BRAIN QUIRKS AND COURTROOM TESTIMONY

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BRAIN QUIRKS AND COURTROOM TESTIMONY

Abstract
Selected findings from the neurosciences addressing ways in which the brain processes information are reviewed from the perspective: “Do the findings inform our understanding of courtroom testimony by witnesses attempting to give accurate accounts of observed events?” Answers to the question include: accurate recall is possible but difficult and infrequent; built-in and learned (possibly?) information processing systems which disrupt memory and bias interpretations are responsible for this outcome; witnesses are seldom aware of disruptions unless they are experiencing difficulty remembering.

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THE CONTEXT

The situation addressed here is this: an individual with a “normal” brain observes an event such as a fender-bender, a fight, or a holdup and subsequently becomes a witness in court where s/he attempts to recall the event as accurately as possible. Not considered here is testimony by individuals with deranged minds, who knowingly deceive, whose testimony is influenced by conflict of interest, or sex differences in the ability to recall (studies indicate that males and females differ in their ability to recall).

BACKGROUND

Perhaps the first point to emphasize is that using research findings from the neurosciences to explain individual behavior is not necessarily easy or straightforward. Difficulties arise in part because of the way in which most neuroscience studies are conducted: data are developed using groups of individuals (“experimental subjects”) and subjected to statistical analysis and presentation, a process which often obscures individual differences among subjects. The state of technical devices is also relevant. They often limit the kinds of questions that can be asked and answered.
Memory provides a convenient example of the types of difficulties that can develop. There is now evidence that both the biochemical and cellular systems responsible for storing memories differ from those systems involved in reconstituting memories (Lee et al., 2004) – the hypothetical witness would be reconstituting a memory. While these are interesting findings, their courtroom implications are not immediately clear. For example, it is possible that a reconstituted memory accurately describes what the witness observed and initially recorded in memory. By analogy: when printing a photograph and then reproducing it on a copying machine, very different scanning and chemical processes are involved but the copy may be indistinguishable from the original print.

But it is also possible that alterations occur in what was observed and initially stored in memory. For example, findings from a number of studies suggest that the brain often suppresses unwanted or unpleasant memories (Miller, 2004) -- examples include observing events in which individuals are seriously injured or severely frightened. Further, new memories, which tend to weaken during the day but which can be strengthened by sleep must be reconstituted in order to persist (Fenn, et al., 2003; Walker et al., 2003) – in effect, memories tend to fade unless there is an active recall effort following sleep. And adrenal hormones associated with stress are known to affect the left and right amygdalas, interior brain structures that play a critical role in processing emotion-laden information (Bower, 2003). One’s level of stress, which may have nothing to do with what is observed, also has a memory disrupting potential. Given these and related findings, at this moment in time, the accuracy of reconstituted memories remains uncertain at best and, at worst, accurate recall seems unlikely.
There are obvious objections to this conclusion. Most of the time people can recall the make of their car, the names of friends, and where the coffee is located. These acts require accurate reconstituted memories. In most instances, these types of memories differ from observing single, often brief, and unexpected events in that they involve repeated memory reconstitution and are reinforced by learning (a process similar to memorizing). Moreover, recall is assisted by the limited number of possible recall options – e.g., the coffee is unlikely to be in the attic so the attic need not be considered when trying to find the coffee. Nevertheless, one does sometimes forget where the coffee is located or believe that it is located where it is not.

BRAIN QUIRKS AND TESTIMONY

What are some of the brain’s information-processing quirks and their courtroom implications? Some are obvious. Others less so. A non-obvious quirk is discussed first.

**Observed objects in short-term memory**

Contrary to the rich phenomenology of our visual-auditory experiences, our visual short-term memory system can maintain representations of only a few objects at a time. Imagine a random list of numbers projected briefly on a screen. It’s easy enough to remember two or three numbers, but when there are 8 or more only one in a hundred individuals can recall them. Short-term memory is the first step in transferring visual, auditory, and tactical information to storage in long-term memory (memories that can be recalled at a later time).
Individuals can store from 1.5 to 5 objects in short-term memory and for most individuals the number remains highly consistent across a variety of research protocols (Vogel and Machizawa, 2004). Studies leading to these findings typically use electrophysiological monitoring. The electrical activity of subjects’ brains is monitored while subjects are briefly shown arrays of objects and asked to recall what they have seen. The amplitude of electrophysiological response predicts the number of objects that individuals can recall. (To illustrate short-term memory at work, close your eyes and set the pause button on an unfamiliar VHS or DVD movie. Look at the scene on the screen by quickly opening and shutting your eyes. Then list what you recall from the scene and compare the list with the scene.)

