Bachelor thesis

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When we feel that we are doing things: The pupil of the eye as a window to experiences of self-agency

Abstract

Previous research shows that people experience more self-agency when an outcome is in line with their goal, or with a subtly presented cue. The present study combined those findings by focusing on the effect of such subtle environmental cues on the experience of self-agency in goal-directed behavior. Participants had the goal to produce a certain color in a computer task containing no primes, goal-consistent primes and goal-inconsistent primes. They indicated whether they felt they were the cause of the outcome color or the computer was. Pupil dilation was used as a measurement of arousal resulting from inconsistencies between goals and primes, and primes and outcomes. Results showed people felt more self-agency when the outcome matched their goal; additional effects of primes were not found. Pupil dilation results did not indicate increased arousal of the sympathetic nervous system as a response to inconsistencies of goals and primes, or primes and outcomes.

Introduction

Human beings possess the unique trait to be aware of their authorship for events caused by themselves. This trait makes us self-aware of our action's effect on the environment. When an action is performed and an effect in line with the action emerges, we like to think our action was the cause of the event. If, for example, a button is pushed and a light switches on, the person who pressed the switch ascribes the light to his own action. The feeling of causing your own actions and their outcomes is called the experience of self-agency (Van der Weiden, Aarts & Ruys, 2010). These self-agency experiences can be subject to a specific mindset. When people have a goal in mind that corresponds with the resulting event, the feeling of causing that event enhances (Moore, Wegner & Haggard, 2009). Imagine you are asked to switch on a light. When your goal to switch on the light turns out to be in line with the actual event of light appearing, you are likely to feel you caused the light to switch on. When the light does not switch on, resulting in an outcome different from your goal, this will come as a surprise.

However, the world around us is full of distracting occurrences which can result in losing focus on the initial goal you had in mind. Such distracting subtle cues from the environment could influence your feeling of causing an event, as it may keep you from concentrating on your intended goal. Experiences of self-agency become particularly interesting since people also appear to ascribe outcomes to themselves when it is not entirely sure they were indeed the agent. These situations often happen in daily life. The development of self-agency skills are considered to play a key role in self-perception and social interaction (Van der Weiden, Ruys & Aarts, 2012). For example, imagine a conversation in which you are trying to make your friend laugh. Suddenly, a colleague walks in with whom you had a disagreement yesterday. Your friend responds to you with a smile, which is in line with your goal of making him laugh. However, the moody face of your colleague could serve as a subtle cue that differs from your goal of a smiling face. Seeing your colleague's moody face causes you to be less certain you indeed caused your friend's laugh as it has provided you with input opposite to your goal. The deviation of the subtle cue from your intended goal could lead to surprise and hence arousal. In this case, seeing your friend laugh even after observing the moody face of your colleague could come as a surprise. Such surprise may present itself as increased arousal. The present study focuses on the effect of subtle cues on the experience of self-agency in goal-directed behavior by exploring variations in pupil size, which is linked to arousal, as a biological marker of self-agency.

The prevailing way of studying whether an action is caused by ourselves when researching the experience of self-agency is by using the motor prediction theory (e.g. Prinz, 1997; Wolpert, Ghahramani & Jordan, 1995). This theory states that a prediction of sensory consequences of an action, based on context and motor commands, is compared to sensory feedback (Blakemore, Goodbody & Wolpert, 1998). Comparison of this prediction and the actual sensory consequences of the movement can contribute to the sense of self-agency. A sense of self-agency arises when sensory feedback matches the prediction of sensory consequences. When a mismatch occurs an outcome is not perceived as self-generated (Frith, Blakemore & Wolpert, 2000).

However, sensory feedback is not always an available source to determine whether a certain outcome is caused by ourselves. Previous research (e.g. Aarts, Custers & Wegner, 2005; Dogge, Schaap, Custers, Wegner & Aarts, 2012; Moore et al., 2009) suggests that the experience of self-agency may be based on high level cognitive processes when low-level, sensory-motor control processes fall short. When sensory feedback is flawed the experience of self-agency is solely an inference between action and outcome, since this causal connection cannot be observed directly (Aarts et al., 2005; Renes et al., 2013). Two routes of inferential processing have been proposed (Aarts et al., 2005; Wegner, 2002). An explicit route in which an inference is drawn on an agreement between outcome and goal: the intention to produce a specific outcome. The other route is an implicit route in which the experience of self-agency is inferred on the relationship between implicitly provided preactivated information about the outcome and that actual outcome (Aarts et al., 2005).

