Bachelor Degree Project

UNIVERSITY OF SKÖVDE

Memory distortion and source amnesia

– A review of why our memories can be badly mistaken

Bachelor Degree Project in Cognitive Neuroscience

Basic level 22.5 ECTS

Spring term 2018

Adam Hedin

Supervisor: Almira Thunström

Examiner: Oskar MacGregor

Abstract

Our memory is prone to distortions which in everyday life can lead to mistaken memories. This thesis investigates memory distortion. In addition, one might recall (e.g. an event) correctly but misremember the source of the event (e.g. place or time of the event); this particular type of memory distortion is called source amnesia. Here, an overview of cognitive theories of memory distortion as well as the neuroscience behind memory distortion is provided. In addition, the particular memory distortion of source amnesia where one is unable to acquire when or where a fact was learned is further investigated. Results indicate that an overlap of qualities related to the information being learned causes information to be linked to wrong sources, thus creating distorted memories. Misinformation is also indicated to produce impairment in memory. In memory distortions, memory impairments are representative in various areas of the brain, including the hippocampus and the amygdala in the medial temporal lobes as well as in the frontal cortex and in the visual cortex. These key areas are also closely related to brain aging in Alzheimer´s disease and in schizophrenia, depression, posttraumatic stress disorder (PTSD) and in drug and alcohol abuse. Individuals inflicted with these disease symptoms seem to be more prone to source amnesia compared to controls. The limitations and future directions of what we can study regarding memory distortion and source amnesia are also presented in this thesis.

Keywords: memory distortion, source amnesia, misattribution, memory impairment

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1. Introduction

It can be stated that even though one can retrieve vivid events of the past, one is prone to do so in a manner of inaccuracy or distortion (Dennis, Bowman, & Turney, 2015). This faulty way of remembering is defined as *memory distortion*. In addition, one might recall (e.g. an event) correctly but misremember the source of the event (e.g. place or time of the event); this is called *source amnesia*.

Consequently, given this mismatch in memory, research highlights the difficulty to differentiate between true and distorted memories, making distorted memories a crucial and demanding area of interest within the field of memory research (Dennis et al., 2015). Memory distortion and in particular source amnesia is an interesting field of study as it helps neuroscientists to study the memory system. Memory distortions and source amnesia can both be a result of a cognitive damage and natural cognitive decline. There are several cognitive theories of why memory distortion occurs. While some theories focus on the social and cultural context in which we form and retrieve memories, (Johnson, Raye, Mitchell, & Ankudowich, 2012), others focus more on how our memory is distorted by external factors such as misinformation and contradictory information (Loftus, 2005). One of the most prominent theories, the Deese-Roediger-McDermott theory, focuses mainly on memory distortions that occur in laboratory settings. Subjects presented with word lists that contain related words such as juice, ham, egg, and pancake; will also recall a word that is not listed but related, such as toast, as the context of the words together forms a breakfast (Roediger & McDermott, 1995). Another aspect of memory distortion is source amnesia. Theories of source amnesia suggest that one can recall a fact without being able to remember where or when the information was originally experienced or acquired, which applies to both memories of facts and personal memories such as one’s childhood. These theories will be further elaborated on in this thesis. There are also many neurobiological and pathological causes to

memory distortion and source amnesia such as drugs, dementia, psychiatric illnesses, and old age, all which will be further described in this paper. The aim of this thesis is to investigate why our memories can be badly mistaken by answering the question:

1. What are the neural correlates of memory distortion and in particular source amnesia?

Initially, memory and different memory systems will be explained in order to better understand how memories are formed. In addition, diagnostic tests that are used to test memory function are presented in this thesis since these can be used to test memory function and source amnesia. The cognitive theories of memory distortion explain why one might experience distorted memories whereas the neuroscience of memory distortion explains how memory distortion can be manifested in the brain. One particular type of memory distortion called source amnesia is provided and explained, using neurobiological and psychiatric aspects. Finally, the results of the research of memory distortion and source amnesia are discussed followed by a presentation of limitations and suggested future research.

2. Memory

Since this essay investigates memory distortion, a shorter explanation of different types of memory will now be presented.

Different models of memory distinguish between memories of shorter length, for example, sensory memory which contains a time-lapse of milliseconds to seconds. Memories that are of short to medium-lived persistence are defined as short-term, whereas working memory have a time-lapse of seconds to minutes and long-term memory which have a memory persistence of decades (Gazzaniga, Ivry, & Mangun, 2013).

Additionally, learning and memory can be divided into three extensive stages of processing. *Encoding*, which processes information that comes in and consequently creates memory traces which is then stored. The stage of encoding consists of two phases; the first phase is called *acquisition*. An extensive amount of stimuli are constantly attacking sensory systems, which in majority produce a very short and temporary sensory response that quickly fades, with a response of 1000 milliseconds after presentation, never reaching short-term memory. In this stage stimuli are able to process, a phase called sensory buffer. A limited amount of these stimuli are then good for a continuance to the short-term memory (Gazzaniga, Ivry, & Mangun, 2013). *Consolidation* is the second phase of encoding in which the brain makes changes in order to maintain a memory over time, creating a memory of long-term. The consolidation gets stronger over time and has a time lapse of days to months and years. The second stage of learning and memory processing is the representation of a permanent record of the information, called *storage*, which is the result of both acquisition and consolidation. The third stage, called *retrieval*, deals with the access to information stored, creating a representation carrying out a learned behaviour (e.g. motor act) (Gazzaniga, Ivry, & Mangun, 2013).

2.1 Memory systems

2.1.1 Short-term memory

In sensory memory, memory lasts (at most) for a couple of seconds. For hearing, sensory memory is called echoic memory and as for vision, it is called iconic memory. In principle, these forms of memories can retain extensive information, however only for a very short time. In addition, in short-term memory, the course of time last from seconds to minutes compared to sensory memory. The capacity of short-term memory is limited. (Gazzaniga, Ivry, & Mangun, 2013).

2.1.2 Long-term memory

Long-term memory refers to the concept of retaining information for a significant time (i.e. days, months and years). The long-term memory can be divided into two divisions due to differences in stored knowledge. The first is called *declarative memory* which deals with memory for general or personal facts and events that one has the conscious access to enable in the memory and thus, for instance can report verbally. This memory is also referred to as explicit memory. Declarative memory is divided into *episodic memory* and *semantic memory*. Episodic memories are personal autobiographical memories, we recall them as what, when, where and whom it happened with, this memory should not be mistaken for personal knowledge, e.g. knowledge of remembering the day of your birth, one does not remember the experience of that day. The episodic memory is the outcome of fast associative learning about a single episode that can be retrieved from our memory (Gazzaniga, Ivry, & Mangun, 2013).

