HAL
open science

Once the money is in sight: Distinctive effects of conscious and unconscious rewards on task performance

Erik Bijleveld, Ruud Custers, Henk Aarts

To cite this version:

Erik Bijleveld, Ruud Custers, Henk Aarts. Once the money is in sight: Distinctive effects of conscious and unconscious rewards on task performance. Journal of Experimental Social Psychology, 2011, 10.1016/j.jesp.2011.03.002 . hal-00981134

HAL Id: hal-00981134

https://hal.science/hal-00981134v1

Submitted on 21 Apr 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Accepted Manuscript

Once the money is in sight: Distinctive effects of conscious and unconscious rewards on task performance

Erik Bijleveld, Ruud Custers, Henk Aarts

PII: S0022-1031(11)00049-7
DOI: doi: 10.1016/j.jesp.2011.03.002
Reference: YJESP 2633

To appear in: *Journal of Experimental Social Psychology*

Received date: 18 December 2010
Revised date: 27 February 2011

Please cite this article as: Bijleveld, E., Custers, R. & Aarts, H., Once the money is in sight: Distinctive effects of conscious and unconscious rewards on task performance, *Journal of Experimental Social Psychology* (2011), doi: 10.1016/j.jesp.2011.03.002

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

ACCEPTED MANUSCRIPT

Running Head: CONSCIOUS AND UNCONSCIOUS REWARDS

Once the Money is In Sight:

Distinctive Effects of Conscious and Unconscious Rewards on Task Performance

Erik Bijleveld*, Ruud Custers, and Henk Aarts

Utrecht University

ACCEPTED MANUSCRIPT

* To whom correspondence should be addressed. Postal address: Utrecht University, Department of Psychology, PO Box 80140, 3508TC Utrecht, The Netherlands. E-mail: e.h.bijleveld@uu.nl. Phone: +31 30 253 1474. Fax: +31 30 253 4718.The work in this paper was supported by grants from the Netherlands Organization for Scientific Research (VENI 451-06-014 and VICI 453-06-002).

ACCEPTED MANUSCRIPT

Abstract

Monetary rewards facilitate performance on behavioral and cognitive tasks, even when these rewards are perceived without conscious awareness. Also, recent research suggests that consciously (vs. unconsciously) perceived rewards may prompt people to more strongly concentrate on task stimuli and details. Here we propose that the latter is sometimes dysfunctional, in that it prevents improvements in task performance. We used an Attentional Blink paradigm, in which such enhanced concentration on task stimuli is detrimental to performance. Participants were consciously (supraliminally) or unconsciously (subliminally) exposed to a high-value or low-value coin that they could earn by performing well on an Attentional Blink trial. As hypothesized, high-value rewards increased performance when they were presented subliminally, while this performance benefit vanished when high-value rewards were presented consciously. We discuss this finding in the context of recent research on unconscious goal pursuit.

.

Keywords: rewards, unconscious motivation, priming, Attentional Blink, working memory performance

ACCEPTED MANUSCRIPT

ACCEPTED MANUSCRIPT

Once the Money is In Sight:

Distinctive effects of Conscious and Unconscious Rewards on Task Performance

In colloquial life, money is everywhere. Humans learn about its use and function starting at a young age (Berti & Bombi, 1988), and it is therefore not surprising that the psychological effects of money are widespread and profound (Lea & Webley, 2006). Money has been used as a powerful motivator for centuries, which makes sense: For money, humans are willing to work. Specifically, when monetary rewards are at stake, people perform better on tasks, generally increasing their chances at reward attainment. But is this always true? Following current perspectives on conscious and unconscious processes in motivation and goal pursuit, we propose that monetary rewards can impact performance unconsciously (Bargh, Gollwitzer, & Oettingen, 2010; Custers & Aarts, 2010). Furthermore, we propose that conscious awareness of these rewards can additionally prompt people to more strongly concentrate on task stimuli and details, and we investigate a situation in which such increased concentration is counterproductive. In so doing, we test the intriguing possibility that monetary reward cues only increase performance when they are processed unconsciously.

