Chapter 4
Conscious and Unconscious Influences of Money: Two Sides of the Same Coin?

Rémi L. Capa and Ruud Custers

Abstract Although people often deliberate about the monetary consequences of their actions, money may also influence us in more subtle ways. The current chapter explores the ways in which cues related to money may influence people's behavior without their awareness. First, cues related to money may convey information about what is at stake in a certain task. In that case subliminal priming of rewards may increase the effort invested in the task. Second, priming the concept of money may—apart from the intensity of their behavior—also influence the direction of their behavior. That is, individual differences in associations with money may cause people to react to money cues in different ways. These two possibilities are discussed and reviewed against the background of the literature on nonconscious goal pursuit. Overall, the discussed empirical work shows that money cues can motivate and change behavior without much conscious awareness.

There is no doubt that money makes the world go round. Those who don't have it pursue it, and those who do have it perhaps pursue it even more. Although money does not directly satisfy our needs or desires it can be converted into almost anything that will. As such, money can be considered desirable in itself and most people will indeed happily invest effort in obtaining monetary rewards if they are sufficiently large. Hence, money is the ultimate all-purpose reward and a powerful motivator (Lea & Webley, 2006, 2014).

R.L. Capa (✉)
INSERM U1114, Department of Psychiatry, University of Strasbourg,
CHR Hôpital Civil, 1 place de l'Hôpital, 67091 Strasbourg Cedex, France
e-mail: capa@unistra.fr

R. Custers
Department of Cognitive, Perceptual and Brain Sciences, University College London,
26 Bedford Way, London WC1H 0AP, UK
e-mail: r.custers@ucl.ac.uk

E. Bijleveld and H. Aarts (eds.), *The Psychological Science of Money*,
DOI 10.1007/978-1-4939-0959-9_4,

Although the pursuit of monetary rewards can be captured in prescriptive and descriptive economic models (e.g., Von Neumann & Morgenstern, 1947), money may also influence us psychologically in more subtle ways. Cues related to money are all around us and quite often we may not even be aware of them. Research over the last decades has suggested that such subtle cues in the environment may instigate and motivate behavior (Bargh, Gollwitzer, & Oettingen, 2010). In the current chapter we will investigate the possibility that perceiving money-related cues may affect and motivate people's behavior without them being aware of it.

We will start out by briefly examining how stimuli in the environment may instigate and motivate behavior in the first place. We will then discuss two ways in which money cues can affect behavior: First we will look at literature demonstrating that cues referring to monetary rewards may modulate the effort people invest in tasks. We will examine the nature of these effects and whether unconscious reward cues affect behavior in the same way as reward cues that people are conscious of. Second, we will look at how cues that activate the *concept* of money can change not only the effort people invest, but also trigger specific behaviors that are associated with money for the individual. Finally, we will discuss how this research may help us to understand the influence of money on human behavior.

Nonconscious Goal Pursuit of Earning Money

The claim that money cues affect motivation and behavior outside people's awareness may seem strange. Most current theories of motivation and goal-directed behavior imply that mental processes that make goal pursuit, and therefore the goal of earning money, possible require consciousness (Atkinson & Raynor, 1974; Bandura, 1986; Locke & Latham, 2002; Vroom, 1964; Wright & Kirby, 2001). Recent discoveries, however, challenge this causal status of conscious will and demonstrate that under some conditions, actions are initiated even though we are unconscious of the source of our pursuits. This recent evidence that goal pursuit can be initiated outside of awareness has been met with resistance and skepticism (Gray, Gray, & Wegner, 2007), perhaps partly due to a lack of knowledge of the principles that render nonconscious goal pursuit more likely to occur.

To fill this gap, Custers and Aarts (2010) postulated that conscious and nonconscious goal pursuit may operate according to the same principles, although they may arise from difference mechanisms. That is, the probability that a given goal is set or adopted and subsequently enacted depends on the ability (a) to mentally access the representation of the goal; (b) to subjectively assess the value of the goal state; (c) to detect, assess, and reduce the discrepancy between the actual and desired state (Aarts, Custers, & Marien, 2008; Custers & Aarts, 2010). Any mechanism that could pull this off would be a mechanism that enables goal pursuit, regardless of whether it is accompanied by consciousness or not. We now will explore those principles in more detail.

Access

The very fact that we can reflect on our goals means that our goals are mentally represented. Bargh (1990) has suggested that for well-rehearsed goals, these representations are stored in memory and not only include information about the objective end state (e.g., eating a cupcake), but also information on its desirability, about how to reach it (e.g., walk to the cafeteria) and about the context in which the goal has been pursued. It is known that temporarily activating these representations makes them more accessible (e.g., easier activated and used) in the setting at hand (Higgins, 1996). Hence, cues in the environment may influence us outside our awareness by rendering a goal representation more accessible (i.e., priming), making it more likely that the representation is activated and used.

Such effects of goal priming have been documented in the literature in a large number of studies (see Bargh et al., 2010 for an overview, and see Hart & Albarracín, 2009; Lowery, Eisenberger, Hardin, & Sinclair, 2007; Shah, 2003 for studies). Bargh and colleagues, for instance, exposed people to achieve goal-related words (or control words) in a puzzle task (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001). Effects on performance were tested on a second puzzle task. It was found that people who were primed with words related to the goal of achievement behaved more in line with this goal (they performed better on the second puzzle task), and that their behavior showed properties that are indicative of motivation and pursuit, such as persistence. As participants claimed to be unaware of the influences on their goal pursuits, these findings are taken as evidence for the idea that goal pursuit was initiated, and perhaps even operated under the radar of conscious awareness. Another study of Hart and Albarracín (2009) examined the hypothesis that situational achievement cues can elicit nonconsciously achievement or fun goals depending on chronic differences in achievement motivation. Results indicated that achievement priming, compared to neutral priming, activated a goal to achieve and inhibited a goal to have fun in individuals with chronically high-achievement motivation but activated a goal to have fun and inhibited a goal to achieve in individuals with chronically low-achievement motivation, and those regardless of participants' awareness.

Crucially, these findings have also been demonstrated using subliminal cues as primes (Fitzsimons & Bargh, 2003; Custers & Aarts, 2007a), which rules out the possibility that people are aware of the primes and their influence. This may seem surprising as there is a widespread agreement that unconsciously activated representations are short-lived (Naccache, Blandin, & Dehaene, 2002). Moreover, it is thought that consciousness is required for executive control—a collection of high-level processes that enables people to adapt to new or complex situations, when highly practiced cognitive abilities or behavior no longer suffice (Baddeley, 1986; Norman & Shallice, 1986). Executive control and consciousness are, therefore, intimately related and are considered as impervious to subliminal stimuli (Dehaene & Naccache, 2001; Jack & Shallice, 2001; Jacoby, 1991; Kunde, 2003; Merikle, Joordens, & Stolz, 1995; Praamstra & Seiss, 2005). One has to bear in mind, though, that those conclusions are based on studies where primed stimuli have no meaning to the participant.

