accuracy at the 2.5 s delay was around 70%. However, if subjects were treating the PEI at the end of the delay as a signal for the start of a new trial, we would have expected accuracy to be around 50% in this condition - which it was not.

In Experiment 2 we sought to further explore the existence of an analogous misinformation effect in another species as well as address the issue of whether a misinformation effect would still arise in a non-human species if the PEI was only associated with (rather than identical to) the original target event. In Experiment 2, therefore, we exposed rats to a visual-spatial event in which we manipulated only a portion of the stimulus array, the position of a lever. Then we exposed them to PEI by flashing a light to cue the rat about the lever's position. Sometimes the PEI was accurate, and sometimes it was inaccurate. We chose rats as our subjects in Experiment 2 because their good visual-spatial abilities made it possible to vary aspects of the event and PEI on multiple modalities.

Experiment 2

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Method

Subjects

Five adult Norway Hooded rats (6 months old at the start of training), with no prior experience in conditional discrimination procedures, were maintained at 80% - 85% of their free-feeding body weights. Supplementary feed was given after the final session of the day to maintain prescribed body weights. Water and untreated wood shavings were available continuously in the homecages. The housing room was maintained at a constant 22°C with lights off between 7:00 AM and 7:00 PM.

Apparatus

Rats were trained individually in a single response chamber, measuring 31 x 32 x 24 cm. Three manipulanda were available; with a single 12W red light mounted above each one. Two retractable levers were located on both the left and right sides of the front interface panel. A third, non-retractable lever was located in the middle of the opposite wall. Reinforcers (0.1 ml of sweetened milk-water mixture) were delivered at floor level in the center of the panel via a dipper mechanism. All experimental events were scheduled and recorded by an IBM[®]-compatible computer running MED-PC[®] software.

Procedure

Recognition performance was assessed at three different delays using an automated DMTS procedure similar to that used with the pigeons except that the event was comprised of retractable levers with a plain white light above each instead of colored lights. Sessions were conducted daily, five days per week, for 64 trials per day or until 48 minutes had elapsed. After preliminary training to respond on the levers, baseline training began. Baseline trials comprised the following sequence of events:

1. **Sample presentation.** Either the left or right lever was inserted randomly into the chamber. If the left lever was inserted, the left light was illuminated. If the right lever was inserted, the right light continuously flashed on and off (with a 0.25/0.25 s on/off cycle). Following three presses on the inserted lever, it was retracted and the corresponding light was switched off.
2. **Delay interval.** A variable delay was initiated that ended with the first rear-lever response after a predetermined time period had elapsed. The scheduled delays were 3.0, 6.0 and 12.0 s. The delays for each trial type (i.e., left or right-lever sample stimulus) were selected on a pseudo-random basis, which ensured that each duration was used equally often for each type of trial.
3. **Forced-choice test.** After the delay, both the left and right front levers were inserted into the chamber. As soon as a single response was made on either of the levers they were retracted. If the response was to the lever that was inserted as the sample stimulus at the beginning of the trial, (i.e., a correct response) a reinforcer was delivered. If the response was made to the other lever, the response was counted as an error and was not reinforced. After 2.5 s of dipper availability (following a correct response) or 2.5 s of time-out (following an error response), a 5 s inter-trial interval began during which the chamber was darkened. Upon completion of the inter-trial interval a new trial was initiated.

Approximately 80 sessions of baseline training were conducted before experimental probe sessions were introduced. During the experimental phase every fifth session was a probe session that assessed the impact of PEI on recognition performance (the remaining sessions were identical to the baseline sessions outlined above). The effects of PEI were examined across two conditions, both of which consisted of three types of trial, as outlined in Experiment 1.

Each rat received both conditions, and each condition was comprised of five probe sessions. In the end-of-delay condition, the PEI was the illumination of a light. Either the left light was

illuminated for a period of 3 s after the delay period had timed out, or the right light was flashed on and off (0.2 s on / 0.25 s off) for 3 s after the delay period had timed out. The beginning-of-delay condition was identical except that the PEI was presented prior to the start of the delay period. After the PEI was presented, the trial proceeded as outlined for baseline trials.