What are the implications for courtroom testimony? First, witnesses will differ in their capacities to accurately recall many of the details of rapidly occurring events such as an automobile accident. Second, witnesses who provide excessive detail about such events are likely to be combining memories and interpretation. Such individuals may believe that their reconstituted memory accurately describes what they observed – we tend to believe our memories more often than not. But the likely explanation for the reported detail is that they have selected objects from several separate short-term memories, organized and interpreted them, and developed a story with excessive but not necessarily accurate detail. This is much like what happens when viewing a motion picture where 32 still photographs are presented each second which the brain then alters so that one experiences continuity of movement and speech. Recalling all of what one observed in a single frame is nearly impossible and, for most individuals, recalling the details of what was observed over a three-four second period is also impossible. Third, it would be possible to test a witness’s short-term memory capacity and compare it with his/her testimony. For example, a witness who has the capacity to recall five
objects in short-term memory should be able to provide more detailed information about an event than a witness with less capacity. If witnesses report they can’t recall an event, deception is a possibility, but memory disruptions due to stress, lack of sleep, or memory suppression are possibilities.

**Time changes during periods of excitement and boredom**

This is perhaps an obvious quirk. Concentration on the passage of time, as often happens when one is bored, triggers brain activity which results in the perception that time is moving slowly. Conversely, when one is focused on an event which one finds exciting, the opposite happens: one senses that time moves rapidly. These two brain states can be differentiated using fMRI technology (BBC, 2004). (Most neuroimagers mapping brain activity favor functional magnetic resonance imaging [fMRI] over other imaging technologies such as Positron Emission Tomography [PET] which expose subjects to radioactivity. fMRI technology is free of radioactivity and it permits repeated monitoring of the same individual.)

There are several possible implications. One is that real time of an event on which one is focused, such as a holdup or a fistfight, might take place over a longer period than one recalls. On the other hand, if one is testifying about the time of an event which was observed during a period of boredom – say, the length of time the gardener spent mowing the next door neighbor’s lawn –, the times might be shorter than one recalls.

Further, recall of the time of an event may vary. Because boredom often involves clock watching, if an observed event is brief and the observer is bored, recalling the time of the event is likely to be more accurate than if s/he were focused where clock watching is less frequent. But there are other possibilities. For example,
should it turn out that boredom is more stressful than focusing, recall among the bored may be less accurate than among the non-bored.

The tangled web of event interpretation
Take the experiment in which two people see the same movie while being monitored simultaneously using fMRI technology. Approximately 25-30% similarity in the activity of specific brain areas is reported (Pessoa, 2004). Similarity is highest when events in the movie are either unexpected or emotion-laden, such as an unexpected suicide or a shooting. In effect, those sharing a visual-auditory experience may see similar things and the initial routing and processing of what is seen through the brain may be similar.

Cross-person similarity in fMRI signals does not extend to the prefrontal cortex, however, that part of the brain in which critical information interpretation functions are carried out. Interpretations are highly individualized and they often involve the selection of different memories as well as unique memory interpretation.

Two potentially interesting implications emerge from these findings. First, what a person observes does not predict how s/he will interpret it. Here, personal history and mood at the time of the observation are the likely influencing factors in determining which objects are selected from short-term memory and how they are interpreted. For example, say you arrive at an automobile accident and find that a close friend of your daughter has been seriously injured. Because you know the injured person (your personal history), your reaction will be different than if the injured person is a stranger. Further, subsequent events may influence memory
reconstitution. Thus, if the injured person dies and your daughter is adversely affected, later recall is likely to undergo alterations.

Second, hearing conflicting testimony by two witnesses who observed the same event may simply reflect normal differences in how individuals process information.

**Personality and happy faces**

Using fMRI technology, if normal individuals are monitored while being shown pictures of happy faces, there is minimal left or right amygdala activation. However, if they are show pictures of fearful faces (non-threatening faces which signal that a person is fearing some one or something), both the left and right amygdalas show moderate activation (Canli, et.al., 2002). Amygdala activation is a rough measure of the emotional response to information and degree of activation influences what is stored in memory, its interpretation, and subsequent behavior. Activation in response to fearful faces thus may reflect the importance the brain gives to detecting potentially dangerous situations. Similar fMRI findings are reported for responses to positive and negative words (Mamann and Mao, 2002).