Indeed, the word "nurse" may only be activated by the prime "doctor" (Meyer & Schvaneveldt, 1971) through spreading activation for a couple of seconds because these are meaningless words. However, this may be a difference if one has the goal to contact the nurse about one's operation that is scheduled the next day (Bargh et al., 2010). As we will see, things may be different depending on the value the primed concept has for the individual.

Value

Evidence for the idea that value or positive affect associated with a behavioral end state motivates people to attain that state comes from research on conscious goal pursuit (Hockey, 1997; Kahneman, 1973) and effort mobilization (Brehm & Self, 1989). The peak of what individuals would be willing to do is determined by variables related to the importance and value of success (Brehm & Self, 1989; Wright & Gendolla, 2011; Wright & Kirby, 2001). Recently, Custers and Aarts (2010) have argued that the value of a primed goal can even be detected if the prime is presented outside of conscious awareness. They propose that apart from the cognitive information embedded in a goal representation (what the end state is and how you should attain it), the positive affect associated with that state serves as a reward signal that determines motivational properties of the resulting behavior.

In one of their experiments, Custers and Aarts (2007b) subliminally primed participants with the concept of socializing and going out (presumably a goal for most of the students who participated) in an alleged letter-detection task and measured the effort they expended in order to realize that activity. They did so by telling participants after the letter-detection task that they would engage in a mouse-click task in which they would have to click with their mouse along several paths on the screen, supposedly to study people's mouse skills. Crucially, participants were told that they might be participating in a second task in which they could win tickets for a popular student party in the city center. The reasoning behind this was that participants who were motivated to attain the goal would speed up their clicking behavior on the mouse-click task in order to be able to get a chance to win the tickets. Finally, after an extensive filler task, participants engaged in the Extrinsic Affective Simon Task (EAST; De Houwer, 2003), in which the internal reward signal of the potential goal of socializing and going out was assessed.

It was found that participants expended more effort in order to engage in socializing and going out when the goal was primed but only when the EAST-score indicated that socializing was positive. This suggests that the reward signal evoked by the representation of socializing and going out (as measured by the EAST) that was activated by priming motivated participants to work harder on the task. Importantly, this demonstrates that priming in itself does not create goals (Sherman, 1987). Priming merely activates the representation of the behavior, which increases the chance that this representation is used to guide behavior. In this case, the internal reward signal that is elicited by activated behavior representation determines whether the effort is invested in order to engage in that behavior.

Similar findings have been obtained using a paradigm in which primes related to potential goals are presented in close proximity to positive affective words (Custers & Aarts, 2005). In one study (Aarts et al., 2008), words related to exertion were repeatedly subliminally primed, immediately followed by neutral or positive words. Subsequently, participants had to squeeze a handgrip in response to a cue for 4 s. It was found that compared to a control condition, priming exertion-related words led to faster squeezing reactions to the cue. However, when the primes were presented together with positive affective words, squeezing reactions were not only faster, but also more forceful.

Capa, Cleeremans, Bustin, Bouquet, and Hansenne (2011) and Capa, Cleeremans, Bustin, and Hansenne (2011) replicated and extended these effects. Students were exposed to a priming task in which subliminal representations of the goal of studying were directly paired (priming-positive group) or not (priming group) to positive words. A control group without subliminal prime of the goal was added. Just after the priming task, students performed an easy or a difficult learning task based on their coursework. Participants in the priming-positive group performed better and had a stronger cardiovascular reactivity related to effort investment (i.e., decrease of pulse-transit time and pulse-wave amplitude) than participants of the two other groups, but only during the difficult condition. This suggests that the positive affective words presented together with the primes evoke a positive reward signal that motivates behavior in service of the primed goal.

Discrepancy

Many theories of conscious goal pursuit have argued that setting or adopting a goal creates a discrepancy between the actual state of the world and the desired state, which individuals are motivated to reduce (e.g., Dijksterhuis & Aarts, 2010; Gollwitzer & Moskowitz, 1996). However, only few studies have tested whether discrepant situations with nonconsciously activated goals encourage individuals to exploit opportunities in novel settings without awareness of operation of the goal (Aarts, Gollwitzer, & Hassin, 2004; Custers & Aarts, 2007b). For instance, Aarts et al. (2004) showed that priming the goal of earning money encouraged participants to play in a lottery that gave access to money but only when they were in need of money. Participants claimed that they were not aware of the priming effects, thus suggesting that the detection and reduction of discrepancies may occur in the absence of conscious processes. In a complementary study, Custers and Aarts (2007b) tested the goal of looking well groomed—an important and desired goal for the students. The authors subliminally primed the goal or not, just before participants were confronted with a situation that was discrepant with the goal (e.g., the shoes they put on were dirty). Next, the speed of identifying actions that are instrumental in reducing the discrepancy (e.g., polishing) was measured. Results suggested that subliminal priming of the goal of looking well-groomed triggered the representations of instrumental actions that were instrumental in reducing the discrepancy.

Conclusion

In conclusion, the pursuit of a goal requires its representation to be accessible, depends on the value of the goal, and relies on processes that facilitate discrepancy reduction. The research discussed above suggests that goal-related cues could trigger goal pursuit outside people's awareness if they render the goal accessible, evoke a positive reward signal and trigger the proper means in the context to attain the goal.

Effects of Conscious and Unconscious Processing of Money

In the light of the research discussed above, there are various ways in which money cues could trigger motivated behavior. First of all, money cues could render goals related to the concept of money (e.g., earning money) accessible, which could lead to the instigation of motivated actions that have been learned to lead to attainment of that desired state (e.g., working) in the past. However, in addition to this full-blown goal pursuit, there may be other instances where it is clear what one has to do to obtain a reward but it is just uncertain what the pay-off may be. In that case, money cues may operate as a reward signal, indicating the value of a particular activity. Below, we will first look at tasks in which money cues mainly relate to the pay-offs of particular actions and the time course of these effects. After that, we look at the effects of money cues that suggest full-blown goal pursuit in less constrained settings.

