No Evidence for Unconscious Reward Priming Effects on Performance

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Abstract

Research shows that people boost effort to obtain rewards. When determining which rewards to pursue, people analyze the expected values of these rewards. Previous research has shown that by doing these analyses frequently, it can become an automatized process where initial cues can boost performance outside of awareness, via unconscious processes. However, there have been a lot of critiques on the way that awareness has been measured in previous research. These critiques depend on fundamental methodological problems within the classic method of signal detection. In this study, we want to exclude the issue of people being aware or not by creating an experiment on trial level where people can earn a monetary reward depending on their performance. Next to the conscious (optimal) and unconscious (suboptimal) trial, we added a baseline trial where people were not exposed to a monetary reward. We focus on the response times of the 'SL/OH' suboptimal trials compared to the 'SL/OX' baseline trial, and therefore ruling out the possibility of people being aware of the monetary reward. Although we replicated previous measure methods and it made us find the classic effect of reward priming on behavior initially, when using a sufficient detection and comparing the 'SL/OH' suboptimal trials with the 'SL/OX' baseline trials there has not been found an effect of reward priming on behavior. Results indicated that priming had no effect on the response times compared to the baseline trial, meaning that a direct effect of reward primes on behavior has not been found.

Keywords: rewards, measuring awareness, primes, baseline trial, (un)consciousness

Introduction

Wanting to achieve a goal can be an initiator for people to work hard in order to obtain that certain goal (Locke & Latham, 2002). This ability to work hard does not come out of nowhere; the belief in oneself that you can achieve your goal and to take action results in motivation (Bandura & Cervone, 1986). But what exactly motivates us human beings? Rewards (Kunda & Schwartz, 1983). Rewards can take on a lot of different shapes; people will work for instance to obtain money, free time, food, weight loss, appreciation or a good grade. When determining which rewards humans should pursue, they usually analyze the expected values of these rewards. Making a decision in what reward to pursue, humans weigh the expected value of a reward against its expectancy and its demands (Feather, 1982). This decision-making process is a conscious process in which people think actively about if the reward they want to obtain is worth the effort. Current research however, has shown that the process of pursuing rewards can also occur without awareness, via an unconscious process (Pessiglione, Schmidt, Draganski, Kalisch, Lau, Dolan & Frith, 2007).

Sigmund Freud (1957) was one of the founders on theories on motivations, drives and so-called rewards. He believed that we have a natural drive and motivation, which stimulates behavior in an instinctive matter (Freud, 1957). This instinctual part of the mind responds immediately to wants and desires, according to Freud completely with absence of consciousness (Freud, 1957). From this theory on, many researchers have created theories and have done a lot of research on drives that stimulate behavior through a completely unconscious process. Within psychology, it has become a common theory and even an adopted fact that humans can make decisions and produce behavior absolutely outside awareness, through the unconscious mind (Freud, 1957; Neuberg, 1988; Chartrand, 2005; Winkielman, Berridge & Wilbarger, 2005; Pessiglione et al., 2007). This initiating factor that affects behavior unconsciously, is a ‘cue’ or ‘stimuli’ that is shown to people below a certain threshold so that it is hard to perceive, known in psychological literature as a ‘prime’ (Fazio, Sanbonmatsu, Powell & Kardes, 1986). Logically, primes that are cues to signal rewards are called reward primes (Pessiglione, et al., 2007).

There has been a lot of research on the effect of reward primes on behavior. The effect is usually measured by the level of awareness that people experience within specific performance tasks. Research has shown that people exert their effort in response to reward primes, even when they are perceived without conscious awareness (Pessiglione et al., 2007). Pessiglione et al., (2007) developed an experiment to show unconscious processes by using suboptimal stimulation. Suboptimal stimulation is referred to as a stimulus that is shown to people below a certain threshold, making it hard to perceive. In this study another condition was compared to the suboptimal one, where a stimulus was easy to perceive by showing it above a certain threshold, called the optimal condition. Pessiglione and colleagues (2007) set up an experiment were participants could either earn 10 cents or 1 cent by doing a performance task. In this experiment, the reward value was adapted in the optimal condition; making the reward value easy to perceive, and the suboptimal condition; making the reward value hard to perceive. By doing this, Pessiglione and colleagues (2007) meant to represent a conscious and an unconscious condition. The goal of this research was to see if there was a direct effect between the suboptimal trial and behavior in showing more effort in the performance task when being primed with a high reward: 10 cents. The result of this research showed that reward cues initially boost effort, regardless of whether people were in the optimal or in the suboptimal condition. Pessiglione and colleagues (2007) took this finding as proof that reward cues boosted effort when being conscious and when being unconscious of the rewards, stating that primes influence people's behavior and effort even when they are not aware of them (Pessiglione et al., 2007).

Research of Pessiglione and colleagues (2007) on the effect of reward primes was extended by Bijleveld, Custers & Aarts (2010). They performed a similar research, were they found similar results compared to the study by Pessiglione and colleagues (2007): while being conscious or unconscious of the reward cues, it enhanced effort of the participants on a performance task. In this research however, Bijleveld, Custer & Aarts (2010) additionally looked at a condition where participants had to make a speed-accuracy tradeoff in both the optimal and the suboptimal condition. This research showed that when participants were to make speed-accuracy tradeoffs, which required more cognitive effort, rewards only influenced participants in the conscious (optimal) condition (Bijleveld et al., 2010).

Furthermore, Custers & Aarts (2010) stated that goals can arise and operate unconsciously, and that conscious awareness of rewards is not particularly necessary to pursuit your goals. A few factors play a role in motivating people towards their goal; having a goal in mind and deciding whether you want to pursue it depending on the actions you have to take and what the value is of the reward you want to obtain. According to Custers & Aarts (2010) this process can happen outside of awareness, where people can unconsciously detect the reward value of a primed goal and take action to obtain it. Custers & Aarts (2010) discuss that the representation of an outcome can initiate action through an ideomotor principle, where imagining an outcome can move the body into taking action without making a conscious decision to actually act. On the other side, deciding the value of the reward can also happen unconsciously; this occurs when the previously experienced positive stimuli within one's brain, related to a previous action, is automatically signaled in the brain. This explains that behavior can be triggered and initiated by means and goals that do not need conscious thoughts to make behavior happen.

What all these studies have in common is that they plead for unconscious processes having a direct effect on behavior. They draw the conclusion from not finding a difference between the optimal and suboptimal condition, using this as proof for primes being able to influence people's behavior directly. This finding in all these studies has been adopted as an absolute fact and truth within the psychological field. It states that primes directly influence behavior, judgments and decisions just like conscious processes can. However, there have been a lot of critiques on these studies and especially on the way awareness has been measured.

Timmermans & Cleeremans (2015) have written an article that shows the entire history of how awareness has been measured and the problems that go with it. They state that even though there has been a lot of progress in the measure methods of awareness over the years, it still fails to be completely exhaustive and sensitive, which results in research relying on potentially biased reports (Timmermans & Cleeremans, 2015). Awareness is usually measured by the additional meta- *d'* within the signal detection theory (SDT) (Galvin, Podd, Drga & Whitmore, 2003). This has been used as a common measurement for awareness, but research has shown some relevant and important critiques on this measure method. For instance, Vadillo, Konstantinidis & Shanks (2016) explain how researchers have been making conclusions and reports about results in measuring awareness, that actually show a lot of wrong assumptions. They mainly focus on false negatives, which are reports that are used as evidence but is actually a support of a false null hypothesis (Fiedler, Kurtzner & Krueger, 2012). In previous research within measuring awareness, usually the absence of it has been interpreted by researchers that the null hypothesis is found to be true and cannot be rejected. Rejection of the null hypothesis led researchers to interpret failure to reject the null hypothesis as implying that the null hypothesis is true. This leads to a lot of debatable interpreted outcomes later on, like assuming that when no difference is found between the suboptimal and optimal condition, this automatically means that primes have a direct effect on behavior with complete absence of awareness (Pesiglione et al., 2007; Bijleveld et al., 2010).