Traditionally, research on reward effects has employed explicit reward cues (or instructions) that can readily be consciously perceived. In typical experiments, participants learn that they will receive money contingent on their performance and are told—or informed by means of a visual cue—how much can be earned in an upcoming task (e.g., Eisenberger & Aselage, 2009; Glucksberg, 1962; Richter & Gendolla, 2009). Such studies suggest that monetary rewards that are at stake generally increase task concentration and engagement, but that this is not always functional as to improving performance (rewards may even be detrimental). Here, we dissociate between unconscious and conscious reward processing to enhance our understanding of when monetary reward cues leads to better performance—and when they do not.

ACCEPTED MANUSCRIPT

Remarkably, recent research shows that conscious awareness of rewards is not a necessary condition for them to increase task performance. Specifically, in an experiment (Pessiglione et al., 2007), participants were shown a coin (of high or low value) that they could earn by forcefully squeezing a handgrip. Not surprisingly, people squeezed harder when a high-value coin was at stake. Strikingly, however, people also exerted more force for high-value coins when these were presented subliminally (i.e., too briefly to be consciously perceived). Thus, bypassing conscious awareness of the reward at stake, just a slight amount of reward-cue input is sufficient to increase task performance.

This finding has been replicated for cognitive tasks. Subliminal rewards seem to increase cognitive performance to the same extent as do 'normal' (consciously perceived) rewards, as revealed by converging evidence from working memory tasks (Zedelius, Veling, & Aarts, in press; Capa, Bustin, Cleeremans, & Hansenne, in press), mathematical tasks (Bijleveld, Custers, & Aarts, 2010), and physiological measurements (Bijleveld, Custers, & Aarts, 2009). These findings indicate that monetary rewards enhance performance on various cognitive tasks, including those reliant on working memory, without awareness.

Recent work in cognitive neuroscience offers an account for these findings. Specifically, reward cues are processed in subcortical brain structures, such as the ventral striatum. While these lower-level structures presumably function independently of conscious awareness, they play a central role in assessing the rewarding value of outcomes. Importantly, these subcortical areas are known to directly connect to brain areas that are implicated in working memory and action control in goal pursuit, located in the frontal cortex (Aston-Jones, & Cohen, 2005). Whereas such higher-order processes are traditionally thought to require conscious intention and awareness to occur (Baars & Franklin, 2003; Baddeley, 1993), the interconnected nature of the subcortical reward center and frontal-cortical areas suggests the possibility that rewards can facilitate cognitive task performance directly and unconsciously.

ACCEPTED MANUSCRIPT

In line with this notion, and building on the conceptual distinction between consciousness and attention (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Koch & Tsuchiya, 2007; Lamme, 2003), Dijksterhuis and Aarts (2010) recently proposed that goals may recruit working memory and attentional control processes, but that these processes do not necessarily require conscious awareness of the goal to occur. Consistent with this suggestion, recent research shows that people can be unconsciously motivated to engage in working memory processes (Aarts, Custers, & Veltkamp, 2008; Hassin, Bargh, Engell, & McCulloch, 2009).

Although the studies alluded to above seem to indicate that rewards evoke the same response irrespective of whether they are perceived consciously, this is not always the case. Instead, several lines of research suggest that (or goals) may change the way people process incoming information and deal with task stimuli when these rewards permeate into consciousness (Baars, 2002; Bijleveld et al., 2010; Dehaene & Naccache, 2001; Dijksterhuis & Aarts, 2010; Zedelius et al., in press). That is, because consciously perceived rewards cause people to reflect on what is at stake, conscious awareness of rewards may prompt people to more strongly concentrate on task stimuli and details. Consistent with this idea, paying money according to performance induces people to focus more strongly on the task that is instrumental in attaining the money (Baumeister, 1984; Hertwig & Ortmann, 2001). Paradoxically, however, this enhanced concentration on task information may sometimes interfere with effective performance, e.g., when enhanced concentration also entails better processing of irrelevant information. In other words, while people may hold the belief that increased concentration on the task helps them to perform better, this may in fact backfire in some tasks.

