False Memory Creation and the Impact of Higher Cortisol Levels on False Memory Recall

Master Thesis

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Introduction

Memories are formed in the brain and do not only contain real experiences. Sometimes, people are made to believe things that actually never happened the way they believe it had happened. Elizabeth Loftus is famous for her experiment of implanting false childhood memories into people's memory. People recall emotional situations that never happened but maybe they dreamed as a child of it or associate a certain character of their childhood with these feelings, and thus they actually believe certain situation, connected to special emotions, had happened to them (Loftus, 2003; Braun et al., 2002).

The functions of memories have a great impact on our behaviour. Our buying behaviour for example is determined by memories of previous product trials, as well as recommendations of relatives, advertisements, or expectations. The biggest impact of advertisements is to make people believe something. Of course, this does not always have to be true, but as long as people believe in it they are going to purchase the product.

This study examines the success of false memory creation. Especially, the degree of success of false memory recall in a state of higher cortisol levels, created through stress, is tested. In other words, whether the state of acute stress and pressure enhances the recall of false memory. Furthermore, it investigates how the recall of false memory is affected by sleep, so the recall after 24 hours with a deep-sleep phase in-between.

The first section is going to give an explanation of what memory is, the different forms of memory, and their functions, including a brief part about the parts in the brain, which are responsible for memory creation as well as an explanation of consciousness.

Further, the placebo effect is going to be elaborated on. This effect is important for the assumption that informational aspects are easier to recall than emotional aspects, which leads to the fourth Hypothesis of this study.

The following section is going to give an introduction to sleep and recall and how sleep affects recall of memories in general. Sleep will be the influential factor for the long-term results of the study.

The next two sections are going to deal with the production of the stress hormone cortisol and the hormonal differences between men and women. For the conducted experiment, these two aspects play a role and thus need to be briefly clarified in order to better understand the setup of the experiment.

The main part is going to concentrate on the hypotheses of this study and the actual methods used to analyse the setting. An experiment was conducted in order to find out the short-term and long-term effects of false memory creation and especially the impact of an increased cortisol level due to stress. 100 participants had to watch a short film and answer several questionnaires on two following days in order to get all the results needed for this study.

The following two sections are going to give the actual results of the experiment, a thorough discussion of the results, possible explanations for the various outcomes of the experiment to all five discussed hypotheses, and an interpretation of the results as well as their implication for managerial use in the future.

The last part of this study is going to give some limitations to the conducted experiment and provides recommendation for possible future research.

Memory

There are two types of memory: explicit/declarative memory and implicit/non-declarative memory. Explicit memory is consciously present in peoples mind. It is characterised as "the ability to consciously recollect, to remember what happened days, weeks, or years ago" (LeDoux, 2003, p. 97).

"Implicit memories are reflected more in the things we do, and the way we do them, than in the things we know" (LeDoux, 2003, p. 116). In other words, implicit memories have an impact beyond our awareness.

This study focuses on the first mentioned type of memory, explicit/declarative memory.

The currently performed tasks are put into working memory. Working memory is "a mental workshop that accommodates one task at a time. As soon as a new task engages working memory, the content of the old task is bumped out" (LeDoux, 2003, p. 175). So, unless one keeps thinking of a certain thing all the time and tries to ignore other stimuli, the previous stimulus does not remain in working memory as soon as a new one is present. Selective attention is the process, which is responsible for this and lets us only focus our thoughts on one task at hand (LeDoux, 2003, p. 228).

However, memories are not only built through the initial experience. Memories are deformed at every retrieval. The original experience is mixed with already stored

information in the brain, as well as other stimuli that affect the human senses. For this reason, memories might change over time (LeDoux, 2003, p. 203).

Memory formation is distinguished into three different processes: “Acquisition, consolidation, and retrieval. Acquisition refers to the learning process whereby the new information is encoded into a neuronal trace. Consolidation refers to processes that continue after learning and stabilize, transform, or enhance the newly encoded memory trace, which is initially fragile and temporary. Thus, consolidation counteracts forgetting due to the decay of the fresh trace or retroactive interference from subsequently encoded material (wixted, 2004). Retrieval refers to the recall of stored memories” (Born et al., 2006). The consolidation of memory happens during sleep, a later section is going to elaborate in more detail about this (LeDoux, 2003, p. 107).

According to Stickgold (2005) the tested form of memory in this study, is episodic declarative memory, “memories of specific events (such as what you had for dinner last night)”. In this experiment, it is the memory on what had happened during the short movie and about the main character itself in the movie, which is going to be explained in the section about the actual experiment and its setting, in more detail.

Formation of false memory is about the recollection of events or information that actually never happened the way it is being recalled (Payne et al., 2009). Since newly acquired memories are mixed with other information or experiences in the brain, processes of reconsolidation deform the actual memories at every retrieval. “What is retrieved from memory can substantially differ from what was originally encoded, and under certain circumstances people even claim to remember events that in fact never happened. Such false memories are typically semantically associated with actually encoded events, and subjects are highly confident about the correctness of these memories” (Diekelmann et al., 2010). This leads us to the assumption that it is possible to create false memory.

Memory in the Brain

The different kinds of memory mentioned earlier are formed and strengthened within different parts of the brain.

“Declarative memory, the formation of which is dependent on the hippocampus and medial temporal lobe, consists primarily of memories for events and facts“ (Stickgold, 2005). It is suggested that early night sleep, which is rich in slow-wave-sleep

supports declarative memory stabilisation and enhancement. Furthermore, since declarative memory is dependent on the hippocampus, and hippocampal activation is greatest during slow-wave-sleep, it is the early stages of sleep, which enhances the stabilisation of declarative memory. Slow-wave-sleep "is characterized by slow (1-4 Hz), high amplitude brain waves in the EEG and is associated with hippocampal sharp ripples, events that may provide a means of communication between hippocampal and neocortical memory stores as memories undergo the process of consolidation" (Payne, 2009). However, the tested video also contains emotionally charged declarative memories, which could also be enhanced by rapid-eye-movement sleep, which is not present in the first stages of sleep, rather in late-night sleep (Stickgold. 2005). Sleep and recall are discussed in more depth in a later section.

"The prefrontal cortex is a convergence zone. It receives connections from various specialized systems (like visual and auditory sensory systems), enabling it to be aware of what's going on in the outside world and to integrate the information it gathers" (LeDoux, 2003, p. 180). Different information and memories are connected and hence deform our memories at each recall in a so-called reconsolidation process.

Consciousness

According to LeDoux (2003), "Consciousness can be thought of as the product of underlying cognitive processes." In other words, the things that we are conscious or aware of are the things that are currently in our working memory. However, "consciousness can only deal with a very small percentage of all incoming information, [a]ll the rest is processed without awareness" (Dijksterhuis et al., 2005).

"During focused attention, mental resources are allocated to the task at hand. The executive, in other words, keeps lower-level processors engaged in activities that support the task being worked on. However, if lower-level processors that are not being worked with at the moment detect some event that is unrelated to the current task but is more important than the current task, resources are allocated to processing the new event. The task management, scheduling, and conflict resolution functions of the executive shift attention to the new event and move information relevant to it into working memory" (LeDoux, 2003, p. 191). This is referred to as selective attention, as briefly mentioned earlier and bumps out the previous task.

However, one is never aware of the actual process itself, only of the consequences of the process which is conscious to us.

Placebo Effect

Perceptions, beliefs, and expectations about people, products, or services are influenced by various factors. The daily experiences are one example. These psychological processes of creating expectations happen beyond people's awareness. One typical known example of creating expectations is that consumers associate low prices to low quality. This expectation leads to a behavioural effect, which is known as a "placebo effect of marketing" (Shiv et al., 2005). So, consumers who value good quality will not buy a cheap product, as they associate it with low quality. The same principle applies to brands. Well-known brands always come with associations. Most people, for example, choose a Coca-Cola instead of Pepsi, or a no-name coke. However, blind tests reveal that most consumers cannot distinguish between Coca-Cola and Pepsi when only tasting the product without seeing the brand (Keller, 2013). However, coke is most often associated with the brand Coca-Cola. Considering the placebo effect in marketing and brands, it is assumed that informational aspects, like real objects, are easier to be recalled than emotional aspects in the underlying experiment introduced later.