Implying that the null hypothesis is true is not always the reality. When an awareness test shows a non-significant result, this can also indicate that the awareness test is inadequate to give a proper conclusion about whether participants were aware or not (Vadillo et al.,

2016). This is exactly what has been found; there are a lot of pitfalls within measuring awareness and a lot of critiques on the quality of the previous methods in measuring it.
One of them is that a lot of studies that measure awareness are actually under-powered studies (Vadillo et al., 2016). Vadillo et al., (2016) states that the researchers that want to demonstrate the absence of an effect depend on null effects, which could actually be false negatives because they are based on low-powered studies. This results from several factors, such as the number of trials that is used in an experiment. The quality of an experiment is amongst other things determined by the number of trials that is used to measure awareness. In previous research however, the number of trials to measure awareness have not been so high (Vadillo et al., 2016). It has been shown that null results are more common within experiments that include only a small number of awareness trials (Vadillo et al., 2016); the chance of finding a significant result increases when the number of trials increases as well (Vadillot et al., 2016). This could mean that if researchers would create an experiment that contains more trials, it could be possible that a significant effect on awareness would be present, meaning that people are actually aware and there is no direct priming effect on behavior.

Another important determinant on the quality of an experiment is the sample size, meaning the number of participants that participate in the experiment. It has been shown that studies that have a larger sample size are more likely to show results that are more comparable to the true effect size. Vadillo et al., (2016) made an equation that indicates that the chance of finding a significant outcome grows with the growth of the sample size. This states the same problem as the numbers of trials: if the sample size had been bigger when measuring awareness, a significant effect could have potentially been found. In order, this would mean that there might actually be awareness present when previous research states there is not, meaning that there might not be a direct effect of primes on behavior unconsciously.

Taking all of these findings together, this shows that null results in under-powered studies can give the impression that a significant effect is absent when this is actually not the case. The fact that this effect has not been an outcome yet might not be due to the fact that it is absent, but due to the fact that the way awareness has been measured is insufficient (Vadillo et al., 2016). Taking the relevant critiques on measuring awareness (Timmermans & Cleeremans, 2015; Vadillo et al., 2016) in consideration, until there has not been found real evidence, research can not go on stating that there is a direct effect of priming on behavior unconsciously.

Apart from these critiques based on methodological terms, there has been another study that states that primes do not necessarily cause a direct effect on behavior (Loersch & Payne, 2011). Loersch & Payne (2011) introduce *the situated inference model* that explains that primes rather become a source of information, which can be used to solve a problem or make a decision dependent on the current situation, than being an unconscious predictor of behavior. According to Loersch & Payne (2011), primes are seen as available additional information that can be used freely by people depending on what situation they are in. However, prime information can easily be mistaken with people's own thoughts and feelings and therefore be used more frequently, making people think they came up with this information or decision themselves. This misattribution of the prime being your own personal thought or decision can be used to answer questions and make decisions depending on what the environment offers you. In this way, Loersch & Payne (2011) criticize the *direct* effect of priming on behavior. They state that priming can occur unconsciously, but that the effect of priming could follow a conscious route where people think actively about what their options are, depending on a certain situation. Within their view, the focus of priming does not lay on an unconscious stimulus that directly influences certain behavior, but it is more seen as an information provider or judgment creator mistaken as one's own thoughts (Loersch & Payne, 2011).

Taking all of this information together, we think it is necessary to test whether reward priming has a direct effect on behavior, because based on the debatable measure methods in previous research it has failed to be proven yet. The experiment in this study will be based on the experiment by Bijleveld et al., (2010), where a monetary reward can be earned based on a performance task. In this current study we hope to exclude the issue if participants are aware or not, by measuring on trial level and adding another trial; the baseline trial. In this trial there will be no reward prime present at all. The main focus will be on the comparison of the suboptimal trials where participants indicate to have seen a low reward (*subjective low* = *'*SL*')* but were actually primed with a high reward *(objective high* = 'OH'), and the baseline trial where participants were not primed at all (*objective x* = *'*OX*'*) but indicated to have seen a low reward (*subjective low* = *'*SL*'*). By making this comparison we hope to exclude the possibility that people could potentially be aware, and we hope to find a direct effect of reward priming on behavior. In this paper we refer to the indication of what the participants saw as '*subjective'*, and what was actually primed as *'objective'.* In the baseline condition where people were not primed at all, we refer to the nonexistent presentation of the reward value as '*objective x*'.

In this study, we expect people to have a faster response time when a high reward value is at stake, in both the condition where the reward is easy to perceive (optimal condition), and in the condition where the reward value is hard to perceive (suboptimal condition). At last, we expect that people will respond faster on the 'SL/OH' suboptimal trials compared to the response times on the 'SL/OX' baseline trials.

Methods

Participants and Design

In this study, 35 participants participated (25 women, 10 men) in exchange for a monetary reward. The study conducted a 2 (reward: 1 cent vs. 10 cent) X 2 (condition: optimal vs suboptimal) within subject design, with a baseline condition where the participants were not primed at all. The monetary reward was dependent on the performance of the participants during the task (*M*= €5,03). In this experiment it was required for participants to have normal or corrected eyesight and a minimal age of 18 years and a maximal age of 40.

Material

The experiment was conducted on a Windows 10 computer with a screen diagonal of 19'' inch. The refresh rate of the computer was set on 75 Hz with a resolution of 1280 x 1024. The experiment was programmed with E-Prime 2.0 (Schneider, Eschman & Zuccolotto, 2012).

Procedure

The participants were instructed to come to the 'Langeveld' building and head to the laboratories. At the laboratories, the participants were guided to the cubicles where the experiment took place. The current experiment followed a previous task that is not related to this study and will not be discussed any further. When entering the cubicle for the experiment, participants were instructed to read the informed-consent form and sign it if they agreed to the terms and conditions. After reading and signing it, the experiment was started and the instructions about the task were shown to the participants on the monitor.

Instructions and Feedback

The first instructions welcomed the participants and explained that participants had to choose if they were right- or left handed. To indicate this, participants had to push the A-key (for left-handed people) or the L-key (for right-handed people). Choosing which key to use was essential for the use of the entire experiment. After choosing the key, participants were instructed to the task. The task was based on the 'crosstask' from Bijleveld, Custers & Aarts (2010), where participants had to change 15 shown 'o''s on the monitor into 15 'x''s as fast as possible. The instructions explained that after this task, they were asked to indicate if they saw a low reward (1 cent), or a high reward (10 cent) before doing the performance task. They could do this by pressing the 1 cent or 10 cent key on the keyboard, that was placed on the G-key (1 cent sticker) and on the H-key (10 cent sticker). The participants were informed that after indicating if they saw a low- or high reward, they would get feedback on if it actually was a low (1cent) or high (10cent) reward, and if they had earned it. After pressing the G- or the H-key, the monitor showed if it was a low or high reward by showing: ‘1 cent’ or ‘10 cent’. The feedback on whether the participants earned the 1 or 10 cents was shown in green or red: if the participants were fast enough and earned the reward, the presented 1 or 10 cents would show up on the monitor in a green font. If the participants were not fast enough and did not earn the reward, the presented 1 or 10 cents would show up on the monitor in a red font. Whether the participants earned the 1 or 10 cents was determined on the speed of their response time on the task. Based on the feedback if they earned their reward, participants were able to indicate if they had to work faster on the next trial. To prevent that participants with a fast response time would earn everything and not be challenged anymore, the experiment was set up to make the computer calculate the average response time of every single participant. The average response time of the last 10 optimal trials of the participants were calculated, to be sure that the participants worked the hardest in these conditions. This calculation was adapted to the experiment, making the response time shorter for participants that performed faster on the trials. In this way, the level of difficulty for this experiment remained the same, independent on the different performances of the participants.