Inspired by this recent literature, we propose that valuable rewards may affect performance or not as a function of whether the reward is consciously perceived. While unconsciously perceived rewards facilitate cognitive (working memory) processes, this should

ACCEPTED MANUSCRIPT

in principle enhance task performance. Nevertheless, focusing too much on task details in response to a consciously perceived valuable reward may thwart this performance enhancement. To test this idea, we used an Attentional Blink paradigm—a paradigm examining the human ability to process serially presented information—in which consciously focusing on details of the task is a dysfunctional strategy.

Rewards and the Attentional Blink. The Attentional Blink (AB) is a phenomenon that occurs when two target stimuli appear in between distracters and in close temporal proximity. While people can generally detect the first target with high accuracy (T1), they can only detect the second target (T2) fairly successfully if it follows the first either directly or after at least 500 ms (Raymond, Shapiro, & Arnell, 1992). If the second target follows the first after 200–500 ms, the AB occurs: during this interval, detection accuracy is severely diminished. The general explanation for this effect pertains to the occurrence of a two-stage process, in which an initial perceptual process is followed by a second stage in which stimuli are transferred into working memory. If both targets successfully pass through these two stages, they can be accurately reported, which is the (only) goal in the AB task. Several studies show that improved performance on the AB task is dependent on working memory functioning (Arnell, Stokes, MacLean, & Gicante, 2010). Therefore, valuable monetary rewards should in principle induce people to perform better on the AB.

While motivational aspects of the AB increasingly enjoy empirical attention (Raymond & O'Brien, 2009), recent research suggests that consciously perceived monetary rewards do not enhance AB performance (Olivers & Nieuwenhuis, 2005, for a null finding). An explanation for this comes from studies showing that focusing too much on AB stimuli is detrimental (instead of beneficial) for performance. Indeed, in the AB, concentrating on task stimuli does not selectively facilitate processing of targets but also of distracters, thereby increasing their potential for interference. For example, when participants are instructed to

ACCEPTED MANUSCRIPT

adopt a more absent-minded processing goal they paradoxically perform better—instead of worse (Olivers & Nieuwenhuis, 2006). Taken together, concentrating too much on the task—a strategy that we hypothesized is adopted only after a valuable reward is consciously perceived—thwarts the otherwise favorable reward effect on AB performance (see also Arend, Johnston, & Shapiro, 2006; Dale & Arnell, 2010).

In sum, we propose that unconsciously perceived valuable rewards facilitate working memory processes (Dijksterhuis & Aarts, 2010), and hence improve performance on the AB. When consciously perceived, however, valuable rewards likely change people's task strategy to focus too much on subsequent task stimuli, including the distracters, which undermines the effects of rewards on AB performance. The present experiment tests this idea by examining effects of consciously (supraliminally) and unconsciously (subliminally) presented high-value vs. low-value monetary rewards on the AB.

Method

Participants and Design. Fifty-three students (15 males; mean age = 20) participated. Participants learned that on each trial they would first see a coin. In line with typical AB tasks, the coin was followed by a stimulus-presentation stream. Participants could earn the coin by accurately reporting the two targets. The experiment started with 15 practice trials, followed by 128 experimental trials, 32 repetitions per lag (see below), which were crossed in a 2(reward: 1 cent versus 50 cents) × 2(presentation: subliminal versus supraliminal) design. Experimental trials were presented in two blocks of equal length.

Procedure and Trials. Figure 1 illustrates the course of a trial. Each trial started with a fixation cross (500 ms), after which participants saw a coin. Participants learned that the coin was sometimes difficult to see. Accordingly, coins were presented either supraliminally (i.e., consciously visible; 300 ms) or subliminally (20 ms). The coin was either of high (50 cents) or low (1 cent) value. It was preceded by a pre-mask and followed by a post-mask to ensure

ACCEPTED MANUSCRIPT

that participants would not be able to consciously see the coin when it was presented very briefly[1]. Irrespective of condition, the pre-mask, the coin, and the post-mask were always on screen for 1000 ms. After the post-mask, participants saw another fixation cross (1500 ms).