Long-Lasting Effect of Subliminal Money Cues as Reward Signals

The first demonstration that money cues can serve as reward signals and motivate the exertion of effort was provided by Pessiglione et al. (2007) who invited participants to perform a task in which they could earn money by squeezing a handgrip. Before each squeeze, the money that could be earned was subliminally or supraliminally presented by displaying the picture of a 1-pound or 1-penny coin on the screen. Regardless of whether participants could (supraliminal condition) or could not (subliminal condition) report how much money was at stake, they deployed more force for higher amounts. Congruently, skin conductance responses—used as an index of sympathetic nervous system activity—were higher to images of 1 pound compared to those of 1 penny.

This study was replicated and extended to cognitive tasks (Bijleveld, Custers, & Aarts, 2009, 2010, 2011, 2012a; Bustin, Quoidbach, Hansenne, & Capa, 2012; Capa, Bouquet, Dreher, & Dufour, 2013; Capa, Bustin, Cleeremans, & Hansenne,

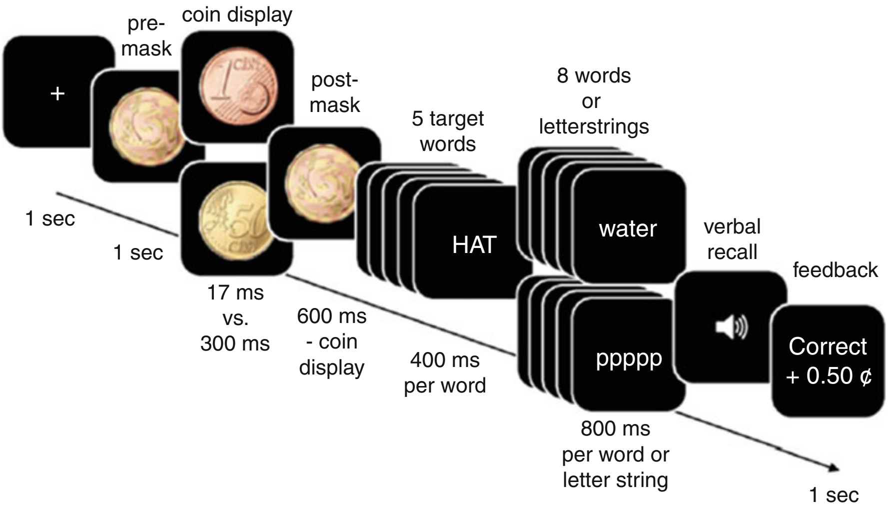

Fig. 4.1 Design of the study. Numbers represent presentation durations in milliseconds. Participants were informed of cumulative earnings at the end of each trial. Participants performed a working memory span task in which they were asked to remember correctly five words. Adapted with permission from "Boosting or choking—How conscious and unconscious reward processing modulate the active maintenance of goal-relevant information." by C.M. Zedelius, H. Veling, and H. Aarts, 2011, *Consciousness and Cognition, 20,* p. 358

2011; Zedelius, Veling, & Aarts, 2011, 2012; Zedelius, Veling, Bijleveld, & Aarts, 2012). In these studies, the delay between the prime and the response was larger than the delay used by Pessiglione et al. (2007) of 100 ms and lasted from 2 to 40 s. This allowed for testing of the long-lasting effects of unconscious processing of money. All these studies are based on the following principles (Fig. 4.1). At the beginning of each trial, a low or a high reward (e.g., 1 vs. 50 cents) was displayed, either subliminally or supraliminally. Participants could earn the reward if they found the correct response(s) on the cognitive task. Cumulative earnings were displayed at the end of each trial. Although these studies differ regarding the cognitive task used, it was commonly found that the possibility of gain presented supraliminally or subliminally, can influence effort mobilization and thus performance.

For instance, Bijleveld et al. (2009) asked participants to memorize digits and then to recall them verbally. At the beginning of each trial, a high reward (50 cents) or a low reward (1 cent) was at stake and was presented either subliminally or supraliminally. Pupil dilation, a physiological measure related to the mobilization of mental effort, was used. Participants showed an increase of pupil dilation—related to an increase of mental effort invested—on highly rewarded trials, and this held regardless of whether the rewards were presented subliminally or supraliminally. Thus, Bijleveld et al. (2009) provided the first evidence that unconscious processing of money can change mobilization of mental effort.

This result on physiological reactivity related to mental effort segues well with recent studies suggesting that unconscious processing of money can change cognitive task performance (Bijleveld et al., 2010, 2011, 2012a; Bustin et al., 2012; Capa, Bustin et al., 2011; 2013; Zedelius et al., 2011; Zedelius, Veling, & Aarts, 2012; Zedelius, Veling, Bijleveld et al., 2012). In brief, everything happens as if nonconscious processing of money involved more mental effort and perseverance to obtain better performance. Capa et al. (2013) confirmed this interpretation. Participants were instructed that, if they responded correctly to each trial of a run of 13 trials, they would receive the money displayed at the beginning of the run. Participants exhibited better performance, as shown by the percentage of correct runs, for a higher than for a lower reward displayed either subliminally or supraliminally. This better performance was probably associated with a greater mobilization of resources, as suggested by a stronger suppression of fronto-central alpha activity. Reduced alpha activity over different cortical areas, from frontal to parietal sites, has been reported during the performance of mental tasks (Gevins, Smith, Mcevoy, & Yu, 1997) and is inversely related to the amount of cortical resources allocated to task performance. Inasmuch as the mean time of run was 40.74 s, subliminal money stimuli can have an effect lasting over several seconds. Moreover, we observed no differences in performance and alpha activity between the beginning and end of each run suggesting, although zero-effects do not allow firm conclusions, that the effect of unconscious reward had not collapsed over time. In conclusion, all these studies are in agreement with the hypothesis that conscious and unconscious reward cues can trigger the investment of effort in a task to obtain the corresponding reward (Custers & Aarts, 2010; Dijksterhuis & Aarts, 2010; Wegner, 2002; Hassin, Uleman, & Bargh, 2005).

Can We Learn Based on Subliminal Stimuli to Obtain Money?

Whereas subliminal money cues may directly represent what can be earned on a particular trial, other cues could indicate monetary rewards, although we may not always be aware of them. Several authors consider that monetary reward learning does not require awareness (Dickinson & Balleine, 2002). People can build associations between a conscious monetary reward and behavior regardless of awareness (Wimmer & Shohamy, 2012). However, an open question is whether people could learn these associations if the monetary reward is displayed subliminally. Only few studies have addressed this. Seitz and Watanabe (2003), however, showed that perceptual learning can occur as a result of exposure to subliminal stimulus, without the participant having to pay attention and without relevance to the particular task in hand. Participants were repeatedly exposed to an irrelevant background motion signal so weak that its direction was not visible. The repetitive exposure improved performance for the direction of the exposed motion in a subsequent suprathreshold test, but only when the motion was associated with a reinforcement acting as a reward.