The general placebo effect originates from medical science, even though it is not a real treatment but just a placebo, as long as people believe in the effect of it, it will actually work. This process happens unconsciously in people's brain. "Two notions are believed to account for placebo effects: expectancy theory and classical conditioning" (Shiv et al., 2005). Expectancy theory in placebo effects is the principle briefly explained earlier, beliefs about a treatment in people's mind act as a placebo and activate expectations about the treatment and thus affect the actual effectiveness of the treatment. Classical conditioning evolves over time and several trials. Known therapeutic treatments serve as the conditioning trials. This active treatment is the unconditioned stimuli. The conditioned stimuli is the way they are presented, e.g. in form of a pill or a medicine bottle with liquid. Pairing these two stimuli over time lets the placebo effect arise. If you take a pill or a liquid from a medicine bottle you immediately associate it with the effectiveness of a medical treatment (Shiv et al., 2005). Believing in something is the essential part of the placebo effect.

Sleep and Recall

Sleep can be divided into different forms. This study focuses only on the sleep during the night, which is characterised mainly by two different phases: rapid-eye-movement sleep and slow-wave sleep (Stickgold, 2005). "More than 80% of slow-wave sleep is concentrated in the first half of the typical 8-h night, whereas the second half of the night contains roughly twice as much rapid-eye-movement sleep as does the first half" (Payne&Nadel, 2004). To make it more clear, the first half is dominated by slow-wave sleep and the second later half is dominated by rapid-eye-movement sleep.

As in phases of slow-wave sleep dreams occasionally consist of memories and not only fiction, as it is most often the case in dreams during rapid-eye-movement sleep, it is assumed that "memory systems needed to generate complete (explicit) episodic retrieval", in other words memory consolidation rather takes place during phases of slow-wave sleep and hence in the early stages of sleep, than during rapid-eye-movement sleep (Payne&Nadel, 2004).

Furthermore, the sleep at night is a longer period of sleep than compared to sleep during the day, which is more considered to be nap and can not be characterised with the two main phases of slow-wave sleep and rapid-eye-movement sleep.

The investigated type of sleep of an over-night sleep "has been identified as a state that optimizes the consolidation of newly acquired information in memory" (Born et al., 2006). "Memory consolidation is often conceptualized as a time-dependent, off-line process that stabilizes memories against interference and decay, allowing them to persist over time" (as cited in Payne, 2009). Thus, information that was forgotten due to the intake of other, at that moment more important, information in working memory can be restored at night. Besides other function, such as rest and recovery, "sleep facilitates the storage of newly encoded information into long-term memory" (Born et al., 2006), and counteracts forgetting things. Müller and Pilzecker (Born et al., 2006) found out that "fresh memories need to consolidate slowly over time to become resistant against interference and decay". Hence, without sleep it is very likely that interference can influence the newly acquired information. Furthermore it seems as if consolidation even goes on after the first night and memories need multiple phases of sleep in order to strengthen and become stable.

However, it might also be possible that under certain conditions, sleep may lead to a qualitative change in pre-existing memory representations, which implies

the development of distorted and false memories due to reorganisation during the consolidation phase (Diekelmann et al., 2010).

False memory might also be created at recall, “when one is attempting to retrieve a target item from memory, semantically related items may be activated during the search for the target information and become linked to the target item” (as cited in Bäuml et al., 2014).

Stress Hormone Cortisol

As three of the tested groups, including one which is important for the study at hand, were tested with an induced higher cortisol level during the false memory creation, it is important to briefly get to know the hormone cortisol. “Cortisol levels can be affected by many conditions, such as physical or emotional stress, strenuous activity, infection, or injury” (webMD, 2014) In this study, a higher cortisol level is produced due to the condition of stress under a math test.

Cortisol belongs to the steroid family and is secreted by the adrenal glands. The hormone has two major tasks. Firstly, it stimulates gluconeogenesis, which is “the breakdown of protein and fat to provide metabolites that can be converted to glucose in the liver”. Secondly, “it activates antistress and anti-flammatory pathways”. Most important to us, it “plays a major role in the body’s response to stress”. Besides other activities, it regulates the blood pressure during the state of stress and maintains the glucose level in the blood (Encyclopaedia Britannica, 2014).

As Cortisol is a hormone, which the body produces as a response to stress, an increase in cortisol secretion most often indicates the current state of stress (Kozlov&Kozlova, 2014). “Bodily feedback in the form of stress hormones can either enhance or impair long-term memory functions of the temporal lobe memory system, which will in turn influence the content of working memory“ (LeDoux, 2003, p. 229). Working memory however is not the only process, which is influenced by the stress hormone. “Cortisol is an important part of the activation of the hypothalamic-pituitary-adrenal (HPA) axis in the body's response to stress and plays a role in cognitive processes, such as working memory, memory consolidation, and extinction learning. In particular, cortisol may serve to activate cognitive resources in the context of stress“ (McHugh et al., 2010).

The normal cortisol level during the day, without any extraordinary infections or stress, rises in the morning and is at its peak at around 7 a.m., from then onwards it gradually decreases and is lowest during the evenings and early phases of sleep (webMD, 2014).

The study at hand is going to concentrate on the impact of cortisol on false memory creation and recall and thus the emphasis is on the process of working memory and memory consolidation and the impact of an increased cortisol level among part of the respondents on these processes.

Gender differences

Different studies on cortisol as a stress hormone reveal that there are some differences between males and females. However, not only differences between genders can be determined, but also between different age groups and phases throughout the day. For example, without extra mental loading, middle-aged men have a higher background level of cortisol during the day than women in the same age category. On the other hand, women generally have a higher cortisol level in the beginning of the day. There are not only differences in the background level of cortisol but also even further differences when exposed to stressors or mental loading and thus, "a clear pattern cannot be proposed for cortisol production in males and females in response to stress or mental loading" (Kozlov&Kozlova, 2014). Not only do differences in males and females exist in the general cortisol level during the day but also as a response to stress (McHugh et al., 2010).

Since differences in male and female exist, this study focuses on only one gender group, males, to keep it simpler and to generally come to a conclusion without having to take possible gender differences into account.

Hypotheses

H1: By the use of questions, containing false information, false memory can be created and recalled later

H2: Higher cortisol levels, created by stress, enhance the false memory recall in the short-term

H3: False memory recall is higher in the short-term than in the long-term

H3a: Sleep decreases the recall of created false memory

H4: False memory recall is higher for informational aspects than for emotional aspects

Method

Subjects The participants were 100 undergraduate and graduate male Students. They received a monetary reward for their participation at the experiment. For the stress test, a high reward was given in order to increase the pressure and production of cortisol, stress hormones, and their performance.

Since this study only focuses on three test groups of the whole experiment, the results are based on only 60 participants of the experiment and the corresponding results. The three test groups taken into account are: the control group with correct information, the control group with false memory creation, and the group with increased cortisol levels immediately before the false memory creation and after the original information in the video.

Procedure Levels of testosterone in men vary throughout the day. Mornings are believed to portray a higher concentration of testosterone levels, which stay more or less stable until early afternoon, which after they start to decrease and are considered being low in the evening (Bird, 2014). In order to eliminate any biased results due to possible fluctuations in testosterone levels of men during the day, participants were tested at the same time of the day. The chosen point of time was 2 pm on both days, in order to have a moderate testosterone level during the experiment.

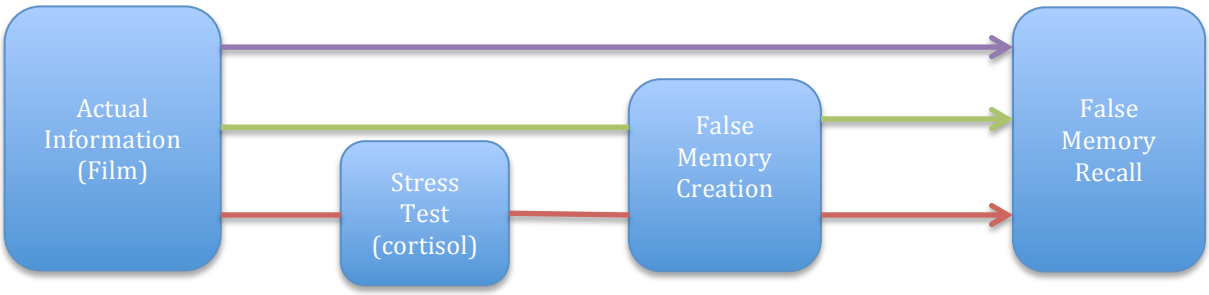
As women are regarded to be less stable in their hormonal levels, only male respondents were tested, in order to relate to the results only to the increase in cortisol and out rule any other hormonal effects.

