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THE LEFT HEMISPHERE INTERPRETER AND CONFABULATION

- a Comparison

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Abstract

The left hemisphere *interpreter* refers to a function in the left hemisphere of the brain that search for and produce causal explanations for events, behaviours and feelings, even though no such apparent pattern exists between them. *Confabulation* is said to occur when a person presents or acts on obviously false information, despite being aware that they are false. People who confabulate also tend to defend their confabulations even when they are presented with counterevidence. Research related to these two areas seems to deal with the same phenomenon, namely the human tendency to infer explanations for events, even if the explanations have no actual bearing in reality. Despite this, research on the left hemisphere interpreter has progressed relatively independently from research related to the concept of confabulation. This thesis has therefore aimed at reviewing each area and comparing them in a search for common relations. What has been found as a common theme is the emphasis they both place on the potentially underlying function of the interpreter and confabulation. Many researchers across the two fields stress the adaptive and vital function of keeping the brain free from both contradiction and unpredictability, and propose that this function is served by confabulations and the left hemisphere interpreter. This finding may provide a possible opening for collaboration across the fields, and for the continued understanding of these exciting and perplexing phenomena.

Keywords: Left hemisphere interpreter, Confabulation, Split-brain, Causal perception, Causal inference, Delusion, Anosognosia

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Introduction

The left hemisphere *interpreter* is a concept coined in the late 1970´s by Michael Gazzaniga (2005) and refers to a function in the left hemisphere of the brain that search for causal explanations for events, even though no such apparent pattern exists between them. Gazzaniga claims that this part of the brain is largely responsible for our language abilities and that it works as a narrator, binding sequences of events together into a story or cohesive whole, in an attempt to make order in chaos. By doing this the brain enables us to interpret complex stimuli and produce appropriate response behaviours, according to Cooney and Gazzaniga (2003). By introducing the method of studying so-called split-brain patients in the 1960´s, where a patient's two hemispheres of the brain are disconnected at the corpus callosum in order to alleviate epilepsy, scientists were able to study the function of each hemisphere separately. They could now begin to unravel the specific functional localizations of the brain, as well as how it enables integration through the corpus callosum (Gazzaniga, 2005).

Confabulation is said to occur when a person presents obviously false information or act on false information, despite being aware of their falsehood. People who confabulate also tend to defend their confabulations, even in the face of evidence to the contrary (Gilboa & Verfaellie, 2010). Traditionally, confabulation has been studied in the realm of neurological as well as psychiatric disorders, related to amnesia and schizophrenia. Confabulation has also been related to the phenomenon of delusion since both these phenomena concern distorted representations of reality, according to Langdon and Turner (2010). Lately, confabulation has gained more and more consideration, but the research area is still struggling with problems of defining confabulation, making the theories of confabulations very much disparate (Langdon & Turner, 2010).

Surprisingly, research related to the concept of the interpreter has progressed relatively independently from the research related to the concept of confabulation, with a separate set of concepts and vocabulary with only modest reference to each others work. In this thesis the aim is therefore to review and compare these two research areas that seem to deal with the same phenomenon, namely humans' tendency to infer explanations for events that happen, even if they have no bearing in reality.

By converging these large research areas, we can gain a much more thorough understanding of this exciting phenomenon. Through the understanding of how the brain enables us to experience a sense of coherence, we can gain insights into how the search for causal relationships can lead to suboptimal behaviours. An example would be when we infer causality where there actually are no simple causal relationships, which potentially can lead to errors in decision-making (Wolford, Miller & Gazzaniga, 2000), as well as lead to pessimism and ultimately depression when we acquire a habit of explaining events in a maladaptive way (a negative explanatory style), that does not correspond well to the actual world (Seligman, 1991). By studying how the brain enables a sense of wholeness we might also gain clues on how our sense of personal identity is brought about by the brain, a question that has long been discussed in philosophy and now also in the field of neuroscience (Gazzaniga, 2009).

The thesis will begin with a review of some of the research that led way for the concept of the interpreter, and then continue with a review of the research related to the concept of confabulation. After that, current research that has attempted to integrate these areas will be presented. Finally, a conclusion will be provided based on these findings, where the focus will be on the common themes.

The left and the right hemisphere

The idea that the brain contains specialized areas devoted to rather specific functions has previously been evoked by behavioural studies on the brain (Gazzaniga, 1995) and few ideas in psychology have had such an impact on the general public as the left- and right brain dichotomy (Walsh, 2000). The opportunity to study the functions of each hemisphere more straightforwardly was made possible in the 1960’s, when a patient who suffered from intractable epilepsy successfully completed full surgical division of the corpus callosum (Gazzaniga, 2005). The corpus callosum consists of a massive band of nerve fibres, connecting the two hemispheres of the cerebral cortex. With its removal the two hemispheres are to a large extent separated and working independently (Walsh, 2000), with the exception of subcortical pathways that have been shown to enable some processing resources and binary information to be shared (Gazzaniga, 2005), as well as the emotional system’s subcortical areas, which overlaps the two hemispheres (Hirstein, 2006). The surgery, called callosotomy was the last resort to control the patient’s epileptic seizures and limit them to one hemisphere. With this successful surgery at hand, Gazzaniga, Bogen and Sperry now began the so called modern split-brain studies on humans, by adapting split-brain testing methods formerly used on animals (Gazzaniga, 2005).

In split-brain testing all patients have suffered from intractable epilepsy, with different aetiologies, and have undergone split-brain surgery (Gazzaniga, 1995). These patients are studied using a technique where stimuli are visually presented to one of the hemispheres exclusively. This is made possible since information presented to the left visual field is processed by the right hemisphere, and information presented to the right visual field is processed by the left hemisphere (Gazzaniga, 2000). In the beginning of split-brain studies, stimuli were presented using a mechanical tachistoscope. There the patient fixated on a point in space, and stimuli were then flashed quickly on each side of the fixation point, depending on which hemisphere that was intended to receive the information. It was necessary that the stimulus was presented quickly, since unwanted eye-movements could inform the other hemisphere of the presented information. Later, this technique advanced and split-brain studies started to use computers for presenting stimuli, together with an image stabilizing system and a Purkinje eye tracker, which moved the stimulus if the patient moved his eyes. In this way, these new technologies ensured that information was presented to one hemisphere exclusively, as well as allowed for prolonged presentation of stimuli (Gazzaniga, 1995, 2000).

Since then, the split-brain methodology together with neuroimaging techniques have made it possible to study the basic neurological mechanisms, the cortical representations of cognitive and perceptual processes, as well as the lateralization of function (Gazzaniga, 2000). It has been found that the brain does have highly specialized systems dedicated to different functions, e.g., the Fusiform Face Area (FFA), Parahippocampal Place Area (PPA) and area V5 in the visual cortex (Cooney & Gazzaniga, 2003), which point to that the brain is not a general-purpose computing device. Instead it consists of functional modules that can be located at distinct areas (Roser & Gazzaniga, 2004), and that are selectively activated by environmental demands (Funk & Gazzaniga, 2009).

So, even though the left- and right brain dichotomy is an oversimplification; with its tendency to emphasize one hemisphere as dominant (Walsh, 2000), there are clear differences between the two hemispheres' functions. The left hemisphere is specialized for language and speech and major problem-solving capacities (Gazzaniga, 1995), while the right hemisphere is specialized for visuospatial processing, and has been shown to dominate tasks such as part-whole relations, apparent motion detection, mental rotation, spatial matching and mirror image discrimination (Gazzaniga, 2005), as well as facial recognition and attentional monitoring (Gazzaniga, 1995).