As in Experiment 1, both conditions consisted of approximately equal numbers of trials categorized as either *Consistent*, *Inconsistent* or *Neutral*, depending on the relationship among the sample stimulus, the PEI and the choice stimuli. If the initial sample-event stimulus (left lever plus left light) was consistent with the postevent cue (i.e., left light at the start or end of the delay), then the trial was a *Consistent* trial. If the initial sample stimulus was inconsistent with the postevent cue (i.e., flashing *right* light during in the delay), then the trial was *Inconsistent*. Finally, if the initial sample stimulus was followed by no illumination of either the left or right lights then the trial was a *Neutral* trial.

Results and Discussion

The central question in Experiment 2 was whether rats would show the same pattern of memory distortions about a visuospatial event as pigeons did about a single modality event. To answer this question, we classified percent correct responses made over the five probe sessions of each condition according to trial type (*Consistent*, *Inconsistent*, or *Neutral*) and delay (3, 6, or 12 s). The top graph in Figure 4 reveals two obvious trends in the data. First, there was a general decrease in accuracy as the delay increased, regardless of trial type. Second, accuracy was greater overall on consistent PEI trials and poorest overall on inconsistent PEI trials. A repeated-measures ANOVA comparing trial type by delay showed a significant main effect of trial type, $F(2,8) = 19.6$, $p < 0.01$, and delay, $F(2,8) = 33.9$, $p < 0.01$, on accuracy but no interaction $F = 1.1$.

As was the case in Experiment 1, the bottom of Figure 4 shows no effect for trial type, and only a general decrease in accuracy as delay length increased; an ANOVA showed an effect on accuracy as delay length increased, $F(2,8) = 4.5$, $p < 0.05$, no interaction between delay and trial type, $F = 1.9$, and no clear difference on accuracy as a product of trial type, $F = 1.2$.

To recap, the pattern of results observed in Experiment 1 with pigeons was replicated in Experiment 2 using multimodal stimuli, and using rats. As in Experiment 1, the lowest levels of accuracy occurred when the PEI was inconsistent with the target sample stimulus, and when the PEI was introduced at the end of a delay. Taken together, Experiments 1 and 2 strongly suggest that a number of animal species can be biased towards reporting incorrectly that a certain stimulus was presented when it was not.

However, we might be criticized for having designed a poor analog of the human misinformation method, because there were at least three differences between our methods using animal subjects and the methods typically used with human subjects. First, human misinformation studies do not typically expose subjects to a large number of repeated trials, as we did in Experiments 1 and 2. Second, humans usually have a delay interval far longer than what we used in our experiments, usually on the order of 10 - 20 minutes. It may be that although pigeons and rats displayed biased performance in our analog procedures, humans would not. Perhaps given multiple trials and very short delays, they would quickly

learn to ignore the biased PEI we presented. Third, human misinformation experiments use quite complex "real life" stimuli, such as a video of a car accident, or a slide sequence of a theft. Our experiments, on the other hand, used very basic stimuli. Perhaps if we used our analog procedure with human subjects, they would fail to be misled at all by the simple abstract stimuli.