All participants had to watch a short video called: Love Sick (Lacy, 2011). Thereafter, they had to answer a questionnaire with open questions and a true or false questionnaire. These surveys contained questions about the main character in the movie, the actual plot and details that had happened, and things that triggered visual and auditory senses. Except for the control group with the correct memory the open questions were manipulated by asking for things that had not happened in the video. However, not all questions were manipulated to not make it too obvious to the respondents. On the second day, all participants had to answer a multiple-choice

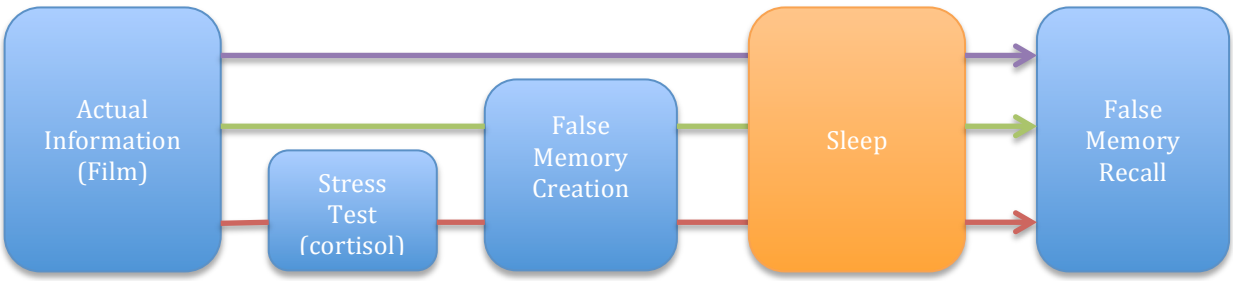
questionnaire. The true or false questionnaire, as well as the multiple-choice questionnaire on the follow up day should show whether the creation of false memory was successful in the short-run and in the long-run. In order to test the effect of a higher cortisol level on the intake of information, a math test was performed within three of the tested groups. The difference within these three groups was the point of time when the math test was conducted. For the study at hand, only one of these three groups is of importance and was tested in the actual analysis. For this group, the math test was conducted immediately after the video and before the creation of false memory by the open questions.

Setup of the Experiment

Short-Term Recall Testing



Long-Term Recall Testing



Group 1 – Correct Memory Control Group
Group 2 – False Memory Control Group
Group 3 – Higher Cortisol Level After Actual Information

Experiment 1

The first experiment observes the overall creation of false memory. Is it possible to create false memory by using questions, which contain words and objects that actually were not present in the shown video? Additionally, do participants recall them as the actual objects in the video? Or do they recognise that these objects were not present in the original movie?

First, all 40 participants were shown the same video. Next, a questionnaire with open questions, followed by a questionnaire with true and false questions, had to be answered. Half of the respondents received a manipulated open questionnaire containing wrong information, objects and events which were not present in the previously shown video. With the true or false questionnaire it could be observed whether the wrong information could be implemented. For the result, the outcomes of the first 20 people who got the original questionnaire were compared with the outcomes of the second group, which contained the manipulated questionnaire.

In short, this experiment focuses on the comparison of the control group with the correct memory and the control group with false memory creation. The aim of the first experiment is to test Hypothesis 1 and find an answer to the question whether it is possible to create false memory, and to find and a possible explanation for the outcome.

Experiment 2

The emphasis of the second experiment lies on the impact of the hormone cortisol on the creation of false memory. By putting the respondents under pressure with a math test, the stress hormone cortisol is produced. It is then tested, whether cortisol increases the likelihood of false memory creation or whether respondents notice the wrong information and recall the correct information from the video more easily. “Studies of the psychological and biochemical reactions in psychologically stringent situations, e.g., in students taking exams, revealed aggravation of the psychological sings of stress and an increase in cortisol” (Kolzlov&Kolzlova, 2014) Hence, a 15-minute math test was taken as a means of a stressor. Furthermore, the stressor needs to be unexpected, in order for cortisol to be produced. Hence fore, the math test was conducted without prior notice to the respondents of the study. Additionally, the best three respondents were promised to get a monetary reward in order to increase the pressure and level of stress because the respondents tried to achieve one of the best three results.

During recent years, a stressor was considered more effective as it contained a threat of social evaluation (Kozlov&Kozlova, 2014). This aspect can be determined as present for the conducted study, since respondents were awarded for good results in the math test and hence they try to perform better in order to be socially honoured with a reward of good performance. Of course, the higher the threat of not performing well enough, the higher the stress level and production of cortisol.

A comparison between this group and the control group without the stress test, with the false information should show the impact of the production of cortisol on false memory creation.

In conclusion, the second experiment is about the results of the control group with false memory creation in comparison to the results of the group with false memory creation under a higher level of the hormone cortisol. This experiment is meant to give an answer to Hypothesis 2, whether higher cortisol levels enhance the false memory recall in the short-run, and find possible explanations for the corresponding results.

Experiment 3

In the third experiment, the observation is on the difference between the recall of information immediately after the video followed by the stress test, and the recall of information on the second day, after an over-night sleep. So the general short-term and long-term results are compared as well as the impact of sleep on memory is observed.

The Question now is, whether memory consolidation during sleep enhances the false memory creation and strengthens the wrong information taken in by the questionnaire, or whether consolidation rules out the false memory creation and enhances the recall of the correct information originally shown in the video, which was taken in unconsciously.

In this experiment, Hypothesis 3,whether false memory recall is higher in the short-term than in the long-term, and Hypothesis 3a, that sleep decreases the recall of false memory, are tested and ideally gives us an answer to the previously posed question. By finding out whether sleep enhances false memory creation or engages negatively in the process of false memory creation also gives us an indication whether the degree of false memory recall is greater in the short-run or in the long-run.

Analysis All three test groups, the control group with correct memory, the control group with the false memory creation, and the higher cortisol level group, were analysed

according to their frequencies in false memory recall for the short- and long-run. This gives a good overview on the three different test groups and their likelihood of successful false memory recall.

Next to that, binomial and poisson generalised linear models were performed. First, an overview of the recall in general for the short- and long-term is given, by treating each variable the same. The poisson regression delivers an outcome on which test group has the greatest impact on the number of false memory recalls in the short- and in the long-run. Next, in order to find out the false memory recall for the different questions, as it can be assumed that they are not equally effective, each question and its recall is treated individually, this can be analysed with the help of binomial generalised linear models. A generalised linear model extents the general linear model by not restricting the range of the dependent variable. In a generalised linear model, the dependent variable can also be binary, so only take two values, or a count variable in the poisson regression (Turner, 2008), which both is the case in the underlying data.

After testing the short-term and long-term false memory recall in general, with only two different generalised linear models, the recall of each specific question is tested. Nine different models for the short-run and nine for the long-run were conducted. In each model, the specific false memory recall for the single question was taken as the dependent variable (e.g. false memory recall of rain), as the independent variable an indicator variable was created, which states whether the respondent belonged to group 1, the control group with correct memory, group 2, the control group with false memory, or group 3, the higher cortisol test group. It can then be observed, whether the different groups have an impact on the recall of false memory, or whether they are irrelevant for the false memory recall.

For the further analysis, it is important to note, that the different questions for false memory creation were categorised into two different groups. In order, to find a more meaningful outcome, the questions are categorised according to their context. The questions were grouped into firstly, more emotional questions, containing human characters and events, and secondly into questions about objects appearing in the movie.

There are nine manipulated questions in total. The first group contains 4 of the 9 manipulated questions and is hereafter called the emotional group of questions. The second set of question includes 5 manipulated questions and is hereafter referred to as the informational group of questions. It can then be determined, whether the group

indicator has a greater effect on one of the two classifications of questions between informational and emotional questions, mentioned earlier, or whether there is no difference between the two sets of questions. Analysing the two different groups with the help of generalised linear models, in this case poisson regression, will give us an answer to Hypothesis 4, whether informational aspects have a greater recall rate than emotional sets of questions.