When drawing inferences, multiple outcomes of an action have to be considered. A button press, for example, can cause a light to switch on or a door to open. On the other hand, an outcome can have multiple causes: it could have been a button press by someone else that caused a light to switch on. Because of this it is often not entirely sure whether it was indeed the agent, the person who performed the action (Wegner & Sparrow, 2004), that caused the outcome. People tend to ascribe an outcome to themselves when the perception of an outcome corresponds with the goal one had in mind (Aarts et al., 2005). A goal stimulates goal-directed behavior that often results in the anticipated outcome. For example, wanting to pick up an object almost inevitably results in the object being picked up; an increased feeling of causing that outcome is subsequently experienced. However, when a goal and an outcome of an action mismatch, the sense of self-agency is generally decreased (Moore et al., 2009). As people anticipate a certain outcome as a result of their goal-directed behavior, a mismatch between goal and outcome may have an arousing effect since a discrepancy between goal and outcome is unexpected. These reactions to the detection of a mismatch may be reflected in arousal levels of the autonomic nervous system (Rydell, McConnell & Mackie, 2008). Arousal can be measured using the constriction and dilation of the pupil, since pupil size is regulated by the sympathetic and parasympathetic nervous system (Fotiou, Fountoulakis, Goulas, Alexopoulos & Palikaras, 2000). In self-agency research, pupil size may be used as a biological marker to observe arousal in response to mismatching information.

It should be noted however, that feelings of self-agency do not exclusively occur when people have a specific goal in mind. Previous research (e.g. Aarts et al., 2005) shows that feelings of self-agency can arise from observing outcomes that are activated in our minds prior to action performance. These implicitly preactivated outcomes are called primes. Even if they are not processed consciously, primes are capable of influencing our perception and behavior (e.g. Baddeley, Eysenck & Anderson, 2009). Goals refer to outcomes people try to attain, while primes refer to outcomes that are activated in the mind before the actual outcome is known. Goals are internal and explicit (consciously) imagined outcomes; primes are an externally and implicitly presented input of possible outcomes. Just as the degree of matching of a goal and outcome influences our sense of self-agency, the degree in which primes match the outcome also influences our feeling of causation. Primed outcomes that match the actual outcome have been shown to increase feelings of self-agency just like goals, even when primes are not processed consciously (Aarts et al., 2005).

The interplay of primes and goals

Whether self-agency arises from inferences based on outcomes that are activated by an explicit goal or by an implicit prime, both increase the sense of being the agent of an outcome if it is in line with the preactivated outcome**.** That is – both increase the sense of self-agency. Aarts and colleagues (2005) showed that the effects of goals and primes on the experience of self-agency are based on two separate processes that can both exist independently. However, the interaction of goal and prime in self-agency experiences has largely been neglected to date: little research has been conducted on the possible influence of a prime on the experience of self-agency caused by a goal. An unpublished initial study of Renes has shown an interesting effect. If people were exposed to a prime inconsistent with their goal and the outcome was in line with their goal, people experienced less self-agency about the resulting outcome as compared to when no prime was presented. As shown before (e.g. Moore et al., 2009), a match between goal and outcome normally causes people to be more certain they have caused the outcome. Compared to when no prime was presented, a prime inconsistent with the goal caused a higher experience of self-agency when the outcome mismatched the goal and thus matched the prime. When no prime is presented, this situation of a mismatch between goal and outcome causes people to feel less self-agency (Moore et al., 2009). In Renes' study (unpublished data), the difference in level of experienced self-agency during matches or mismatches between goal and outcome was influenced by the presence of a prime inconsistent with this goal.

The present study investigates how primes influence goal-directed behavior in the process of self-agency ascription. More specifically, the effects of primes (in)consistent with the goal and (mis)matching with the outcome are inspected by ratings of self-agency experiences and measures of arousal: pupillometry will be used as a window to experiences of self-agency. It is known that the pupil dilates and constricts not only in response to changes in light but also in response to emotional changes and arousing stimuli (Fontana, 1765). Previous studies have found that the pupil typically dilates as cognitive demands increase (Goldinger & Papesh, 2012). Furthermore, a close relationship between arousal and pupil diameter exists; an increase of arousal is accompanied by dilation of the pupil (Loewenfeld, 1993). The autonomic nervous system, consisting of the sympathetic and parasympathetic nervous system, regulates the response to arousing stimuli and the subsequent dilation and constriction of the pupil, respectively. The sympathetic nervous system prepares the body for action, which can be observed by an increase of arousal. The counteracting parasympathetic nervous system is activated when arousal decreases and the body is at rest (Fotiou et al., 2000).