Trials

On each trial, participants could see a fixation cross, followed by a mask of a duration time of 400 ms. After the first mask, the coin was shown; either a low (1 cent) or a high (10 cent) reward value, followed by a second mask that made the coin either perceivable or hard to perceive. In the optimal condition, the duration time of the second mask was 300 ms, making the coin easy to perceive. In the suboptimal condition, the duration time of the second mask was 586,7 ms, making the coin hard to perceive. The duration of the presentation of the coin in the suboptimal condition (prime) was 13,3 ms. Next, another fixation cross appeared that was followed by 15 shown ‘o’’s to change into 15 ‘x’s. After completing the task, participants received the feedback whether they earned the monetary reward or not. The current study consisted of four blocks of 50 trials; one block of 50 practice trial, two blocks of 50 suboptimal and optimal trials and one block of 50 baseline trials. At first an example was shown to the participants, where they could see and try out what it looked like to turn the ‘o’’s in to ‘x’’s. After that, a practice block followed with 50 trials. In this practice block, a combination of the optimal and suboptimal condition were present. This means that in some conditions the participants could perceive what monetary reward they could earn (optimal) and in other conditions the participants were primed with the monetary reward, making it hard to perceive what monetary reward they could earn (suboptimal). After the practice block the participants could see on the monitor how much money they earned in total. The earned money on the practice block was not included in the final monetary reward that the participants could earn. Two blocks of 50 trials followed the practice block where participants were able to earn the monetary reward depending on their performance. At last, a block of 50 trials was presented to the participants; the baseline trial. This trial contained neither an optimal nor a suboptimal condition. In these trials there was no prime presented; only the mask followed by nothing and then followed by a mask again. Participants were still instructed to indicate if they saw a high or low reward. After the participants finished all the trials, the monitor showed them how much they earned in total. They were requested to get the experimenter and that they had finished the experiment.

Detection feedback

After a few reactions of confusion from the participants regarding the feedback of the detection and whether they earned it, we decided to change the feedback instructions into a more clear and specific description. The instructions after the change were as follows:

After each row you will receive feedback on whether the reward at stake was 1 or 10 cent, and whether you were fast enough to earn this reward (green feedback) or not (red feedback). So whether you earn the reward or not is dependent on your speed and not on whether you correctly identified the coin.
After this feedback, you will also see whether your total amount has increased (green feedback) or not (red feedback).
Press the spacebar to continue.

Results

This study used the statistic analyze software program IBM SPSS Statistics 25.0 (IBM Corp, 2018) to perform a repeated-measure analysis of variance; ANOVA. Before performing any analysis, participants that had any missing data were deleted from the dataset to make the analysis as accurate and relevant as possible. The missing data took shape in participants that showed an unusual response on the detection question, for instance by always reporting a high reward or always reporting a low reward on the detection question. This resulted in missing outcomes and empty cells within the design that could not be used for further analysis in this study. In this way, the number of participants used for the analysis in this study went from $N = 35$ to $N = 27$.

To check if the manipulation of visibility had an effect on the reward detection, a paired samples *t* test was used $t(26) = 10.07$, $p < .001$, $d = 2.25$. This finding was significant, meaning that the manipulation check works and that that manipulation of visibility has an effect on the reward detection.

To check whether participants detected the correct reward above chance level within the optimal and suboptimal trials, a one sample *t* test was used to compare the accuracy on the optimal trials ($M = 93.21$, $SD = 12.62$) and the suboptimal trials ($M = 62.61$, $SD = 15.00$). The difference was significant, with a much bigger significant effect for the optimal trials $t(26) = 17.80$, $p < .001$, $d = 3.43$ than on the suboptimal trials $t(26) = 4.21$, $p < .001$, $d = 0.81$. This indicates that the participant were able to detect the rewards in both the optimal and suboptimal trials, but with a much bigger range in the optimal trials compared to the suboptimal trials.

To analyze the effects of reward and visibility, a repeated measure analysis of variance, the ANOVA was performed. This analysis found a main effect of reward value $F\ (1, 26) = 20.75$, $p = .001$, $\eta 2 = .44$, meaning that participants would respond faster when there was more at stake. On the other hand, there has not been found a main effect of visibility $F\ (1, 26) = .18$, $p = .68$, $\eta 2 = .01$ meaning that participants would not respond significantly faster on the visible trials. Furthermore, there has been found a significant effect of Reward X Visibility interaction, $F\ (1, 26) = 18.54$, $p = .001$, $\eta 2 = .42$. This interaction indicates that the reward effect was bigger in the visible condition compared to the invisible condition, shown below in Figure 1. To see how precisely this interaction unfolds, a paired samples *t* test is used that shows that within the interaction effect the optimal trials have a significant effect on reward $t(26) = 4.92$, $p < .001$, $d = 0.38$ and a significant effect of the suboptimal trials on reward $t(26) = 2.04$, $p = 0.03$, $d = 0.08$, tested one tailed. This indicates that the effect of reward is significant within the optimal and suboptimal trials, making the participants work harder on trials where they saw a high reward and where the high reward was hard to perceive.

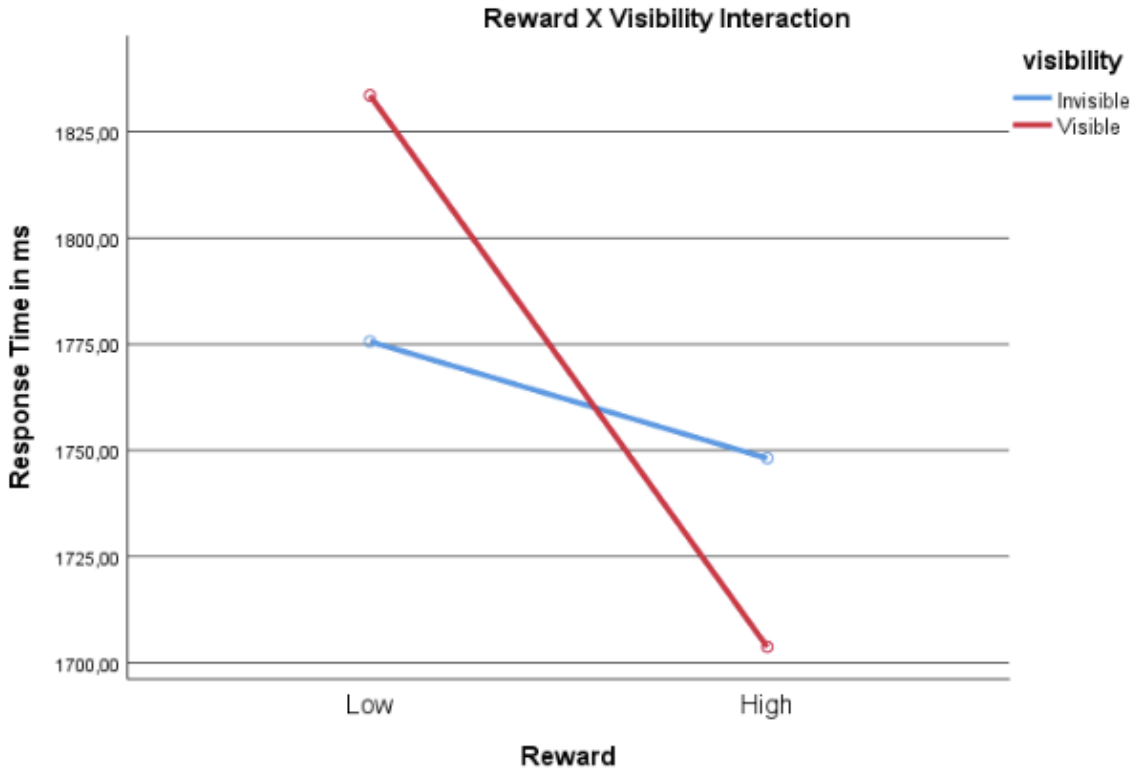

Figure 1. The Interaction Effect of Reward Value and Visibility.

To check whether there was a performance effect of the response times on the baseline condition (where no primes were presented), a paired samples *t* test was performed. Within this analysis, this study looks if response times were significantly higher when participants indicated that they saw a high reward compared to a low reward, even though there was no prime presented at all. The results show that when participants indicated that they saw a high reward, 'SH' (*subjective high*), they did not respond significantly faster than when they indicated to have seen a low reward, 'SL' (*subjective low*); $t(26) = 1.39$, $p = .089$, $d = 0.06$, tested one tailed.