This distinction though, is not clear cut, and there are a few cases where split-brain patients have shown evidence of developing rudimentary speech in their right hemisphere, most likely as a result of long-time plasticity (Gazzaniga et. al., 1996; see also Gazzaniga, 1995). Likewise, it would be reasonable to assume that the left hemisphere also possesses some visuospatial abilities in order to enable tasks such as reading and object recognition (Corballis, 2003).

According to Gazzaniga (2000), this specialization of function of each hemisphere would, from an evolutionary perspective, bee made possible by the corpus callosum. The corpus callosum could have allowed the development of language in the left hemisphere, while at the same time preserving other essential functions in the right hemisphere. It could then integrate these specific functions according to purpose and produce a better decision-making device, which Gazzaniga claims is the one major role of the brain; to make decisions that increase probability of reproduction (Gazzaniga, 2000). Seen in this way, the question of which hemisphere is more dominant is according to Walsh (2000) pointless, as it depends on the nature of the task.

Causal perception and causal inference

Since the brain is claimed to be a decision-making device, it would be reasonable to assume that it provides us with an ability to understand cause and effect in order to make sense of our physical world, and to guide action in an adaptive way (Gazzaniga, 2005). Roser, Fugelsang, Dunbar, Corballis and Gazzaniga (2005) performed a study with two split-brain patients and a group of neurologically normal participants which has influenced the way in which the human understanding of causality is studied. The study indicated that the capacity for understanding causality is not a distinct function, but consists of both a perceptual process and an inferential process, that are lateralized to the right hemisphere and the left hemisphere respectively (Roser, et. al., 2005; see also Gazzaniga, 2005).

Perceptual causality is referred to as the direct impression of causality from dynamic object interactions, like when a billiard ball comes into collision with another ball and seems to cause the other ball to move. Inferential causality instead refers to the use of logical rules, conceptual and abstract knowledge when interpreting events in causal terms, like when a person is crying and other people observing it assume that the person is sad (Roser et. al., 2005).

Gazzaniga (2000) claims that in an evolutionary perspective the advantages of having both a system in the brain that keeps a more veridical record of events, and a system that goes beyond perceptual information and asks for reasons for the events, is comprehensible. In an intact brain these two systems would complement each other and serve for a more complete understanding of the physical world. The right hemisphere would ensure truth and accuracy, while the left hemisphere's search for associations and patterns would ensure order in chaos, as the world to a large degree consists of underlying causal patterns. This would make the brain more prepared and efficient in dealing with upcoming events, according to Gazzaniga (2000).

Causal perception.

It has been demonstrated that people use many cues when deciding whether an action and an effect are causally linked, according to Fugelsang, Roser, Corballis, Gazzaniga and Dunbar (2005). Among these cues are: covariations, temporal order, contiguity (closeness) in time and space, mechanisms information, and similarity between cause and effect. The cues most commonly studied are spatial and temporal contiguity since they seem to have apparent effects on the perception of causality. Areas that have been associated with perceptual causality are the right prefrontal, right parietal and right temporal cortex (Fugelsang et. al., 2005).

It has been suggested that causal perception is not a learned ability, but an automatic accomplishment of the visual system (Blakemore et. al., 2001; Leslie & Keeble, 1987) which seems sensitive to *collision events*, as when a billiard ball causes another ball to move. Experiments using collision events have termed the effect the *launching effect* (Roser, et. al., 2005) and are the most common method of studying perceptual causality. Small spatial-temporal variations and delays of the two stimuli have been shown by Roser et al. (2005) to have a large effect on whether a non-causal collision event appears causal, or whether an actual causal collision event is recognized as causal.

Cheng (1997) make the claim that causal connections per se are not something that can be observed or even deduced, but are something that is induced from the observable events. This claim could be explained by the recent finding by Buehner and Humpreys (2010) that even the human perceptual system seems biased in favour of causal relations, as a way to resolve uncertainty. This finding can be compared with the visual grouping and illusory contour completion effects (Fugelsang et al., 2005).

Important to keep in mind though, is that much of the evidence for causal perception struggles with problems of assessing perceptual causality (Roser et. al., 2005). Many studies rely on self-reports that are open to post-perceptual interpretation, and causal perception could therefore be confused with causal inference.

Other studies have also been made that focus on how people distinguish between events that really happened and events that were only inferred, according to Metcalfe, Funnell and Gazzaniga (1995). Studies of false memories have for example shown that people actually can remember events that never took place, if the false memories are associated with some real events and are repeatedly recalled (Roediger & McDermott, 1995), and this tendency remains to a certain degree even if people are informed in advance about this fallacy (Gallo, Roberts & Seamon, 1997). It has also been found that factors such as the clarity and the amount of sensory information present, as well as memory for the cognitive operations, seem to be of importance in order to distinguish between real and inferred events (Metcalfe et. al., 1995).

Metcalfe and colleagues suggest that the two hemispheres of the brain possess different memory functions related to real and imagined events. A series of experiments (Metcalfe et. al., 1995) investigated probable memory differences for categorically associated events in the two hemispheres of a split-brain patient. These studies showed that the right hemisphere stores more exact memory traces than the left hemisphere. It was therefore concluded that the right hemisphere possesses more veridical memory. A proposed explanation for the left hemisphere tendency was that it encodes and stores not only the real events, but also the inferences and generalization it creates from these events, making memory for the real events more distorted in the process (Metcalfe et. al., 1995).

Earlier descriptions of left and right hemisphere asymmetries put little emphasis on the ability of the right hemisphere to create a veridical representation of the world from mere visual perceptions, but its capacity is now receiving more attention. A reaction to the proposed cognitive intelligence of the left hemisphere has rendered several studies of visuospatial asymmetries in split-brain patients, which support the idea that the right hemisphere is more visually or perceptually intelligent than the left hemisphere (Corballis, 2003). Corballis has coined the term *the right hemisphere interpreter* in order to appreciate the right hemisphere’s superior capacity in tasks such as modal boundary completion (when the visual system adds contours to figures e.g., squares, and it that way make them appear to be completed figures) and illusory line motion (when a line is instantly shown on a display, but visually appears to be drawn from one end to the other). He has also found that the right hemisphere is better able to detect if two images are identical or mirror reversed, and that it is better at making fine spatial discriminations (Corballis, 2003).

Causal inference and the interpreter.

One of the first signs that the left hemisphere hosts a capacity for interpreting events became evident when a simultaneous concept test was used on split-brain patients. In this test the patient is shown two pictures, one to each hemisphere, and in front of him he has a set of pictures from which the patient is supposed to choose the ones that are associated with the pictures shown to each hemisphere (Gazzaniga, 1995). In one of maybe the most prominent examples of this test, a picture of a chicken-claw was flashed to the left hemisphere, and a picture of a snow scene was flashed to the right hemisphere. Of the set of pictures that were presented, the obvious association was a chicken for the chicken claw, and a shovel for the snow scene. But the patient chose the shovel with the left hand (right hemisphere) and the chicken with the right hand (left hemisphere). The interesting thing was that when the patient was asked about the choices he had made, he verbally responded (left hemisphere) “Oh, that’s simple. The chicken claw goes with the chicken, and you need a shovel to clean out the chicken shed” (Gazzaniga, 1995, p. 225). The explanation provided for this phenomenon was that the left hemisphere observed the left hand’s (right hemisphere) response and interpreted it in terms of its own knowledge and context, which did not include information of the snow scene presented to the right hemisphere (Gazzaniga, 1995).