With respect to the present study, two possible situations could cause increased arousal. Arousal as a response to an inconsistency between a prime and goal may occur and will be measured during presentation of the prime. Alternatively, a prime inconsistent with the outcome could cause arousal the moment a mismatch between prime and outcome is perceived. The timeframe of arousal as a response to the inconsistency of the prime with either goal or outcome could explain more about the organization of cognitive mechanisms responsible for the experience of self-agency. This could offer insight in whether the processing of self-agency experiences functions separately for goal and prime, or whether priming information is combined with the initial goal-information before the experience of self-agency comes about. Altogether, this study will investigate the role of subtle cues on goal-directed behavior in the process of self-agency ascription and the subsequent arousing effect in the autonomic nervous system by measuring pupil size.

The first aim of this study is to replicate findings of the initial study by Renes (unpublished data). It is expected that when goal and outcome match people feel more self-agency as compared to when the outcome mismatches the goal. This difference in self-agency experiences in match and mismatch conditions is not expected to be influenced by primes that are consistent with the goal. However, primes inconsistent with the goal are expected to influence feelings of self-agency in such match-mismatch conditions. When goals match the outcome, it is expected that a prime inconsistent with the goal decreases the experience of self-agency, as compared to when no prime is presented. When goals mismatch the outcome, a prime inconsistent with the goal is expected to increase sense of self-agency as compared to when no prime is presented (Renes, unpublished data). The second aim of this study is to measure pupil dilation as a biological marker of self-agency by use of an eye tracker. Pupil dilation as a result of increased arousal due to sympathetic nervous system activity is assumed to be visible during presentation of the prime as well as during presentation of the outcome. More specifically, in those moments inconsistencies between either goal and prime or between prime and outcome will become apparent to the participant.

Methods

Participants

Sixty-seven undergraduates of Utrecht University participated in return for course credit or a small fee. Since low variance in self-agency ratings could indicate negligent performance caused by a number of reasons, for an example fatigue or insufficient motivation, participants whose ratings had a variance lower than 0.5 were excluded from the data set. After exclusion 60 participants[1] remained (male N=14) with a mean age of 21.5 years (SD = 3.0).

Design

A 2 (goal-outcome match, goal-outcome mismatch) x 3 (no prime, goal-inconsistent prime, goal-consistent prime) within-subjects design is used. One type of prime consisted of a string of random letters and will as of now be referred to as no prime or the no prime condition, since random letter strings were also used to mask the other two types of primes. Other primes were either inconsistent with the goal (in the match condition also inconsistent with the

[1] Including all participants yielded similar results of analysis of self-agency experiences.

outcome, in the mismatch condition consistent with the outcome) or consistent with the goal (in the match condition also consistent with the outcome, in the mismatch condition inconsistent with the outcome; see *Figure 1*).