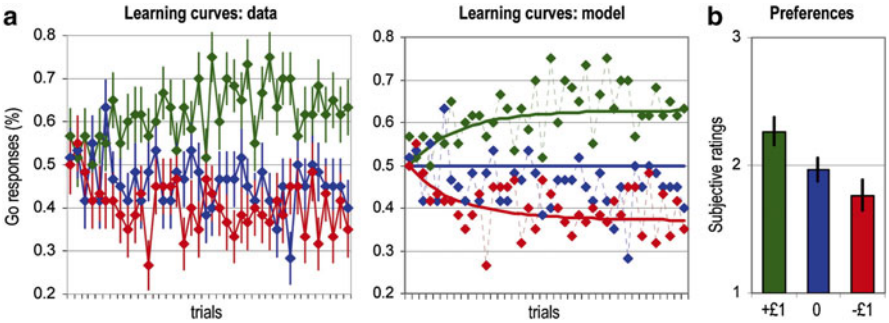

Fig. 4.2 (**a**) Colors indicate cues for which responses are rewarded (*green*), neutral (*blue*), or punished (*red*). *Diamonds* are the percentage of participants that pressed the button across trials. On the *left*, the continuous lines join the diamonds to illustrate choices made by participants. On the *right*, the continuous lines represent the probabilities of button press estimated by an optimized Q-learning algorithm (Sutton & Barto, 1998). For each cue, the model estimates the expected value of the risky response, on the basis of individual sequences of choices and outcomes. This value, called a Q value, is essentially the amount of reward expected from choosing the risky response given the contextual cue. (**b**) Subjective ratings of preferences of the cues from the most (3) to the least liked (1) evaluated at the end of the experiment. Adapted with permission from "Subliminal instrumental conditioning demonstrated in the human brain." by M. Pessiglione, P. Petrovic, J. Daunizeau, S. Palminteri, R.J. Dolan, C.D. Frith, 2008, *Neuron*, 59, p. 562

In another study, Pessiglione et al. (2008) asked participants, just after seeing a mask contextual cue flashed, to choose to press or not press a response key and subsequently observe the outcome (i.e., a cumulative earning score presented at the end of each trial). Three cues were used, one cue was rewarding (+£1), one was punishing (–£1), and the last was neutral (£0). Behavioral data showed that participants developed a propensity to choose cues associated with monetary rewards relative to punishments (Fig. 4.2a). Even without conscious processing of contextual cues, participants can learn their reward value and use them to provide a bias on decision making. Moreover, at the end of the task, cues were presented to the participants and they rated them in the order of preferences. Ratings were higher for reward compared to punishment cues, suggesting a learning of the affective values of subliminal cues and, consequently, long-lasting effects of unconscious processes (Fig. 4.2b). Functional neuroimaging showed that during conditioning cue values and prediction errors, generated from a computational model, both correlated with activity in ventral striatum.

The studies of Seitz and Watanabe (2003) and of Pessiglione et al. (2008) suggest that we can learn based on subliminal stimulus to obtain a reward or a monetary cue. Although these findings may go against some assumptions that reward learning requires awareness (Shanks, 2010), and such learning is based on striatal learning: a common neurobiological mechanism, which does not always seem to require consciousness (Pessiglione et al., 2008). More research will have to reveal the precise role of consciousness—if any—in this process.

Effects of (Un-)Conscious Processing of Money Cues on Executive Control

It is generally assumed that executive control requires consciousness and that subliminal stimuli cannot influence it (Dehaene & Naccache, 2001; Jack & Shallice, 2001; Jacoby, 1991; Kunde, 2003; Merikle et al., 1995; Praamstra & Seiss, 2005). However, a few studies have reported short-lived effects of subliminal stimuli on high-order executive control functions such as inhibitory (Boy, Husain, & Sumner, 2010; Van Gaal, Ridderinkhof, Fahrenfort, Scholte, & Lamme, 2008) and switching (Lau & Passingham, 2007) control processes. These studies have used, however, subliminal stimuli not related to motivation, such as an arrow to prime a response. Thus, little is known about the potential long-lasting effects of unconscious monetary reward on executive control. In this paragraph, we present studies challenging this perspective and show that the different functions of executive control (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000), such as updating (Bustin et al., 2012; Capa, Bustin et al., 2011) and switching (Capa et al., 2013) can be driven by unconscious monetary cues.

The task used by Capa, Bustin et al. (2011) was based on the memory updating paradigm of Salthouse, Babcock, and Shaw (1991). In this task, participants have to memorize five numbers and update those numbers independently according to a series of six successive arithmetic operations. At the beginning of each trial, the reward at stake (1 euro or 5 cents) was presented either subliminally (27 ms) or supraliminally (300 ms). If participants successfully reported the final correct series of numbers, they earned the reward. The delay between the prime and the response was of approximately 30 s. Results showed better performance when a high (conscious or unconscious) monetary reward was at stake compared to a low monetary reward. Bustin et al. (2012) replicated and extended this study as a function of personality. Dopaminergic projections from the midbrain are important for learning to predict rewarding outcomes (Schultz, 2004) and have been strongly linked to personality traits such as novelty seeking (Bódi et al., 2009). Novelty seeking can be defined as a trait involving activation or initiation of behaviors such as exploratory activity and approach to monetary rewards (Cloninger, Svrakic, & Przybeck, 1993). In addition to being hyper-responsive to reward cues, high novelty seeking individuals are characterized as impulsive and excitable, while low novelty seeking persons are stoic and rigid.

Results showed that low novelty seeking participants performed better for a high reward than a low reward displayed supraliminally or subliminally. High novelty seeking participants' performance, however, did not differ as a function of reward and presentation duration of the reward. These results suggest that reward can lead people, and more particularly individuals hyper-responsive to reward cues such as high novelty seeking participants, to concentrate too much on the task, which paradoxically impair performance (e.g., Baumeister, Masicampo, & Vohs, 2011). In both studies (Bustin et al., 2012; Capa, Bustin et al., 2011), debriefing participants before the prime visibility test revealed that none of them was able to report whether the subliminal coins were of 1 euro or 5 cents. Furthermore, the mean percentage of correct responses for the subliminal stimuli did not differ significantly from chance.

These two studies indicate that nonconscious processing of money can have a long-lasting influence on updating—a component process of executive control traditionally thought to require consciousness. These studies are in line with the hypothesis that motivation, when a conscious reward is at stake, fine-tunes executive functions required to perform the task and recalibrates the allocation of processing resources available to executive functions (Pessoa, 2009).