To conduct our final analysis by comparing the suboptimal condition to the baseline condition, a paired samples *t* test was used. In this analysis we wanted to see whether the response times were faster in the 'SL/OH' suboptimal condition, compared to the 'SL/OX' baseline trial. First, participants showed a slower response time on the 'SH/OL' suboptimal trials (*subjective high, objective low*) (*M* = 1773.20, *SD* = 398.89), compared to the 'SH/OX' baseline trials (*subjective high, objective x)* (*M* = 1752.06, *SD* = 345.62). This difference in response time was, however, not significant *t*(26) = 1,05, *p* = .305, *d* = 0.05. This effect shows that there is no significant difference between the baseline condition and the suboptimal condition when 'SH' (*subjective high*).

In contrast with our expectations, we found that participants had a slower response time on the 'SL/OH' suboptimal trials (*M* = 1821.46, *SD* = 344.02), compared to the 'SL/OX' baseline trials (*M* = 1774.85, *SD* = 345.62). The difference in response time however was not significant *t*(26) = 1.98, *p* = .058, *d* = 0.14 and the effect even goes the opposite direction of what we expected. This indicates that, when being unconscious of the prime by reporting a low reward ('SL') even though participants were primed with a high reward ('OH'), the response time is still slower when participants report a low reward ('SL') with no prime present at all ('OX'). This means that participants work harder when there is no (high) reward prime present compared to when there actually is a high reward prime present.

Discussion

In the current research we tested whether we can find a direct effect of reward primes on behavior. Based on previous research (Bijleveld, Custers & Aarts, 2010), we set up an experiment where participants were instructed to do a performance task where they could earn a monetary reward. We compared a ‘SL/OH’ suboptimal condition (a condition where the reward would be hard to perceive due to priming) with a ‘SL/OX’ baseline condition (a condition where there was no reward presented at all). Our intention was to compare these two conditions and thereby exclude the issue if participants were aware or not, hoping to find a result that would prove the direct effect of reward primes on behavior. Our main conclusion is that initially we do find a direct effect of reward priming on behavior when using the classic measure method that has been used in previous research (Pessiglione et al., 2007; Bijleveld et al., 2010). However, when comparing the ‘SL/OH’ suboptimal trials with the ‘SL/OX’ baseline trials, an effect of reward priming on behavior has not been found.

Our findings showed that an effect was found of visibility on reward detection, meaning that the manipulation check of visibility worked. Within the optimal and suboptimal condition, our findings showed that participants were able to detect what reward was at stake in both conditions, but with a much bigger effect in the optimal condition than in the suboptimal condition.

Furthermore, our findings show a main effect of reward value, indicating that participants would respond faster when there was more at stake. However, there has not been found a main effect of visibility, which means that participants would not respond significantly faster on the optimal trials compared to the suboptimal trials. Additionally, an interaction effect of reward and visibility was found, indicating that the reward effect was bigger in the visible condition compared to the invisible condition. Participants responded faster to the high reward when the reward was in the optimal condition compared to the suboptimal condition. Both optimal and suboptimal conditions made the participants work harder on the trials when a high reward prime was present.

When looking at the baseline condition, there was no significant effect found from performance on detection, meaning that the detection in the baseline condition was not driven by self-perception (Bem, 1972). This means, that when participants indicated to have seen a high reward, they did not respond significantly faster than when they indicated to have seen a low reward. As our last analysis, we compared the response times on the ‘SL/OH’ suboptimal trials with the response times of the ‘SL/OX’ baseline trials. Our expectation was that the response time on the 'SL/OH' suboptimal condition would be significantly faster, which would mean that priming actually has a direct effect on behavior. In contrast with our expectations, results showed that there was no significant effect and that response times were slower on the suboptimal trials, regardless of whether they indicated to have seen a high ('SH') or low ('SL') reward compared to the baseline trials. These findings indicate that there is no direct effect of reward priming on behavior and that this even goes in an opposite direction than we expected; not being primed at all resulted in faster response times.

Taking all of these results together, by using the classic method, it appeared that participants in the optimal and suboptimal condition showed more effort when they were primed with a high reward compared to when they were primed with a low reward. This is in line with the previous classic effect showing a direct effect of reward priming on behavior. However, there has also been found an effect of detection; the detection is above chance level. This means that the participants in the suboptimal condition could actually detect the prime, meaning that the suboptimal condition was not 'subliminal'; the prime detection was above chance level. In previous research (Pessiglione et al., 2007; Bijleveld et al., 2010) this effect of detection has not been found, what led to the conclusion that the participants were unconscious and a direct effect of reward priming on behavior could be assured. How is it possible that the detection is above chance level in this current research, but not in previous research? Vadillo et al., (2016) pointed out some shortcomings within previous research, with a focus on the small amount of trials that had been used and detection that has been added at the end of every experiment. The low amount of trials resulted in not finding a significant effect, which was used as evidence for not detecting awareness (Vadillo et al., 2016). In this current experiment, we tackled these problems by measuring on trial level, with a high number of trials and adding a detection after every trial to make the detection as accurate as possible. By doing this, we found out that the detection was actually above chance level and that the participants in the suboptimal condition were aware of the prime being presented to them. This result could mean that participants in previous research might have been aware as well in the suboptimal condition, but the quality of the detection and measurement of awareness was too insufficient to show it.

On top of that, when looking at the last analysis, by comparing the 'SL/OH' suboptimal trials with the 'SL/OX' baseline trials, results show that there is no effect found and that participants did not respond faster on the 'SL/OH' suboptimal trials. From these findings we can conclude that priming has no direct effect on behavior. This is in contrast with our expectations; by comparing the 'SL/OH' suboptimal condition to the 'SL/OX' baseline condition we hoped to exclude the chance that participants might have seen a reward value after all, and we expected participants to work harder on the 'SL/OH' suboptimal trials. Furthermore, the results show that this research is mainly driven by trials that were actually conscious, the optimal trials, instead of the suboptimal trials that were the main focus of this research. The lack of evidence for a direct effect of priming on behavior does not mean that we can bluntly state that in previous research (Pessiglione et al., 2007; Bijleveld et al., 2010), where an effect was found, this was not true or that the participants were all actually conscious. But as mentioned before, a lot of previous research has used debatable methods; not measuring on trial level and the small amount of trials, which resulted in not finding an effect of awareness. Additionally, not finding this effect was used as evidence for 'not detecting awareness' and therefore stating that all participants were unconscious (Vadillo et al., 2016). The non-significant result they found, could have also been an indication that the awareness test was not exclusive enough to give a conclusion about whether participants were aware or not (Vadillo et al., 2016). By comparing the 'SL/OH' suboptimal condition with the 'SL/OX' baseline condition we hoped to exclude this question of being aware or not, but even by doing this a direct effect of reward priming on behavior has not been found.

Our findings show that when we use the classic method of measuring that has been done in previous research, we do find a direct effect of reward priming on behavior. However, a detection effect has been found as well, meaning that participants were aware of the primes being presented to them. When the 'SL/OH' suboptimal trials were compared with the 'SL/OX' baseline trials, where we wanted to rule out the problem of being aware or not, we did not find an effect at all. These findings raise questions about the way consciousness has been measured before and how this resulted in finding a direct effect of reward priming on behavior. It might have been possible that previous research would not have found this direct effect when using a more sufficient detection and would measure on trial level. However, we want to be careful with making any conclusions just yet. To really state that a direct effect of reward priming on behavior does not exist, it is needed to make a replication of this study with a few adjustments before any further conclusions are made.