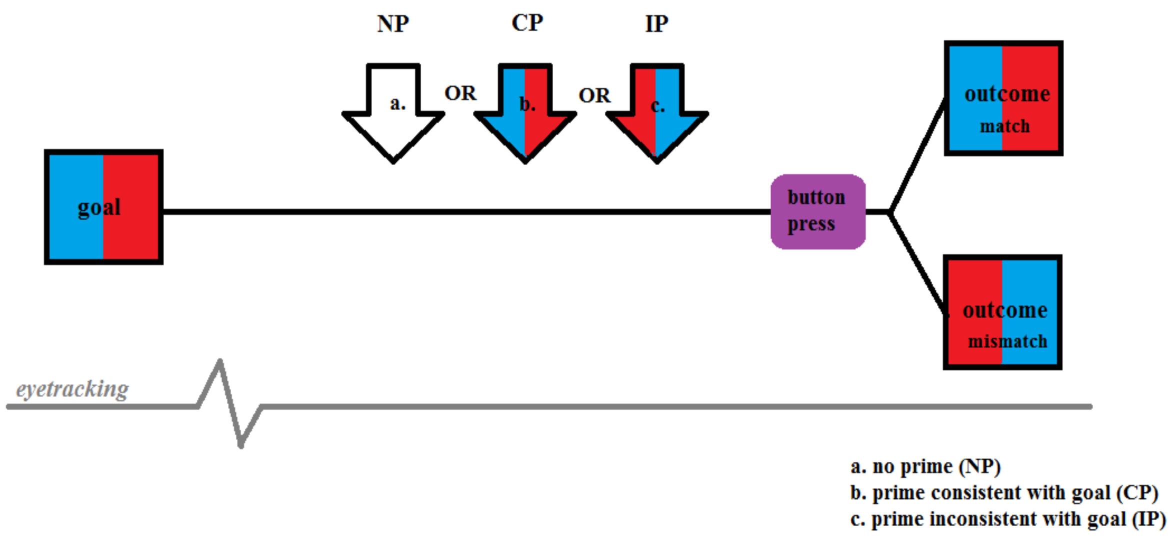

Figure 1. A schematic set-up of the self-agency paradigm. First a goal is presented followed by either no prime, a prime inconsistent with the goal or a prime consistent with the goal. A keypress results in an outcome that either matches or mismatches the goal.

Procedure

Calibration of the Tobii 1750 eye tracker (Tobii Technology, Falls Church, VA) to the participant's eyes was done prior to starting the task. The self-agency paradigm was completely digitized and was displayed on a computer screen with the Tobii 1750 placed below the screen. Instructions were shown on the screen. In addition, participants were verbally instructed to read the instructions thoroughly and were informed shortly that they had the goal to produce a specific color. Furthermore, it was stressed to participants to follow their intuition and not to overthink the task, as it could sometimes be difficult to decide whether they were the cause of the presented color or the computer was. After this the instructor started the task and left the room. Instructions on the task were shown on several screens through which participants could go by pressing the spacebar. Once the participant had finished reading the instructions, the task started. After completing the task, a number of questions concerning motivation, attention and environmental circumstances were displayed on the screen. Examples are 'I thought it was important to perform well on this task' and 'During the task, I stayed focused on the screen' (see *Appendix* for all post-task questions in Dutch). Total testing time accumulated to approximately 30 minutes.

Task and measures

<u>Self-agency paradigm</u>

To measure the perceived experience of self-agency, a paradigm with random letter strings was used. For this purpose, participants operated a computer task comparable to a slot machine that was programmed in E-prime. More specifically, participants were asked to stop a sequence of rapidly alternating random letter strings with either an 'R' or 'B' in it by pressing the middle key on a key panel the moment a stop cue was presented on the computer screen. Participants were instructed that pressing the stop key caused either the Dutch word 'rood' (red) or 'blauw' (blue) to be selected based on whether they pressed the stop key when a letter string containing an 'R' or 'B' was presented, respectively. After the keypress, the outcome of the selected color was shown in the middle of the screen. Each trial began with a small fixation cross, followed by the alternation of letter strings. Then a stop cue (a circle) was shown indicating the need for the keypress. The circle was presented either above or below the letter strings. At the end of the trial the outcome was shown depending on when the stop key was pressed.

Practice trials consisted of a random selection of six out of a series of rapidly alternating letter strings. After completing three practice trials participants were told they were no longer the sole author of the presented outcomes, as it now would be randomly determined whether the shown outcome was their doing or that of the computer. In reality, all outcomes were randomly predetermined, such that the outcome was not influenced by the moment the participant pressed the stop key. After each outcome, participants were asked to indicate to what extent they felt they caused the shown outcome color to appear on an 8-point scale (not me [1] - me [8]). Both colors were presented in words 16 times as outcome in all three priming conditions, where half matched the outcome and the other half mismatched the outcome. Trials were presented randomly.

As a goal, participants were instructed to attempt to cause one of two colors: either 'blauw' (blue) or 'rood' (red). To measure the effect of a prime on the goal, a prime either consistent or inconsistent with the goal was presented. The priming event of 200 ms consisted of five random letter strings that preceded a prime (either the complete word 'rood' or the complete word ‘blauw’). The prime and each letter string were again presented for 33 ms each, constituting 2 cycles on a 60 Hz monitor. In a non-priming event, five random letter strings preceded a non-word, derived from each prime, either ‘ordo’ or ‘awblu’. The prime phase consisted of eight priming-events (1600 ms), four non-priming events as a mask (800 ms) and four non-priming events in which the participant had to press the stop key (800 ms). In the last 600 ms, a small circle was presented above the non-priming events to which participants had to react to with a keypress. As described above, the timing of that keypress supposedly determined which letter string, and in turn which color, was shown as the outcome. After this, a 100 ms blank screen was presented. Subsequently participants were shown the outcome for 1500 ms during the outcome phase. Finally, participants could indicate their self-agency experience on an 8-point scale. Every participant completed 16 trials in every condition, coming to a total of 96 trials. See *Figure 1* for a schematic overview of the task.