The following section is going to give all numeric outcomes of the experiment and tests mentioned in this part. It is going to be divided into the short-term results, long-term results, and the difference between informational and emotional results.

Results

The respondents had an average age of 22 years, with a standard deviation of 3. The youngest participant was 18 years old and the oldest had an age of 32 years. The cultural origin of the participants was very diverse. The majority was Dutch, as well as from other European countries like Germany, Italy, and Britain for example. However, there were also a few Asian participants, hence a very diverse cultural distribution of the participants is present.

Short-Term Recall Testing

Experiment 1

The results of Experiment 1 clearly show that it is not just random that the respondents give the wrong information as a correct answer. The frequency is much higher in the false memory control group than in the correct memory control group.

Hypothesis 1 is supported. It is possible to create false memory by using manipulated questions containing false information.

In more detail, the overall frequency in the false memory control group is 24.44%. So, 24.44% of all manipulated questions was recalled and regarded to be the correct information, although it never happened in the actual video. This percentage resembles 44 false memory recalls.

Experiment 2

Experiment 2 compares the control group with false memory creation and the third test group with the stress test, and hence production of higher cortisol levels, for the short-

term. This experiment leads us to the outcome that there is only a slight increase in false memory recall for the test group with a higher cortisol level.

Hypothesis 2 is slightly supported.

Comparing the short-term results of false memory recall in the control group with false memory recall, in the higher cortisol test group, only a slight increase can be determined. The false memory creation control group has a percentage of 24.44 of false memory recall and the higher cortisol test group has a percentage of 26.11, resulting in an increase of 1.67%.

If one assumes that the false memory recall of the variables is interchangeable, a poisson linear model, which is also a form of generalised linear model, can be applied. Here, we assume that it is a general probability that a respondent will form a false memory recall irrespectively of the certain variable. So, it is assumed that false memory can be formed for each variable with the same likelihood. The dependent output variable in this case is the number of false memories formed, which is determined by the independent Group indicator variable. In other words, we want to find if the group the respondents belong to have an impact on the number of false memories that could be created and recalled.

For the short-run, the maximum a respondent recalled was five false memory variables. The mean was 1.74 (standard deviation= 1.5252). The number of false memory recalls is 3.357 times higher for group 3, the higher cortisol level group, than for group 1, the correct memory control group, and 3.143 times higher for the false memory control group, group 2. These results lead us to the beta values and the following equation:

$$\text{Number False Memory Recalls\_Short} = -0.357 + 1.211 * \text{Group3} + 1.145 * \text{Group2}$$

If we however assume that the likelihood of false memory creation and recall is not the same for all variables, the specific results in this section apply. For the short-term, the binomial generalised linear models gave the following results:

			Independent Variables[a]	
Dependent Variable	**Percentage of False Memory Recall**	**Independent Variable: Group Indicator**	**Group 3**	**Group 2**
Hat	28.3%	Insignificant	8	8
Bus	15%	Insignificant	Insignificant	Insignificant
Christmas	16.7%	Insignificant	Insignificant	Insignificant
Skateboard	0%	-		
Taxi	43.3%	Significant	6	6
Starbucks	41.7%	Significant	5.5	6
Kick	21.7%	Insignificant	Insignificant	Insignificant
Dog	1.7%	Quasi-complete separation		
Rain	6.7%			

Table1: Short-Term Recall

[a] Indication of how many times more/less the likelihood of false memory recall of the dependent variable for group 3 or 2 is, compared to the reference group, group 1.

The manipulated question about the *Justin Bieber Hat* was recalled by 28.3% of all 60 respondents. Group 3, the higher cortisol level test group, recalled it eight times more than the control group with correct memory, which was taken as the reference group. Also group 2, the control group with false memory creation, was eight times more likely to recall the *Justin Bieber Hat*, than the reference group, group 1. This results in a generalised linear model for the short-term recall of the *Justin Bieber Hat* as follows*:*

$$Hat\_Short = -2.996 + 2.079*Group3 + 2.079*Group2$$

This means, if the respondent belongs to either group 3, or group 2, the likelihood of false memory recall of the *Justin Bieber Hat* goes up by 2.079.

15% of all respondents recalled the *Bus* instead of the Tram in the actual video. However, for this question the independent variable, which specifies to which group the respondents belong is not significant for the model. In other words, the variable *Group* does not add any value compared to the so-called zero-Model, which only takes the dependent variable and all respondents into account, and thus it does not matter for the recall of the variable *Bus* to which test group the respondents belong.

The false recall about remembering the main characters celebrating *Christmas* was recalled by 16.7% of the respondents. However, also for this question the *Group* variable is insignificant and thus did not add any value to the zero-model.

The *skateboard* did not have any success at all to be recalled. All respondents recalled the bike correctly, and hence no false memory creation did take place for the *skateboard.*

The *Taxi*, instead of the white car shown in the video, was recalled by 43.3% of all respondents. With a significance of 0.032, the *Group* variable is significant for this model. Hence, it does make a difference for the recall of the *Taxi* to which test group the respondents belong. For both test groups, group 3 and group 2, the likelihood of false memory recall of the *Taxi* was six times higher than for group 1, the correct memory control group. The equation for the recall of the *Taxi* in the short-run is as follows:

$$\text{Taxi\_Short} = -2.303 + 1.792*\text{Group3} + 1.792*\text{Group2}$$

The *Starbucks Café* was falsely recalled by 41.7% of all 60 respondents. The *Group* variable was significant for this model, with a significance of 0.036. The recall rate of the *Starbucks Café* was 5.5 times higher for the higher cortisol test group, than for the control group with the correct memory. The control group with false memory creation had a recall rate of false memory of the *Starbucks Café* in the short-run, which is six times higher than the recall rate of the control group with the correct memory. This results in an equation for the recall of the *Starbucks Café* in the short-run as follows:

$$\text{Starbucks\_Short} = -2.303 + 1.705*\text{Group3} + 1.792*\text{Group2}$$

The short-term recall of the variable *Kick* accounts for 21.7% of all respondents. However, for this question, the *Group* indicator was insignificant. It does not change the recall rate of the variable Kick whether you belong to groups 3 or 2, compared to test group 1 with no manipulation.

The recall rate of the variable *Dog* was only 1.7%, which is only one respondent out of 60. A similar low recall rate was observed for the variable *Rain*, only 6.7% recalled the rain falsely, this resembles 4 respondents out of the 60 in total. For both models a quasi-complete separation exists, and hence no validity of the model fit can be given. Quasi-complete separation means that no maximum likelihood estimation exists (Boyle, 1996). So, the independent variable, in this case the *Group* indicator, yields a perfect prediction of the response variable, the rate of false memory recall for *Rain* and *Dog,* for most, but not all, values of the Group indicator.

Long-Term Recall Testing

Experiment 3

Experiment 3 shows that the false memory recall is higher in the short-run than in the long-run. As in Hypothesis 3a suggested, sleep can consequently be determined as a cause of reduction of false memory recall.

Hypothesis 3 and Hypothesis 3a are supported.

For both groups, the false memory control group, as well as the higher cortisol level group, the short-term results have a higher degree of false memory recall than the long-term results.

As mentioned in Experiment 2, the false memory control group resulted in a 24.44% recall of false memory in the short-run. For the long-run, only a degree of 14.44% of recall of false memory could be detected. This is, if you only take the single answers on the second day into account. However, taking the false memory creation for both, the long-term and short-term as the measurement of the real false memory creation, the intercept of the short-term and long-term has to be considered. In other words, it is only a long-term recall of false memory if it was recalled in the short-run as well. Then, only a percentage of 10.56 of false memory were successfully recalled.

The test group with a higher cortisol level resulted in a 26.11% recall of false memory in the short-term, as mentioned earlier. On the second day, the false memory recall decreased to only 15%. Which is a decrease of 11.11%. However, if you take the intercept as a means of measurement for the long-run, only a percentage of 9.45 of recall of false memory can be successfully detected.