The semantic memory is knowledge of objective character which is of a factual kind but does not indicate the situation of which it was learned, meaning, one might know a fact but he or she do not know where that specific fact was learned (e.g. telling time). Furthermore, we have *nondeclarative memory* also called implicit memory which cannot be verbally reported due to the knowledge not being consciously accessible, e.g. memory types as habituation, priming or conditioning. Finally, there is the *procedural memory*, a form of nondeclarative memory of which depends on repeated and extensive experience (e.g. how to read or swim) (Gazzaniga, Ivry, & Mangun, 2013).

2.1.3 Semantic and episodic memory

Memory and its context concerning an event are often important to an individual. In order for an organism to successfully adapt to its environment, it must retain some information concerning acquired knowledge so that future actions can be modified or elicited

appropriately. If one is able to recollect contextual details of previous experiences one is also setting the foundation of forming an important distinction between semantic memory and episodic memory (Tulving, 1983). According to Tulving (1983), the semantic memory is our general knowledge of the world e.g. rules, meanings, and factual details. We, for instance, know that Paris is the capital of France and that 7 x 6 = 42. These types of knowledge are useful even though we cannot usually remember when and where we learned them. The episodic memory, in contrast, is the recollection of personally-experienced events. This type of memory includes knowledge about something that has occurred and also some recollection of the time and place of what has occurred. If one has to recollect for instance the memory of a car crash, contextual details of the place, time, and sequence are of great importance (Tulving, 1983).

2.2 Memory and diagnostic tests

Several diagnostic tests could be used in order to test prefrontal function and source memory function in participants with source amnesia; some of them are explained next.

2.2.1 The verbal fluency test

In the verbal fluency test which is a short test of verbal functioning two tasks is typically consisted (Shao, Janse, Visser, & Meyer, 2014). One task tests category fluency and one letter fluency (sometimes called phonemic fluency). Participants have one minute to produce as many unique words as possible within a semantic category (category fluency) or starting with a given letter (letter fluency) in the standard versions of the task. In each task, the participant's score is the number of unique correct words. Verbal fluency tasks are often included in clinical practice, neuropsychological assessment and in research. The verbal fluency tasks have for instance been used to support diagnoses of attention-deficit/hyperactivity disorder and in cognitive impairment in persons who have neurodegenerative diseases, such as Parkinson’s disease or Alzheimer's disease (Shao, Janse,

Visser, & Meyer, 2014). Verbal fluency tasks have also been used in research on groups that are non-clinical to measure verbal ability which includes lexical retrieval and lexical knowledge and as a test of the ability of executive control. The participants have to retrieve words of their language, which require them to access their mental lexicon, they have to focus on the task, the words and its constraints as well as avoiding repetition and this involves executive control processes. Thus, serious deficits in either verbal ability or executive control should indicate a poor performance in the fluency tasks (Shao, Janse, Visser, & Meyer, 2014).

2.2.2 Wisconsin Card Sorting Test

To test prefrontal function, one can use the Wisconsin Card Sorting Test. First, different stimulus cards are presented to the subject. Then the participant has to match the cards, but the subject is not told how to match the cards, however, the subject is told if a particular match is right or wrong. The Wisconsin Card Sorting Test can e.g. consist of four key cards and 128 response cards with geometric figures that vary in form, colour or number, they are then sorted thereafter. Subjects have to find the correct classification by trial and error and examiner feedback. After 10 following correct matches, the classification rules changes without warning. The test is not timed and the subject continues to sort the cards until all cards are sorted (Nyhus & Barceló, 2009).

2.2.3 The Stroop Color and Word Test

The Stroop Color and Word Test (SCWT), often used in clinical and experimental settings, is a neuropsychological test that deals with cognitive interference. In this task, subjects are told to name what colour of which the ink of an incongruent word is (e.g. the word RED is printed in green ink). Reading a word is told to be more of an automatic cognitive process compared to colour naming. The participant has to solve this cognitive interference and hinder themselves to respond incorrectly. SCWT may be possible to use in

order to measure different cognitive functions, for instance executive processes, mediated by the frontal lobe (Adleman et al., 2002).

3. Memory distortion

Sometimes our memory is incorrect; this is called memory distortion (Schacter, & Slotnick, 2004). Memory distortion can inter alia be explained through *misattribution* and *suggestibility*. Misattribution is the result of retrieved information being linked to the wrong source (e.g. having a previously imagined event, mistaking it for a real event). In suggestibility (e.g. misleading questions) one incorporates wrong information from external sources (Schacter, & Slotnick, 2004). Additionally in one specific type of memory distortion called source amnesia, one can remember a few facts but not where or when those facts have been learned; this is a concept that will be further explained next, after a presentation of cognitive theories of memory distortion and the neuroscience of memory distortion.

3.1 Cognitive theories of memory distortion

Memory distortions are errors and misinterpretation of memories (Johnson et al., 2012). In addition, memory distortion is a phrase used for several types of errors in the encoding and retrieving of short or long-term memories (Johnson et al., 2012). There is a wide diversity when it comes to memory distortions; some appear in everyday life, some of in controlled laboratory tasks, others in traumatic life events, which can lead to legal consequences (Brainerd & Reyna, 2002). For the sake of simplicity one possible solution to better understand memory distortion is to investigate theories of which are most widely studied in relation to distorted memories (Brainerd, & Reyna, 2018).

3.1.1 The source monitoring framework

The source monitoring framework proposes that memories (remembering) are attributions to on-going mental experiences such as one’s subjective aspects, beliefs, prior

knowledge, social context, goals and motives, features of which can be composed together during a specific event (Johnson et al., 2012). Mental experiences can be divided into perceptual information (e.g. sound, colour) contextual information (e.g. temporal and spatial characteristics), emotion, semantic concepts, cognitive activities (e.g. imaging, retrieving added information) as well as recency and familiarity which are less specific qualities. All qualities judge the root of the mental experience due to the fact that different sources differ on dimensions (e.g. we ought to have very strange content in dreams compared to real life). The overlap of qualities from different sources creates misattribution, for instance, one having a specific vivid imagination from the past, claiming it to be a previous perception (Johnson et al., 2012). The outcome of a source monitoring process is labelled *memory attribution*, a process of which collects evidence from different mental experiences. The amount of information which the process considers depends on e.g. past experience, motives, and task content. Furthermore, our cognitive system can work in systematic processes of which enable the possibility to retrieve extra information, examining plausibility with given knowledge and how consistent a memory is in a narrative. The processes function as a correcting system which creates doubt about clear but doubtful memories or about believable but faulty memories (Johnson et al., 2012).