Within this study there are a few shortcomings that could be addressed and changed for further research. First, there are shortcomings that refer to the experiment itself and how it was set up. When starting the analysis, participants with any missing data were excluded from the dataset and were not taken into any further analysis, making $N = 35$ going down to $N = 27$. Eight participants excluded from this study was quite a high number, which gave the impression that the instructions within the experiment must have not been very clear to a few participants. The participants responded in such a different and unexpected way that it seemed as if they did not understand that they had to 'guess' on the trials what reward value they saw. This resulted in participants who, regardless of what they might have seen, always reported to have seen a high reward, and even one participant that reported to have always seen a low reward. These findings made it questionable whether the instructions were clear, especially regarding the feedback instructions. As mentioned before in the methods section, the feedback instructions were changed into more specified instructions. This was due to a few participants who reported that they thought the feedback applied to whether they detected the 'right' reward value (1 cent or 10 cent), instead of whether they earned it. These findings made us change the feedback instructions within the experiment, to make it more clearly to the participants what the feedback was about. Taking into consideration that the feedback was confusing to the participants, it would be useful to replicate this study for further research with different and / or adjusted feedback instructions from the start. In this way the results would reduce noise within the experiment and participants would no longer be confused about what is being asked from them within the feedback. The feedback on the reward value being shown in colors red and green could also be confusing, because it might give an automatic feeling of reporting something correct or false. It would be an idea for further research to change these colors and add clearer instructions to make it less confusing for the participants.

Another aspect of the experiment itself, which could be changed for further research, is the use of the practice block at the beginning of the experiment. A practice block of 50 trials was introduced to the participants within the experiment, to see how the trials would look like and to try out the performance task. Before the practice block started, the instructions made clear that this was a practice block and that therefore the monetary reward that would show up at the end of the trial would not actually be a part of their earned monetary reward. As mentioned in the methods section, the average response time of the participants were measured by the computer from the last 10 optimal trials, adapting it to the level of difficulty of the experiment. This means, when response times were very fast, the computer would make the time to respond even shorter on the next trial, to remain the level of difficulty of the experiment. In this way, even participants with a very fast response time kept being challenged within the experiment. The starting point of when this calculation took place was from the practice block on, meaning that already in the practice block the average response time was taking into account. During the experiment, it was noticed that a lot of participants earned above the expected average we had in mind before the experiment. Looking at the results, it showed that in the beginning of the experiment (after the practice trials), participants earned the monetary reward more often than later on in the experiment. It seemed that participants worked less hard on the practice trials, because they were aware of the fact that they would not actually earn the monetary reward in the practice trials. The slow response times on the practice trials therefore, calculated a new response time average for the following trials, which made it easier to earn the rewards on the first trials where the monetary reward could actually be earned. This could have influenced the results, because the way that the participants performed on the practice trials influenced the performance on the first trials where money could be earned by making it easier for them. To prevent this effect from happening again in further research, it would be useful to not make use of a practice block no longer, or make the practice block stricter by setting shorter response times from the beginning on. If one would want to delete the practice block, this could be done by only making them practice on one particular trial, followed by blocks of trials where participants earn the monetary reward straight away without having a practice block first.

Besides, a useful change for any further replication of this study would be to change the performance task. By using the task in this current study, we were unable to find an effect of reward priming on behavior, but that does not mean it might be impossible to find an effect when using a different task. It might be interesting to replicate this study with a different task to see whether this might be of an influence on any results. In previous research (Bijleveld et al., 2010) an effect was found when using a mathematical task, which might imply that it is still possible to find a direct effect of reward priming on behavior when using a different task.

Furthermore, it is of importance to take a critical look at the reward detection that has been added after every trial in this current study. The detection takes shape as the questions whether participants saw a low reward value or a high reward value after each trial. Apart from the previously mentioned fact that the feedback on this question confused the participants about the goal of the task, the detection itself could also be a disturbing factor to the performance on the experiment. When asking whether participants saw a low or high reward value, it is possible that they are disturbed from the actual task, giving them time to think about something else instead of the performance task itself. It might be distracting and it could make the participants less focused to perform on the performance task. On top of that, the detection question could cause the participants to evaluate their performance and what they have seen differently than they would have without the detection question. This idea refers to the self-perception theory (Bem, 1972). This theory describes that when people do not know what their initial response or attitude is, they tend to create an idea of this, based on observing their own behavior. In this way, they draw their conclusions of the initial response or attitude from evaluating their own behavior. This could unfold in this study in the following way; by getting asked whether participants saw a low or high reward value, it makes the participants think about their behavior. They could think that they have no idea whether it was high or low, but based on their behavior they could indicate what it might have been. For instance, when a participant is asked the detection question, he or she could recall that they have no idea, but if they worked hard on the trial they could think that it must have been a high reward. In this way, the evaluation of their behavior influences their indication of detection. To check whether this might have occurred in this experiment, the self-perception theory (Bem, 1972) was taken into consideration in the analysis. It turned out that there has not been found a significant effect of performance on detection in the baseline condition, which indicates that the self-perception theory does not apply in this current research. However, we think that it is of great importance to always take this effect into consideration when using a detection question, which will be valuable to use in any further research.

Conclusion

In conclusion, it can be said that more research and replicated studies are needed to draw any further conclusions about the effect of reward primes on behavior. In this research we initially found the classic direct effect of reward priming on behavior, by using the classic method that has been used in previous research. However, an effect of detection was found as well, showing that participants in the suboptimal condition could actually detect the reward value. On top of that, when comparing the 'SL/OH' suboptimal trials with the 'SL/OX' baseline trial, there was no priming effect on behavior found at all. In this research, we found no evidence for a direct effect of priming on behavior, making it questionable if this direct effect exists after all. However, we want to be careful with making any conclusions just yet, and we are convinced that this should be studied further in the future to really draw any conclusions about the effect of reward primes on behavior. For future research it would be wise to take a few things into consideration when replicating this experiment; more specified instructions regarding the feedback, a stricter or deleted practice block, potentially a different performance task and a changed detection question. The lack of finding an effect does not mean that this study is irrelevant or shows uninteresting results. It is still of great importance that the direct unconscious effect of priming has not been found on behavior in this research, meaning that until now researchers have not succeeded to actually find the effect even when testing this on trial level. Taking all of this together, it is important to be careful with making any conclusions just yet, but further research will hopefully help to exclude any current issues related to the topic.

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Appendix A

Syntax

Calculating accuracy conscious trials

```
* Encoding: UTF-8.

Compute ACCVisible = mean(ACC2_11, ACC2_12, ACC2_13, ACC2_14, ACC2_15,
ACC2_16, ACC2_17, ACC2_18, ACC2_19, ACC2_20,

ACC3_11, ACC3_12, ACC3_13, ACC3_14, ACC3_15, ACC3_16, ACC3_17, ACC3_18,
ACC3_19, ACC3_20,

ACC4_11, ACC4_12, ACC4_13, ACC4_14, ACC4_15, ACC4_16, ACC4_17, ACC4_18,
ACC4_19, ACC4_20,

ACC2_31, ACC2_32, ACC2_33, ACC2_34, ACC2_35, ACC2_36, ACC2_37, ACC2_38,
ACC2_39, ACC2_40,

ACC3_31, ACC3_32, ACC3_33, ACC3_34, ACC3_35, ACC3_36, ACC3_37, ACC3_38,
ACC3_39, ACC3_40,

ACC4_31, ACC4_32, ACC4_33, ACC4_34, ACC4_35, ACC4_36, ACC4_37, ACC4_38,
ACC4_39, ACC4_40).
```

Calculating accuracy unconscious trials

```
Compute ACCInvisible = mean(ACC2_1, ACC2_2, ACC2_3, ACC2_4, ACC2_5, ACC2_6,
ACC2_7, ACC2_8, ACC2_9, ACC2_10,

ACC3_1, ACC3_2, ACC3_3, ACC3_4, ACC3_5, ACC3_6, ACC3_7, ACC3_8, ACC3_9,
ACC3_10,

ACC4_1, ACC4_2, ACC4_3, ACC4_4, ACC4_5, ACC4_6, ACC4_7, ACC4_8, ACC4_9,
ACC4_10,

ACC2_21, ACC2_22, ACC2_23, ACC2_24, ACC2_25, ACC2_26, ACC2_27, ACC2_28,
ACC2_29, ACC2_30,

ACC3_21, ACC3_22, ACC3_23, ACC3_24, ACC3_25, ACC3_26, ACC3_27, ACC3_28,
ACC3_29, ACC3_30,

ACC4_21, ACC4_22, ACC4_23, ACC4_24, ACC4_25, ACC4_26, ACC4_27, ACC4_28,
ACC4_29, ACC4_30).
```

execute.