Next, participants saw a typical AB stream, containing 19 distractors (uppercase white letters) and two targets (white digits). Distractors and targets were randomly drawn from the alphabet or the digits 2–9, respectively. However, the letters I, O, Q, and S were left out because of their resemblance to digits; the digit 5 was left out because of its relation to the high-value coin. In rapid succession, items were presented for 50 ms each, followed by 50 ms blanks. The first digit (T1) appeared on the 10–13th temporal position. The position of T2 (i.e., the Lag factor) was 1, 2, 3, or 7 temporal positions after T1. After having seen the AB stream, participants reported the two targets in order. Next, participants received feedback: when they had correctly identified T1 and T2, they saw a coin with a plus-sign (indicating reward attainment). When they were incorrect, they saw a coin blotted out by a red cross (indicating no reward). Finally, they saw their earnings, cumulative over trials.

Results

To assess performance on the AB task, average T1 and T2 identification accuracy were submitted to an ANOVA according to the design. Trials were scored as accurate when T1 and T2 were reported in order.

Figure 2 (top panels) shows the results for T1. There was only a main effect of Lag, $F(3, 153) = 142.80$, $p < .001$, $\eta^2_p = .74$, indicating that accuracy was higher at longer lags (other F's < 1). Figure 2 (bottom panels) shows the results for T2 when T1 was identified correctly, which is the standard measure for the AB effect. There was a main effect of Lag, $F(3, 153) = 61.18$, $p < .001$, $\eta^2_p = .55$, indicating a strong AB effect (Raymond et al., 1992). Importantly, this effect was qualified by the Reward x Presentation x Lag interaction, $F(3, 153) = 2.64$, $p = .05$, $\eta^2_p = .049$. Inspection of the pattern of means suggests that the direction

ACCEPTED MANUSCRIPT

of this interaction is in line with the hypothesis that rewards mainly improve AB performance when they are presented subliminally (vs. supraliminally). To test this hypothesis, we conducted 2(Reward) x 4(Lag) analyses separately for the subliminal and supraliminal conditions.

In the subliminal condition, there was a main effect of Lag, $F(3, 153) = 39.00$, $p < .001$, $\eta^2_p = .43$. Moreover, there was a marginally significant effect of Reward, $F(1, 51) = 2.82$, $p = .10$, $\eta^2_p = .05$. Importantly, these effects were qualified by the predicted Reward × Lag interaction, $F(3, 153) = 3.83$, $p = .01$, $\eta^2_p = .07$. Consistent with our predictions, the pattern of means indicated that the drop in accuracy on lags 2 and 3—as compared to 1 and 7—was shallower when a high reward was at stake. To establish this pattern statistically, we tested whether the quadratic contrast of the Lag factor interacted with Reward, which turned out to be the case, $F(1, 51) = 9.78$, $p = .004$, $\eta^2_p = .16$. In other words, subliminal rewards improved AB performance.

In the supraliminal condition, there was a main effect of Lag, $F(3, 153) = 50.24$, $p < .001$, $\eta^2_p = .50$, indicating the presence of the AB effect. Importantly, there was no effect of Reward, $F(1, 51) < 1$, nor a Reward × Lag interaction, $F(3, 153) < 1$. Thus, in line with our predictions, supraliminal rewards did not improve AB performance.

To further substantiate the idea that subliminal but not supraliminal rewards significantly increase performance during the specific AB interval (i.e., lags 2 and 3),we conducted a separate 2(reward: 1 cent vs. 50 cents) × 2(presentation: subliminal vs. supraliminal) × 2(lag: 2 vs. 3) ANOVA. This analysis revealed the predicted Reward x Presentation interaction, $F(1, 51) = 5.38$, $p = .024$, $\eta^2_p = .10$, confirming that rewards enhanced performance during the AB interval when they were subliminally presented, $F(1, 51) = 7.23$, $p = .010$, $\eta^2_p = .12$, but not when they were supraliminally presented, $F(1, 51) < 1$.