Eye tracking

To measure arousal, pupil size was recorded by using a Tobii 1750 infrared eye tracker sampling at 120 Hz (Tobii Technology, Falls Church, VA). The video frames were digitized and transferred to a computer with a frame grabber interface. Image processing software detected the pupil on each single frame and calculated its diameter (Wilhelm, 2003). In each trial, three moments were filtered out of the eye track recordings. Average pupil size during presentation of a fixation point, consisting of the first 50 data points of the trial, served as a baseline for the pupil dilation data. In addition to baseline data, maximum scores of pupil dilation during prime phase (1600 ms) and outcome phase (1500 ms) were obtained.

Statistical analysis

The statistical analysis was done using SPSS version 20.0 (SPSS, Inc., 2011, Armonk, NY). Averaged agency feelings over matching and mismatching outcomes were computed and compared for every priming condition by means of a 2 (goal-outcome match, goal-outcome mismatch) x 3 (no prime, goal-inconsistent prime, goal-consistent prime) repeated-measures analysis of variance (ANOVA). Obtained eye tracking data were processed using R. Raw pupil data were corrected for artifacts and filtered (Kuchinke, Võ, Hofmann & Jacobs, 2007). Subsequently eye track recordings were subjected to a repeated-measures ANOVA. This second ANOVA compared baseline pupil dilation with maximum pupil dilation during prime phase and outcome phase.

Results

Feelings of self-agency

Average ratings in each of the six conditions were computed and these values were subjected to a repeated-measures ANOVA. A main effect for (mis)matching of goal and outcome was found, $F(1,59) = 16.41$, $p < .001$, $\eta_p^2 = 0.22$ (see *Figure 2*). More specifically, feelings of self-agency were significantly higher in the match condition ($M = 4.84$, $SD = 0.80$) compared to the mismatch condition ($M = 4.28$, $SD = 0.82$). No main effect was found for type of priming, $F < 1$. This indicates that no significant differences were found between the effects of no prime presentation or consistent or inconsistent prime presentation on feelings of self-agency. Finally, no interaction effect of (mis)matching and type of prime was found, $F(2,58) = 2.08$, $p = .14$, $\eta_p^2 = 0.07$. None of the three types of primes had a greater effect in one of the match condition as compared to the other match condition.

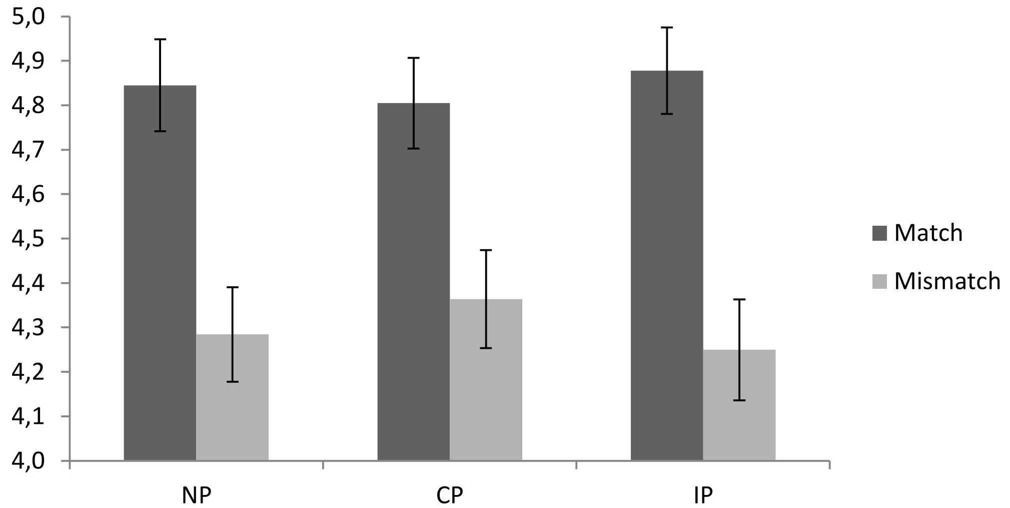

Figure 2. Mean self-agency experiences as a function of matching (goal-outcome match or mismatch) and priming (NP = no prime, CP = goal-consistent prime, IP = goal-inconsistent prime).