Other studies on the interpreter have shown the same tendency. In one study, a patient was flashed the word *telephone* to the right hemisphere. The patient responded by saying:

> ‘I’m not sure I got that one. I think it’s a clap – that wouldn’t be right, would it’?
>
> He was then asked to draw what he had seen and with his left hand he drew a

> telephone. When he was finished he said ‘Telephone’. I don’t know where I got clap out of telephone’. He was then asked, ‘You said clap but you drew a phone. Do you know why you drew a phone?’ He responded ‘No. Too many pills – it makes me feel high’. (Gazzaniga, 2000, p. 1318)

Another study flashed the word *bell* to the right hemisphere and the word *music* to the left hemisphere of a split-brain patient. When the patient got to choose from a set of pictures, his left hand (right hemisphere) pointed to a picture of a bell. When asked why he chose this picture, he responded “’Music – last time I heard any music was from the bells outside here, banging away’. [He] was referring to the bells that ring regularly from the Dartmouth library” (Gazzaniga, 2000, p. 1318).

A study was also carried out with a split-brain patient that in addition to a speaking left hemisphere (the most common condition where you have a language-dominant left hemisphere) could make a few word utterances with her right hemisphere. When a picture of a hurdler was shown to her left hemisphere she could describe it in great detail. She said:

> ‘I don’t know if he’s an athlete or not, but he’s a man running over hurdles. He’s got gym shorts on and I don’t know for sure if he had a shirt on. I think he did and tennis shoes, jogger’s shoes’. (Gazzaniga, 2000, p. 1318)

Later, when the same picture was shown to her rudimentary-speaking right hemisphere she uttered the word *athlete,* and when the left hemisphere heard the right hemisphere’s response, it started to add descriptions of the picture it had not even seen: “A basketball guy? Had a uniform. His back was facing me, and he was on an angle. He looked like he had been walking, and he was gonna take another step because one foot was like more out” (Gazzaniga, 2000, p. 1318).

The same left hemisphere tendency for trying to make sense of events and behaviours has also been found when it comes to more internal processes, like mood-shifts. Studies were made on split-brain patients where they manipulated the right hemisphere, either by triggering a negative or positive mood-shift by flashing arousing stimuli to the right hemisphere. This trigger made the patient interpret a previously neutral situation in a more positive or negative way. In one example a patient, while still claiming to see nothing, suddenly claimed that she was upset and that the experimenter was the one who had upset her. The explanation provided for this result was that the left hemisphere felt the valence of the emotional response, but due to lack of information as to what caused the response, it invented a reason for it (Gazzaniga, 2000).

Schachter and Singer (1962) performed a similar study, as discussed by Gazzaniga (2000) where subjects were injected with epinephrine, which activates the sympathetic nervous system and lead to increased heart rate, hand tremors and facial flushing. The subjects were then exposed to a person that behaved either in an angry or a joyful manner. The subjects that had not been informed of the effects of epinephrine attributed their physical reaction to the environment, as being angry or joyful themselves, while the subjects that were informed of the effects of epinephrine attributed their physical symptoms to the drug instead. These findings indicate that we try to find reasons for our own inner processes as well as external processes, and also that when we are given an explanation we accept it (Gazzaniga, 2000).

Considering these findings it has been proposed, as noted earlier, that the two hemispheres possess different memory functions. A prediction based on this would then be that the two hemispheres respond differently in some mnemonic tasks. Such a study was performed by Metcalfe and colleagues (1995) where split-brain patients were shown pictures of a common scene, and then they were tested two hours later with a lateralized yes-no recognition test. This test contained distracter pictures that were either *consistent* or *non-consistent* with the original picture, and the two hemispheres were to determine this by responding *yes* or *no*. The result was that the two hemispheres responded differently, the left hemisphere performed below chance on consistent distracter pictures, while the right hemisphere performed above chance. The right hemisphere seemed to reject pictures that were not actually witnessed, while the left hemisphere falsely recognized pictures as consistent with the original picture (Metcalfe et. al., 1995; see also Gazzaniga, 1995).

Studies of probability-guessing have also led us to gain clues on how the two hemispheres might use different strategies for problem-solving. In one such experiment (Wolford et. al., 2000), two split-brain subjects were supposed to guess which of two events would occur next in a sequence of events. What the subjects did not know was that each event had a different probability of occurrence (such that a red stimulus might appear 75% of the time, and a green stimulus 25% of the time), while the order was kept random. There are two strategies that can be used for this task; *maximizing* and *matching*. Maximizing means guessing for the same event (red stimulus) every time, ensuring a probability of 75% for choosing the right answer. This strategy has been shown to be favoured among animals in earlier studies. Matching instead, means that we try to figure out the frequency or pattern of occurrence for the two stimuli respectively, and base our guesses on this. This is what humans tend to do, even when we are told that the sequences are random. The result indicated that the left hemisphere approached frequency matching, while the right hemisphere approached maximizing (Wolford et. al., 2000).

A conceptual replication (where the same phenomenon was studied using the same procedures but using subjects with different head-traumas) was also made on this study, using this time patients with unilateral damage to either the left or the right hemisphere. These results support that the left hemisphere engage in hypothesis formation and a search for patterns, while the right hemisphere is proposed to try to solve the task in the simplest way possible (Wolford et. al., 2000; see also Gazzaniga, 2000).

One might wonder why this left hemisphere function would be adaptive since accuracy is reduced, for example when it comes to recognition. Walsh (2000) provides an explanation for this and says that in a world of limited trials and possibilities, the right hemisphere's more accurate strategy would seem reasonable. But as the number of possibilities and repeated events increase, as it has done in the last three million years, the left hemisphere's elaboration strategy would seem more necessary (Walsh, 2000). In general, that would make it easier to deal with new information, and it has been suggested that the left hemisphere uses visual information primarily for identification, and not for spatial precision like the right hemisphere (Corballis, 2003).

When it comes to the localization of the interpreter, it has been proposed that its likely site is in the frontal cortex, including Broca's area which is associated with self-generated behaviours. It is suggested to be part of an ensemble where the left pre-motor cortex is needed for selecting actions and the ventromedial prefrontal cortex is needed to estimate the consequences of actions (Walsh, 2000). Gazzaniga, according to Hirstein (2006) has not made any specific remarks on where the interpreter would be localized in the left hemisphere, but he proposes that it lies in the distribution of the middle cerebral artery. This is a branch of the internal carotid artery that supplies both hemispheres' lateral surfaces with blood, including primary motor and sensory areas, language areas, as well as globus pallidus, putamen, and internal capsule (Internet Stroke Center, 1997-2010).

Confabulation

Gilboa and Verfaellie (2010) suggest that people who confabulate present information, or act on information, that is obviously false and they are unaware of their inaccuracy. They also tend to stick to their false information even when confronted with counterarguments, or even the truth. This is as close to an agreed definition of confabulation as we might come at this stage. Despite a century of research there is still no clear definition of confabulation, which also means that everything else concerning confabulation remains controversial (Gilboa & Verfaellie, 2010). A lot of definitions have been suggested, but a commonly used one, according to Langdon and Turner (2010) is that confabulation is defined as a false *memory* and that it is often associated with neurological disorders like amnesia. When discussing confabulation, authors also often cover the related phenomenon of delusion, which is commonly defined as a false *belief* and is associated with psychiatric disorders like schizophrenia (Langdon & Turner, 2010).