We tried to investigate more precisely the influence of conscious and unconscious monetary reward by recording evoked potentials and neural activity dynamics during cued task-switching performance (Capa et al., 2013). In this study, participants performed long runs of task switching (i.e., 13 trials). A change of task was required on 50 % of the trials. During each run, participants had to switch among three tasks: judging whether the number was odd or even (parity task), whether the number was smaller or greater than 5 (magnitude task), and whether the number was inside (i.e., 3, 4, and 6, 7) or outside (i.e., 1, 2 and 8, 9) the continuum of 1 to 9 (inner/outer task). The different tasks to be executed during each run were signaled by a task-cue presented 1,750 ms (cue-period). The stimulus remained on the screen until the participant responded or until 2,000 ms had elapsed (task period). At the beginning of each run, a reward (50 cents or 1 cent) was displayed, either subliminally or supraliminally. Participants earned the reward contingent upon their correct responses to each trial of the run.

We have shown that at the tonic level, a higher percentage of runs was achieved with higher (conscious and unconscious) than lower monetary rewards. This behavioral result fits well with the greater mobilization of resources, as shown by a stronger suppression of neural activity of alpha band (Gevins et al., 1997), recorded for the first to the last trial of each run. In conclusion, unconscious and conscious monetary rewards induced a general allocation of effort on the cognitive system.

At the phasic level or with short-lived processes, event-related potential (ERP) results indicated that the parietal P3 observed during cue-period (Fig. 4.3) and the fronto-central N2 observed during task execution (Fig. 4.4) were increased more in switch than in repetition trials. Several neurophysiological studies investigating ERP components in task switching have reported a larger parietal positivity in the preparation interval for switch than for repetition trials (e.g., Periáñez & Barceló, 2009). Consistent with these findings, the differential switch-related positivity we observed may reflect the preparatory updating of S-R mapping. The greater N2 indicates (Gajewski, Kleinsorge, & Falkenstein, 2010) that the amplitude of post-target N2 may be the main source of residual switch costs, defined as the switch cost persisting even when there is ample time to prepare for the upcoming task (Rogers & Monsell, 1995).

These both results indicate that manipulation of task switching is generally successful and support previous findings that the anticipatory reconfiguration of a task-set on switch trials is associated with a cognitive process distinct from that involved in task execution. Interestingly, we found that unconscious and conscious rewards influenced preparatory effort in task preparation, as suggested by a greater fronto-central contingent negative variation (CNV) starting at cue-onset (Fig. 4.3).

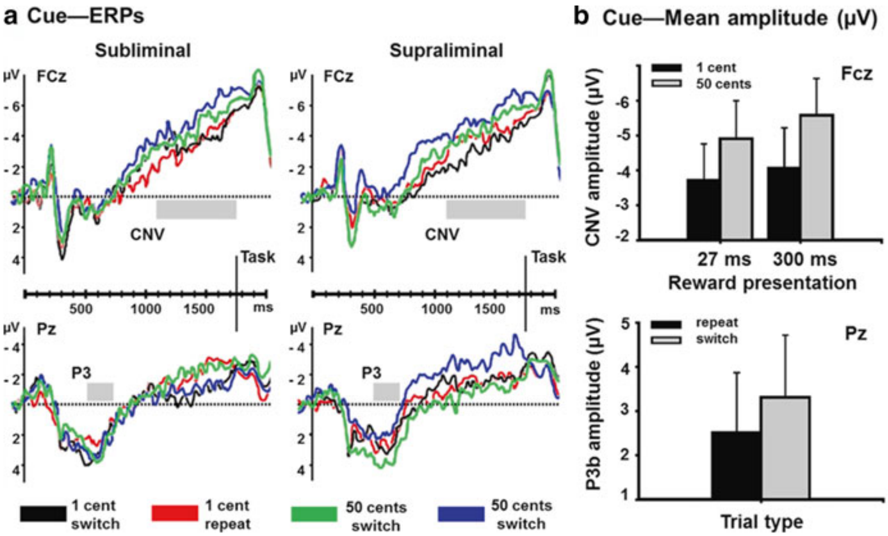

Fig. 4.3 (**a**) Epoch cue grand mean ERP waveforms as a function of experimental conditions. The *grey bars* indicate that CNV was significantly more negative at FCz when 50 cents than when 1 cent was at stake and that P3b was larger at Pz during switch than during repeat trials. The epoch task started 1,750 ms after onset of cue presentation. (**b**) Mean amplitude at the cue of the CNV at FCz and of the P3b at Pz as a function of trial type (repeat vs. switch). *Error bars* represent standard errors of the mean. Adapted with permission from "Long-lasting effects of performance-contingent unconscious and conscious reward incentives during cued task-switching." by R.L. Capa, C.A. Bouquet, J.-C. Dreher, A. Dufour, *Cortex*, 49: p. 1949–1950

However, a greater parietal P3 associated with better reaction times was observed only under conditions of conscious high reward, suggesting a larger amount of working memory invested during task performance (Fig. 4.4). These results—CNV during the cue-period, P3 and reaction times during the task period—indicate that unconscious and conscious monetary rewards have both similarities during early stages of task-switching preparation but differ during task performance. Concerning the switch cost, we found that both unconscious and conscious rewards had no specific effect on reaction times and ERP.[1]

[1] Switch cost has been attributed to time consumed by executive control processes necessary for a change of task (Rogers & Monsell, 1995) and may involve a number of subcomponents, such as retrieving the rules and procedures required for task completion into working memory, initializing stimulus–response mappings, and suppressing activation of the previously active task set. The switch cost is defined as the difference in performance between switch trials and repeat trials within the same block (Rogers & Monsell, 1995).