Analysis of eye track data

Pupil dilation changes of interest were measured during presentation of prime and outcome. In the prime phase, no main effect was found for goal-outcome (mis)matching, $F(1,56) = 1.45$, $p = .23$, $\eta_p^2 = 0.03$. Priming information also did not affect pupil size, $F(2,55) = 1.75$, $p = .18$, $\eta_p^2 = 0.06$. Lastly, no interaction effect of (mis)matching and priming was found to affect pupil dilation during prime presentation, $F < 1$ (see *Figure 3).*

Similar results were found for priming and (mis)matching during presentation of the outcome; for both variables $F < 1$ was seen. No interaction effect of (mis)matching and priming was found during presentation of the outcome: $F(2,55) = 1.52$, $p = .23$, $\eta_p^2 = 0.05$ (see *Figure 4*). These results imply that pupil size was not reactive to goal nor prime nor outcome information during prime phase and outcome phase.

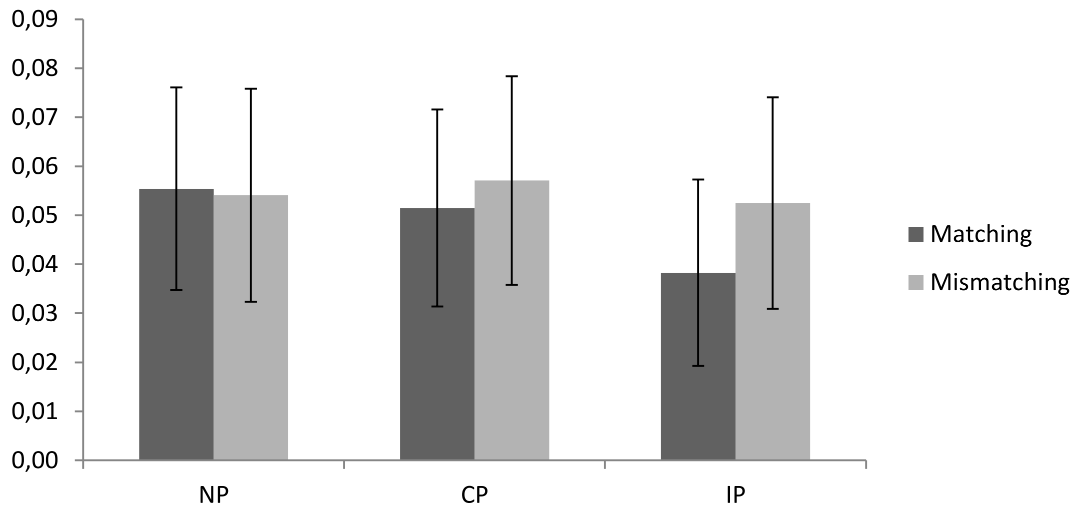

Figure 3. Maximum pupil dilation during prime phase as a function of matching (goal-outcome match or mismatch) and priming (NP = no prime, CP = goal-consistent prime, IP = goal-inconsistent prime).

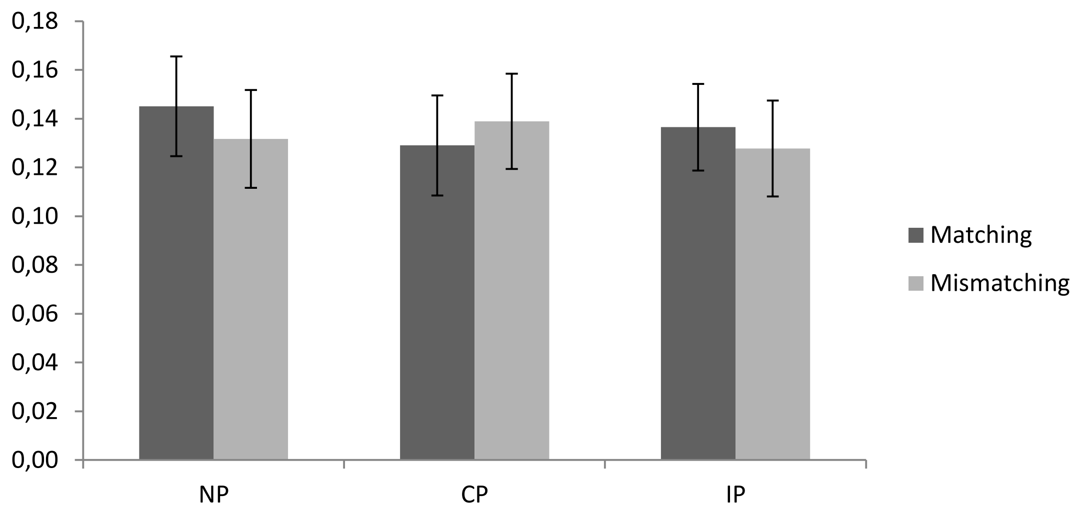

Figure 4. Maximum pupil dilation during outcome phase as a function of matching (goal-outcome match or mismatch) and priming (NP = no prime, CP = goal-consistent prime, IP = goal-inconsistent prime).