Research on confabulation is gaining more and more attention, but the research area is still very much scattered. There is no clear agreement on how to define confabulation, or how to conceptually distinct it (if at all) from related phenomena such as delusions, since confabulation seems to arise from different neural pathologies (Bortolotti & Cox, 2009; Corlett, Taylor, Wang, Fletcher & Krystal, 2010; Gilboa & Verfaellie, 2010). These include for example: Split-brain syndrome, anosognosia for hemiplegia, Korsakoff’s syndrome, Capgra’s syndrome, Anton’s syndrome, Alzheimer’s disease, aneurysm of the anterior communicating artery (ACoA), and schizophrenia (Hirstein, 2006). No theory exists that can fully explain the rich aetiology of confabulation. There is also no agreement on what the relation is between pathological confabulation, delusion, and more non-pathological fabrications made by healthy people (Bortolotti & Cox, 2009; McKay & Kinsbourne, 2010). Some forms of confabulation are even seen as a normal response in certain situations, like to an erroneous memory (Dalla Barba & Boissé, 2010), and confabulation has also been reported among young children, hypnotized subjects, people who describe their mental states, and people who are asked to give explanations for opinions (Hirstein, 2006). Despite this incongruity, the research on confabulation and delusion share a common theme in that they all study distorted representations of reality (Langdon & Turner, 2010).

The fact that there remain controversies concerning the definition of confabulation as well as its neuroanatomical underpinnings, could be reflected in the more fundamental lack of a unified neurocognitive theory of confabulation, according to Gilboa and Verfaellie (2010). If the neurocognitive processes at work could be unravelled, it would help us to explain the commonality of the different surface features of confabulation, and also generate an understanding of these processes in healthy people. The different neurocognitive theories that have been proposed have commonly been categorized into three broad groups: (a) temporality/source confusion theories, (b) strategic retrieval theories, (c) and motivational theories (Gilboa & Verfaellie, 2010). However, there are also two additional theories that do not seem to fit under these rubrics, and thus will be presented separately; false probabilistic inferences, and the two-error theory.

Gilboa and Verfaellie (2010) distinguish between the main neurocognitive theories in that *temporality* theories view confabulation as involving a disturbed sense of chronology for events, or a more general impairment in context and source-monitoring. The *strategic retrieval* theories view confabulation as an intrinsic memory phenomenon and focus on how memory-monitoring processes malfunction in confabulation. In recent years, there has also been an upsurge of interest in the specific *contents* of confabulations, something that has previously been neglected to a large degree. These theories, termed *motivational* theories, suggest that the contents of confabulations are biased in a self-enhancing way, and that motivational factors thus play a part in confabulation. Motivational theories have also often been combined with neurocognitive theories which emphasize the deficits of confabulation (Gilboa & Verfaellie, 2010). A brief review of some of these theories will now be presented.

Theories of confabulation

Temporality/source confusion theories.

Kopelman (2010) is of the opinion that the three concepts of confabulation, delusional memories and delusion, should be kept conceptually distinct, since current research models (of delusions especially), is in no position to grasp the complexity of the phenomena. He means that a comprehensive theory would have to grasp all the different aspects of, and situations in which confabulation and delusion arise. And even though the different types of confabulation and delusion seem to share some commonalties, there are still marked differences between them that have to be acknowledged at this early stage.

Confabulation, which Kopelman (2010) place on a par with false memories, tends to be variable and multifaceted and almost always connected to executive dysfunction. He emphasizes a contrast between *spontaneous* and *provoked* confabulations, which is now also commonly used by many researchers in the field, according to Langdon and Turner (2010). Spontaneous confabulation is explained by Kopelman (1987, 2010) as unprovoked memories, which can have implausible or even fantastic content, and still be believed with absolute certainty. Spontaneous confabulation is relatively rare and has commonly been related to frontal lobe pathology and executive dysfunction, and lately more specifically to pathology in the ventromedial frontal cortex or orbitofrontal cortex. Provoked confabulations, in contrast, can be explained as a result of direct challenging of a memory (such as in a memory test), which trigger small distortions or interferences in memory. Provoked confabulation is often viewed as a normal phenomenon, meaning that it can arise in healthy subjects whenever memory is week, and therefore does not necessarily requires pathology, even though it may arise together with pathology and spontaneous confabulation (Kopelman, 1987, 2010).

Delusion is defined by Kopelman (2010) as a false belief, since it is not necessarily a memory phenomenon (even though they do become integrated into memory), but instead commonly arises as abnormal perceptual experience or attentional bias, or a malfunctioning belief-evaluating system. Delusions arise in many different situations (e.g., without no given cause, as a consequence of preceding anxiety, hallucinations, mania, depression and medical disorders, or neurological diseases like epilepsy and dementia) and are preserved with absolute certainty, as well as they are preoccupying and extraordinary in content. *Delusional memories*, in contrast, are apparent memory phenomena, arising either from true memories that have triggered delusional interpretations, or from psychotic disorders that have triggered false memories. Delusional memories tend to be thematic and not related to executive function, and their presence is rare in psychiatric patients, compared to delusions (Kopelman, 2010).

Dalla Barba and Boissé (2010) claim, in response to Kopelman, that the provoked/spontaneous distinction of confabulation is inadequate to capture the nature of confabulations. They performed a study where they analysed 284 provoked and 52 spontaneous confabulations, which showed that the majority of the provoked (52%) and spontaneous (73%) confabulations could not be classified into the categories of provoked and spontaneous confabulations. These confabulations instead fell under what Dalla Barba and Boissé (2010) describe as *general memories, habits and misplacements*, meaning that the confabulations are true events misplaced in time or place, or involve *general* memories of habits and routines, which are recalled as *specific* memories (e.g., when a subject is asked to describe a specific Christmas, she responds by describing what she has probably done during many Christmases). Dalla Barba and colleagues thus propose the *memory, consciousness, and temporality* theory that ascribe this tendency to a cognitive abnormality in the integrity of the Medial Temporal Lobe (MTL), and claim that this is what these confabulators have in common. The MLT seems to enable our Temporal Consciousness (TC), which can be viewed as a parallel consciousness *of time*, dedicated specifically to the structuring of objects, in the mode of temporality. The MLT thus allows us to be aware of our personal past, present and future (Dalla Barba & Boissé, 2010; see also Langdon & Turner, 2010).

O'Connor, Lever and Moulin (2010) have started to investigate a new form of false memory, which highlights the boundary that has been placed between false memory and false belief. In this new phenomenon, called *déjà vecú*, the subject experiences events he believes have happened before, in comparison to *déjà vu*, where a subject knows that this familiar feeling is wrong, and therefore reject it. O´Connor and colleagues claim that this new form of memory resembles delusions, since the subjects show a delusional conviction towards the memory. This new phenomenon also seems to emerge especially for novel stimuli. They suggest that a dysfunction of the hippocampal memory system for the separating, encoding and retrieval modes, could explain this phenomenon, and present the *encoding-experienced-as-retrieval* hypothesis for this new form of false memory (O'Connor, Lever & Moulin, 2010).

Strategic retrieval theories.