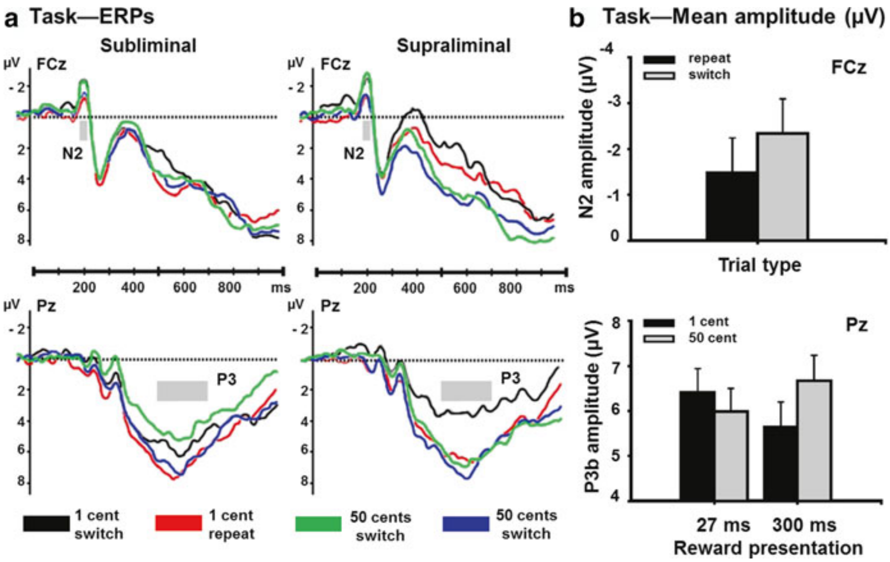

Fig. 4.4 (**a**) Epoch task grand mean ERP waveforms as a function of experimental conditions. *Grey bars* indicate that N2 was significantly larger at FCz and a significant interaction between duration of reward presentation and reward value on the amplitude of P3b at Pz. (**b**) During task performance, mean amplitudes of the N2 at FCz as a function of trial type (repeat vs. switch) and of the P3b at Pz as a function of duration of reward presentation and reward value. Error bars represent standard errors of the mean. Adapted with permission from "Long-lasting effects of performance-contingent unconscious and conscious reward incentives during cued task-switching." by R.L. Capa, C.A. Bouquet, J.-C. Dreher, A. Dufour, *Cortex*, 49: p. 1951––1952

Differences and Similarities Between Conscious and Unconscious Processing of Money

These recent studies suggest that unconscious processing of money can change cognitive task performance (Bijleveld et al., 2010, 2011, 2012a; Bustin et al., 2012; Capa, Bustin et al., 2011; 2013; Zedelius et al., 2011; Zedelius, Veling, & Aarts, 2012; Zedelius, Veling, Bijleveld et al., 2012). However, differences and similarities between conscious and unconscious processing of money emerged. For instance, in the initial study of Pessiglione et al. (2007), the same basal forebrain region was involved for both subliminal and supraliminal rewards. This implies that the cerebral structures involved in subliminal and supraliminal reward conditions were qualitatively similar. Similarly, Bijleveld et al. (2009) tested the effects of conscious and unconscious monetary reward on an easy (i.e., three digits) and a difficult (i.e., five digits) memory task. The effect of reward on pupil dilation was present in the difficult condition but not in the easy condition. These results segue well with the classical features of effort mobilization (Brehm & Self, 1989; Wright & Gendolla, 2011; Wright & Kirby, 2001): People mobilize no more energy than necessary to achieve a conscious goal when performing an easy task. However, when task difficulty is high, individuals will strive to reach the highest possible performance level that is necessary to ensure goal attainment. In short, these two studies suggest that conscious and unconscious incentive processes enhance effort mobilization in a similar way.

On the other side, differences between conscious and unconscious monetary reward also emerged (e.g., Bustin et al., 2012; Capa et al., 2013). These differences are well illustrated in the study of Bijleveld et al. (2010). Participants were invited to perform a task in which they could earn money by solving a mathematical equation in a speed-accuracy paradigm. Thus, on each trial the monetary incentive declined with time and only accurate responses were rewarded. Subliminal high rewards made participants more eager with faster but equally accurate responses. In contrast, supraliminal high rewards caused participants to become more cautious with slower but more accurate responses. The possibility to gain a conscious reward thus permitted participants to make strategic choices in the service of reward attainment.

Bijleveld, Custers, and Aarts (2012b) propose a framework for understanding human reward processing and its similar or distinctive effects on task performance. They propose that people first process rewards in rudimentary, subcortical brain structures. One of these structures in particular is the striatum—a cerebral structure which does not require consciousness (Pessiglione et al., 2008). As observed by several studies, this initial processing can facilitate task performance directly by prompting the recruitment of effort in the service of reward attainment. This initial processing of reward requires little perceptual input and is not consciously experienced. When participants are aware of the reward at stake, rewards may undergo full processing. In that case, brain structures that are engaged may involve higher-level cognitive functions located in the frontal brain, in addition to the rudimentary structures already engaged by initial reward processing, such as the anterior cingulate cortex, the dorsolateral prefrontal cortex, and the medial prefrontal cortex. These cerebral structures are related to cognitive functions such as strategy and decision making, executive control, and maintenance of reward information over time (Haber & Knutson, 2009). Thus, full reward processing may lead individuals to consciously choose a strategy.

In brief, if the quality of task performance is mainly determined by effort mobilization, then initial and full processing of money may induce the same behaviors (e.g., Bijleveld et al., 2009; Pessiglione et al., 2007). However, in circumstances of strategy and decision making, initial and full reward processing may diverge (Bijleveld et al., 2010; Bustin et al., 2012; Capa et al., 2013). Future imaging researches will have to explore whether similar or distinct cerebral structures are involved when conscious and unconscious goals of earning money are activated.

Conclusion

In this review, we showed that conscious and unconscious priming of money can have effects in various ways. First of all, money cues can signal potential reward and influence behavior in a way that is relatively long-lasting (through effort mobilization and reinforcement learning). Conscious effects of money on the executive control (e.g., updating and task-switching processes) are evident (Pessoa, 2009; Krug & Braver, 2014), and less is known about the unconscious effects of money. Results, however, reflected a general effect of unconscious monetary reward cues on task updating and switching performance.

These results seem to support the view that cues related to monetary rewards are processes at a rudimentary level, which mainly leads to the boosting of effort invested in the task. Consciously perceived cues, however, are subjected to full reward processing which allows for strategic decisions based on the reward information (Bijleveld et al., 2012b). Importantly, this theoretical distinction helps to make predictions about when consciously and nonconsciously perceived, reward cues have different effects: when performance can only be increased by just trying harder, conscious and unconscious reward cues will have the same effect. When a task allows for different strategies to be used, the effects of conscious and unconscious reward cues may diverge, with conscious reward cues either helping or hurting performance. As such, conscious and unconscious influences of money are two sides of the same coin.

It must be noted, though, that these effects are very much dependent on the experimental situation in which the participant knows that the prime represents the reward to be earned. Perceiving a coin on a table in real life from the corner of your eye may not have the same effect. However, these effects are important because they demonstrate that people *can* to a certain extent process these reward cues without awareness. This conclusion is invaluable when considering the more complex effects of social goal related to money. Whereas coins may only be motivating in a certain experimental context, people's goals are mentally represented as rewarding or desirable. Priming such goals through money cues may trigger a reward signal based on these representations, which may help to explain the motivational effects that money primes and primes related to other social goals have.