Doubt can be very practical in that it assists in further efforts to seek proof, to remember, plant judgment, or enabling the option to live in uncertainty. Source monitoring processes are affected by beliefs (e.g. the quality of a memory source), knowledge and an evaluation and consultation about a social/cultural context in memories. The social and cultural context is proposed as the deciding mechanism behind what we remember and how often we do so, as well as what we consider good evidence in recalling an event (Johnson et al., 2012).

3.1.2 The misinformation effect

The misinformation effect (or misinformation paradigm) refers to the notion of impairment in memory of the past that appears after one is exposed to information of which is misleading (Loftus, 2005). Loftus, Miller, & Burns (1978) evoked false memories of a traffic sign in a series of five experiments. The three-stage procedure applied was named the misinformation paradigm and has since been used by various research groups. The misinformation paradigm contains three standard stages: first, one is experiencing an event, secondly one is receiving misinformation about the event, and third, one is being tested in regards to a memory of the specific event (Loftus, 2005).

With the misinformation paradigm in mind, subjects first see a complex event, e.g. a fake automobile accident (Loftus, 2005). Thereafter, one-half of the subjects receive information which is misleading about the accident while the other half receives no misinformation. Finally, all subjects try to remember the original accident. In one study using the misinformation paradigm, subjects saw an accident and thereafter some of them received misinformation about the type of traffic sign used to control the traffic. Subjects of which got mislead received the false suggestion that they actually had seen a yield sign, not a stop sign. Later when asked what kind of traffic sign they remembered seeing at the intersection, the subjects who were given the false suggestion were likely to accept it as their memory; consequently claiming seeing a yield sign. Subjects who did not receive the misinformation had memories of which were much more accurate (Loftus, 2005).

In addition, when talking to other people, seeing biased coverage in media about an event or when we are interrogated in a suggestive manner, misinformation can contaminate our memories. Furthermore, it can be stated that it is easier to modify memories when the passage of time manage the original memory to fade. While faded and weakened, memories become vulnerable to contamination (Loftus, 2005).

Loftus (2005) proposes a series of questions in order to understand the misinformation paradigm. The first question states under which conditions people are susceptible to misinformation and its negative impact. Theories stipulate that people are more prone to having their memories affected when misinformation is introduced after the time passage has managed the original event memory to fade (Loftus et al., 1978). As earlier mentioned in the passage of time, the memory of the event is weakened, and thus, there is a limited chance that the individual notice a difference while the misinformation is being processed. With very long intervals between an event and after misinformation, the memory of the event might be so weak that it is as if it has not even been presented. Consequently, there would be no difference and detection between the misinformation and the original memory meaning the subject might easily accept the misinformation (Loftus, 2005). In addition, to temporarily change someone´s state can increase the effect of misinformation e.g. individuals are more susceptible if they are led to believe that they, for instance, have been drinking alcohol (Assefi & Garry, 2003). Susceptibility is also greater in those who are hypnotized, (Scoboria, Mazzoni, Kirsch, & Milling, 2002).

3.1.3 Confabulation and delusion

Confabulation is a term often used to describe amnesia patient's production of false memories, whereas delusion can be defined as false beliefs of which conditions suffer in psychiatric cases e.g. schizophrenia, or in some cases people who suffer from neurological damage (Turner & Coltheart, 2010). Patients suffering from these conditions can vary greatly in the claims they make. A patient who is confabulating might claim that he is a hospital porter when the fact is that he is treated for brain injury as an inpatient of the hospital. If a patient suffers from e.g. Capgras delusion he might claim that an identical imposter has replaced his wife. Furthermore, there are patients with delusions of control, who might claim that an outside force is controlling their actions. Confabulations and delusions might be very

different but still, they share several characteristics. The term delusion is usually used to describe false beliefs that are: consistent over time, farfetched or bizarre and held with conviction. Confabulation, however, is argued to not meet these criteria's, thus one should be treating the term separately from delusion (Turner & Coltheart, 2010). According to Fotopoulou, Conway and Solms (2007), confabulation can be defined as the production of distorted, misinterpreted or fabricated memories concerning oneself or the world. This is done without the conscious intention to deceive. Furthermore, serious misattributions can occur and thus create confabulation if the frontal cortex (ventromedial prefrontal cortex in particular) gets damaged (Damasio et al., 1985; Johnson, 1990; Johnson et al., 2000; Moscovitch, 1995; Schnider, 2008). In a study, Mercer, Wapner, Gardner, & Benson, (1977) examined if confabulation can reflect a patient's suggestibility. The patients were made to believe that they previously had given a response concerning some questions of which they, in fact, had answered "I don't know", they were then asked to reproduce their answer. Mild and severe confabulators both generally stood by their previous answer of "I don't know" and there was no inclination of answering the questions concerned.

3.1.4 The Deese-Roediger-McDermott Paradigm

In the Deese-Roediger-McDermott (DRM) task, lists of words which associate with one another (e.g., hospital, nurse) are presented to subjects (Pardilla-Delgado & Payne, 2017). After sufficient time has passed, the participants are asked to recognize or recall the words from the list. Furthermore, participants are asked in the recognition memory version of the DRM task if they remember the words which were presented in the list as well as related words (which were not presented) e.g. critical lure words (e.g. doctor, a word related to hospital and nurse). The critical word is usually identified by the subject with high confidence (Pardilla-Delgado & Payne, 2017). According to Pardilla-Delgado & Payne (2017) the delay

between encoding and the memory test of the false memory effect has been shown for a shorter time (e.g., directly, 20 min) and a longer delay of (e.g., one, seven or 60 days).

Originally, Deese (1959) made a report about the illusion and in addition, Roediger and McDermott (1995) connected the illusion to memory distortion. Furthermore, Roediger and McDermott (1995) argued that the DRM task was a reliable way to study distorted memories under carefully controlled laboratory conditions. Roediger and McDermott (1995) induced false recognition and false recall for words that were not presented in lists. Subjects had to study 24 lists of 15 words that were related to a common word (critical target or critical lure) that was not on the list. False recognition and false recall of the critical lure occurred frequently in response to the lists presented.

Knowingly, the memories of a list of words are more limited and less complicated than memories which are of autobiographical character (e.g., social context, perceptual details, personal relevance, etc.). It can be stated that the DRM illusion can be applied broadly (Gallo, 2010). Roediger (1996) suggest that the DRM illusion enable one to be informed about one's memory and its basic understanding (Roediger, 1996). Furthermore, the DRM illusion is advantageous compared to other approaches concerning memory distortion in that it provides a simple way of demonstrating memory distortion (Gallo, 2010).