Discussion

ACCEPTED MANUSCRIPT

The present research showed that subliminal presentation of a valuable reward improves performance on the Attentional Blink task (Raymond et al., 1992), whereas supraliminal presentation of the same valuable reward does not. The former finding indicates that unconscious rewards can increase performance on a task that relies on working memory and attention processes, thus offering support for recent models that propose that people can engage in working memory processes in the absence of awareness of the goals they pursue (Dijksterhuis & Aarts, 2010). Importantly, however, our data also suggest that this facilitating response is thwarted when people consciously reflect on the reward, likely due to a dysfunctional task strategy of concentrating too much on the task at hand (Olivers & Nieuwenhuis, 2006).

In support of this suggestion, research shows that conscious, task-related strategies paradoxically impede performance in various other domains as well, such as category learning (DeCaro, Albert, Thomas, & Beilock, in press), decision making (Dijksterhuis & Nordgren, 2006), and skilled motor performance (Lewis & Linder, 1997). Moreover, rewarding performance with money is thought to encourage exactly these strategies, as this induces people to become more concerned with doing well on the task and with complying with task instructions (Hertwig & Ortmann, 2001). The current findings thus contribute to a growing body of literature that shows that increased task focus can hurt performance, and support the specific idea that such negative performance effects are rooted in consciousness (Baumeister, Masicampo, & Vohs, 2011; Dijksterhuis & Aarts, 2010).

Previously, research on unconscious processes in the pursuit of rewards and goals has generally taken the approach of showing that unconsciously induced motivation (e.g., via priming) has the same qualities as consciously induced motivation (Bargh, 2006; Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001; Bijleveld et al., 2009; Custers & Aarts, 2005; Gollwitzer, Parks-Stamm, & Oettingen, 2008). This approach has certainly been

ACCEPTED MANUSCRIPT

informative, but has led some to suggest that the effects of unconscious manipulations (e.g., priming effects on behavior) are mediated by conscious processes, e.g., biasing of conscious perceptions (see Custers & Aarts, 2010, for a discussion). By revealing an effect that only holds for unconscious rewards, we provide compelling evidence in support of the idea that the unconscious component has a favorable effect by itself, free of any conscious intervention.

The present research suggests that consciously reflecting on a reward prompts people to use strategies that they think will increase the probability of reward attainment (Bijleveld et al., 2010). While this may sometimes support performance, the present research shows that such a money-induced task focus is not always a good thing (Beilock & Carr, 2001; Dijksterhuis & Nordgren, 2006; Olivers & Nieuwenhuis, 2006). Furthermore, as money is generally assumed to be a powerful motivator for performance (Lea & Webley, 2006), our findings offer intriguing and novel evidence indicating how money may not be desirable (cf. Deci, Koestner, & Ryan, 1999). Accordingly, by demonstrating that the reward-effect that otherwise would occur may be thwarted when people are aware of what is at stake, the present work breaks new ground in examining the role of conscious awareness in the pursuit of rewards and goals.

Footnote

[1]Subliminality of the stimuli was confirmed in a separate task. Twenty different participants were randomly presented with a set of 1 cent and 50 cents coins, masked in the same way as the 20-ms condition. Participants indicated the value of each presented coin (1c or 50c). Performance at discriminating between the coins was no better than chance, $M_{accuracy} = .516$ (SD = .113), $t(19) = .61$, $p = .55$.

ACCEPTED MANUSCRIPT

References

Aarts, H., Custers, R., & Veltkamp, M. (2008). Goal priming and the affective-motivational route to nonconscious goal pursuit. *Social Cognition*, *26*, 555-577. doi:10.1521/soco.2008.26.5.555

Arend, I., Johnston, S., & Shapiro, K. (2006). Task-irrelevant visual motion and flicker attenuate the attentional blink. *Psychonomic Bulletin and Review*, *13*, 600-607. doi: 10.3758/BF03193969

Arnell, K. M., Stokes, K. A., MacLean, M. H., & Gicante, C. (2010). Executive control processes of working memory predict attentional blink magnitude over and above storage capacity. *Psychological Research*, *74*, 1-11. doi:10.1007/s00426-008-0200-4

Baars, B. J. (2002). The conscious access hypothesis: Origins and recent evidence. *Trends in Cognitive Sciences*, *6*, 47-52. doi:10.1016/S1364-6613(00)01819-2