In short, when it comes to research on subtle influences on human behavior, money is on the one hand what it was intended to be: a helpful tool that substitutes real rewards. On the other hand, recent research shows that the concept of money is so intricately related to our social world that the concept itself has a place amongst the other goals we pursue in life. It is this realization that money is not just a reward that may in the end help us to understand all kinds of money-related behaviors and transgressions that are hard to explain by economic models.

References

Aarts, H., Custers, R., & Marien, H. (2008). Preparing and motivating behavior outside of awareness. *Science, 319*, 1639.

Aarts, H., Gollwitzer, P. M., & Hassin, R. R. (2004). Goal contagion: Perceiving is for pursuing. *Journal of Personality and Social Psychology, 87*, 23–37.

Atkinson, J. W., & Raynor, J. O. (1974). *Motivation and achievement*. Washington, DC: V. H. Winston.

Baddeley, A. D. (1986). *Working memory*. Oxford, England: Clarendon.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bargh, J. A. (1990). Auto-motives: Preconscious determinants of social interaction. In E. T. Higgins & R. M. Sorrentino (Eds.), *Handbook of motivation and cognition* (Vol. 2, pp. 93–130). New York: Guilford Press.

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.

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

Baumeister, R. F., Masicampo, E. J., & Vohs, K. D. (2011). Do conscious thoughts cause behavior? *Annual Review of Psychology, 62*, 331–361.

Bijleveld, E., Custers, R., & Aarts, H. (2009). The unconscious eye opener: Pupil dilation reveals strategic recruitment of resources upon presentation of subliminal reward cues. *Psychological Science, 20*, 1313–1315.

Bijleveld, E., Custers, R., & Aarts, H. (2010). Unconscious reward cues increase invested effort, but do not change speed-accuracy tradeoffs. *Cognition, 115*, 330–335.

Bijleveld, E., Custers, R., & Aarts, H. (2011). Once the money is in sight: Distinctive effects of conscious and unconscious reward on task performance. *Journal of Experimental Social Psychology, 47*, 865–869.

Bijleveld, E., Custers, R., & Aarts, H. (2012a). Adaptive reward pursuit: How effort requirements affect unconscious reward responses and conscious reward decisions. *Journal of Experimental Psychology: General, 141*, 728–742.

Bijleveld, E., Custers, R., & Aarts, H. (2012b). Human reward pursuit: From rudimentary to higher-level functions. *Current Directions in Psychological Science, 21*, 194–199.

Bódi, N., Kéri, S., Nagy, H., Moustafa, A., Myers, C. E., Daw, N., et al. (2009). Reward-learning and the novelty seeking personality: A between- and within-subjects study of the effects of dopamine agonists on young Parkinson's patients. *Brain, 132*, 2385–2395.

Boy, F., Husain, M., & Sumner, P. (2010). Unconscious inhibition separates two forms of cognitive control. *Proceedings of the National Academy of Sciences of the United States of America, 107*, 11134–11139.

Brehm, J. W., & Self, E. A. (1989). The intensity of motivation. *Annual Review of Psychology, 40*, 109–131.

Bustin, G. M., Quoidbach, J., Hansenne, M., & Capa, R. L. (2012). Personality modulation of (un) conscious processing: Novelty seeking and performance following supraliminal and subliminal reward cues. *Consciousness and Cognition, 21*, 947–952.

Capa, R. L., Bouquet, C. A., Dreher, J.-C., & Dufour, A. (2013). Long-lasting effects of performance-contingent unconscious and conscious reward incentives during cued task-switching. *Cortex, 49*, 1943–1954.

Capa, R. L., Bustin, G. M., Cleeremans, A., & Hansenne, M. (2011). Conscious and unconscious reward cues can affect a critical component of executive control: (Un)conscious updating? *Experimental Psychology, 58*, 370–375.

Capa, R. L., Cleeremans, A., Bustin, G. M., Bouquet, C. A., & Hansenne, M. (2011). Effects of subliminal priming on nonconscious goal pursuit and effort-related cardiovascular response. *Social Cognition, 29*, 430–444.

Capa, R. L., Cleeremans, A., Bustin, G. M., & Hansenne, M. (2011). Long-lasting effect of subliminal processes on effort-related cardiovascular and performance. *International Journal of Psychophysiology, 81*, 22–30

Cloninger, C. R., Svrakic, D. M., & Przybeck, T. R. (1993). A psychobiological model of temperament and character. *Archives of General Psychiatry, 50*, 975–990.

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.

Custers, R., & Aarts, H. (2007a). In search of the nonconscious sources of goal pursuit: Accessibility and positive affective valence of the goal state. *Journal of Experimental Social Psychology, 43*, 312–318.

Custers, R., & Aarts, H. (2007b). Goal-discrepant situations prime goal-directed actions if goals are temporarily or chronically accessible. *Personality and Social Psychology Bulletin, 33*, 623–633.

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

De Houwer, J. (2003). The extrinsic affective Simon task. *Experimental Psychology, 50*, 77–85.

Dehaene, S., & Naccache, L. (2001). Towards a cognitive neuroscience of consciousness: Basic evidence and a workspace framework. *Cognition, 79*, 1–37.

Dickinson, A., & Balleine, B. (2002). The role of learning in the operation of motivational systems. In C. R. Gallistel (Ed.), *Stevens' handbook of experimental psychology: Learning, motivation, and emotion* (Vol. 3, pp. 497–534). New York: Wiley.

Dijksterhuis, A., & Aarts, H. (2010). Goals, attention, and (un)consciousness. *Annual Review of Psychology, 61*, 467–490.

Fitzsimons, G. M., & Bargh, J. A. (2003). Thinking of you: Nonconscious pursuit of interpersonal goals associated with relationship partners. *Journal of Personality and Social Psychology, 84*, 148–163.

Gajewski, P. D., Kleinsorge, T., & Falkenstein, M. (2010). Electrophysiological correlates of residual switch costs. *Cortex, 46*, 1138–1148.

Gevins, A., Smith, M. E., Mcevoy, L., & Yu, D. (1997). High-resolution EEG mapping of cortical activation related to working memory: Effects of task difficulty, type of processing, and practice. *Cerebral Cortex, 7*, 374–385.

Gollwitzer, P. M., & Moskowitz, G. B. (1996). Goal effects on action and cognition. In E. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 361–399). New York: Guilford Press.