According to Gallo, (2010), the DRM illusion mirrors the phenomena of memory distortion and wrongful recall. Miller and Wolford (1999) proceed from the so-called signal detection theory and implies that the illusion of DRM may be the result of a response bias concerning any word which appeared to be similar or related to the study list, participants might assume or guess that the related bait word did exist in the list due to strongly being associated with the studied words.

Furthermore, Gallo (2010) implies that the theoretical process that is the cause of the DRM illusion can be divided into a framework of activation and monitoring. It can be stated that the part of activation is explaining processes of which can mentally activate for instance bait or the retrieval of information of what might be false information. The phenomena of monitoring explain the process of decision and any memory editing that can assist in determining the foundation of information of which is activated. By activation, wrong memories do enhance, whereas in monitoring memories are suggested to be reduced (Gallo, 2010).

3.1.5 Fuzzy-trace theory

The fuzzy-trace theory (FTT) does not solely focus on memory, rather it is an interdisciplinary model of cognition. The theory is interdisciplinary in the sense that it rests on two different factors. The first factor argues that FTT is not enclosed to memory alone; the theory also concerns the ability of higher reasoning. The goal is to integrate theories and conclusions within the domains of memory and reasoning by examining the relationship between these two domains of study (Brainerd & Reyna, 2004). According to Brainerd & Reyna, (1990); Reyna & Brainerd, (1991), FTT started as a model of reasoning of which was driven by two questions. The first question was concerning the relationship between representational processes in psycholinguistics. The second question involved children's ability to solve logical problems in which reasoning was used in relation to the children's ability to recall the background information of which enabled a solution to the concerned problem (Brainerd & Kingma, 1985).The other factor concerning FTT and its interdisciplinary character is the fact that FTT focuses on developmental and non-developmental work (Brainerd & Reyna, 2004). Within the theory of FTT, the goal is to integrate three essential approaches to cognition: mainstream cognitive psychology (studies of normal adults), mainstream cognitive development (developmental studies), and studies of

mainstream neuropsychology (brain mechanisms) (Brainerd & Reyna, 2004). FTT has concerning true and wrong memory reports integrated these approaches by initially doing several developmental studies which evolved into adult experimentation to furthermore continue into investigations of neurophysiological character (Brainerd & Reyna, 2004).

Brainerd & Reyna, (2004) continues to describe the explanatory principles of FTT. There are two approaches to memory development in relation to FTT. First, the explanation of memory development can be described by how information is represented in memory followed by how these representations later are retrieved and preserved. FTT makes a distinct difference between representations of which apprehend the surface of an experience and representations of which apprehend the gist of an experience. Secondly, the focus lies on securing tests of which are strong, this is done by generating new predictions concerning memory development, in particular, predictions of which are counterintuitive (Brainerd & Reyna, 2004).

The human brain enables a distinction between verbatim and gist traces of experiences. Verbatim traces are representations of which are integrated of a memory targets surface, also associated with item-specific information such as contextual cues (Brainerd & Reyna, 2004). Traces that are of verbatim character are shallow but accurate representations which can be forgotten quickly (Reyna, 2012). On the other hand, gist traces represents elaborative information about a memory target such as semantic and relational information, the essential meaning of the situation (Reyna, 2012). Together, representations of gist and verbatim are formed in parallel, representing a variety of qualities of a stimulus. In order to make accurate calculations for instance; adding numbers, using logic or computing probability, one is acquired to use the representations of verbatim. It is assumed that people rather work with gist-based representations due to verbatim representations being more difficult to work with (Reyna, 2012).

One major difference between information which is verbatim and information which is gist information is that the verbatim information could be found in the memory targets which subjects experience (e.g., the fonts used in the words which are printed on a study list), whereas in the gist information the information is accessed by the rememberer himself by using retrieval cues in form of gist traces in one's index experience (Brainerd & Reyna, 2004). Furthermore, traces of verbatim memory are representations of the rememberers actual experience, and traces of gist can be thought as the representation of what the rememberers understand of their experience (Brainerd & Reyna, 2004). FTT suggest that gist-based memory errors occur when people falsely recognize or recall a new word, picture or other types of items that are either conceptually or perceptually related to an item that they did previously encounter (Schacter, Guerin, & Jacques, 2011). Individuals fail to recollect specific details of the experience and instead general information or the gist of what happened is remembered. According to FTT, the memory distortion in gist-based memory can be produced in the DRM-paradigm, a paradigm earlier explained (Schacter, Guerin, & Jacques, 2011).

3.2 The neuroscience of memory distortion

Due to numerous developments in neuroimaging, especially in functional resonance imaging (fMRI), one is able to track cognitive processes of which partake in memory retrieval, encoding, and error (Johnson et al., 2012). The focus of the research field is not solely on understanding neural correlates in regards to cognitive processes but also studying what someone currently is thinking by analysing neural activity and patterns (Haynes & Rees, 2006). Consequently, one is able to e.g. study honest and deceptive responses (Abe et al., 2008).

3.2.1 The medial temporal lobe

The medial temporal lobe is often implicated in memory distortion or dementia, hippocampus in particular, due to it being affected in amnesia (bilateral hippocampal damage is often present in amnesia patients) (e.g., Eichenbaum & Cohen, 2001; Milner, Squire, & Kandel, 1998). The anterior hippocampus is associated with the binding of memory (Johnson et al., 2012). According to Addis, Moscovitch, Crawley, & McAndrews (2004), hippocampal activity during the remembering of autobiographical events has a positive correlation to rated memories for details, which is essential for avoiding grave source amnesia. Dysfunctions of the medial temporal lobe are highly implicated as a key area associated with memory distortion and source amnesia (Addis, Moscovitch, Crawley, & McAndrews, 2004).

Gonsalves et al. (2004) were able to look at brain activity through fMRI when subjects saw pictures and when they had to imagine pictures. They were then asked to recall images, and categorise them according to “seen” or “imagined”. The results indicated that greater activity could be found in the precuneus (PCu) for items of which were imagined that participants falsely reported to have “seen” than for those that they correctly reported being “imagined”. Distorted memories have a tendency to have less detail compared to memories that are true (Gonsalves et al., 2004). Numerous neuroimaging studies indicate that there is less activity for wrong compared to true memories in areas of which represent the encoding and retrieval of perceptual detail (e.g., Mather, Henkel, & Johnson, 1997; Norman & Schacter, 1997; Schooler, Gerhard, & Loftus, 1986).