Gilboa and Verfaellie (2010) also emphasize memory-related confabulations, but claim that confabulations concern defective strategic retrieval of memories. Strategic retrieval means that the relevant memory is not elicited automatically by the cue, but has to be recovered through a more conscious strategic search, similar to problem-solving. This function seems to be defective in confabulators. Strategic retrieval hypothesis builds on observations where confabulation has been found to affect both memories acquired long before the injury, as well as memories acquired after the injury. Thus, confabulation seems to involve retrieval processes rather than encoding processes, according to Gilboa and Verfaellie (2010), even though a recent study (Attali, De Anna, Dubois & Dalla Barba, 2009) has revealed a role for poor encoding in confabulation of Alzheimer patients.

Gilboa et al. (2006) performed a series of three experiments that tested two of the three main theories concerning the neurocognitive mechanisms of confabulation; the strategic retrieval hypothesis as opposed to the temporality hypothesis. These experiments indicated that monitoring dysfunctions of retrieved memories seems particularly critical for confabulation, and thus supported the strategic retrieval hypothesis.

Carr (2010) focuses specifically on delusions and schizophrenia, and claims that the search for meaning which can be observed in schizophrenic patients can be seen as a result of reduced prefrontal monitoring. He means that some pre-psychotic experience leads to the outcome that our actual experience differ from our expectancies, which then trigger an usually normal response to interpret the situation in a way that provides a sense of meaning. But if the constraints of the prefrontal cortex is poor (e.g., low self-reflection, low volitional control), then quite unfiltered ideas can appear and result in idiosyncratic associations, and finally a reassuring delusional belief can start to form. This might explain why the discovery of a meaning that is unifying, go together with a strong feeling of rightness for people suffering from delusions and schizophrenia, and also why they resist counterarguments and counterevidence (Carr, 2010).

Motivational theories.

Motivational factors can be viewed as goal-directed states or processes that produce and organize action, e.g., desires and intentions, according to McKay and Kinsbourne (2010). They state that, traditionally, there have been two main approaches proposing motivational factors for confabulation. The first theory view confabulations as a way to conceal gaps in memories. This view has a long history, but has yielded little empirical support to date, and is thus not further examined here. The second theory views confabulation as a reflection of systematic positive bias, meaning that the confabulating content is positively self-enhancing, and this view has yielded promising results (McKay & Kinsbourne, 2010).

Fotopoulou (2010) advocate the latter of these motivational approaches, in that she emphasizes the importance of emotional and motivational influences on confabulations and delusion. She argues that academic traditions have led to a general division between psychological and neurological approaches, with their own ways of explaining phenomena. The neurocognitive view has mainly been favoured, and this has in this case, led to some neglect of the emotional and motivational components of confabulation and delusion. She nonetheless acknowledges that these affective influences could be initiated either directly by a neural deficit, or more indirectly from changed social circumstances, or maybe a combination of these. In this way, she combines the motivational view with a more neuropsychological approach, which she means is valuable for understanding the various symptoms of confabulation and delusion, as well as to better understand the relation between emotion and cognition (Fotopoulou, 2010).

Fotopoulou, Conway and Solms (2007) performed an experiment where they investigated whether confabulating patients would misrecognise pleasant events over unpleasant events as part of their recent past. They found that both non-confabulating and confabulating patients were prone to misrecognise pleasant events, but the results were significantly more frequent for confabulating patients. They also found that the more severely confabulating patients misrecognized imagined events at the same frequency as they misrecognized real events misplaced in time, which also suggests a role for defective reality and temporality-monitoring in confabulation.

Another study (Fotopoulou et. al., 2008) showed the same tendency when unbiased raters rated the emotional valence of false memories produced by confabulators. The confabulators significantly distorted the earlier experiences in a positive and self- enhancing way. Paradoxically, they also found an association between depressed mood and positive emotional content, in that the more depressed mood the patients had, the more positive confabulations they produced. Fotopoulou and colleagues argue that it may be so that the production of positive confabulations is commonly associated with occurrences of low mood, but they acknowledge that this finding needs further examination. They concluded with the general proposition that the contents of confabulations often seems to be positive in nature (Fotopoulou et. al, 2008).

McKay and Kinsbourne (2010) agree with Fotopoulou, that there is a role for motivational factors across the different syndromes, including confabulation, delusion and anosognosia (a condition where the subject either denies or is unaware of his impairment or disease). McKay and Kinsbourne are interested in the false public claims they propose are the key features of confabulation, delusion and anosognosia. They mean that there is a motivational component in these cases of false public claims. It may be in the form of a secondary response to a psychologically new reality due to a neurological deficit, or a release of a motivational process, such as a defence mechanism. Moreover, they argue that all people end up with false beliefs in some instances, and that these false beliefs provide the basis for false claims. They propose that false beliefs arise from different reasons, such as normal cognitive limitations, social influence and deceit, or neural deficits. Evolution has put cognitive limitations on our ability to create accurate representations of reality, and our ability to hold true beliefs is imperfect. As a result, false beliefs arise as normal incidences due to the imperfections of cognitive processes. McKay and Kinsbourne have therefore extended their interest in false claims in pathology, to embrace also the existence of false claims in normal cognitive functioning (McKay & Kinsbourne, 2010). This has according to Langdon and Turner (2010) brought them closer to a continuity approach of confabulation; that there is an interplay between normal and abnormal functioning in confabulation. An approach that has received increased interest lately.

Metcalf, Langdon and Coltheart (2010) also advocate a role for emotional biases in confabulation, but they have found that the biases do not need to be emotionally positive. They performed a study of six confabulating patients, with different aetiologies, in order to investigate the effect of personal biases on confabulations. They found that the positive emotional biases were not universal, and instead proposed that the emotional biases across aetiologies could be better explained in terms of self-coherence; that we are driven to maintain a consistent self-concept, whether positive or negative (Metcalf, Langdon & Coltheart, 2010; see also Langdon & Turner, 2010).

A similar proposition is given by Bajo, Fleminger and Kopelman (2010) who performed a study where they investigated the content of confabulations compared to true memories of 24 patients (with diverse memory-related aetiologies). They found that confabulations do have more affective content than true memories, but that the affective valence of the confabulations rather was related to the patients' current mood state, instead of being self-enhancing. The implication, they argue, is that the emotional content of confabulations, as well as for true memories, at least to some extent is linked to the mood of the person (Bajo, Fleminger & Kopelman, 2010).

Building on the findings above, Bortolotti and Cox (2009) claim that confabulation can be seen to serve two motivational functions: (1) to establish continuity in one's own personal narrative and produce coherence, as well as (2) to preserve a positive self-image. Wilson & Ross (2003) have found that normal people tend to present themselves in both a coherent and a favourable way. But since this tendency reflects a possible tension between the ambition to preserve coherence and being constrained by reality, one might wonder what people would choose when they are forced to choose between them. Studies have found that people choose coherence over reality and truth (Cox & Barnier, 2009; Haidt, 2001; Nisbett & Wilson, 1977; see also Bortolotti & Cox, 2009).

Producing narratives is one way of preserving coherence, and the role of self-narratives has already been found to be highly significant for feelings of autonomy and self-governance, as well as for psychological well-being (Bortolotti & Cox, 2009). Other clear health benefits have also been found for keeping a coherent and structured narration. Mar (2004) has found that the more coherent account a person creates for a past trauma, the more helpful it is in dealing with the trauma. The same has been found in clinical treatments of post-traumatic-stress-disorder, where it is fundamental to create a coherent story of the traumatic event, and integrate this into one's self-representation in order to recover (Mar, 2004).