Gray, H. M., Gray, K., & Wegner, D. M. (2007). Dimensions of mind perception. *Science, 315*, 619.

Haber, S. N., & Knutson, B. (2009). The reward circuit: Linking primate anatomy and human imaging. *Neuropsychopharmacology, 35*, 4–26.

Hart, W., & Albarracín, D. (2009). The effects of chronic achievement motivation and achievement primes on the activation of achievement and fun goals. *Journal of Personality and Social Psychology, 97*, 1129–1141.

Hassin, R. R., Uleman, J. S., & Bargh, J. A. (2005). *The new unconscious*. New York: Oxford University Press.

Higgins, E. T. (1996). Knowledge activation: Accessibility, applicability, and salience. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 133–168). New York: Guilford Press.

Hockey, G. R. J. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive-energetical framework. *Biological Psychology, 45*, 73–93.

Jack, A. I., & Shallice, T. (2001). Introspective physicalism as an approach to the science of consciousness. *Cognition, 79*, 161–196.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30*, 513–541.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.

Krug, M. K., & Braver, T. S. (2014). Motivation and cognitive control: Going beyond monetary incentives. In E. Bijleveld & H. Aarts (Eds.), *The psychological science of money*. New York: Springer.

Kunde, W. (2003). Sequential modulations of stimulus-response correspondence effects depend on awareness of response conflict. *Psychonomic Bulletin and Review, 10*, 198–205.

Lau, H. C., & Passingham, R. E. (2007). Unconscious activation of the cognitive control system in the human prefrontal cortex. *The Journal of Neuroscience, 23*, 5805–5811.

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.

Lea, S. E. G., & Webley, P. (2014). Money: Metaphors and motives. In E. Bijleveld & H. Aarts (Eds.), *The psychological science of money*. New York: Springer.

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist, 57*, 705–717.

Lowery, B. S., Eisenberger, N. I., Hardin, C. D., & Sinclair, S. (2007). Long-term effects of subliminal priming on academic performance. *Basic and Applied Social Psychology, 29*, 151–157.

Merikle, P. M., Joordens, S., & Stolz, J. A. (1995). Measuring the relative magnitude of unconscious influences. *Consciousness and Cognition, 4*, 422–439.

Meyer, D. E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90*, 227–234.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., & Howerter, A. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*, 49–100.

Naccache, L., Blandin, E., & Dehaene, S. (2002). Unconscious masked priming depends on temporal attention. *Psychological Science, 13*, 416–424.

Norman, D., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In R. Davidson, G. Schwartz, & D. Shapiro (Eds.), *Consciousness and self-regulation: Advances in research and theory* (Vol. 4, pp. 1–18). New York: Plenum Press.

Periáñez, J. A., & Barceló, F. (2009). Updating sensory versus task representations during task-switching: Insights from cognitive brain potentials in humans. *Neuropsychologia, 47*, 1160–1172.

Pessiglione, M., Petrovic, P., Daunizeau, J., Palminteri, S., Dolan, R. J., & Frith, C. D. (2008). Subliminal instrumental conditioning demonstrated in the human brain. *Neuron, 59*, 561–567.

Pessiglione, M., Schmidt, L., Draganski, B., Kalisch, R., Lau, H., Dolan, R. J., et al. (2007). How the brain translates money into force: A neuroimaging study of subliminal motivation. *Science, 316*, 904–906.

Pessoa, L. (2009). How do emotion and motivation direct executive control? *Trends in Cognitive Sciences, 13*, 160–166.

Praamstra, P., & Seiss, E. (2005). The neurophysiology of response competition: Motor cortex activation and inhibition following subliminal response priming. *Journal of Cognitive Neuroscience, 17*, 483–493.

Rogers, R. D., & Monsell, S. (1995). The costs of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General, 124*, 207–231.

Salthouse, T. A., Babcock, R. L., & Shaw, R. J. (1991). Effects of adult age on structural and operational capacities in working memory. *Psychology and Aging, 6*, 118–127.

Schultz, W. (2004). Behavioural theories and the neurophysiology of reward. *Annual Review of Psychology, 57*, 87–115.

Seitz, A. R., & Watanabe, T. (2003). Is subliminal learning really passive? *Nature, 422*, 36.

Shah, J. (2003). The motivational looking glass: How significant others implicitly affect goal appraisals. *Journal of Personality and Social Psychology, 85*, 424–439.

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

Sherman, S. (1987). Cognitive processes in the formation, change, and expression of attitudes. In M. P. Zanna, J. M. Olson, & C. P. Herman (Eds.), *Social influence: The Ontario symposium* (Vol. 5, pp. 75–106). Hillsdale, NJ: Lawrence Erlbaum.

Sutton, R. S., & Barto, A. G. (1998). *Reinforcement learning: An introduction*. Cambridge, MA: MIT Press.

Van Gaal, S., Ridderinkhof, R., Fahrenfort, J. J., Scholte, H. S., & Lamme, V. A. F. (2008). Frontal cortex mediates unconsciously triggered inhibitory control. *The Journal of Neuroscience, 28*, 8053–8062.

Von Neumann, J., & Morgenstern, O. (1947). *Theory of games and economic behavior*. Princeton, NJ: Princeton University Press.

Vroom, V. H. (1964). *Work and motivation*. New York: Wiley.

Wegner, D. M. (2002). *The illusion of conscious will*. Cambridge, MA: MIT Press.

Wimmer, G. E., & Shohamy, D. (2012). Preference by association: How memory mechanisms in the hippocampus bias decisions. *Science, 338*, 270–273.

Wright, R. A., & Gendolla, G. H. E. (2011). *How motivation affects cardiovascular response: Mechanisms and applications*. Washington, DC: APA Press.

Wright, R. A., & Kirby, L. D. (2001). Effort determination of cardiovascular response: An integrative analysis with applications in social psychology. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 33, pp. 255–307). New York: Academic Press.

Zedelius, C. M., Veling, H., & Aarts, H. (2011). Boosting or choking—How conscious and unconscious reward processing modulate the active maintenance of goal-relevant information. *Consciousness and Cognition, 20*, 355–362.

Zedelius, C. M., Veling, H., & Aarts, H. (2012). When unconscious rewards boost cognitive task performance inefficiently: The role of consciousness in integrating value and attainability information. *Frontiers in Human Neuroscience, 6*, 219. doi:10.3389/fnhum.

Zedelius, C. M., Veling, H., Bijleveld, E., & Aarts, H. (2012). Promising high monetary rewards for future task performance increases intermediate task performance. *PLoS One, 7*, e42547. doi:10.1371/journal.pone.0042547.