1. Manipulation check

temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0 and missing(LRT)=0.

T-TEST PAIRS=ACCVisible WITH ACCInvisible (PAIRED)

/CRITERIA=CI(.9500)

/MISSING=ANALYSIS.

1.2 Average and SD accuracy

temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0 and missing(LRT)=0.

T-TEST

/TESTVAL=0.5

/MISSING=ANALYSIS

/VARIABLES=ACCVisible ACCInvisible

/CRITERIA=CI(.95).

2.0 GLM

temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0 and missing(LRT)=0.

GLM RTInvisibleLow RTVisibleLow RTInvisibleHigh RTVisibleHigh

/WSFACTOR=reward 2 Polynomial visibility 2 Polynomial

/METHOD=SSTYPE(3)

/EMMEANS=TABLES(reward*visibility) COMPARE (reward)

/CRITERIA=ALPHA(.05)

/WSDESIGN=reward visibility reward*visibility.

2.1 Interaction effect Reward X Visibility

temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0 and missing(LRT)=0.

T-TEST PAIRS=RTInvisibleLow WITH RTInvisibleHigh (PAIRED)

/CRITERIA=CI(.9500)

/MISSING=ANALYSIS.

temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0 and missing(LRT)=0.

T-TEST PAIRS=RTVisibleLow WITH RTVisibleHigh (PAIRED)

/CRITERIA=CI(.9500)

/MISSING=ANALYSIS.

Calculating average in cells Reward x Visibility

Compute RTVisibleHigh = mean(RT2_11, RT2_12, RT2_13, RT2_14, RT2_15, RT2_16, RT2_17, RT2_18, RT2_19, RT2_20,

RT3_11, RT3_12, RT3_13, RT3_14, RT3_15, RT3_16, RT3_17, RT3_18, RT3_19, RT3_20,

RT4_11, RT4_12, RT4_13, RT4_14, RT4_15, RT4_16, RT4_17, RT4_18, RT4_19, RT4_20).

Compute RTVisibleLow = mean(RT2_31, RT2_32, RT2_33, RT2_34, RT2_35, RT2_36, RT2_37, RT2_38, RT2_39, RT2_40,

RT3_31, RT3_32, RT3_33, RT3_34, RT3_35, RT3_36, RT3_37, RT3_38, RT3_39, RT3_40,

RT4_31, RT4_32, RT4_33, RT4_34, RT4_35, RT4_36, RT4_37, RT4_38, RT4_39, RT4_40)

Compute RTInvisibleHigh = mean(RT2_1, RT2_2, RT2_3, RT2_4, RT2_5, RT2_6, RT2_7, RT2_8, RT2_9, RT2_10,

RT3_1, RT3_2, RT3_3, RT3_4, RT3_5, RT3_6, RT3_7, RT3_8, RT3_9, RT3_10,

RT4_1, RT4_2, RT4_3, RT4_4, RT4_5, RT4_6, RT4_7, RT4_8, RT4_9, RT4_10).

Compute RTInvisibleLow = mean(RT2_21, RT2_22, RT2_23, RT2_24, RT2_25, RT2_26, RT2_27, RT2_28, RT2_29, RT2_30,

RT3_21, RT3_22, RT3_23, RT3_24, RT3_25, RT3_26, RT3_27, RT3_28, RT3_29, RT3_30,

RT4_21, RT4_22, RT4_23, RT4_24, RT4_25, RT4_26, RT4_27, RT4_28, RT4_29, RT4_30).

Baseline condition & detecion high reward

*No prime, conscious 10

do repeat

x = ACC2_41

ACC2_42

ACC2_43

ACC2_44

ACC2_45

ACC3_41

ACC3_42

ACC3_43

ACC3_44

ACC3_45

ACC4_41

ACC4_42

ACC4_43

ACC4_44

ACC4_45

/y = RT2_41

RT2_42

RT2_43

RT2_44

RT2_45

RT3_41

RT3_42

RT3_43

RT3_44

RT3_45

RT4_41

RT4_42

RT4_43

RT4_44

RT4_45

/z = HRT2_41

HRT2_42

HRT2_43

HRT2_44

HRT2_45

HRT3_41

HRT3_42

HRT3_43

HRT3_44

HRT3_45

HRT4_41

HRT4_42

HRT4_43

HRT4_44

HRT4_45

/w = RES2_41

RES2_42

RES2_43

RES2_44

RES2_45

RES3_41

RES3_42

RES3_43

RES3_44

RES3_45

RES4_41

RES4_42

RES4_43

RES4_44

RES4_45

.

if (x = 0) z = y.

if (x = 0) w = 1.

if (x = 1) w = 0.

end repeat print.

do repeat

x = ACC2_46

ACC2_47

ACC2_48

ACC2_49

ACC2_50

ACC3_46

ACC3_47

ACC3_48

ACC3_49

ACC3_50

ACC4_46

ACC4_47

ACC4_48

ACC4_49

ACC4_50

/y = RT2_46

RT2_47

RT2_48

RT2_49

RT2_50

RT3_46

RT3_47

RT3_48

RT3_49

RT3_50

RT4_46

RT4_47

RT4_48

RT4_49

RT4_50

/z = HRT2_46

HRT2_47

HRT2_48

HRT2_49

HRT2_50

HRT3_46

HRT3_47

HRT3_48

HRT3_49

HRT3_50

```
HRT4_46

HRT4_47

HRT4_48

HRT4_49

HRT4_50

/w = RES2_46

RES2_47

RES2_48

RES2_49

RES2_50

RES3_46

RES3_47

RES3_48

RES3_49

RES3_50

RES4_46

RES4_47

RES4_48

RES4_49

RES4_50.

if (x = 1) z = y.

if (x = 1) w = 1.

if (x = 0) w = 0.

end repeat print.
```

Baseline condition & Detection low reward
*No prime, conscious 1

do repeat

x = ACC2_41

ACC2_42

ACC2_43

ACC2_44

ACC2_45

ACC3_41

ACC3_42

ACC3_43

ACC3_44

ACC3_45

ACC4_41

ACC4_42

ACC4_43

ACC4_44

ACC4_45

/y = RT2_41

RT2_42

RT2_43

RT2_44

RT2_45

RT3_41

RT3_42

RT3_43

RT3_44

RT3_45

RT4_41

RT4_42

RT4_43

RT4_44

RT4_45

/z = LRT2_41

LRT2_42

LRT2_43

LRT2_44

LRT2_45

LRT3_41

LRT3_42

LRT3_43

LRT3_44

LRT3_45

LRT4_41

LRT4_42

LRT4_43

LRT4_44

LRT4_45

```
.
if (x = 1) z = y.
end repeat print.

do repeat
x = ACC2_46
ACC2_47
ACC2_48
ACC2_49
ACC2_50
ACC3_46
ACC3_47
ACC3_48
ACC3_49
ACC3_50
ACC4_46
ACC4_47
ACC4_48
ACC4_49
ACC4_50
/y = RT2_46
RT2_47
RT2_48
RT2_49
```

RT2_50

RT3_46

RT3_47

RT3_48

RT3_49

RT3_50

RT4_46

RT4_47

RT4_48

RT4_49

RT4_50

/z = LRT2_46

LRT2_47

LRT2_48

LRT2_49

LRT2_50

LRT3_46

LRT3_47

LRT3_48

LRT3_49

LRT3_50

LRT4_46

LRT4_47

LRT4_48

LRT4_49

LRT4_50.

if (x = 0) z = y.

end repeat print.