The benefits of narratives also extend outside the realm of traumatic events, according to Mar (2004). It has been found that people use similar processes like story construction when they form their own personal history, through selection and ordering of memories into a representation of the self. We may also use the same process when making reasoned judgements. It has for example been found that jurors decide upon verdicts based on coherence-testing of the different stories that are presented by the lawyers, which are constructed to fit the current evidence (Mar, 2004).

Bortolotti & Cox (2009) also advocate for a potential benefit of confabulations, but maybe in more epistemic terms. They suggest in general, that epistemic definitions of confabulation should be favoured, since it does not seem plausible for confabulation to be captured in just one aetiological definition at this stage. Epistemological definitions would capture the surface features and behavioural manifestations of confabulation and ensure a more complete picture of the phenomenon, with no danger of narrowing down to early. The literature on confabulation shows a clear tendency towards more than one causal explanation of confabulation, since different pathologies seem to differ in their neurobiological bases and since confabulation also occurs in non-pathological people.

They nonetheless acknowledge that the existing epistemic definitions of confabulation suffer from weaknesses, in that most of them emphasize the epistemic *disadvantage* of confabulation and not its potential *benefits*. They suggest that confabulation may serve epistemic, as well as pragmatic and adaptive benefits. It is for example socially rewarded to give a confident answer (even though the answer may be faulty) instead of saying 'I don't know'. Confabulations may also serve as a protection from undesirable truths and keeping depression and anxiety at bay, and even serve as a preservation of a sense of self (Bortolotti & Cox, 2009).

False probabilistic inferences.

Corlett et al. (2010) study delusions from a cognitive neuropsychiatric viewpoint, and they claim that delusions are extraordinary persistent beliefs which patients with various illnesses (e.g., schizophrenia, Alzheimer's and Parkinson's disease) suffer from. They take the premise that the brain works as an inference device, originally put forward by Helmholtz (1878/1971), as discussed by Corlett et al. (2010). They claim the beliefs people hold can be seen as inferences, which are probabilistic in nature. The function of these inferences or beliefs is the same as for memories; to organize current information and to help produce adaptive responses, as described by Dennett (1995). On this reasoning, Corlett and colleagues suggest that delusions are false probabilistic inferences that fail to represent the world accurately, and therefore people may fail to produce adaptive responses.

Corlett et al. (2010) further claim that beliefs (whether normal or false), are formed by both inherent and learned processes (for a review of learning-processes, see Shanks, 2010). They also claim that beliefs, like any other form of information, correspond to the strength of synaptic connections on the neural level. This could also explain why delusions become so imprinted into memory. Delusions may arise as new beliefs which bring such relief that they turn into a new foundational scheme. Corlett and colleagues nonetheless acknowledge the difficulty of studying the concept of belief, especially in the realm of neuroscience, since it is such a complex concept to both define and study (Corlett et. al., 2010). For a further discussion on the concept of belief see Dennett (1995).

The two-error theory.

Hirstein (2006) suggests a general distinction between confabulation and delusion, where the former is conceived as a mistaken *claim* that need to be communicated to others, while the latter is conceived as a mistaken *belief* that does not have to be communicated to others. As for the similarities among confabulation and delusion, Hirstein means that a *two-error theory* could conceptually explain the two conditions. This theory include a *knowledge*-error (concerning the content), and a *correction*-error (a failure to dispute the implausible claim). Hirstein means that both errors are necessary to fully account for the symptoms in confabulation (Hirstein, 2006; see also Langdon & Turner, 2010).

Langdon and Turner (2010) follow on Hirstein's two-error theory when they discuss the proposition that confabulation and delusion may be differing regarding the first error. They view the first deficit as caused by a neuropsychological impairment which affects cognitive or affective mechanisms, and depending on the impairment, the two syndromes are become different. The second deficit, they mean, is shared in confabulation and delusion in that they share common monitoring-deficits. This might explain their similarity in the failure to dispute implausible thoughts (Langdon & Turner, 2010).

Integration of the left hemisphere interpreter and confabulation

Ramachandran (1996) has attempted to integrate research on the interpreter with research on confabulation. He agrees with Gazzaniga in the claim that confabulatory explanations help to preserve the status quo and to preserve a coherent system of beliefs. He also agrees that this is the function of the left hemisphere, but also adds that the right hemisphere serve a function in that it detects anomalies between the produced explanations and reality. In this way, this right hemisphere monitoring-mechanism eventually forces a revision of the belief system. He additionally claims that the more this monitoring-mechanism (which search for inconsistencies) malfunctions, the more and more delusional the person becomes, and might finally lead to conditions such as anosognosia. He thus suggests that confabulations and delusions are exaggerations of normal defence mechanisms that actually serve an adaptive function. The evolutionary account, according to Ramachandran, would be that the left hemisphere maintains a coherent belief system and keeps the brain from ending up in directionless indecision, following the principle that any decision (as long as it is probably correct) is better than no decision at all. The right hemisphere, which is more in tune with reality, would instead work as a counterbalance to the left hemisphere. The right hemisphere prevents us from becoming too deluded and forces us to update our cognitive schema or belief system when a certain threshold is reached (Ramachandran, 1996).

The fact that humans seem to welcome roughly any explanation over indecisiveness could be explained by a phenomenon known in social psychology as *cognitive dissonance* (Festinger, 1957) which claims that humans have a distinct motivation for maintaining consonance, or consistency. Gazzaniga (2009) incorporates this theory with the research on the left hemisphere, and allocates this motivation for consonance to the rationalizing function of the left hemisphere interpreter. He says that humans experience contradictory information as mentally painful to deal with, and since our meta-cognition cannot just shut down every time confusing information is received, it have to work with the information at hand. Thus it immediately starts to rationalize and create a story that is coherent and makes cognitive sense. Gazzaniga says that this could be seen as a way to protect ourselves, even though it may distort reality in the process (Gazzaniga, 2009).

Ramachandran (1996) continues by claiming that anosognosia commonly arises from right hemispheric damage, resulting in paralysis of the left side of the body. This would mean that the brain's reality-monitoring function (the right hemisphere) is not working properly and that the left hemisphere has a more free scope for its explanations. The result we would get is a condition that would resemble anosognosia. Ramachandran thus claims that anosognosia has a neurological basis, rather than psychological, since the reversed state of affairs where the left hemisphere is damaged, does not lead to the same symptoms. If anosognosia would have a psychological basis, in that it would result from the mental disturbance of losing significant information, it would be equally disturbing irrespective of which hemisphere would be damaged. Some clinical evidence have even shown that patients with right frontal strokes are happily unconcerned of their condition, while patients with left frontal damage often are depressed, which could be explained by the different hemispheric functions. Ramachandran says that perhaps patients with left hemisphere damage lack the coping strategies to handle the harsh reality (Ramachandran, 1996).

Ramachandran demonstrates a resemblance between the function of the left hemisphere interpreter and Freudian defence mechanisms. He says that it is easy to disregard everything that Freud claimed in light of his more questionable speculations. But we risk the "danger of throwing the baby out with the bathwater" (Ramachandran, 1996, p. 348). The main point that Freud wanted to demonstrate, Ramachandran claims, is that a lot of our behaviour is governed by unconscious processes, which is still a valid claim (Ramachandran, 1996). Ramachandran continues by claiming that the defence mechanisms of rationalization, denial, repression of upsetting memories and reaction formation are related to the phenomenon of self-deception, and subsequently that the origin of anosognosia can be related to an exaggerated form of self-deception (Ramachandran, 1996).