Cabeza, Rao, Wagner, Mayer, & Schacter (2001) made a study that investigated types of memory traces recovered by the medial temporal lobe; neural activity during authentic and illusory recognition was measured with fMRI. 12 healthy adults watched a segment of a videotape in which two narrators alternated presenting lists of associated words, then the subjects performed a recognition test including words presented in the study lists,

called *true items*, new words in close relation to the studied words, called *wrong items*, and new unrelated words, called *new items*. The result showed that activity in the regions of the anterior medial temporal lobe did not distinguish true from false, whereas activity in the posterior medial temporal lobe regions did. This suggests that there is a specific subconscious mechanism for true and wrong memories (Cabeza, Rao, Wagner, Mayer, & Schacter, 2001).

3.2.2 The amygdala

The amygdala, a part of the limbic system located in the medial temporal lobe near the hippocampus is representing the process of emotion (LeDoux, 2000). It is suggested that during encoding in participants of which are healthy, the activity of the amygdala is greater for emotional cues compared to cues which are neutral e.g. (Cahill et al., 1996). In addition, greater activity in the amygdala can be shown during encoding for remembered compared to emotional items of which are forgotten (Dolcos, LaBar, & Cabeza, 2004).

3.2.3 The frontal cortex

Serious misattributions can occur and thus create confabulation if areas in the frontal cortex (ventromedial prefrontal cortex in particular) - are damaged either through trauma or neurodegeneration (Damasio, Graff-Radford, Eslinger, Damasio, & Kassell, 1985; Johnson, 1990; Johnson, Hayes, D'Esposito, & Raye, 2000; Moscovitch, 1995; Schnider, 2008).

3.2.4 The visual cortex

In regions associated with visual processing, a greater local activity was attributed to true memories compared to subsequent false memories, thus indicating that visual processing is important in the encoding and retrieval of true memories (Baym & Gonsalves, 2010). Greater activity in the right frontal cortex and bilateral medial temporal lobe was on the other hand more indicated in both true and wrong memories compared to forgetting. The results presented by neuroimaging suggest that wrong memories need at least some information

about the original event to be encoded in order for the misinformation to have an effect on later memory (Baym & Gonsalves, 2010). Strong encoding of the general contextual frame of an event, in combination with a weaker encoding of specific important details, such as identity or features of objects present during the event, are important factors for the construction of distorted memories (Baym & Gonsalves, 2010).

4. Source amnesia

Source amnesia is about one recognizing a person or recalling a fact, however one is not able to remember where or when this information about the fact or person was originally learned (Donaldson & Tulving, 1972). It is suggested that source amnesia occurs due to a disconnection that is between the semantic memory and the episodic memory. Knowledge that is semantic is kept by the individual, but one is missing the episodic knowledge to show the context in which the knowledge was obtained (Donaldson & Tulving, 1972). Furthermore, observations suggest that patients with signs of frontal lobe dysfunction have difficulties remembering the episodes of which information has been acquired (Craik, Morris, Morris, R. G., & Loewen, 1990).

4.1 Neurobiological aspects of source amnesia

Source amnesia can appear in everyday life. There are both normal and more serious examples of source amnesia which can be caused by numerous aspects, these aspects are explained next.

4.1.1 The aging brain

Cognitive decline which is age related is a well-documented phenomenon in episodic memory tasks. During the course of normal aging, the structural integrity of the medial temporal lobe and the prefrontal cortex, as well as one’s ability to recall episodic memories correctly, is greatly compromised (Berron, Neumann, Maass, Schütze et al., 2018). Since

episodic memory and the medial temporal lobe both are very much involved in accurate memory recall, and both are compromised in healthy aging brains, this may explain, to some extent, increased memory distortion in the aging population (Berron et al., 2018).

In a study made by Schacter, Harbluk, & McLachlan (1984), older people showed greater forgetting of newly acquired facts and had greater overall level of source amnesia in comparison to younger groups of participants.

Research indicates that age-related increases in distorted memories are the result from impairments in memory encoding, retrieval and monitoring mechanisms that rely on a number of regions in the medial temporal lobe and in the prefrontal cortex (Devitt & Schacter, 2016). Associate binding is reduced, meaning that memory traces are less distinctive, causing source misattributions and gist-based errors. In addition more declines in strategic monitoring processes are apparent with age. Adults which are older show less cognitively demanding and less accurate effects in monitoring mechanisms, such as making source decisions in regards to familiarity (Devitt & Schacter, 2016). Adults who are older are also more prone to form wrong associations between incoming stimuli and are likely to be distracted by cues that are not significant to the correct source (Devitt & Schacter, 2016).

4.1.2 Alzheimer´s disease

Alzheimer´s disease (AD) is defined by degenerative changes in numerous neurotransmitter systems and neural systems that release norepinephrine, glutamine, and serotonin (Wenk, 2003). Degenerative changes can also be found in selected brain regions including the temporal and parietal lobes and regions within the frontal cortex and cingulate gyrus. The degeneration of these systems might influence specific aspects of dementia in association with AD. The frontal lobe dysfunction involved in AD can cause source amnesia and general memory distortion. Brain tissue from patients diagnosed with AD can

predominantly be studied after death and many of its biomarkers are hard to measure, thus making the timeline and the progression of the disease hard to measure (Wenk, 2003). One commonly measured biomarker for AD is beta-amyloid. The natural role of beta-amyloid is still largely unknown however its presence seems to increase an inflammation that leads to neuronal plaque (Wenk, 2003). Plaque can be observed in normal healthy and young brains, but is more prominent and accumulated in older adults (Esparza et al., 2013). Beta-amyloid is also known to increase the production of prostaglandins which in turn increase glutamate which consequently causes the death of neurons (Wenk, 2003).

In a study made by Barba, Nedjam & Dubois (1999) the relationship between confabulation, source memory, and executive functions in 17 AD patients and 18 normal controls are addressed. Using executive functions in various tasks, the subjects had to distinguish between the origin of given information, i.e. visual perception or imagination. The results indicated that the patients which suffered from AD were distinctly impaired on tests of executive functions, and showed poor monitoring abilities for the source of information. AD patients also confabulated when they were required to retrieve a personal episode (Barba, Nedjam & Dubois, 1999).

It is likely that the inability for AD patients to attribute to the source of memories is related to the deficits of reality monitoring (Devitt & Schacter, 2016). Reality monitoring can be explained as information that people receive from two sources: external (also called perceptual processes) and internal processes (such as thought, imagination, and reasoning) (Devitt & Schacter, 2016).

4.2 Psychiatric diseases and addiction and source amnesia

Both psychiatric diseases and addiction are prominent influencers of the memory distortion of source amnesia acting through different psychological and biological pathways.

In the coming section, the contribution of addiction and mental health will be explored in connection to the memory distortion of source amnesia.

4.2.1 Schizophrenia

Individuals with the psychiatric illness of schizophrenia suffer from hallucinations, erratic behaviour, and delusional ideas, for instance believing that they are controlled by malevolent outside forces (Vinogradov, Luks, Schulman, & Simpson, 2008).