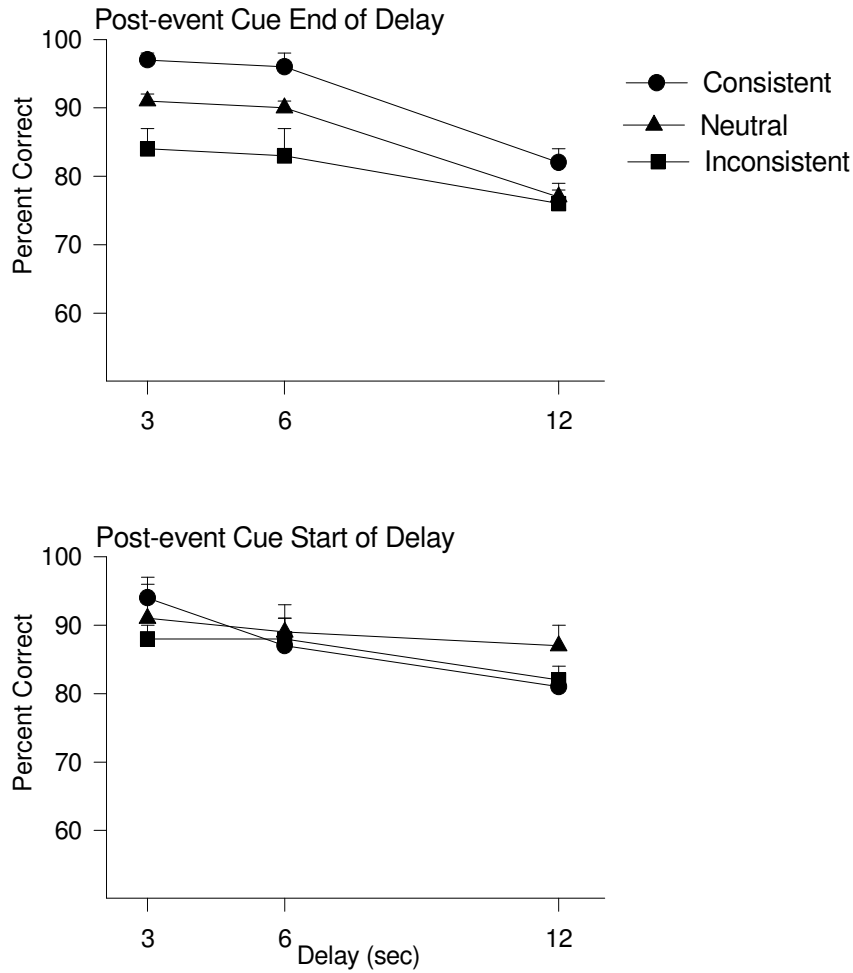


Figure 4. Mean percent correct as a function of delay in Experiment 2 when the PEI was presented at the end of the delay (top graph) or start of the delay (lower graph). Accuracy is shown separately for *Consistent*, *Neutral*, and *Inconsistent* trials. Error bars show standard error of the mean.

To address these differences, in Experiment 3 we took the basic elements of our tasks from Experiments 1 and 2—which we had translated from the basic elements of a human misinformation task—and "back translated" them into a simple human misinformation task. That is, we exposed human subjects to repeated trials, using a limited pool of kaleidoscope images and relatively short delays. Our aim was to create a task that was more like the animal tasks, but still complex enough so that our human subjects could not assign verbal labels to aspects of the stimulus array. After all, pigeons do not have the advantage of labeling a stimulus as "red light" to facilitate encoding and retrieval. The main question we ask in Experiment 3 is whether the patterns we observed in Experiments 1 and 2 would also emerge with our human adaptation. If the answer is yes, then we have evidence that misinformation effects occur across species.

Experiment 3

Method

Subjects

Thirty students (age range 18 to 38 years) responded to recruiting fliers. They were equally allocated to one of two conditions (described below), and were given \$5 for their participation.

Apparatus

All experimental events were presented on IBM®-compatible 486 computers using SuperLab® software. The background screen color was white at all times.

Procedure

Recognition performance was assessed at two delays using a computerized DMTS procedure similar to that used in the previous experiments with the following exceptions. First, instead of either colored lights or lever position serving as target stimuli, we used black and white kaleidoscope images. Second, we collected data in a single session comprised of 70 trials and lasting approximately 25 minutes. Before starting the experiment participants were told that they would be performing a memory task and that they were required to remember kaleidoscope images. They were asked to pay careful attention to the screen and the images that appear on it at all times. Subjects were asked to remember the four images presented simultaneously at the beginning of the trial. They were told that their task was to report which of the two images presented after a short delay was the same as one of the images seen at the start of the trial.