Hirstein is also one of few that have attempted to integrate the research on the left hemisphere interpreter and confabulation, and he presents maybe the most conceptually sophisticated description of confabulation to date (Bortolotti & Cox, 2009). In his book, Hirstein (2006) reviews Gazzaniga's research on the left hemisphere and specifically comments the additional function which the interpreter is claimed to play; the formation of beliefs. Beliefs are, according to Hirstein's understanding of Gazzaniga, mental constructs that enable us to act in a way that is not governed by stimulus-response. But Hirstein claims that the production of these enabling thoughts is only one part of the belief-formation process. In order for a thought to become a belief, in the normal brain, it has to go through certain checks. Hirstein says that the general function of the temporal and parietal areas is to create responses, while the function of the frontal lobe is to check, place in context and maybe inhibit responses. Hirstein thus make the claim that confabulation not necessarily is a problem of memory, but a problem of knowledge, since it seems to be the checking-functions for information that is malfunctioning. So what confabulators have in common, according to Hirstein, is a knowledge-deficit. He draws a parallel between anosognosic and split-brain patients in that both could be confabulating because they lack information, and in addition they both have an inability to notice that they lack this information (Hirstein, 2006).

Hirstein (2006), like Ramachandran, relates the phenomenon of confabulation to the phenomenon of self-deception, in that both are caused by a failure of the brain's belief-checking process. He goes on to discuss why we may be prone to self-deception in the first place. Confabulation may be one of the cognitive errors and human fallacies that we are prone towards. He acknowledges that it may serve a protective function, a protection from the often harsh truth. But he also claims that it may be a by-product from our human representational ability, or an illustration of our creativity in an uncontrolled form. Confabulation might also be good for social reasons, in that overconfident and stable people (even if they are confabulating) are more pleasant to be with, even thought the cost is neglect of the truth. This could subsequently mean that truth is secondary to us, that truth is just a means to a more socially motivated goal (Hirstein, 2006).

Conclusion

The research on the left hemisphere interpreter and confabulation are still to one extent contrasting, and yet still share a core theme in that they both study the human tendency to infer explanations for events, even if they have no bearing in reality. When considering these both areas, a common emphasis on the possible underlying function of the interpreter and confabulation has emerged. Many researchers stress the adaptive and vital function of keeping the brain free from both contradiction and unpredictability, and that confabulations may serve this purpose.

For example, Gazzaniga (1995, 2000, 2005) claims that the brain first and foremost is a decision-making device and that the function of the left hemisphere interpreter is to create order in chaos. It fills in missing information and tries to make cognitive sense out of events, behaviours and feelings, so that appropriate response behaviours can be produced. It has also been found in studies of perceptual causality (Cheng, 1997; Buehner & Humphreys, 2010), that even the brain's visual system seems primed to search for causal relations, as a way to resolve uncertainty. Metcalf, Langdon and Coltheart (2010), as well as Bajo, Fleminger and Kopelman (2010), claim that people are driven to maintain a coherent and consistent self-concept. Bortolotti and Cox (2009) and Mar (2004) show that producing self-narratives is a way to preserve coherence, and that it has been related to autonomy, self-governance, and psychological well-being. Studies have even shown that people prefer stability and coherence over reality (Cox & Barnier, 2009; Haidt, 2001, Nisbett & Wilson, 1977).

Ramachandran (1996) also claims that confabulations help to preserve the status quo, and that they may preserve a coherent system of beliefs so that the brain does not end up in indecision. The theory of cognitive dissonance (Festinger, 1957) which claims that contradictory information is experienced as mentally painful, and that we use different types of defence mechanisms (like rationalization) to protect ourselves, is also incorporated with the function of the interpreter by Gazzaniga (2009). In addition, both Hirstein (2006) and Ramachandran (1996) relates confabulation to the concept of self-deception, also a form of defence mechanism, and they acknowledge that the function of self-deception could be to protect us from a harsh reality. These common themes on the possible functional role of confabulations may be a possible opening for cooperation across the fields.

It is a tempting as well as a reasonable conclusion that the brain dislikes contradiction and uncertainty so much that it uses defence mechanisms like confabulation and false beliefs in order to preserve coherence. It makes sense. But maybe we should not swallow this conclusion entirely and uncritically. It would be good to remember one thing that has recently been highlighted by Langdon and Turner (2010), namely the fact that there seems to be a general assumption in the confabulation literature that people often *act* on their beliefs; that beliefs strongly influence behaviour. But it actually varies among non-clinical and clinical cases of confabulation in how much they act on their beliefs. They argue that it might be so that people act on their beliefs according to how much they care about their beliefs, and how much they care about their beliefs could be influenced by other factors such as unconscious reward and punish-signals, emotional and motivational factors, as well as conscious control (Langdon & Turner, 2010).

Recent findings by Funk and Gazzaniga (2009) also support this reasoning. They mean that people have a strong intuitive idea that we base our judgements on deliberate reasoning. But recent studies on the neural basis of moral reasoning show that our moral reasoning seem to emerge *secondary* to automatic processing, and thus can be seen as a *post hoc* explanation offered for the cause and effect of our moral intuitions (Funk & Gazzaniga, 2009).

A concluding comment is therefore that we should be careful with ascribing cognitive beliefs and higher cognitive functions such a causal power as to determine our behaviour, even if they obviously do have an effect on us. Other factors, such as emotional forces, also influence us to a large degree. The directions for further study could thus be additional investigation of the phenomenon of beliefs; what they are, how they are created, their causal power in determining behaviour, as well as their accessibility for introspection and whether they can be counteracted. Additional investigation of the exciting phenomena of self-deception and cognitive dissonance and in what amount they influence us is also desirable. Furthermore it is important that the recent upsurge of interest in the role of emotional and motivational factors in confabulation continues. This might be critical to consider when discussing the possible functions or benefits of confabulations, and these diverse endeavours might aid in the continued investigation on the phenomenon of confabulation.

References

Attali, E., De Anna, F., Bubois, B., & Dalla Barba, G. (2009). Confabulation in Alzheimer's disease: Poor encoding and retrieval of over-learned information. *Brain, 132,* 204-212.

Bajo, A., Fleminger, S., & Kopelman, M. (2010). Confabulations are emotionally charged, but not always for the best. *Journal of the International Neuropsychological Society, 16,* 975-983.

Blakemore, S-J., Fonlup, P., Pachot-Clouard, M., Darmon, C., Boyer, P., Meltzoff, A.N., … Decety, J. (2001). How the brain perceives causality: An event-related fMRI study. *NeuroReport*, *12*, 3741-3746.

Bortolotti, L., & Cox, R.E. (2009). Faultless ignorance: Strengths and limitations of epistemic definitions of confabulation. *Consciousness and Cognition, 18,* 952-965.

Buehner, M.J., & Humphreys, G.R. (2010). Causal contraction: Spatial binding in the perception of collision events. *Psychological Science, 21,* 44-48.

Carr, V.J. (2010). Beauty and belief: William James and the aesthetics of delusions in schizophrenia. *Cognitive Neuropsychiatry, 15*, 181-201.

Cheng, P.W. (1997). From covariation to causation: A causal power theory. *Psychological Review, 104*, 367-405.