Episodic memory deficits can be associated with schizophrenia, characterized by a confusion of real events and internal stimuli (Vinogradov et al., 1997). Individuals suffering from schizophrenia are more prone to source amnesia - that is the failures in remembering the source of information. Additionally, source monitoring, a concept of memory that judge the origin of information, has been found to be more prone to errors in schizophrenic individuals compared to healthy persons (Vinogradov et al., 1997). In a study made by Vinogradov et al. (1997) schizophrenic subjects who had been free from medication for one week (N=26) and demographically matched normal subjects (N=21) performed a source monitoring task and were evaluated on, frontal lobe functioning, current psychiatric symptoms, and IQ. The results indicated that the schizophrenic subjects made more errors than the comparison subjects in identifying the source of target words (Vinogradov et al., 1997).

People that suffers from schizophrenia and have deficits in source memory usually show an impairment in reality-monitoring that consequently leads to hallucinations and the individual is unable to differentiate between internal and external information (Vinogradov et al., 2008). Individuals with schizophrenia often assign internal circumstance, for instance, delusions and hallucinations to a source that is external, (e.g. another person) which results in that the schizophrenic is unsuccessful in understanding that they themselves are the source of the idea or belief that they assign to an outside source. Reality monitoring and its neural bases

concerning schizophrenia are not fully explored, however using fMRI; Vinogradov et al., (2008) asked schizophrenia patients who had a stable condition to remember if they had (or not) generated a target word during an earlier sentence completion task. The results of the source memory task indicated that the schizophrenia subjects showed a deficit in rostral medial prefrontal cortex activity—a brain region that is representative for the retrieval of self-referential information in healthy subjects. The impairment in the rostral medial prefrontal cortex function is likely to play a role in the disturbances that characterize schizophrenia (Vinogradov et al., 2008).

In schizophrenia, deficits in the hippocampus and in the prefrontal cortex occur and consequently a dysfunction within the dopamine system occurs (Gomes & Grace, 2018).

Dysregulation of the dopamine system is a known component of schizophrenia pathophysiology, with differences in dopamine targets thought to shape the symptoms of the disease. Increased presynaptic striatal dopamine synthesis and release are the most consistent findings in patients. This dysregulation of dopamine might affect memory thus creating source amnesia in schizophrenic patients (Gomes & Grace, 2018).

4.2.2 Depression

According to studies in autobiographical memory and source attribution in psychiatric disorders, there is a possibility that memory might be biased by ones current state of mood (Williams et al., 2007). Individuals with a sad mood have been shown to recall negative events faster than positive events. In suicidal patients, it has been found that in addition to being slower to respond to positive cues than controls, the suicidal patients, in their responses to both positive and negative cue words, failed to give a specific memory (Williams et al., 2007). In one study conducted by Williams & Broadbent (1986) suicidal participants are asked to respond to each word with an event that the word reminds them of.

They are told that the event recalled can be trivial or important and from a long time ago or recent, but that it should be a specific event, something that happened at a particular place and time that lasted for a day or less. The suicidal patients responded with a memory that summarized a category of similar events and in contrast the control group of the specific study was specific on more than 80% of the occasions. The poor performance of suicidal patients on this particular task suggests that the autobiographical memories of suicidal patients might differ in form as well as in content or speed of retrieval (Williams & Broadbent, 1986). In addition, Demyttenaere, et al. (2006) indicated that poor source attribution besides its connection to depression also can be associated with rumination. In a study made by Siegle, Thompson, Carter, Steinhauer, & Thase, (2007) it was found that relative to control subjects, depressed subjects showed sustained amygdala reactivity on emotional tasks.

To investigate if emotional arousal affects memorial feature binding, Mather et al. (2006) had participants complete a short-term source-monitoring task—remembering the locations of four different pictures over a brief delay. On each of the trials, the four pictures were all either high arousal, medium arousal, or low arousal. Memory for picture-location conjunctions decreased as arousal increased. In addition, source memory for the location of negative pictures was worse among participants with higher depression scores (Mather et al., 2006). Two subsequent fMRI experiments showed that relative to low-arousal trials, high- and medium-arousal trials resulted in greater activity in areas associated with visual processing (fusiform gyrus, middle temporal gyrus/middle occipital gyrus, lingual gyrus) and less activity in superior precentral gyrus and the precentral-superior temporal intersect. These findings suggest that arousal recruits attention to items thereby disrupting working memory processes that help bind features together (Mather et al., 2006).

4.2.3 Posttraumatic stress disorder

Posttraumatic stress disorder (PTSD) is an illness that is characterized by one being exposed to a traumatic event followed by a development of a variety of symptoms Liberzon & Sripada, 2007). These symptoms commonly include re-experiencing phenomena (e.g., nightmares or flashbacks), hyperarousal (e.g., exaggerated startle response or vigilance), and avoidance behaviour (e.g., avoiding situations or individuals that are similar of the traumatic event) (Liberzon & Sripada, 2007). It has been shown that PTSD patients indicate memory distortion and source amnesia in episodic memory concerning events that appear after the traumatic event and also in identifying the overall source of emotional and neutral information (Golier, Harvey, Steiner, & Yehuda, 1997). The cognitive symptoms of PTSD in general and the re-experiencing symptoms in particular may result from a failure to correctly identify the source of traumatic memories. For instance, the re-experiencing symptoms, such as flashbacks or intrusive thoughts, consist of retrieved memory information that is incorrectly interpreted as currently taking place. A consistent tendency towards confusion of information from different sources could also lead to anticipatory anxiety. Thus, poor ability to monitor the source of information due to deficits in the encoding process in memory could correlate with the presence of PTSD (Golier, Harvey, Steiner, & Yehuda, 1997).

For several years PTSD research has focused on the role of the hippocampus, a brain area particularly sensitive to the effects of stress (Samuelson, 2011). Studies showing glucocorticoid toxicity in the hippocampus and memory dysfunction in animals under stress led to the hypothesis that severe stress, in particular traumatic stress, may result in similar changes in humans. Adults with PTSD reveal smaller hippocampal volume in both the left and right sides. fMRI studies have demonstrated abnormal cerebral blood flow to the hippocampus during declarative memory tasks (Samuelson, 2011). Other studies have found reductions in N-acetylaspartate (NAA), a marker of neuronal integrity. In addition, the

hypothalamic-pituitary-adrenal (HPA) axis which has been shown to have an important part in the controlling of our reaction to stress is shown to indicate a dysregulation in PTSD (Samuelson, 2011).