Discussion

The first aim of this study was to replicate previous findings by Renes (unpublished data). This study suggests an effect of subtle environmental cues on self-agency experiences caused by goal-directed behavior. More specifically, goal-inconsistent primes were found to exert influence on self-agency experiences, as opposed to when only goals were presented. However, the present study did not replicate these results. A main effect was found demonstrating increased experiences of self-agency when the outcome matched the goal as compared to when a goal-outcome mismatch occurred. Furthermore, the eye track data did not provide evidence of an arousing effect when priming information inconsistent with the goal or the outcome was presented. Possible explanations for the absence of a priming effect in this study could lie in procedural differences or theoretical deficiencies.

As expected self-agency experiences were susceptible to (mis)matches between goal and outcome, since a match between goal and outcome increased the feeling of causing the outcome and a mismatch led to a decrease in feelings of self-agency. This was the case regardless of what type of prime was used. As was anticipated, adding goal-consistent primes did not affect the experience of self-agency caused by goal-outcome (mis)matches; primes in line with the goal neither increased nor decreased experience of self-agency. Goal-inconsistent primes, on the other hand, were hypothesized to create interference between goal and outcome. In goal-outcome match trials it was hypothesized that feelings of self-agency would decrease, while in goal-outcome mismatch trials goal-inconsistent primes would increase feelings of self-agency. Interestingly, no such interference was found. These results give no indication that the primed information has had an effect on behavioral level; primes did not influence the process that brings about feelings of self-agency when goals and outcomes (mis)match.

Pupil dilation has not found to be significantly greater than baseline either during presentation of priming information or during presentation of outcome information. This indicates that goal-prime and prime-outcome inconsistencies did not cause increased arousal of the sympathetic nervous system. Therefore, our results give no indication that the primed information has had an effect on a physiological level, as pupil dilation did not react to different types of primes.

Procedural differences

A previous study by Renes (unpublished data) used a similar paradigm and reported a notable effect of priming information on goal-directed behavior. While the present study has stayed very close to Renes' methodology, adding the eye tracking device to the paradigm accounted for some inevitable deviations. First of all, a check-up by the eye tracker appeared every eight trials to ensure the correct position of the eyes was maintained. This may have led to decreased focus of the participants in the current study as compared to the participants of Renes' study (unpublished data), in which no eye tracker was used. Second, use of the eye tracker could have caused differences in motivation. It may be the case that participants were more likely to make an effort because the involvement of an eye tracker made the experiment more interesting to participate in, as compared to the computer paradigm by itself. Comparison of post-task question data of Renes (unpublished data) and the current study, however, did not show indications for any significant differences in motivation or focus. Nevertheless, such ratings may not be entirely reliable as they are made at the end of the experiment when participants may become impatient to finish. Additional studies combining the paradigm and an eye tracker are needed to clarify whether addition of an eye tracking device indeed influenced these aspects of task performance and subsequently, the results.

Using a within-subjects design could have caused a diminished response to changes in priming conditions, because trials quickly alternated between the three priming types. These rapidly changing priming conditions could decrease the strength of the priming effect itself. Therefore, the influence of a prime on the outcome becomes less powerful than the effect of a goal on the outcome. This could offer an explanation as to why goal-inconsistent primes have not been found to cause the expected interference. Because the results of the present study suggest a goal effect but an absent priming effect, a different design could be able to disclose the interplay of goals and primes. A between-subjects design in which consistent and inconsistent primes are separated and tested in individual groups could result in a stronger priming effect, because in such a design no interference of consistent and inconsistent primes is possible. It should be noted, however, that priming events are presented for a short period and the activation of primed information usually takes a very short time. Previous research (e.g. Michotte, 1963; Wegner, 2002) suggests that when events are close together in space and time those events will be perceived as causally related. These findings indicate that the priming effect presumably only influences the trial a prime is presented in. For this reason, the occurrence of interference between priming conditions is less plausible.