Average baseline condition but detection low reward

* bereken gemiddelde laag zeggen maar geen prime

compute LRT = mean (LRT2_41, LRT2_42, LRT2_43, LRT2_44, LRT2_45, LRT3_41, LRT3_42, LRT3_43, LRT3_44, LRT3_45, LRT4_41, LRT4_42, LRT4_43, LRT4_44, LRT4_45,

LRT2_46, LRT2_47, LRT2_48, LRT2_49, LRT2_50, LRT3_46, LRT3_47, LRT3_48, LRT3_49, LRT3_50, LRT4_46, LRT4_47, LRT4_48, LRT4_49, LRT4_50).

Average baseline condition but detection high reward

* bereken gemiddelde hoog zeggen maar geen prime

compute HRT = mean (HRT2_41, HRT2_42, HRT2_43, HRT2_44, HRT2_45, HRT3_41, HRT3_42, HRT3_43, HRT3_44, HRT3_45, HRT4_41, HRT4_42, HRT4_43, HRT4_44, HRT4_45,

HRT2_46, HRT2_47, HRT2_48, HRT2_49, HRT2_50, HRT3_46, HRT3_47, HRT3_48, HRT3_49, HRT3_50, HRT4_46, HRT4_47, HRT4_48, HRT4_49, HRT4_50).

compute RES = mean (RES2_41, RES2_42, RES2_43, RES2_44, RES2_45, RES3_41, RES3_42, RES3_43, RES3_44, RES3_45, RES4_41, RES4_42, RES4_43, RES4_44, RES4_45,

RES2_46, RES2_47, RES2_48, RES2_49, RES2_50, RES3_46, RES3_47, RES3_48, RES3_49, RES3_50, RES4_46, RES4_47, RES4_48, RES4_49, RES4_50).

Performance effect from the baseline condition on detection (self perception effect)

*baseline test

temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0 and missing(LRT)=0.

T-TEST PAIRS=HRT WITH LRT(PAIRED)

/CRITERIA=CI(.9500)

/MISSING=ANALYSIS.

4.

*3. baseline effect

temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0 and missing(LRT)=0.

temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0 and missing(LRT)=0.

T-TEST PAIRS=LRT WITH HRT (PAIRED)

/CRITERIA=CI(.9500)

/MISSING=ANALYSIS.

*compute baslinediff = LRT-HRT.

Suboptimal condition high reward, detection low reward

*10 prime, conscious 1

do repeat

x = ACC2_1

ACC2_2

ACC2_3

ACC2_4

ACC2_5

ACC2_6

ACC2_7

ACC2_8

ACC2_9

ACC2_10

ACC3_1

ACC3_2

ACC3_3

ACC3_4

ACC3_5

ACC3_6

ACC3_7

ACC3_8

ACC3_9

ACC3_10

ACC4_1

ACC4_2

ACC4_3

ACC4_4

ACC4_5

ACC4_6

ACC4_7

ACC4_8

ACC4_9

ACC4_10

/y = RT2_1

RT2_2

RT2_3

RT2_4

RT2_5

RT2_6

RT2_7

RT2_8

RT2_9

RT2_10

RT3_1

RT3_2

RT3_3

RT3_4

RT3_5

RT3_6

RT3_7

RT3_8

RT3_9

RT3_10

RT4_1

RT4_2

RT4_3

RT4_4

RT4_5

RT4_6

RT4_7

RT4_8

RT4_9

RT4_10

/z = LRT2_1

LRT2_2

LRT2_3

LRT2_4

LRT2_5

LRT2_6

LRT2_7

LRT2_8

LRT2_9

LRT2_10

LRT3_1

LRT3_2

LRT3_3

LRT3_4

LRT3_5

LRT3_6

LRT3_7

LRT3_8

LRT3_9

LRT3_10

LRT4_1

LRT4_2

LRT4_3

LRT4_4

LRT4_5

LRT4_6

LRT4_7

LRT4_8

LRT4_9

LRT4_10

/w = RES2_1

RES2_2

RES2_3

RES2_4

RES2_5

RES2_6

RES2_7

RES2_8

RES2_9

RES2_10

RES3_1

RES3_2

RES3_3

RES3_4

RES3_5

RES3_6

RES3_7

RES3_8

RES3_9

RES3_10

RES4_1

RES4_2

RES4_3

RES4_4

RES4_5

RES4_6

RES4_7

RES4_8

RES4_9

RES4_10

.

if (x = 0) z = y.

if (x = 1) w = 1.

if (x = 0) w = 0.

end repeat print.

Compute LRTInvisibleHigh = mean(LRT2_1, LRT2_2, LRT2_3, LRT2_4, LRT2_5, LRT2_6, LRT2_7, LRT2_8, LRT2_9, LRT2_10,

LRT3_1, LRT3_2, LRT3_3, LRT3_4, LRT3_5, LRT3_6, LRT3_7, LRT3_8, LRT3_9, LRT3_10,

LRT4_1, LRT4_2, LRT4_3, LRT4_4, LRT4_5, LRT4_6, LRT4_7, LRT4_8, LRT4_9, LRT4_10).

Suboptimal condition high reward, detection high reward
*10 prime, conscious 10

do repeat

x = ACC2_1

ACC2_2

ACC2_3

ACC2_4

ACC2_5

ACC2_6

ACC2_7

ACC2_8

ACC2_9

ACC2_10

ACC3_1

ACC3_2

ACC3_3

ACC3_4

ACC3_5

ACC3_6

ACC3_7

ACC3_8

ACC3_9

ACC3_10

ACC4_1

ACC4_2

ACC4_3

ACC4_4

ACC4_5

ACC4_6

ACC4_7

ACC4_8

ACC4_9

ACC4_10

/y = RT2_1

RT2_2

RT2_3

RT2_4

RT2_5

RT2_6

RT2_7

RT2_8

RT2_9

RT2_10

RT3_1

RT3_2

RT3_3

RT3_4

RT3_5

RT3_6

RT3_7

RT3_8

RT3_9

RT3_10

RT4_1

RT4_2

RT4_3

RT4_4

RT4_5

RT4_6

RT4_7

RT4_8

RT4_9

RT4_10

/z = HRT2_1

HRT2_2

HRT2_3

HRT2_4

HRT2_5

HRT2_6

HRT2_7

HRT2_8

HRT2_9

HRT2_10

HRT3_1

HRT3_2

HRT3_3

HRT3_4

HRT3_5

HRT3_6

HRT3_7

HRT3_8

HRT3_9

HRT3_10

HRT4_1

HRT4_2

HRT4_3

HRT4_4

HRT4_5

HRT4_6

HRT4_7

HRT4_8

HRT4_9

HRT4_10

.

if (x = 1) z = y.

end repeat print.

Compute HRTInvisibleHigh = mean(HRT2_1, HRT2_2, HRT2_3, HRT2_4, HRT2_5, HRT2_6, HRT2_7, HRT2_8, HRT2_9, HRT2_10,

HRT3_1, HRT3_2, HRT3_3, HRT3_4, HRT3_5, HRT3_6, HRT3_7, HRT3_8, HRT3_9, HRT3_10,

HRT4_1, HRT4_2, HRT4_3, HRT4_4, HRT4_5, HRT4_6, HRT4_7, HRT4_8, HRT4_9, HRT4_10).

Suboptimal condition low reward, detection high reward
*1 prime, conscious 10

do repeat

x = ACC2_21

ACC2_22

ACC2_23

ACC2_24

ACC2_25

ACC2_26

ACC2_27

ACC2_28

ACC2_29

ACC2_30

ACC3_21

ACC3_22

ACC3_23

ACC3_24

ACC3_25

ACC3_26

ACC3_27

ACC3_28

ACC3_29

ACC3_30

ACC4_21

ACC4_22

ACC4_23

ACC4_24

ACC4_25

ACC4_26

ACC4_27

ACC4_28

ACC4_29

ACC4_30

/y = RT2_21

RT2_22

RT2_23

RT2_24

RT2_25

RT2_26

RT2_27

RT2_28

RT2_29

RT2_30

RT3_21

RT3_22

RT3_23

RT3_24

RT3_25

RT3_26

RT3_27

RT3_28

RT3_29

RT3_30

RT4_21

RT4_22

RT4_23

RT4_24

RT4_25

RT4_26

RT4_27

RT4_28

RT4_29

RT4_30

/z = HRT2_21

HRT2_22

HRT2_23

HRT2_24

HRT2_25

HRT2_26

HRT2_27

HRT2_28

HRT2_29

HRT2_30

HRT3_21

HRT3_22

HRT3_23

HRT3_24

HRT3_25

HRT3_26

HRT3_27

HRT3_28

HRT3_29

HRT3_30

HRT4_21

HRT4_22

HRT4_23

HRT4_24

HRT4_25

HRT4_26

HRT4_27

HRT4_28

HRT4_29

HRT4_30

.

if (x = 0) z = y.

end repeat print.