Bargh, J. A. (2006). What have we been priming all these years? On the development, mechanisms, and ecology of nonconscious social behavior. *European Journal of Social Psychology*, *36*, 147-168. doi:10.1002/ejsp.336

Bargh, J. A., Gollwitzer, P. M., Lee-Chai, A., Barndollar, K., & Trötschel, R. (2001). The automated will: Nonconscious activation and pursuit of behavioral goals. *Journal of Personality and Social Psychology*, *81*, 1014-1027. doi:10.1037/0022-3514.81.6.1014

Bargh, J. A., Gollwitzer, P. M., & Oettingen, G. (2010). Motivation. In S. T. Fiske, D. T. Gilbert, & G. Lindzey (Eds.), *Handbook of social psychology* (5e ed., pp. 268-316). New York: Wiley.

Baumeister, R. F. (1984). Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology*, *46*, 610-620. doi:10.1037/0022-3514.46.3.610

Baumeister, R. F., Masicampo, E. J., & Vohs, K. D. (2011). Do conscious thoughts cause

ACCEPTED MANUSCRIPT

behavior? *Annual Review of Psychology*, *62*, 331-361. doi:10.1146/annurev.psych.093008.131126

Beilock, S. L., & Carr, T. H. (2001). On the fragility of skilled performance: What governs choking under pressure? *Journal of Experimental Psychology: General*, *130*, 701-725. doi:10.1037/0096-3445.130.4.701

Berti, A. E., & Bombi, A. S. (1988). *The child's construction of economics.* (G. Duveen, Tran.). Cambridge: Cambridge University Press.

Bijleveld, E., Custers, R., & Aarts, H. (2009). The unconscious eye-opener: Pupil size reveals strategic recruitment of resources upon presentation of subliminal reward cues. *Psychological Science*, *20*, 1313-1315. doi:10.1111/j.1467-9280.2009.02443.x

Bijleveld, E., Custers, R., & Aarts, H. (2010). Unconscious reward cues increase invested effort, but do not change speed-accuracy tradeoffs. *Cognition*, *115*, 330-335. doi:10.1016/j.cognition.2009.12.012

Capa, R. L., Bustin, G. M., Cleeremans, A., & Hansenne, M. (in press). Conscious and unconscious reward cues can affect a critical component of executive control: (Un)conscious updating? *Experimental Psychology*.

Custers, R., & Aarts, H. (2005). Positive affect as implicit motivator: On the nonconscious operation of behavioral goals. *Journal of Personality and Social Psychology*, *89*, 129-142. doi:10.1037/0022-3514.89.2.129

Custers, R., & Aarts, H. (2010). The unconscious will: How the pursuit of goals operates outside of conscious awareness. *Science*, *329*, 47-50. doi:10.1126/science.1188595

Dale, G., & Arnell, K. M. (2010). Individual differences in dispositional focus of attention predict attentional blink magnitude. *Attention, Perception, & Psychophysics*, *72*, 602-606. doi:10.3758/APP.72.3.602

DeCaro, M. S., Albert, N. B., Thomas, R. D., & Beilock, S. L. (in press). Choking under

ACCEPTED MANUSCRIPT

pressure: Multiple routes to skill failure. *Journal of Experimental Psychology: General*.

Deci, E., Koestner, R., & Ryan, R. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological bulletin*, *125*, 627-668. doi:10.1037/0033-2909.125.6.627

Dehaene, S., Changeux, J., Naccache, L., Sackur, J., & Sergent, C. (2006). Conscious, preconscious, and subliminal processing: A testable taxonomy. *Trends in Cognitive Sciences*, *10*, 204-211. doi:10.1016/j.tics.2006.03.007

Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: Basic evidence and a workspace framework. *Cognition*, *79*, 1-37. doi:10.1016/S0010-0277(00)00123-2

Dijksterhuis, A., & Aarts, H. (2010). Goals, attention, and (un)consciousness. *Annual Review of Psychology*, *61*, 467-490. doi:10.1146/annurev.psych.093008.100445