4.2.4 Drugs and alcohol

Studies on the impact of cannabis use have found memory deficits in working and declarative memory (Riba et al., 2015). In addition to impaired performance, cannabis user's show reduced activation in areas associated with memory processing within the lateral and medial temporal lobe and in parietal and frontal brain regions involved in attention and performance monitoring. Furthermore, the consumption of cannabis and its effect on medial temporal lobe activity, suggests that the drug is especially dangerous to the episodic aspects of memory. Findings indicate that cannabis users have an increased susceptibility to memory distortions even when abstinent and drug-free, suggesting a long-lasting compromise of memory and cognitive control mechanisms involved in reality monitoring (Riba et al., 2015).

Studies also suggest that chronic alcoholism is known to impair the function of episodic memory (Pitel et al., 2007). In a study made by Pitel et al., (2007), 40 recently detoxified alcoholic inpatients at alcohol entry treatment and 55 group-matched controls underwent a neuropsychological assessment of episodic memory and executive functions. The episodic memory evaluation consisted of three tasks that complemented each other designed to measure the different episodic memory components (learning, storage, encoding and retrieval, contextual memory and autonoetic consciousness) and five executive tasks testing capacities of inhibition, flexibility, organization, up-dating and integration. In comparison to control subjects, alcoholic patients indicated impaired learning abilities, retrieval processes, encoding processes, contextual memory and autonoetic consciousness. There was, however, no difference between the two groups in regards to the storage capacities assessed by the rate of forgetting. Looking at executive functions, the alcoholics showed deficits in each executive

task that was used. The analyses made indicated that only performances on fluency tasks were significantly predictive of some of the episodic memory disorders (encoding processes for 20%, learning abilities for 40%, state of consciousness associated with memories for 26% and temporal memory for 21%) in the alcoholic group. Since many of these functions are an important part of source amnesia and memory distortion it is fair to say that long and short-term effects of alcohol on the brain can cause memory distortion (Pitel et al., 2007).

5. Discussion

In this essay, the aim was to investigate the question: What are the neural correlates of memory distortion and in particular source amnesia?

Initially, cognitive theories of memory distortion and source amnesia studies have been presented, showing that we judge the source of our mental experience and memories in the theory of the source monitoring framework which also implies that memories are attributions to on-going mental experiences such as one's subjective aspects, beliefs or prior knowledge. When our memory is incorrect, it causes us to have distorted memories; this is also called misattribution, which is a result of retrieved information being linked to the wrong source, due to an overlap of qualities from different sources (Johnson et al., 2012). In the misinformation effect, another theory of memory distortion, one is exposed to information that is misleading, as a consequence of this one receives an impairment in memory concerning past events (Loftus, 2005). Studies indicate that subjects who do not receive misinformation about an event, have memories of which are much more accurate (Loftus, 2005). In confabulation, the individual produce distorted, misinterpreted or fabricated memories concerning oneself or the world. Findings indicate that if the ventromedial prefrontal cortex in particular gets damaged serious misattributions can occur and thus create confabulation (Damasio et al., 1985). Furthermore, several studies indicate that memory distortion can be

elicited using the Deese-Roediger-McDermott paradigm (DRM), designed to elicit memory errors through the use of word lists showing that subjects tend to falsely recognize critical lure words frequently (Gallo, 2010). The memory distortion of DRM may be the result of a response bias concerning any word which appears to be similar or related to the study list (Miller & Wolford, 1999). Finally, the Fuzzy-trace theory (FTT) is a model that explains a distinction between verbatim and gist traces of experiences (Reyna, 2012). Verbatim memory is associated with item-specific information, shallow but accurate representations which can be forgotten quickly whereas gist traces represents semantic and relational information, the essential meaning of a situation (Reyna, 2012). The theory of FTT is used within the field of memory development studying how memory is retrieved and preserved, this might help one better understand our memory and thus memory distortion studying e.g. different memory traces such as gist and verbatim memory. FTT also looks at the concept of gist-based memory errors.

Furthermore, the main focus in this essay has also been on one particular type of memory distortion called source amnesia, which has been showed to be a phenomenon that occurs under normal and more serious types of conditions. Usually in source amnesia one might recognize a person or recall a fact; however he or she can not remember where or when this particular information about the person or the fact was originally learned. Research suggests that we experience source amnesia because we have a disconnection that is between the semantic memory and the episodic memory (Donaldson & Tulving, 1972). Several, if not all of the theories have faced criticism over the years. Many of the theories are based on studies which have very few and homogenous research populations. The theories are also largely based on tests which are in controlled laboratory settings. One can question the DRM procedure and its relevance to other types of memory distortions. Freyd and Gleaves (1996) strongly criticized Roediger and McDermott's (1995) suggestion that conclusions drawn by

the DRM illusion can be applied to memories created in non-laboratory settings. In addition, DePrince, Allard, Oh, & Freyd, (2004) made the statement that the term memory distortions or so-called “false memories” should not be used in relation to the DRM illusion, in order to prevent confusion with false-memory debates in relation to autobiographical memory (e.g. memory recovery in psychotherapy). Overall there is still much debate to what extent the current cognitive theories and connected fMRI studies can be representative of how memory distortion and source amnesia are presented in a general population.

As for the cause of memory distortion in particular source amnesia, research has shown that several factors can have an influence such as neurobiological aspects in the aging brain. During normal aging, the medial temporal lobe and the prefrontal cortex, as well as one’s ability to correctly recall episodic memories, are considered to be compromised. This occurs due to a reduced associative binding. Memory traces become less distinctive and affect encoding, retrieval and monitoring in the medial temporal lobe and in the prefrontal cortex, allowing for source misattributions and gist-based errors to occur (Devitt, & Schacter, 2016). However, studies by Aberle, Rendell, Rose, McDaniel & Kliegel, (2010), show that older adults had no significant decline in source amnesia or memory distortion as well as other cognitive tasks compared to younger individuals.

Additionally, findings show that source amnesia can occur in Alzheimer’s disease (AD) showing degenerative changes in numerous neurotransmitter systems, neural systems that release norepinephrine, glutamine and serotonin, temporal and parietal lobes and regions within the frontal cortex and cingulate gyrus are also affected by the disease (Wenk, 2003). In one study, patients who suffered from AD were distinctly impaired on tests of executive functions and showed poor monitoring abilities for the source of information, indicating that source amnesia occurs in AD patients (Barba et al., 1999). In regards to AD, many AD patients suffer from other somatic diseases and have side effects from drugs, which may

worsen or cause memory distortions such as source amnesia. They often suffer from hallucinations and reality distortions as well.