Compute HRTInvisibleLow = mean(HRT2_21, HRT2_22, HRT2_23, HRT2_24, HRT2_25, HRT2_26, HRT2_27, HRT2_28, HRT2_29, HRT2_30,

HRT3_21, HRT3_22, HRT3_23, HRT3_24, HRT3_25, HRT3_26, HRT3_27, HRT3_28, HRT3_29, HRT3_30,

HRT4_21, HRT4_22, HRT4_23, HRT4_24, HRT4_25, HRT4_26, HRT4_27, HRT4_28, HRT4_29, HRT4_30).

Suboptimal condition low reward, detection low reward
*1 prime, conscious 1

do repeat

x = ACC2_21

ACC2_22

ACC2_23

ACC2_24

ACC2_25

ACC2_26

ACC2_27

ACC2_28

ACC2_29

ACC2_30

ACC3_21

ACC3_22

ACC3_23

ACC3_24

ACC3_25

ACC3_26

ACC3_27

ACC3_28

ACC3_29

ACC3_30

ACC4_21

ACC4_22

ACC4_23

ACC4_24

ACC4_25

ACC4_26

ACC4_27

ACC4_28

ACC4_29

ACC4_30

/y = RT2_21

RT2_22

RT2_23

RT2_24

RT2_25

RT2_26

RT2_27

RT2_28

RT2_29

RT2_30

RT3_21

RT3_22

RT3_23

RT3_24

RT3_25

RT3_26

RT3_27

RT3_28

RT3_29

RT3_30

RT4_21

RT4_22

RT4_23

RT4_24

RT4_25

RT4_26

RT4_27

RT4_28

RT4_29

RT4_30

/z = LRT2_21

LRT2_22

LRT2_23

LRT2_24

LRT2_25

LRT2_26

LRT2_27

LRT2_28

LRT2_29

LRT2_30

LRT3_21

LRT3_22

LRT3_23

LRT3_24

LRT3_25

LRT3_26

LRT3_27

LRT3_28

LRT3_29

LRT3_30

LRT4_21

LRT4_22

LRT4_23

LRT4_24

LRT4_25

LRT4_26

LRT4_27

LRT4_28

LRT4_29

LRT4_30

.

if (x = 1) z = y.

end repeat print.

Compute LRTInvisibleLow = mean(LRT2_21, LRT2_22, LRT2_23, LRT2_24, LRT2_25, LRT2_26, LRT2_27, LRT2_28, LRT2_29, LRT2_30,

LRT3_21, LRT3_22, LRT3_23, LRT3_24, LRT3_25, LRT3_26, LRT3_27, LRT3_28, LRT3_29, LRT3_30,

LRT4_21, LRT4_22, LRT4_23, LRT4_24, LRT4_25, LRT4_26, LRT4_27, LRT4_28, LRT4_29, LRT4_30).

Suboptimal condition and the baseline condition

*4. prime effecten tov baseline

```
temporary.

select if missing(HRTInvisibleLow)=0 and missing(LRTInvisibleHigh)=0 and missing(HRT)=0
and missing(LRT)=0.

  T-TEST PAIRS=HRTInvisibleLow LRTInvisibleHigh WITH HRT LRT(PAIRED)

  /CRITERIA=CI(.9500)

  /MISSING=ANALYSIS.
```

Appendix B

Thesis Proposal **Hannah van Lier**

17 dec 2019

Within psychology it has become an adopted fact that humans can make decisions and produce behavior absolutely outside awareness through the unconscious mind. This initiating factor that affects behavior is a 'cue' or 'stimuli' that is shown to people on a level so that it is not perceived with awareness, known in psychological literature as a 'prime' (Fazio, Sanbonmatsu, Powell & Kardes, 1986). Logically, primes that are cues to signal rewards are called reward primes (Pessiglione, et al., 2007).

There has been a lot of research on the effect of reward primes on behavior. The effect is usually measured by the level of awareness that people experience within a specific performance task. Research has shown that people exert their effort in response to reward primes, even when they are perceived without conscious awareness (Pessiglione et al., 2007). [after this: explanation of Pessiglione's study]. The result of this research showed that reward cues initially boost effort, regardless of whether or not people are aware of them, meaning that primes influence people's behavior and effort even when they are not aware of them (Pessiglione et al., 2007).

Pessiglione and colleagues (2007) were not the only ones who did their research on the effect of reward primes on behavior. Bijleveld, Custers & Aarts (2010) performed a similar research, were they found [......]. What all these studies have in common is that their results show an absence of difference between the conscious and unconscious conditions, meaning that reward primes influences people's behavior directly.

These studies that confirm the direct effect of priming on behavior have been adopted as an absolute fact and truth within the psychological field. It states that primes directly influence behavior, judgments and decisions just like conscious processes can. However, there has been a lot of critique on these studies and especially on the way awareness has been measured. Timmermans & Cleeremans (2015) have written an article that shows the entire history of how awareness has been measured and the problems that go with it [explanation Timmermans & Cleeremans].

..... but research has shown some relevant and important critique on this measure method. For instance, Vadillo, Konstantinidis & Shanks (2016) wrote an article that focuses on how researchers have been making conclusions and reports about results in measuring awareness, that actually show a lot of wrong assumptions. They mainly focus on false negatives, which are reports that are used as evidence but is actually a support of a false null hypothesis (Fiedler, Kurtzner & Krueger, 2012). [Explanation about the null hypothesis]. Implying that the null hypothesis is true is not always the reality. When an awareness test shows a non-significant result, this can also indicate that the awareness test is inadequate to give a proper conclusion about whether participants were aware or not (Vadillo et al., 2016). This is exactly what has been found; there are a lot of pitfalls within measuring awareness and a lot of critique on the quality of the previous methods in measuring it. [more points about Vadillo et al: underpowered studies, sample size criticism etc].

Taking all of these findings together, this shows that null results in underpowered studies can give the impression that a significant effect is absent when this is actually not the case. The fact that this effect has not been an outcome yet is not due to the fact that it is not there, but due to the fact that the way awareness has been measured lacks statistical sensitivity (Vadillo et al., 2016). Taking the extremely relevant critiques on measuring awareness (Timmermans & Cleeremans, 2015; Vadillo et al., 2016) in consideration, until there has not been found real evidence, research can not go on stating that there is a direct effect of priming on behavior unconsciously. [followed by critique of Loersch & Payne, 2011)

Research question: In this study we will test if reward primes have a direct effect on behavior / motivation, or if it does not. We will do this by letting participants do an experiment were they will have to do a reward task, similar to the tasks by Pessiglione et al. (2007) and Bijleveld et al. (2010). This time, we will have one condition added to the experiment, called the baseline condition. In this condition the participants will not be shown a reward at all (no subliminal one, no supraliminal one). We will compare the results on the baseline condition with the subliminal condition, to see if the response time on the subliminal condition (primed one) is faster than the response time on the baseline condition. By doing this we hope to find if reward primes have a direct effect on behavior or not.

I started my thesis in semester 1. Therefore, I already wrote an introduction and I am done with my data collection. This thesis proposal is used as a formality to proof that the thesis topic / work method is approved by the first and second assessor.

Time table:

The goal is to start writing my methods and results over the Christmas holidays and January so I can finish my thesis by the end of February.