Our three-stage adaptation of the DMTS/misinformation procedure involved the following sequence:

1. **Sample presentation.** At the start of a trial, subjects saw an array of four black and white kaleidoscope images on the screen for a total of 1.5 s. The four images were arranged equidistantly around the center point of the computer screen with a boundary of 1 cm of white space separating the edges of the individual images. Each image in the array was 5 cm high by 5 cm wide.
2. **Delay and PEI.** After the sample image disappeared, a delay period began. The delay lasted for either 4 s or 12 s, randomly determined. Subjects were asked to pay attention to the screen at all times. During the delay, the PEI appeared in the center of the screen. It was a single

kaleidoscope image (5 cm x 5 cm), and remained on the screen until the participant pressed a labeled key on the keyboard. The appearance of PEI during the delay was varied across two conditions, either at the end of the delay (immediately after either 4 s or 12 s of delay interval had timed out) or at the start of the delay interval (immediately after presentation of the array of four images but before the delay interval commenced).

3. **Forced-choice test.** After the delay interval had timed out, two kaleidoscope images (each 5 cm x 5 cm) appeared on the screen. One image was positioned 0.5 cm to the left of center and the other image was 0.5 cm to the right of center with both images centered on the vertical plane. Participants were instructed to press the 'LEFT' button on the keyboard if they thought the left image was the one from the original array of four images at the start of the trial and the 'RIGHT' button if they thought it was the right image. The LEFT and RIGHT response options were labeled with stickers and corresponded to the letters 'Z' and 'M' on a standard keyboard. As soon as a single response was made on either of the keys, the images disappeared and a 1 s intertrial interval occurred before the next trial was initiated. A response was labeled as correct if it corresponded to the target image presented among the array of four at the start of the trial. There were sixteen different kaleidoscope images used. Across trials all images were used as target stimuli, postevent cues, and incorrect recognition options. Across trials the position of any given kaleidoscope image in the original array of four varied, as did the four separate images that were combined in to a single array, and the position of the correct target image varied (both with respect to its position among the original array of four images and its position either on the left or right of the screen at recognition).

In all conditions there were three types of trial: *Consistent*, *Inconsistent* and *Neutral*. These trials were defined in the same way as in Experiments 1 and 2. However, the first 10 trials scheduled in a session were all of the Consistent type and were not included in subsequent analyses. We manipulated the first 10 trials in this fashion because in our pilot research, where we randomized the three trial types right from the first trial, we found that subjects quickly learned to mistrust the PEI, and avoided selecting it at test. Of course, in real world situations, PEI has the power to mislead precisely because we learn to trust sources of information that are ostensibly faithful records of an event. Thus, we included the 10 consistent trials to encourage subjects to trust the PEI. The remaining 60 trials were comprised of 20 Consistent, 20 Inconsistent and 20 Neutral trials arranged in random order.

Results and Discussion

The main research question in Experiment 3 was whether human subjects would show the same pattern of memory distortions using our DMTS analog as pigeons and rats did in the two earlier experiments. Figure 5 shows that the answer is yes. The top panel in Figure 5 shows the mean percent correct (averaged over all subjects) across delays for the three trial types when PEI was presented at the end of each delay. More to the point, it shows the same trends that emerged in the equivalent condition in Experiments 1 and 2. Specifically, consistent PEI trials produced the greatest accuracy, and inconsistent PEI produced the lowest accuracy, $F(2,28) = 16.3, p < 0.01$. There was no interaction between delay and trial type, $F = 0.1$.

The bottom panel in Figure 5 shows the mean percent correct when PEI was presented at the start of each delay. Although accuracy decreased as delay increased, $F(1,14) = 7.65, p < 0.05$, the PEI had no effect on accuracy, $F = 0.7$. There was no interaction between delay and trial type, $F = 0.5$.