Treating the likelihood of the false memory creation and recall equally for the different variables, the following results of the poisson model apply. For the long-term recall, the maximum was three recalls at a time. The mean for the long-run recall is 1.068 (Standard deviation = 0.8683). For group 3, the higher cortisol level test group, the number of false recalls was 2.565 times greater than for group 1, the reference group with correct memory. The number of recalls is 0.904 times greater for group 2 than for the reference group, group 1.

Number False Memory Recalls_Long = -0.642 + 0.942*Group3 + 0.904*Group2

Going into more specific results and assuming that the likelihood of false memory creation and recall is not equal among all nine variable, the following results can be

determined from the underlying data. For the long-term recall of the specific questions, the binomial generalised linear models yield the following outcomes:

			Independent Variables[a]	
Dependent Variable	**Percentage of False Memory Recall**	**Independent Variable: Group Indicator**	**Group 3**	**Group 2**
Hat	43.3%	Insignificant	2.4	Insignificant
Bus	18.3%	Insignificant	Insignificant	Insignificant
Christmas	6.7%	Insignificant	Insignificant	Insignificant
Skateboard	3.3%	Quasi-complete separation		
Taxi	23.3%	Insignificant	Insignificant	Insignificant
Starbucks	8.3%	Quasi-complete separation		
Kick	1.7%			
Dog	0%			
Rain	1.7%	Quasi-complete separation		

Table 2: Long-Term Recall

[a] Indication of how many times more/less the likelihood of false memory recall of the dependent variable for group 3 or 2 is, compared to the reference group, group 1.

The recall of the *Justin Bieber Hat* was made by 43.3% of all respondents on the follow up day. This is an increase of 15% for the long-term recall compared to the short-term recall. The recall rate of the higher cortisol level test group was 2.4 times higher than the false memory recall rate of the control group with the correct memory. This leads to a beta value for the *group* indicator of 0.875. Group 2, the control group with the false memory creation, however was not significantly different compared to group 1 and thus gives us an equation of:

$$Hat\_Long = -1.386 + 0.875*Group3$$

The recall of the variable *Bus* also increased for the long-term recall. An increase of the recall rate by 3.3% compared to the recall rate in the short-run can be observed. The *Group* indicator variable was however insignificant, which was also the case for the short-run. So, the recall rate in the long-run of the variable *Bus* is not affected by the difference of group the respondents belong to.

The recall rate of the variable *Christmas*, however, decreased in the long-term recall by 10% and is now only 6.7% of all 60 respondents. The Group indicator is insignificant in this model as well. This does not deviate from the short-term model

where the *group* indicator is also insignificant and does not add any value to the zero-model.

Skateboard, the variable which was not at all recalled in the short term, is recalled by two respondents in the long-run. This gives us a recall rate of *Skateboard* of 3.3%. As these two respondents do not belong to only one test group but to the correct memory control group and to the other respondent to the higher cortisol level test group, a quasi-complete separation exists and thus a validity of the model fit cannot be given.

As mentioned earlier, the variable *Taxi* was recalled by 43.3% of all respondents in the short-term. In the long-term, the variable was only recalled by 23.3%, which gives us a decrease of 20% in the recall rate of the variable *Taxi* for the long-run. In contrast to the short-term, the *Group* indicator variable is insignificant for the long-term recall rate of the variable *Taxi*.

The greatest decreased in the recall rate can be observed for the variable *Starbucks Café*. In the short-run it was recalled by 41.7% and in the long-run only by 8.3%, which is a decrease of 33.4%.

The variable *Kick*, as well as the variable *Rain* is only recalled by one respondent in the long-term. This results in a recall rate of 1.7% for both variables in the long-run. The recall rate of *Kick* is thus reduced by 20%, as it was 21.7% for the short-term and the recall rate of the variable *Rain* is decreased by 5% which are three respondents less than in the short-term. For all three last mentioned variables, *Starbucks Café*, *Kick*, and *Rain*, a quasi-complete separation is present. For all three variables it can be assumed that it is the case because all three test group almost exists only of distributions of a 0 value, which means that the false memory of the variable was not recalled.

The recall rate of the variable *Dog* decreased in the long-run by 1.7% which means that it was not recalled by a single respondents in the long-run testing.

Informational versus Emotional Recall Testing

Classifying the nine questions in the two different groups of informational and emotional sets of questions results in the following outcomes.

As mentioned in the short-term recall part, the false memory control group has a frequency of 44 false memory recalls. 34 out of the 44 false memory recalls, thus resembling 77.24%, belong to the informational group of questions. Only 22.23%, meaning 10 false memory recalls, belong to the emotional set of questions. Concluding,

the informational aspects are easier to manipulate in the false memory control group for the short-run.

In contrast, the control group with the correct memory questions contained only 14 false recalls in total. The 14 total recalls are equally divided between the two types of questions. 50%, so 7 false recalled questions, belong to the group of emotional questions, and 50%, so the remaining 7 falsely recalled questions, belong to the set of informational questions. Concluding, for the control group with the correct memory and no manipulation, so false recalls are equally distributed between the two types of questions for the short run.

Taking the averages of the binomial generalised models for each question leads us to the following averages for the distribution informational and emotional false memory recall. On average 25.66% of the respondents recalled the informational false memory and only on average 11.6% of the respondents recalled the emotional false memory in the short-run. In general, it can be said that the informational set of questions had on average a higher recall rate in the short-run

The mean for the number of the recall of informational memory in the short-run is 1.283 (Standard Deviation = 1.1658) and the maximum of recalls per respondent are 4 recalls for the short-term. The number of informational variables is 5.143 times greater for the higher cortisol level group compared to the control group with correct memory, and 4.857 times higher for the false memory control group. The corresponding betas of the poisson linear model lead to the following equation for the recall of the informational questions in the short-run:

$$\text{Informational\_Short} = -1.05 + 1.638*\text{Group3} + 1.58*\text{Group2}$$

The maximum for the emotional memory recalls per respondent are 2. The mean for the emotional memory recall in the short-run is 0.467 (standard deviation = 0.6235). For the model of the number of false emotional memory recalls the Group indicator variable is insignificant. The affiliation to the separate groups is not of importance and does not add any value to the zero-model of the emotional false memory recall in the short-run.

For the long-run, it can be said that the false memory control group had a degree of false memory recall of 92.31% for the informational questions and only a percentage of 7.7 for the emotional set of questions, from the overall 14.44% meaning 26 recalls of

false memory out of 180 manipulated questions. The test group with a higher cortisol level show almost the same results. The informational questions had 92.6% of false memory recall and the emotional only 7.4%, from the overall 15%, which are 27 recalls of false memory out of 180 manipulated questions.

However, if you only regard the intercepts as real false memory recall then out of the 10.56% of false memory recall in the false memory control group, 94.74% belong to the informational set of questions and 5.26% to the emotional group of questions. For the test group with a higher cortisol level, 100% of the 9.44% of false memory recall, so 17 out of 180 questions, belong to the informational set of questions. No emotional question was successful in the interception of short-term and long-term recall of false memory for the group with a higher cortisol level.

Taking the averages of the binomial generalised models of each question for the long-run, leads us to the following averages for the distribution of informational and emotional false memory recall. The average recall rate of informational questions decreased by 6.36% to 19.3% in the long-run. For the emotional set of questions the decrease of the average recall rate is even greater with 9.075%, to only 2.525% for the long-run recall.

The results of the poissson generalised linear model reveal the following: For the long-run, the maximum informational false memory recalls per respondent are 3 recalls. The mean for the informational false memory recalls is 0.967 (standard deviation=0.8227). Respondents belonging to the test group with a higher cortisol level increase the number of informational false memory recalls by 2.778 times compared to the reference group of correct memory control group. The belongingness to group 2, the false memory control group, increases the number of informational false memory recalls by 2.667 compared to the reference group for the short-run. The corresponding betas lead to the following equation:

$$\text{Informational\_Long} = -0.799 + 1.022*\text{Group3} + 0.981*\text{Group2}$$

The maximum emotional false memory recalls per respondent are two in the long-run, with a mean of 0.1 (standard deviation=0.3542). As there are in total only 6 recalls and they are distributed to two recalls in each test group, the group indicator variable is insignificant for this generalised linear model.