Dijksterhuis, A., & Nordgren, L. F. (2006). A theory of unconscious thought. *Perspectives on Psychological Science*, *1*, 95 -109. doi:10.1111/j.1745-6916.2006.00007.x

Eisenberger, R., & Aselage, J. (2009). Incremental effects of reward on experienced performance pressure: positive outcomes for intrinsic interest and creativity. *Journal of Organizational Behavior*, *30*, 95-117. doi:10.1002/job.543

Glucksberg, S. (1962). The influence of strength of drive on functional fixedness and perceptual recognition. *Journal of Experimental Psychology*, *63*, 36-41. doi:10.1037/h0044683

Gollwitzer, P. M., Parks-Stamm, E. J., & Oettingen, G. (2008). Living on the edge: Shifting between nonconscious and conscious goal pursuit. In E. Morsella, J. A. Bargh, & P. M. Gollwitzer (Eds.), *Oxford Handbook of Human Action*. New York: Oxford University Press.

ACCEPTED MANUSCRIPT

Hassin, R. R., Bargh, J. A., Engell, A. D., & McCulloch, K. C. (2009). Implicit working memory. *Consciousness and Cognition*, *18*, 665-678. doi:10.1016/j.concog.2009.04.003

Hertwig, R., & Ortmann, A. (2001). Experimental practices in economics: A methodological challenge for psychologists? *Behavioral and Brain Sciences*, *24*, 383-403.

Koch, C., & Tsuchiya, N. (2007). Attention and consciousness: Two distinct brain processes. *Trends in Cognitive Sciences*, *11*, 16-22. doi:10.1016/j.tics.2006.10.012

Lamme, V. A. F. (2003). Why visual attention and awareness are different. *Trends in Cognitive Sciences*, *7*, 12-18. doi:10.1016/S1364-6613(02)00013-X

Lea, S. E. G., & Webley, P. (2006). Money as tool, money as drug: The biological psychology of a strong incentive. *Behavioral and Brain Sciences*, *29*, 161-209. doi:10.1017/S0140525X06009046

Lewis, B. P., & Linder, D. E. (1997). Thinking about choking? Attentional processes and paradoxical performance. *Personality and Social Psychology Bulletin*, *23*, 937 -944. doi:10.1177/0146167297239003

Olivers, C. N. L., & Nieuwenhuis, S. (2005). The beneficial effect of concurrent task-irrelevant mental activity on temporal attention. *Psychological Science*, *16*, 265-269. doi:10.1111/j.0956-7976.2005.01526.x

Olivers, C. N. L., & Nieuwenhuis, S. (2006). The beneficial effects of additional task load, positive affect, and instruction on the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *32*, 364-379. doi:10.1037/0096-1523.32.2.364

Pessiglione, M., Schmidt, L., Draganski, B., Kalisch, R., Lau, H., Dolan, R. J., & Frith, C. D. (2007). How the brain translates money into force: A neuroimaging study of subliminal motivation. *Science*, *316*, 904-906. doi:10.1126/science.1140459

ACCEPTED MANUSCRIPT

Raymond, J. E., & O'Brien, J. L. (2009). Selective visual attention and motivation. *Psychological Science*, *20*, 981 -988. doi:10.1111/j.1467-9280.2009.02391.x

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An Attentional Blink? *Journal of Experimental Psychology: Human Perception and Performance*, *18*, 849-860. doi:10.1037/0096-1523.18.3.849