Exceptions to these “normal” responses are found among extroverts (individuals strongly interested in their social and/or physical environments). Compared to non-extroverts who show minimal amygdala activation in response to pictures of happy faces, extroverts show moderate left amygdala activation. The left amygdala is associated with positive feelings toward others and social relating behavior. Extroverts, however, show minimal amygdala activation to fearful faces which among non-extroverts result in moderate left and right amygdala activation.
The key implication here seems clear: personality type may influence how individuals respond to social signals, the objects that are stored in short-term memory, and their interpretation. In effect, personality types can be viewed as information filtering and interpretation systems.

But wait, it doesn’t get simpler – another amygdala study.
Again, the experimental setting is that of using fMRI technology to monitor the activity of the brain’s functional areas. If an angry face is directed at normal subjects, there is moderate left and right amygdala activation. However, if an angry face is averted (not looking at the subject) left and right amygdala activation increases nearly three-fold. The opposite occurs with fearful faces: an averted fearful face results in moderate left and right amygdala activation while a direct fearful face leads to a two-fold increase in left and right amygdala activation (Adams et.al., 2003).

What are the possible implications? First, physical location will influence how witnesses respond to others’ fearful and angry faces. Consider a situation in which potential witnesses circle a person who exhibits an angry face. Depending on the location of the witnesses, different levels of amygdala activation are likely. And because amygdala activation influences what is stored in memory and interpreted, if each of the encircling individuals becomes a witness their accounts of the event will differ.

Second, the brain appears to be especially sensitive to ambiguous information. In averted and non-avered gaze studies described above, the ambiguous information is the non-verted fearful face and the averted angry face. Said another way, the brain appears to have built-in expectations about how others signal their mood states. If the signals don’t map to the expectations (e.g., fearface directed at a
subject rather than the source of the fear), the brain is alerted, one indication of which is amygdala activation. Such responses are similar to those that occur with unexpected changes in familiar physical environments, e.g., one may barely notice the location of furniture in a familiar room unless it has been changed.

To add a footnote to the proceeding findings, there is evidence for what might be termed “set point changes” in what the brain expects. This applies particularly to faces (Webster et al, 2004) where repeated exposure to pictures of faces that are systematically altered leads to changes in what subjects view as a “normal face.” Applied to everyday experience, if one spends the morning at a nursery school observing children and then has an unexpected encounter with a same-age friend, the friend will look older than one recalls s/he looks. The opposite response would occur when a same-age friend brings a baby into a group of adults: the friend won’t look older but the baby will look younger than s/he is. Here, an implication is that one’s experiences in the moments prior to observing an event may influence perception and event interpretation.

The brain’s negative bias
Studies of the brain’s biases are straightforward and they demonstrate that the brain has greater sensitivity to negative (unpleasant or undesired information) than positive information. The usual measure of sensitivity is the brain’s electrophysiological response to negative information (e.g., a picture of a mutilated person) compared to positive (e.g., a Ferrari) and neutral information (e.g., a plate). And, if they are recalled, unpleasant experiences are recalled for longer periods than pleasant ones (Marano, 2003).
This is the glass half-full and half-empty story and there are good evolutionary reasons for a negative bias – it may help keep one out of harm’s way. Thus, a reasonable assumption about witnesses is that their reports of events that have both positive and negative features will be biased toward the negative. Negative bias may also be intensified among certain personality types in which case testimony may deviate significantly when compared to persons with an average negative bias.

Compromise is the name of the brain’s game – the 7% principle

It turns out that the brain ignores small changes in the environment or the behavior of others. Consider the situation in which you are driving on a freeway. If carefully observed, everyone is driving a bit differently, some more to the right than the left sides of their lanes, some weaving more than others, and so forth. The brain tends to discount this variance unless it is excessive – a 7% change in expected behavior is a way of saying the same thing.

Ways in which the brain disregards small changes can be demonstrated by asking subjects to view a dot on a large screen (Tweed, 2003). The dot is then moved various distances and subjects report if the dot has moved. Small moves are usually invisible to subjects but all subjects recognize large moves. “The brain takes in raw data from its surroundings through sensors and interprets it, rejecting interpretations it consider unlikely” (Tweed, 2003, pg. 1). Inbuilt (innate/evolved) and learned (possibly?) processes appear to be involved in such assessments and, if learning is involved, it requires the refinement of interpretation algorithms that are stable against slight changes in signals (Tomasi, 2004).