Hypothesis 4 is supported since for both, the short- and the long-run, the recall rate for informational false memory is greater than for emotional false memory. This shows that not only for the short-run but also for the long-run it seems to be easier to manipulate informational aspects rather than emotional characteristics.

Summing up all results, the following can be said. It is possible to create false memory by manipulating a set of questions and respondents recall this information and regard it as true, thus Hypothesis 1 is supported. The results for Hypothesis 2 show that the impact of cortisol on the recall of false memory is only a little increase compared to the false memory control group. Hypothesis 2 is therefore only slightly supported. The frequency distributions as well as the generalised linear models show that the recall rate is greater in the short-term than in the long-term and thus support Hypothesis 3. This also implies that Hypothesis 3a is supported since the long-term testing implies a state of sleep. The analysis of the two different sets of questions revealed that the false memory recall of informational aspects is greater than of emotional aspects and thus supports Hypothesis 4.

The next section is going to examine the results in the context of the theory discussed earlier in this study. And gives an answer to the Hypotheses not in a numeric way but with an explanation of the applied theories.

Discussion

According to the outcome of the experiment, Hypothesis 1, and Hypothesis 3, it is possible to create false memory and the immediate recall of false memory is stronger than after a longer period of time. It can be assumed that the production of cortisol, due to the stress test immediately after the intake of information from the video, causes a distraction from the actual important information. Hence, the respondents regard any other information told after the math test as true, since they do not recall the actual information of the video. The principal of selective attention is responsible for the intake of the math test into working memory and therefore bumps the information of the video out of the working memory. As a consequence, the wrong information from the manipulated questionnaire is the last stimulus, which entered working memory before answering the true/false questionnaire to check whether false memory creation worked. This results in the high rate of false memory recall in the short-run.

However, it is questionable whether the higher level of cortisol is the reason for the high rate of recall. As the results show, Hypothesis 2 is only slightly supported. For the false memory control group there was no increased cortisol level and still the recall rate of false memory was only slightly less than in the test group with a higher cortisol level. The last stimulus for both groups was, however, the same, the false memory creation. It can therefore be concluded that the principal of selective attention and working memory have the greatest impact on the false memory recall in the short-run and the impact of cortisol is only small.

Still, there are small differences in the results, which might be even greater when testing a larger group. A possible explanation might be that the "high cortisol levels can disrupt the function of the hippocampal formation" (Payne&Nadel, 2004) and hence the previously exposed information cannot be stored properly. At least, this is the case during the later phases of sleep, cortisol levels rise through these phases and hence hippocampal formation does not function properly anymore. In more detail, the functionality of hippocampal – neocortical interaction is reduced at a higher cortisol level during rapid-eye-movement sleep. As during the day a similar communication as during rapid-eye-movement sleep can be observed, namely that newly information and observations about the external world "first activates the neocortex and then reaches the hippocampus via the entorhinal cortex" (Payne&Nadel, 2004), it can be assumed, and should further be tested, that a disruption of the hippocamapal – neocortical interaction due to a higher cortisol level at night, also happens at a higher cortisol level during the day. This then leads to a decrease in correct memory recall.

The intake of the actual information of the video is assumed to be unconscious, due to the fact that it is not present in working memory any more, but it is regarded to be present in the memory without our awareness. Memory consolidation during sleep brings back the actual information of the video into our memory. Hence, the impact of the false memory creation is less strong after the second day and a night sleep, which supports Hypothesis 3a that sleep, due to consolidation of the correct memory, reduces the recall of the created false memory.

According to Stickgold (2005), even a nap during the day increases performance, so an over-night sleep is not especially necessary for an improvement of recall. In his experiment, retesting after 72 hours had the most improvement (26%). Hence, improvement and learning during sleep is not restricted to the first night after exposure, it continues in the following nights.

As tested in Hypothesis 4, informational beliefs among people seem to be easier to manipulate than emotional aspects. This outcome reveals a suggestion for marketers and managers to use more informational aspects in their advertisements. Since consumers are easier to be manipulated regarding informational characteristics, you can make them believe the advertised information about a product and hence get them to purchase the product more easily than by the use of false emotional aspects. People seem to be less susceptible to manipulation in emotional aspects, especially in the long-run. The placebo effect is a possible explanation for this outcome. As Starbucks Café is one of the most often recalled false memory variables, especially in the short-run, it can be assumed that people immediately associate a café with the brand Starbucks. When asking after the video, whether there was a Starbucks café in the video, they answer "yes" and recall the false memory of a Starbucks Café. The same principle could be true for the variable Taxi. Taxi is the most often recalled false memory in the short-run and second most often recalled false memory for the long-term. It can be assumed that people who see a white car in the video associate it with a taxi, as in many countries taxis are most often in a very light colour. When being ask later whether there was a taxi in the video, they falsely recall it.

This results in the conclusion that with brands and well-known names people can be manipulated quicker. The placebo effect has some major implications for brands. Especially for smaller brands this is a tough issue. As the more known the brand is, the more people recall the false memory and the more effective is the implantation of false memory. This leads to an advertising clutter for smaller brands, even though they advertise a lot people will still recall well-known names better.

With the outcome that informational false memory creation and recall seems to work better than emotional false memory creation, another question arises, whether during sleep informational memory consolidates faster or better than emotional memories. One aspect that needs to be taken into account is that the emotional set of questions might not be regarded as hippocampus-dependent declarative memories and hence does not consolidate during slow-wave sleep. The modulations of emotional memories and arousal have been implicated in the rapid-eye-movement sleep phase (Kleim et al., 2013). Thus, the assumption that consolidation during sleep is different for emotional information in contrast to informational aspects rises, which might lead to a changed effectiveness.

Limitations and Recommendations

The subject pool only consisted of undergraduate and graduate students, thus going out during the week is highly possible. It is therefore likely that small amounts of alcohol on the day of the experiment still influenced their hormone levels, which in turn influenced their reaction to the experiment. For further research it is advisable to make sure that the participants abstained from alcohol throughout the experiment and even one to two days prior to the experiment.

The number of 20 respondents per test group also limits the strength of the outcome. A larger test group would therefore validate the results more and is recommended in order to get a clear and strong outcome of the experiment.

Students were not observed during the second day while answering the follow up survey, to investigate the impact of sleep on the false memory recall, thus the respondents might have rushed through the questionnaire and did not take it as serious.

The age distribution as well as the country of origin was not respected in the actual analysis, which might be interesting to find out, whether there is a relationship between the recall of false memory and age, and the recall of false memory and the country of origin. For this purpose however you need more participants belonging to the same cultural background and not too many diverse cultures.

Furthermore, no general statements, only statements on male recall and false memory implantations can be made. Women might react differently and their degree of recall might vary to that of men. Thus it might be interesting for further research, to investigate females as well, in order to find out how females react to false memory creation and whether differences between males and females really exist in a great extent.

Further research should also be conducted on the different stages of sleep and their effect on memory stabilisation and enhancement, since it is not for sure clear which stages of sleep influence the different types of memory. However, it is assumed that slow-wave sleep is most likely to be responsible for the consolidation of explicit memory. Since the first half of memory is characterised by 80% of slow-wave sleep, it should be tested whether also a shorter period of sleep, maybe even a nap, might be enough for explicit memory consolidation. As cited in Kleim et al. (2013), “significant effects of sleep on memory occur after naps of 1-2h”, hence a nap during the day might already achieve the same results as a full night sleep.

Long-term effects should be retested in order to find out whether 24 hours are already considered as long-term, or whether the effect of false memory recall is greater or different after a longer period of time and multiple nights of sleep in-between.

It might be interesting to investigate whether the outcome of the math test is related to the false memory creation. So, whether more concentrated and better performing participants where more distracted by the math test and thus were easier to influence with false memory creation. Hence, poorer performing participants were less influenced by the false memory creation. Or, on the other hand, it might be true that poorer performing participants were more stressed and thus more distracted and easier to engage in false memory creation.

Furthermore, a following experiment should contain a group with the stress test and the correct information, so no false memory creation. The results of this extra group can give a better indication on the influence of a higher level of cortisol. A comparison to the same group only with false memory creation might be of big interest, in order to find out whether despite the distraction and change in working memory still leads to the correct recall of information or whether they also do recall the wrong information. Additionally, a comparison between the newly suggested group and the control group with the correct information could give a pure result on the impact of the higher stress level.