A final issue affecting the results may be the colors used: red and blue. Red has traditionally been linked to danger and much has been hypothesized about the effects of the color on performance (e.g. Goldstein, 1942; Ainsworth, Simpson & Cassell, 1993; Hulbert & Ling, 2007). Elliot, Maier, Moller, Friedman and Meinhardt (2007) state that colors serve as subtle environmental cues, like primes, to exert influence on a behavioral level. Furthermore, their study suggests that the color red may stimulate avoidance motivation and can compromise performance. Additional analysis of our data has not shown deviations between trials when the goal was either red or blue, but those findings may be the result of decreased power due to the division of trials into blue and red.

Theoretical deficiencies

A more theoretical explanation for the absence of a priming effect on feelings of self-agency in goal-directed behavior could lie in the fact that goals are processed differently than primes (Van der Weiden et al., 2012). With goals, attention is focused on one specific desired outcome. However, priming effects depend on an inferential process that is more open to associative processing of related outcome information; primes focus less directly on an outcome (Van der Weiden et al., 2012). This is in line with the theory of goal-shielding stating that the activation of a specific goal inhibits the accessibility of alternative goals (Shah & Kruglanski, 2002). In the present study activation of a specific goal could inhibit accessibility of alternative input: the less specifically activated priming information.

While goals and primes may differ in the influence they exert on processes of establishing feelings of self-agency, one should also consider the effect of the degree to one is motivated to reach a certain goal. It is known people are generally more motivated to accomplish self-appointed goals than goals that are set for them by an external source (McDoherty, 1999). Perhaps the degree to which one is determined to fulfill a goal influences the extent to which primes are experienced as being different from the goal. For instance, when one is highly motivated to accomplish a goal (this will be termed a ‘strong’ goal, as compared to a goal that is not cared much about, or a ‘weak’ goal) this could heighten the extent to which the inconsistency of a prime is noticed. A strong goal is highly activated in the brain and any discrepancies between goal and prime may therefore be more focused on. This heightened noticing could result in an intensified reaction of the sympathetic nervous system that would be evident in greater pupil dilation (Fotiou et al., 2000). Future research could create strong goals, for an example by offering monetary rewards and compare strong and weak goals to determine if there is indeed a difference between the extent to which both types of goals increase attentiveness to the inconsistency of a prime. If such a difference indeed exists, strong goals could enhance inconsistency attentiveness and thereby increase measurability of sympathetic arousal by pupil dilation in reaction to such goal-inconsistent primed information.

In conclusion, people experience more self-agency when an outcome is in line with their goal. The addition of a prime to this goal-directed behavior did not have an effect on a behavioral or physiological level, unlike what was hypothesized. Participants did not report differences in feelings of self-agency when a prime either consistent or inconsistent with the goal was presented as compared to when no prime was presented. Pupil dilation representing activation of the sympathetic nervous system as a hypothesized biological marker of self-agency also did not appear to be present. Based on the present results, no clarification on the cognitive processes in which self-agency takes place can be provided.

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Appendix

Ratings post-task questions: 1-9

	N	Min.	Max.	Mean	SD
In hoeverre was je er op gericht zo snel mogelijk op de knop te drukken wanneer het stipje boven of onder in beeld verscheen?	65	3	9	6.69	1.610
In hoeverre was je er op gericht te bepalen welke kleur zou verschijnen nadat je op de middelste knop had gedrukt?	65	1	9	5.86	2.179
Deze taak was leuk om te doen.	65	1	8	4.77	2.029
Ik voelde me vaardig om deze taak te doen.	65	1	9	5.22	2.240
Tijdens de taak had ik het gevoel controle te hebben over welke kleur er verscheen	65	1	7	3.63	1.842
Hoe denk je dat de verhouding was tussen het aantal kleuren dat jij veroorzaakte en het aantal kleuren die de computer veroorzaakte? Geef een antwoord op basis van je gevoel, en geef een getal verder richting de 1 als je denkt dat de computer vaker de oorzaak was, en een getal verder richting de 9 als je denkt dat jij vaker de oorzaak was.	65	1	8	4.28	1.941
Ik ben tijdens de taak goed op het scherm blijven letten.	65	4	9	7.97	1.118
Ik heb me tijdens de taak goed kunnen concentreren.	65	3	9	7.31	1.489
Ik vond het belangrijk om de taak goed uit te voeren.	65	5	9	7.83	1.180
Ik heb tijdens de taak veel last gehad van lawaai.	65	1	9	1.83	1.876