In this essay, psychiatric diseases and addiction and its relation to source amnesia have been presented. In the psychiatric illness of schizophrenia individuals that have impairments in source memory usually show an abnormal functioning in reality-monitoring that may lead to one having hallucinations which results in the individual having difficulties to understand both internal and external information (Vinogradov et al., 2008). Available research also shows that schizophrenic patients are more prone to source amnesia and make more errors in recognizing the source of target words compared to control groups. The schizophrenic patient usually assigns internal experiences to sources that are external, for instance other persons (Vinogradov et al., 2008). A dysregulation in dopamine and a deficit in the rostral medial prefrontal cortex activity is said to be potential explanations of schizophrenia thus causing source amnesia (Vinogradov et al., 2008).

In addition, individuals who suffer from depression, particularly with suicidal tendencies, are more prone to a deficit in autobiographical memories which affect the speed of retrieval; poor source attribution can also be displayed in depressed individuals (Demyttenaere et al., 2006). PTSD patients indicate memory distortion and source amnesia concerning events that appears after the traumatic event but also in identifying the overall source of emotional and neutral information (Golier et al., 1997). The cause of PTSD is suggested to be smaller hippocampal volume, abnormal cerebral blood flow to the hippocampus and reductions in N-acetylaspartate (NAA), a marker of neuronal integrity, research also shows a deregulation of the hypothalamic-pituitary-adrenal (HPA) axis, important in the controlling of our reaction to stress (Samuelson, 2011). Drugs and alcohol are also said to affect episodic memory. Cannabis, for instance, indicate impaired performance in memory processing within the medial temporal lobe and in parietal and frontal brain regions

involved in attention and performance-monitoring (Riba et al., 2015). Cannabis consumption can also affect the medial temporal lobes activity, consequently being especially detrimental to the episodic aspects of memory causing source amnesia (Riba et al., 2015). However, some drugs have shown to enhance memory. A study by Hutten et al., (2018), showed that administering cocaine improved prospective memory in memory tasks. The health and brain damages that come with cocaine use still weigh heavier than the benefits as a memory-enhancing drug. Alcohol is also explained as a factor of source amnesia and its impairment of the episodic memory function (Pitel et al., 2007).

The diagnostic tests that are used for detecting memory distortion and source amnesia focus mainly on verbal fluency and vigilance. Although, even if the Wisconsin Card Sorting Test is a valuable indicator of prefrontal function (Nelson, 1976), it may not solely detect source amnesia. Watson, Bunting, Poole & Conway, (2005) critics the use of word lists and vigilance tests to "produce" and test memory distortions and these tests are too generalised and pick up other factors and cognitive errors. As memory distortion and source amnesia are highly associated with the medial temporal lobe and the prefrontal cortex, two areas which are common in most neurodegenerative disorders, one should truly consider if they are the best suited for zooming in on memory distortions or if they are picking up early dementia.

5.1 Limitations and future directions

The existing research about memory and memory distortion is an interesting approach; however, several questions do exist for future research to be further investigated. One problem investigating memory distortion and source amnesia is the complexity of the field; many of the theories as earlier presented have faced criticism over the years. There are also many variables to why one can experience memory distortion and source amnesia as

shown in this thesis, however, as discussed it is difficult to capture all variables and particularly those which are not in a laboratory setting. The studies are performed on very healthy individuals or very sick individuals; this may give a skewed picture.

In the future, researchers should focus on creating new theories about memory distortion and source amnesia where cognitive theories and connected fMRI studies can be representative of how memory distortion and source amnesia could be presented in a general population. More studies about natural cognitive decline related to source amnesia are also of interest; today many studies examine rather extreme cases of source amnesia.

Memory distortion through misinformation seems to be one of several factors as to why our memories can be badly mistaken and perhaps one of the most current problems to investigate in this day and age. Today, individuals are constantly receiving extensive information that might be misinformation from different types of sources e.g. ”fake news” published on social media (Allcott & Gentzkow, 2017). It would, therefore, be interesting for further research to investigate how people react to misleading information and why they would discard or accept the presented misinformation. Possible questions to help to solve the problems of misinformation could be:

- How do we monitor and adjust misinformation today?
- How can technology and humans help to find, label, filter and remove misinformation in order to prevent distorted memories?
- How can misinformation be better implemented and studied in cognitive and neural research using relevant technologies?

In source amnesia, future research should focus more on poor memory encoding and poor memory retrieval since this is a prominent problem in this type of memory distortion. In

addition, both treatment and prevention of source amnesia should be focused on in future research. Possible future questions regarding source amnesia could be:

- How can information be better integrated into the brain in order to retrieve specific and correct source information?
- How can people without brain impairments and deficits be better studied in source amnesia?

It seems that the existing research of today in this field mostly focus on memory and how the human mind functions using different types of cognitive memory models and neuroscientific research. As shown in this thesis, another approach within the field of human memory is taken, showing that we sometimes reconstruct our memories unintentionally which results in distorted memories and source amnesia and there are numerous variables to why we may misremember, as explained in this thesis. The research field of memory has a long history according to available literature. The field of memory seems to be a well-studied area within the research community and we seem to know numerous things about how the memory system work or should work, however, there still need to be more research about both memory distortion and source amnesia and why our memory system and memories sometimes fail to produce accurate memories. By investigating the knowledge about the imperfections of memory one might hopefully learn several new ways to better understand the human brain and why our memories can be badly mistaken. The information provided in this thesis hopefully provide the reader with more knowledge about the experience of distorted memories and source amnesia, showing that we indeed are vulnerable and not always as correct or accurate as we think we are when we for instance try to remember what we did a couple of days ago or who we encountered at a particular place in a particular time.

5.2 Conclusion

This thesis aimed to investigate the neural correlates of memory distortion and in particular source amnesia. The cognitive theories presented in this thesis aimed to explain why memory distortion occurs, whereas the sections of neuroscience aimed to show how in the brain memory distortion occurs. To go more in depth, one particular memory distortion called source amnesia was further investigated and explained. In this thesis several cognitive theories can explain why we might experience mistaken memories, e.g. misattribution in memory due to an overlap in qualities or exposure to misinformation. The primary neural correlates of memory distortion and source amnesia are the medial temporal lobe and the hippocampus and amygdala, the frontal cortex and the visual cortex are also implicated as key areas. As explained in this thesis, source amnesia has been showed to be a dissociation of memory that results from one having frontal lobe dysfunction due to neurobiological aspects such as the cognitive decline that comes with an aging brain or neurodegenerative changes in neurotransmitter systems that appears in for instance Alzheimer´s disease. This thesis also indicates that numerous psychiatric diseases as well as addiction have shown to have an effect on source memory, causing source amnesia. It has been showed that individuals suffering from diseases such as schizophrenia, depression, posttraumatic stress disorder or drug and alcohol abuse seems to be more prone to experience source amnesia compared to healthy individuals due to pathological abnormalities in the brain.

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