It should further be tested the long-term recall of false memory to find out what the better measurement is. It might be the case that the single long-term recall is the most accurate indicator regardless of what happened in the short-term. It could however also be the case that it is important what happened in the short-run to refer to it as real long-term memory and to exclude the risk that it was only recalled or mentioned by chance.

References

Bäuml, Karl-Heinz T., Christoph Holterman, and Magdalena Abel (2014), "Sleep Can Reduce the Testing Effect: It Enhances Recall and Restudied Items but Can Leave Recall of Retrieved Items Unaffected," *Journal of Experimental Psychology: Learning, Memory, and Cognition*

Bird, Beverly (2014), "How Does Testosterone Vary During the Day?," retrieved on the 26th of August 2014 from: http://www.livestrong.com/article/302085-how-does-testosterone-vary-during-the-day/

Born, Jan, Björn Rasch, and Steffen Gais (2006), "Sleep to Remember," *The Neuroscientist*, Vol. 12, No 5

Boyle, Madeline J. (1996), *Quasicomplete Separation in Logistic Regression: A Medical Example*

Braun, Kathryn A., R. Ellis, and E. Loftus (2002), "Make My Memory: How Advertising Can Change Our Memories of the Past," *Psychology & Marketing*, Vol. 19, Issue 1

Diekelmann, Susanne, Jan Born, and Ullrich Wagner (2010), "Sleep enhances false memories depending on general memory performance," *Behavioural Brain Research*

Encyclopaedia Britannica (2014), *Cortisol,* retrieved on the 26th of August 2014 from: http://www.britannica.com/EBchecked/topic/138929/cortisol

Hair, Joseph F. Jr., William C. Black, Barry J. Babin, and Rolph E. Anderson (2010), *Multivariate Data Analysis*, A Global Perspective, Seventh Edition

Janssens, Wim, K. Wijnen, P. de Pelsmacker, and P. van Kenhove (2008), *Marketing Research with SPSS*

Keller, Kevin Lane (2013), "Strategic Brand Management," *Building, Measuring, and Managing Brand Equity,* 4th Edition

Kleim, B., F. Wilhelm, L. Temp, J. Margraf, B. Wiederhold . and B. Rasch (2014), "Sleep enhances exposure therapy," *Psychological Medicine*, Vol. 44

Kozlov, A. I. and M. A. Kozlova (2014), "Cortisol As a Marker of Stress," *Human Physiology,* Vol. 40, No. 2

Lacy, Kevin (2011), "*Love Sick (Short Film)*," retrieved on the 26th of August 2014 from: https://www.youtube.com/watch?v=JFDAvcwDPTA

LeDoux, Joseph (2003), Synaptic Self, *How out brains become who we are*

Loftus, Elizabeth (2003), Our Changeable Memories: Legal and Practical Implications, *Nature Reviews Neuroscience*, Vol. 4, Issue 3

McGaugh, J. L. (2000), "Memory – A Century of Consolidation," *Science*, Vol. 287

McHugh, R. Kathryn, E. Behar, C. A. Gutner, D. Geem, and M. W. Otto (2010), "Cortisol, Stress, and Attentional Bias toward Stress," *Anxiety, Stress & Coping: An International Journal*, Vol. 23, Issue 5

Payne, Jessica D., D. Schacter, R. Propper, L. Huang, E. Wamsley, M. Tucker, M. Walker, and R. Stickgold (2009), "The role of sleep in false memory formation," *Neurobiology of Learning and Memory*

Payne, Jessica D. and Lynn Nadel (2004), "Sleep, Dreams, and Memory Consolidation: The Role of the Stress Hormone Cortisol," *Learning & Memory,* Vol. 11, Issue 6

Shiv, Baba, Ziv Cameron, and Dan Ariely (2005), "Placebo Effects of Marketing Actions: Consumers May Get What They Pay For," *Journal of Marketing Research*, Vol. 42

Stickgold, R. (2005), "Sleep-dependent memory consolidation," *NATURE*, Vol. 437

Turner, Heather (2008), "Introduction To Generalized Linear Models," *ESRC National Centre for Research Methods and Department of Statistics*, University of Warwick, Retrieved on 4th of September 2014 from: http://statmath.wu.ac.at/courses/heather_turner/glmCourse_001.pdf

webMD (2014), "*Cortisol in Blood*," retrieved on the 26th of August 2014 from: http://www.webmd.com/a-to-z-guides/cortisol-14668

Appendices

A1 – Set-Up of the Experiment

	Correct Memory Control Group	False Memory Control Group	Higher Cortisol Level Test Group
1.	Video	Video	Video
2.	Open Questions Correct Memory (A2)	Open Questions False Memory (A3)	Stress Test (A5)
3.	True/False Statements (A4)	True/False statements (A4)	Open Questions False Memory (A3)
4.	Second Day Multiple Choice Test (A6)	Second Day Multiple Choice Test (A6)	True/False Statements (A4)
5.			Second Day Multiple Choice Test (A6)

A2 – Open Questions Correct Memory

Please fill in the following questions and follow you initial feeling.

1. As the last girl in the pink sweater was running away, how did the music affect the mood of the scene?
2. In the scene when he finally found the second girl, what happened to the music when the guy showed up?
3. Did you realize they used bells every time he saw a girl?
4. When he stole the bike from the boy with the Justin Bieber Hair what did the music mirror in that moment?
5. What happened after he recognized that he missed the tram the girl was on?
6. What happened with the music when he was thinking about his future with the girl of his dreams?
7. What happened to the music when the white car ran him over?
8. Was there happy music when he found the girl in the Café?
9. Let's go back to the end of the video, when the girl in the pink sweater was running in the park. Do you think that was a happy ending?
10. When he was sitting in the park at the end of the movie, how do you think did that influence the mood?

A3 – Open Questions False Memory

Please fill in the following questions and follow you initial feeling.

1. As the last girl in the pink sweater was running away, how did the music affect the mood of the scene?

2. In the scene when he finally found the second girl what happened to the music when the guy showed up?

3. Did you realize they used bells every time he saw a girl?

4. When he stole the skateboard from the boy with the Justin Bieber Hat what did the music mirror in that moment?

5. What happened after he recognized that he missed the bus the girl was on?

6. What happened with the music when he was thinking about celebrating Christmas with the girl of his dreams?

7. What happened to the music when the taxi ran him over?

8. Was there happy music when he found the girl again in the Starbucks Café?

9. Let's go back to the end of the video, when the girl in the pink sweater was running with her dog. Do you think that was a happy ending?

10. When he was sitting in the rain at the end of the movie, how do you think did that influence the mood?

A4 – True/False Statements – Short-term Recall

Please state whether the following sentences are true or false.

1. Every time the guy sees a girl bells ring.
   a) True
   b) False

2. The boy on the bike wears a Justin Bieber Hat.
   a) True
   b) False

3. The guy does not have to wait for traffic lights to turn green.
   a) True
   b) False

4. The second girl gets away because the guy misses the bus.
   a) True
   b) False

5. When the guy sees the second girl for the first time he pictures them celebrating Christmas.
   a) True
   b) False

6. The guy steals a skateboard to catch up with the second girl.
   a) True
   b) False

7. While taking the short-cut the guy is run over by a taxi.
   a) True
   b) False

8. Eventually he finds the second girl in a Starbucks Café.
   a) True
   b) False

9. The guy is kicked by the second girl's boyfriend when he finally gets to talk to her.
   a) True
   b) False

10. The guy sees the third girl while she is walking with her dog.
    a) True
    b) False

11. When the guy sees the third girl he is sitting in the rain.
    a) True
    b) False

A5 – Stress Test

Please fill in the following questions. This is a numerical reasoning test similar to those used by many employers when recruiting. You will have 20 minutes to complete this test, which consists of 20 questions. Only one answer is correct, so please only circle one answer. If you score above average on this test you can win a (Dutch) National Cinema voucher or €50 for the best score.

Name:……

Age:……..

Gender:……..

Nationality:……...

Respondent number:…….