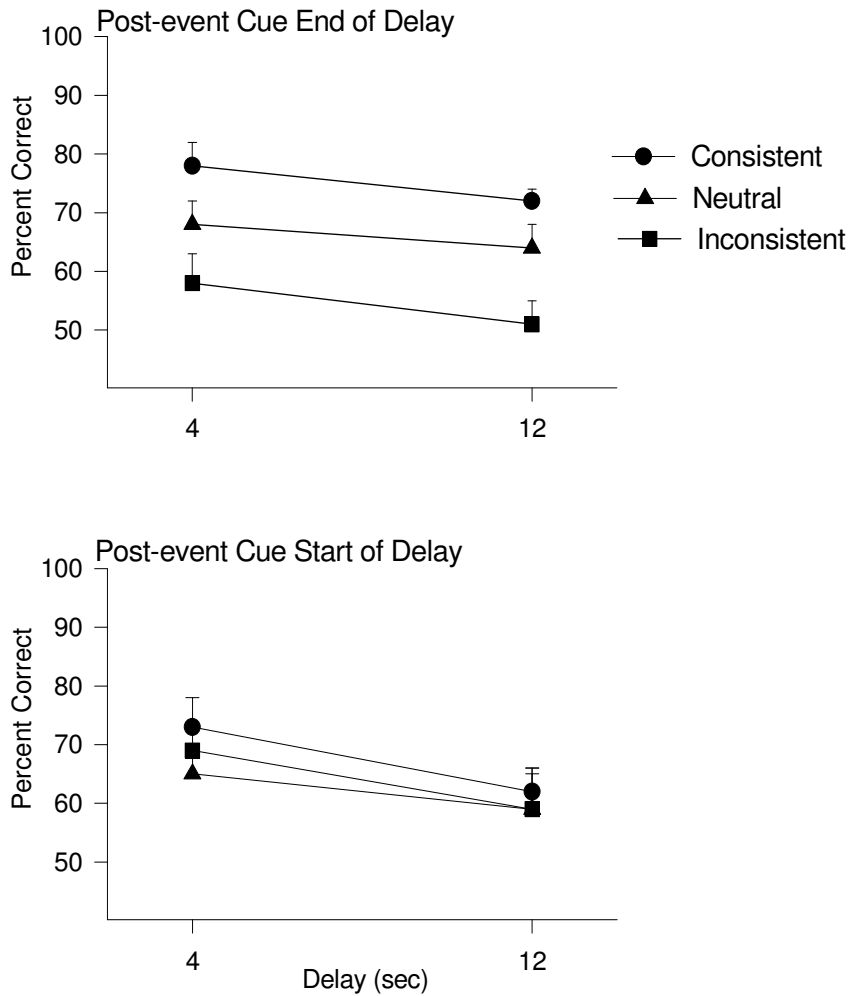


Figure 5. Mean percent correct as a function of delay in Experiment 3 when the PEI was presented at the end of the delay (top graph) or start of the delay (lower graph). Accuracy is shown separately for 'consistent', 'neutral', and 'inconsistent' trials. Error bars show standard error of the mean.

In summary, the pattern of results observed in Experiment 3 with humans replicated the four basic patterns observed in Experiments 1 and 2 using pigeons and rats. First, accuracy systematically decreased as the delay between the sample stimulus and recognition increased. Second, the rate of this decrease in accuracy across delays was not affected by the different types of PEI presented either at the

beginning or the end of the delay period. Third, whether PEI had an effect on overall accuracy depended on whether it was presented at the beginning or the end of the delay interval. Fourth, only when the PEI occurred at the end of the delay interval was there an effect on recognition performance. In such a condition accuracy was greater, relative to the neutral baseline condition, when the PEI was consistent with the target sample stimulus. However, lowest levels of accuracy occurred when the PEI was inconsistent with the target sample stimulus.