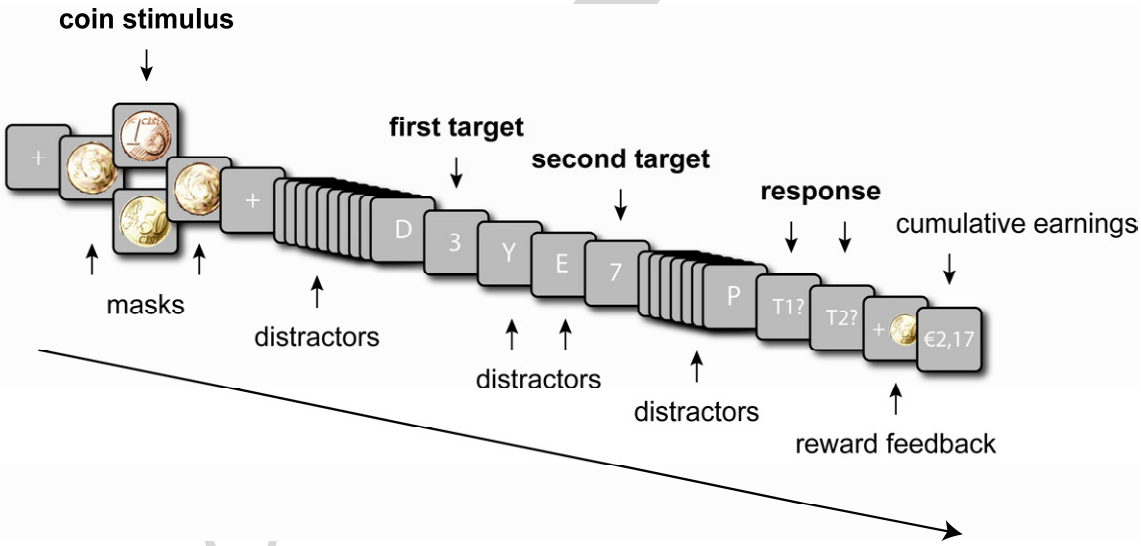
Richter, M., & Gendolla, G. H. E. (2009). The heart contracts to reward: Monetary incentives and preejection period. *Psychophysiology*, *46*, 451-457. doi:10.1111/j.1469-8986.2009.00795.x

Zedelius, C. M., Veling, H., & Aarts, H. (in press). Boosting or choking - How conscious and unconscious reward processing modulate the active maintenance of goal-relevant information. *Consciousness and Cognition.* doi: 10.1016/j.concog.2010.05.001.

ACCEPTED MANUSCRIPT

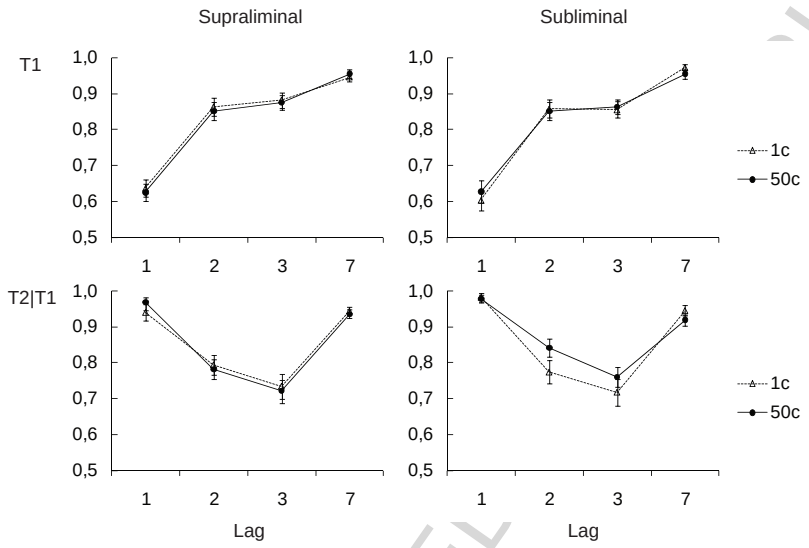
ACCEPTED MANUSCRIPT

Figure 1. The course of a trial. First, participants saw a coin of high or low value that was masked such that it could be consciously perceivable or not. Then, 21 items were displayed in fast succession (50 ms each; each followed by a 50 ms blank). Among the distracter items (letters) were two targets (digits), that participants had to report on the end of each trial. The interval between the two targets (i.e., lag) varied (1, 2, 3, or 7). When participants correctly reported the two digits, they received the coin.



ACCEPTED MANUSCRIPT

Figure 2. Performance (accuracy) as a function of reward presentation, lag, and reward value. Top panels indicate detection of the first target (T1). Bottom panels indicate detection of the second target on trials where the first was accurately detected (T2|T1).



ACCEPTED MANUSCRIPT