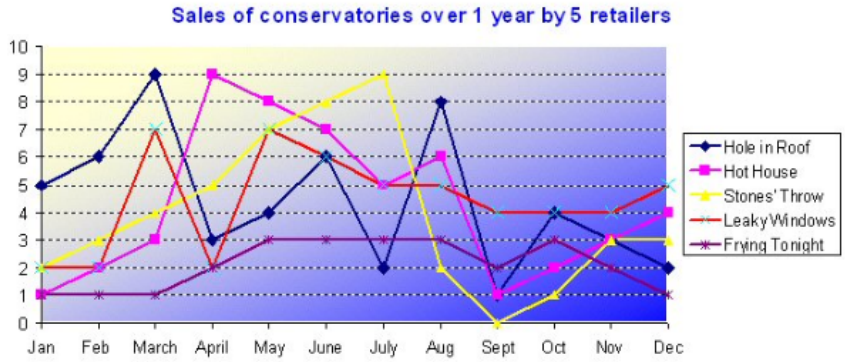
Thank you for your participation.

1. What is the missing number?

   83 - 17 = 56 + ?

   A) 6 B) 10 C) 16 D) 20 E) 30

2. See the graph below. Which company's sales were most consistent throughout the year?

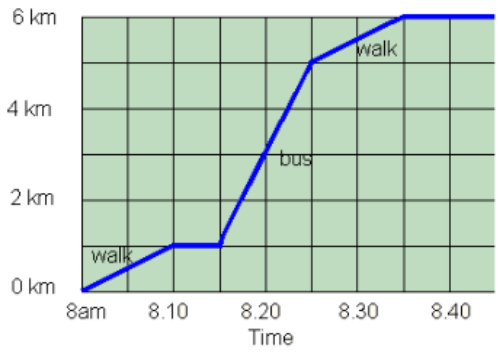


   A) Hole in Roof B) Hot House C) Stones' Throw D) Leaky Windows E) Frying Tonight

3. See the graph above. Which month gave the largest number of sales for all the companies combined?

   A) April B) May C) June D) July E) August

4. See the graph below. How far does the student walk in total?



A student walks to the bus stop to catch a bus to the university. He then walks from the bus stop at the university to the students union arriving there at 8.35 am.

A) 1km B) 2km C) 3km D) 4km E) 5km

5. See the graph above. How far is he from the university students' union at 8.20 am?

A) 1km B) 2km C) 3km D) 4km E) 5km

6. What is the missing number?

56 / 7 = ? – 5

A) 11 B) 13 C) 14 D) 15 E) 16

7. What is the missing number?

20 / 0.8 = ?

A) 14 B) 15 C) 16 D) 24 E) 25

8. Which is the largest fraction?

3/4 7/8 4/5 7/9 7/10

A) 3/4 B) 7/8 C) 4/5 D) 7/9 E) 7/10

9. If oranges cost 5 for 75c how many can you buy for $2.70? (Assuming they can be bought singly)

A) 15 B) 16 C) 17 D) 18 E) 19

10. A car left Canterbury at 7.12 am and arrived in Birmingham, 180 miles distant at 10.57 am. What was its average speed in miles per hour?

A) 42 B) 44 C) 46 D) 48 E) 50

11. An aircraft flies 930 miles in 75 minutes. How many miles does it fly in 4 hours 45 minutes assuming a constant speed?

A) 3112 B) 3477 C) 3512 D) 3522 E) 3534

12. You get a wage increase of 4% plus an extra five pounds per week. Your present wages are 250 pounds per week. What will your new wage be in pounds?

A) 260 B) 265 C) 270 D) 275 E) 280

13. See the information below. What is the total income in pounds of the taxi driver for the whole year?

A taxi driver works 46 weeks of the year and gets an average of 70 customers per week which average 4 miles each at 90 pence per mile.

Her expenditure is as follows:

Car Service/Repair/MOT/Insurance	£1,250 per annum
Diesel fuel costs	6 pence per mile.
Mortgage costs	£250 per month
Other expenditure - food/electricity etc.	£125 per week

A) 11,592 B) 12,192 C) 12,692 D) 12,992 E) 13,192

14. See the information above. What is her total expenditure over the year to the nearest pound?

A) 9,353 B) 9,953 C) 10,453 D) 10,953 E) 11,523

15. A cube has a volume of 8 cubic meters. If each side is doubled in length what will its new volume be in cubic meters?

A) 16 B) 24 C) 32 D) 48 E) 64

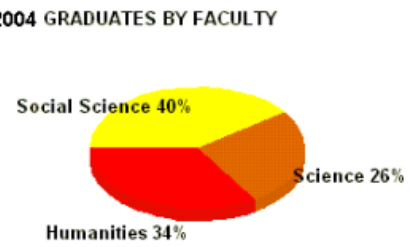
16. A driver drives 8 km South then 6 km W. and 2 km S. again. She then drives 3 km E. to avoid a traffic jam before driving 6 km N. How many kilometers is she from her starting point?

A) 4 B) 5 C) 6 D) 7 E) 8

17. See the graph below. What was the largest number of students in any year that went on to further study?

First Destinations of Students from the University of Poppleton

	2002	2003	2004
Total no. of grads	1700	1600	1500
% in employment	40	38	37
% in further study	33	36	39
% unemployment	4	6	8
% other	23	20	17

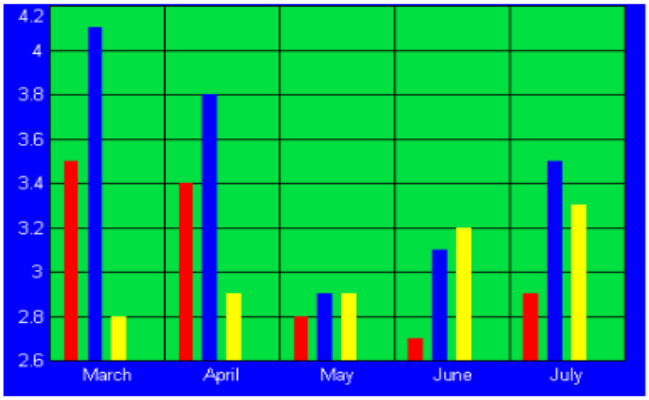


A) 561 B) 576 C) 585 D) 592 E) Can't say

18. See graph above. What was the decrease in the number of graduates in employment between 2002 and 2004?

A) 125 B) 135 C) 140 D) 180 E) Can't say

19. See the graph below. Which month showed the largest total decrease in PC sales over the previous month?



The graph to the left gives the number of computers sold each month (in thousands) by three different computer manufacturers. Manufacturer 1 (in red), Manufacturer 2 (in blue) and Manufacturer 3 (in yellow).

A) March B) April C) May D) June E) July

20. See the graph above. What percentage of Manufacturer 2's sales were made in April (to the nearest percent)?

A) 16 B) 22 C) 27 D) 33 E) 38

A6 – Second Day Multiple Choice Test – Long-term Recall

1. What happens every time the guy sees a girl?

   a) Bells ring
   b) A piano plays
   c) A saxophone plays

2. What does the guy steal to catch up with the second girl?

   a) A skateboard
   b) A motorbike
   c) A bike

3. While taking the short-cut, the guy is run over by:

   a) A white car
   b) A Taxi
   c) A bike

4. What is the weather like when the guy sees the third girl?

   a) It is raining
   b) The sun is shining
   c) It is neither raining nor is the sun shining

5. When the guy finally gets to the second girl, what happens?

   a) Her boyfriend kicks the guy
   b) Her boyfriend punches the guy in the face
   c) Her boyfriend tells him to go away

6. Why does the second girl get away?

    a) He misses the bus
    b) He misses the tram
    c) He misses the underground

7. What does the boy on the bike wear on his head?

    a) Nothing
    b) A Justin Bieber hat
    c) A hood

8. Where does he eventually find the second girl?

    a) In a Starbucks Café
    b) In a Coffeecompany Café
    c) In a random Cafè

9. While running to catch up with the second girl, what happens?

    a) He has to wait until the traffic light turns green
    b) He has to wait because there was a car in the way
    c) He does not have to wait

10. What is the third girl doing when the guy sees her?

    a) She is running
    b) She is walking with her dog
    c) She is inline skating

11. What does the guy picture in his mind, when he sees the second girl?

    a) Marrying the girl
    b) Kissing the girl
    c) Celebrating Christmas with the girl