Cooney, J.W., & Gazzaniga, M.S. (2003). Neurological disorders and the structure of human consciousness. *Trends in Cognitive Sciences,* 7, 161-165.

Corballis, P.M. (2003). Visuospatial processing and the right-hemisphere interpreter. *Brain and Cognition, 53*, 171-176.

Corlett, P.E., Taylor, J.R., Wang, X-J., Fletcher, P.C., & Krystal, J.H. (2010). Toward a neurobiology of delusions. *Progress in Neurobiology, 92,* 345-369.

Cox, R.E., & Barnier, A.J. (2009). Hypnotic illusions and clinical delusions: A hypnotic paradigm for investigating delusions of misidentification. *The International Journal of Clinical and Experimental Hypnosis, 57*, 1-32.

Dalla Barba, G., & Boissé, M-F. (2010). Temporal consciousness and confabulation: Is the medial temporal lobe temporal? *Cognitive Neuropsychiatry*, *15*, 95-117.

Dennett, D.C. (1995). Do animals have beliefs? In H. Roiblat, J-A. Meyer (Eds.), *Comparative approaches to cognitive science* (pp. 111-118). London, England: The MIT press.

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford, California: Stanford University Press.

Fotopoulou, A. (2010). The affective neuropsychology of confabulation and delusion. *Cognitive Neuropsychiatry, 15*, 38-63.

Fotopouluo, A., Conway, M.A., & Solms, M. (2007). Confabulation: Motivated reality monitoring. *Neuropsychologia, 45*, 2180-2190.

Fotopoulou, A., Conway, M.A., Tyrer, S., Birchall, D., Griffiths, P., & Solms, M. (2008). Is the content of confabulation positive? An experimental study. *Cortex, 44*, 764-772.

Fugelsang, J., Roser, M.E., Corballis, P.M., Gazzaniga, M.S., & Dunbar, K.N. (2005). Brain mechanisms underlying perceptual causality. *Cognitive Brain Research, 24*, 41-47.

Funk, C.M., & Gazzaniga M.S. (2009). The functional architecture of human morality. *Current Opinion in Neurobiology, 53*, 678-681.

Gallo, D.A., Roberts, M.J, & Seamon, J.G. (1997). Remembering words not presented in lists: Can we avoid creating false memories? *Psychonomic Bulletin & Review, 4*, 271-276.

Gazzaniga, M.S. (1995). Principles of human brain organization derived from split-brain studies. *Neuron, 14*, 217-228.

Gazzaniga, M.S. (2000). Cerebral specialization and interhemispheric communication: Does the corpus callosum enable the human condition? *Brain, 123*, 1293-1326.

Gazzaniga, M.S. (2005). Forty-five years of split-brain research and still going strong. *Nature Reviews Neuroscience*, 6, 653-659.

Gazzaniga, M.S. (2009). The fictional self. In D.J.H. Mathews, H. Bok, P.V. Rabins (Eds.), *Personal identity and fractured selves: Perspectives from philosophy, ethics, and neuroscience* (pp. 174-185). Baltimore: The Johns Hopkins University Press.

Gazzaniga, M.S., Eliassen, J.C., Nisenson, L., Wessinger C.M., Fendrich, R., & Baynes, K. (1996). Collaboration between the hemispheres of a callosotomy patient: Emerging right hemisphere speech and the left hemisphere interpreter. *Brain, 119*, 1255-1262.

Gilboa, A., Alain, C., Stuss, D.T., Melo, B., Miller, S., & Moscovitch, M. (2006). Mechanisms of spontaneous confabulations: A strategic retrieval account. *Brain, 129*, 1399-1414.

Gilboa, A., & Verfaellie, M. (2010). Telling it like it isn't: The cognitive neuroscience of confabulation. *Journal of the International Neuropsychological Society, 16*, 961-966.

Haidt, J. (2001). The emotional dog and its rational tail: A social intuitionist approach to moral judgment. *Psychological review, 108*, 814-834.

Helmholtz, H.von. (1878/1971). The facts of perception. In R. Kahl (Ed.), *Selected Writings of Herman von Helmholtz*. Middletown, Connecticut: Weslyan University Press.

Hirstein, W. (2006). *Brain fiction: Self-deception and the riddle of confabulation.* London, England: MIT Press.

Internet Stroke Center, (1997-2010). Glossary of neurological terms: Middle cerebral artery. Retrieved June 9, 2011 from Internet Stroke Center at Washington University: **http://www.strokecenter.org/education/glossary.html#m**

Kopelman, M.D. (1987). Two types of confabulation. *Journal of Neurology, Neurosurgery, and Psychiatry, 50*, 1482-1487.

Kopelman, M.D. (2010). Varieties of confabulation and delusion. *Cognitive Neuropsychiatry, 15*, 14-37.

Langdon, R., & Turner, M. (2010). Delusion and confabulation: Overlapping or distinct distortions of reality? *Cognitive Neuropsychiatry, 15,* 1-13.

Leslie, A.M., & Keeble, S. (1987). Do six-month-old infants perceive causality? *Cognition, 25*, 265-288.

Mar, R.A. (2004). The neuropsychology of narrative: Story comprehension, story production and their interrelation. *Neuropsychologia, 42*, 1414-1434.

McKay, R., & Kinsbourne, M. (2010). Confabulation, delusion, and anosognosia: Motivational factors and false claims. *Cognitive Neuropsychiatry, 15*, 288-318.

Metcalf, K., Langdon, R., & Coltheart, M. (2010). The role of personal biases in the explanation of confabulation. *Cognitive Neuropsychiatry, 15,* 64-94.

Metcalfe, J., Funnel, M., & Gazzaniga, M.S. (1995). Right-hemisphere memory superiority: Studies of a split-brain patient. *Psychological Science, 6*, 157-164.

Nisbett, R.E., & Wilson, T.D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84,* 231-259.

O'Connor, A.R., Lever, C., & Moulin, C.J.A. (2010). Novel insights into false recollection: A model of déjà vécu. Cognitive Neuropsychiatry, 15, 118-144.

Ramachandran, V.S. (1996). The evolutionary biology of self-deception, laughter, dreaming and depression: Some clues from anosognosia. *Medical Hypothesis, 47,* 347-362.

Roediger, H.L., & McDermott, K.B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology. Learning, Memory and Cognition, 21,* 803-814.

Roser, M.E., Fugelsang, J.A., Dunbar, K.N., Corballis, P.M., & Gazzaniga, M.S. (2005). Dissociating processes supporting causal perception and causal inference in the brain. *Neuropsychology, 19,* 591-602.

Roser, M., & Gazzaniga, M.S. (2004). Automatic brains – Interpretive minds. *Current Directions in Psychological Science, 13,* 56-59.

Schachter, S., & Singer, J. (1962). Cognitive, social, physiological determinants of emotional state. *Psychological Review, 69,* 379-399.

Seligman, M.E.P. (1991). *Learned optimism.* New York: Knopf.

Shanks, D.R. (2010). Learning: From association to cognition. *Annual Review of Psychology, 61,* 273-301.

Walsh, V. (2000). Hemispheric asymmetries: A brain in two minds. *Current Biology, 10,* 460-462.

Wilson, A.E., & Ross, M. (2003). The identity function of autobiographical memory: Time is on our side. *Memory, 11,* 137-149.

Wolford, G., Miller, M.B., & Gazzaniga, M. (2000). The left hemisphere's role in hypothesis formation. *The Journal of Neuroscience, 20,* RC64.