General Discussion

Does the misinformation effect occur across species? We believe the answer is 'yes'. We base our answer on three important results across our experiments. First, we used a DMTS analog of the classic three-stage procedure used in human research with pigeons, and produced a pattern of results very similar to that found by Loftus et al. (1978): misleading PEI lowers memory accuracy; consistent PEI increases memory accuracy. In both cases the effect increases as delay between the event and exposure to PEI increases. Second, we refined our analog with rats so it was more like the human misinformation methods; we used an event with visual-spatial information, and altered details in that event. Again, we found a pattern of results in line with Loftus et al. Third, we back translated our DMTS analog for use with human subjects, developing a complex event they would have found difficult to embellish with verbal labels. They too showed the misinformation effect.

Before exploring the reasons why the misinformation effect may arise, it is worth noting that the current paradigm and results correspond very well with an even older and parallel line of research in the animal literature concerning 'retroactive interference effects'. Retroactive interference studies also involve the presentation of stimuli after an original target even has been presented (see for example, Harper & White, 1997; White, 1985). The emphasis of retroactive interference studies, in contrast to the misinformation literature, has been in terms of the disruptive effects of PEI on memory-task performance (essentially one side of the misinformation phenomenon). The current results not only show that memory is disrupted by PEI (as in the retroactive interference literature), but that accuracy can also be enhanced. Furthermore, the current findings are quite consistent with the retroactive interference findings. For example, as shown here, Miller, Greco, Marlin and Balaz (1985) found that inconsistent PEI had a greater negative impact on accuracy the more similar it was to the incorrect response option and the further it was away (temporally) to the original event in a maze task with rats.

Why should both humans and nonhumans be similarly influenced by misleading PEI? One possible answer to this lies with the possibility that errors that occur as a result of exposure to PEI are not errors at all. Perhaps they are simply the byproduct of an adaptive mechanism that—in certain contrived situations—produce unwanted effects. What could possibly be adaptive about memory influences caused by PEI? Schacter (1999) has speculated that they are

the price we pay for being able to spend time on what he calls the psychological equivalent of autopilot. Put another way, humans and animals alike have little need to remember all details great and small, so it is easy—perhaps even essential—that we rely on multiple, supplemental sources of information for understanding something.

In fact, it is often necessary to rely on supplemental sources of information, and thus we do not expect them to mislead us. Kugler, Shaw, Vincente, and Kinsella-Shaw (1990) argued that these supplemental postevent sources of information have the ability to fill in and update our "persisting knowledge" of an event or the environment (p.76). In other words, all PEI—whether misleading or not—allows organisms to remain coordinated with some information that is not perceivable now. For example, we refer to our notes when we want to recapture information from a lecture, and we rely on maps when we are lost. Animals may not be that different. Take the shark, for instance. According to Turvey, Shaw, Reed, and Mace, (1981), sharks detect food and locomotive obstacles electronically. One of its favorite foods, the flatfish, produces a distinctive bioelectric field that is detectable when the shark swims over it. The shark uses this electric field to remain coordinated with its environment. When researchers bury electrodes in the sand and reproduce the electric field patterning, the shark looks for flatfish, even digging around the electrodes. What are we to make of the shark's behavior? One might say that the shark has made a mistake, behaving as though a flatfish will soon appear. But Turvey et al. (1981) make a different interpretation of the same data: given that the instrument duplicated information that points to a flatfish, the shark would have made an error only if it had *not* searched. Would we really expect the shark to be able to know that the electronic information had been planted by scientists? We would no more expect the shark to know that the electronic field was an electrode dressed up as a flatfish than we would expect people in an experiment to know that the postevent narrative was a collection of mistakes dressed up as a summary, or that the questions the police officer put to eyewitnesses were inaccurate and would later distort their memories for the event.

Deleted:

The traditional study of misinformation effects has similarly viewed the effect as the result of error; the standard parlance of misinformation research uses words such as *error* and *misremembering*. In light of the experiments we have presented here, we urge researchers to reconsider what they mean by a memory error and to consider theoretical perspectives that conceptualize memory 'errors' in the context of environmental information currently available to the organism (such as White's theory of 'direct remembering,' 2001).

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