The 7% figure reflects findings from similar studies which show that many stimuli need to undergo somewhere between a 5-8% change before change is recognized.
Seven percent can also be looked at from an evolutionary perspective. Literally all of the information we receive through our eyes and ears and other senses is partially flawed because of the limitations of our sensory systems, and this may be added to such factors as our angle of view, our personalities, our different past experiences, etc. Thus it is not surprising that objects are sometimes misperceived, that we misinterpret words, and that we sometimes mistake an unknown individual for an old friend. The brain is stuck with trying to make sense out of flawed information and it appears to do so in part by disregarding small changes from what is expected. Thus, when driving, minor variations in others’ driving styles usually go unnoticed. But when the driver ahead suddenly drifts out of his lane onto the shoulder, the brain awakes.

Returning to courtroom testimony, assuming that witnesses will disregard minor details of events should be the rule, not the exception.

**Serotonin and social status**

Although the brain is usually thought of as a separate organ, there is another way to think about it, namely as a “social brain,” where its day-to-day functions are inseparable from its social context and the social signals it receives. This view makes sense intuitively. For example, receiving disconcerting news about a loved one changes how one thinks, feels, and acts and it is the brain that is doing the thinking, feeling, and initiating the acting in response to such information. An informative example of the social brain concept is found among high-status male vervet monkeys where brain serotonin levels (a neurochemical involved in information transmission) and turnover rates significantly exceed those of lower-status monkeys. And when a monkey’s status changes, so do his brain serotonin levels and turnover rates (Raleigh et.al., 1984, 1991).
A key implication of these findings is suggested by the responses of high- and low-status animals to memory, learning, and decision-making tasks. High-status animals learn faster than lower-status animals. They recall things they have learned longer. And they are more rapid and accurate decision makers. These findings extrapolate to humans (Madsen, 1985, 1994). Thus, one’s social status may be another factor influencing which objects are stored in short-term memory, the content of long-term memory, and memory interpretation (Zizzo, 2002). Indirect support for this view comes from studies showing that serotonin depletion of the prefrontal cortex (an executive function area) decreases behavioral and cognitive flexibility (Clarke et al, 2004).

Some final points
If one recalls that one’s car is at location X but after searching finds the car at location Y, there is usually a moment of awareness about the fallibility of one’s memory. But if the car is at location X, there is no such awareness. Most of us live and work in familiar environments, that is environments in which we use repeated memories the majority of which are accurate – the fax machine is where it was yesterday and one’s dog has the same name day after day. In such environments it is easy enough to assume that one’s memories are accurate. But if one engages in a novel but unfamiliar task, say, constructing a garden shed, the number of memory errors (e.g., believing tool Z is at location L only to find it at location Q) noticeably increases.

There are also memories one deems worth remembering and those not worth remembering. One may observe the license plate number of a car parked next to one’s car in a parking lot but few people think it is worth remembering. Observing
a holdup or living through a highly positive emotional event is another matter, however. Most people would work at preserving the memory of these events in as much detail as possible. Still, such memories are subject to considerable revision. This occurs frequently when the memory of an emotion-laden event is shared with others, who, through their comments and questions (“Are you sure it happened that way?”) inadvertently influence revision.

DISCUSSION

It might seem that the preceding discussion would lead to only one conclusion: reports by witnesses are inaccurate, biased, incomplete, conflated, etc. (a view, although in a milder form, that is often privately voiced by lawyers with courtroom experience). Even for the most straightforward recall situations, there are simply too many possible memory-disrupting processes to suggest a more positive conclusion. Yet as noted earlier, countering this conclusion is everyday experience where we remember most important things most of the time. But it is also true that people sometimes forget where they put their glasses, scheduled appointments, or if they cashed checks, all seeming important things to remember.

As far as further neuroscience research is concerned, will it clarify things? There will be progress. Yet, one should adopt a healthy skepticism about the neurosciences providing definitive memory-clarifying insights in the near future. Since the Enlightenment there have been serious efforts to connect the findings of science with the richness of human experience. Science has generally called for unifying theories that would make the world simple. Every day experience has had an opposite calling with its emphasis on the richness and complexity of human
experience. Findings from the neurosciences do little to provide insights into the characters of Proust, Dickens, Musil, or Steinbeck. So, connection, if it is to occur, will likely require modifications in scientific concepts, methodologies, and questions because our rich and complex perceptions are unlikely to change.\textsuperscript{1}
1. On the lighter side, there may be help on the way for those who frequently forget such things are their car keys and glasses. A Canadian group has come up with the idea of labeling items people normally take with them (e.g., car keys) with radio frequency identification tags (RFID) which are small electronic labels used to automate commercial goods tracking. A specially designed watch sends a beep when the items are outside three meters. Unfortunately, the watch doesn’t tell you where you might have left your glasses. (New Scientist, August 14, 2004).
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