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Mirrors, masks, and motivation: Implicit and explicit self-focused attention influence effort-related cardiovascular reactivity☆

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Abstract

Using motivational intensity theory as a framework, three experiments examined how implicit self-focus (manipulated with masked first-name priming) and explicit self-focus (manipulated with a large mirror) influence effort-related cardiovascular activity, particularly systolic blood pressure reactivity. Theories of self-focused attention suggest that both implicit and explicit self-focus bring about self-evaluation and thus make meeting a goal more important. For a "do your best" task of unfixed difficulty, implicit and explicit self-focus both increased effort (Experiment 1) compared to a control condition. For a task that varied in difficulty, implicit and explicit self-focus promoted more effort as the task became increasingly hard (Experiments 2 and 3). Taken together, the findings suggest that implicit and explicit self-processes share a similar motivational architecture. The discussion explores the value of integrating motivational intensity theory with self-awareness theory and considers the emerging interest in implicit aspects of effort regulation.

Keywords

Effort; Cardiovascular reactivity; Self-focused attention; Implicit priming; Motivational intensity; Active coping

1. Introduction

How people control their behavior is one of the fundamental problems of self-regulation (Carver and Scheier, 1998). Because people often fail to engage with important goals, research has examined the conditions that foster engagement, effort, and goal striving. The present research intersects two traditions of research in self-regulation: self-awareness theory, which concerns how self-reflection influences self-evaluation (Duval and Wicklund, 1972), and motivational intensity theory, which concerns how people regulate effort in the face of challenges (Brehm and Self, 1989). In particular, the present work explores how implicit and explicit self-focus influence effort regulation across a range of difficulty levels and types. Theories of self-evaluation disagree over whether implicit and explicit forms of self-focus differ, so three experiments examined how implicit and explicit self-focus influence effort-related cardiovascular reactivity during active coping.

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1.1. Self-focus and self-regulation

According to self-awareness theory, focusing attention on the self brings about a state of self-evaluation, in which people compare the self to salient standards of correctness (Duval and Wicklund, 1972; Silvia and Gendolla, 2001). This self-evaluative process motivates people to try to meet goals that they find worthwhile and attainable. Few studies in the large literature on self-awareness have used psychophysiological measures of effort and engagement. Instead, they have examined self-regulation using measures of performance (how well people did on a task), persistence (how long people spent on a task), or self-reported affect and attribution (for reviews, see Duval and Silvia, 2001; Silvia and Duval, 2001a; Silvia and Eddington, 2012).

Historically, research on self-awareness has emphasized *explicit self-focus*, which is brought about by obvious reminders of the self. These manipulations create conscious self-evaluative thoughts and a subjective feeling of self-consciousness. The most common manipulations of self-awareness, for example, involve placing people in front of large mirrors (Silvia and Phillips, in press; Phillips and Silvia, 2005), showing people their image via a video feed (Duval, 1976; Duval and Silvia, 2002; Silvia and Duval, 2001b), playing people a recording of their voice (Ickes et al., 1973), or making people feel like they stick out in some respect (Silvia and Eichstaedt, 2004; Silvia and Phillips, 2004; Snow et al., 2004).

An alternative pathway, however, involves manipulating *implicit self-focus* via priming of self-knowledge. This approach activates self-evaluative processes more directly and circumvents conscious thoughts about the self. Implicit self-focus is just beginning to receive attention in the self-regulation literature, but research thus far suggests that implicit self-focus influences self-regulation. Priming last names (a 30 ms prime followed by a 30 ms mask) affected the mental control of stereotypes (Macrae et al., 1998), and priming first-person pronouns (a 17 ms pronoun followed by a 1000 ms mask) influenced the self-regulation of affective states (Koole and Coenen, 2007). Recently, priming first names has been shown to affect behavioral self-regulation. First-name priming (27 ms followed by a 100 ms mask) significantly increased behavioral adherence to salient situational standards (Silvia and Phillips, in press). In a psychophysiological study, priming first names significantly increased systolic blood pressure reactivity during a self-paced cognitive task (Silvia et al., 2011a).

The similarity between explicit and implicit self-focus, however, is a point of contention. On the one hand, theories of self-awareness propose that implicit and explicit self-focus should have similar effects. Evaluating the self against standards and goals is central to self-regulation (Miller et al., 1960), so the self-evaluation process should be general and versatile—a wide range of things should be capable of initiating it, it should be capable of unfolding without people's conscious initiation or control, and it should be capable of resulting in a wide range of behavioral outcomes (Carver, 2003; Carver and Scheier, 1998). If evaluating the self against goals required conscious attention and control, then it would have limited applicability.

On the other hand, some theories propose that implicit and explicit self-evaluation processes are qualitatively different, with distinct causes and consequences. The dual-evaluation model (Koole et al., 2001, p. 670), for example, proposes that "implicit and explicit self-evaluations represent two qualitatively different kinds of self-evaluation." Implicit and explicit self-evaluation processes are said to differ in their antecedents and their outcomes. Implicit self-evaluation is primarily associationistic (Dijksterhuis, 2004), such as the linking of the self to positive or negative information via evaluative conditioning; explicit self-evaluation, in contrast, involves "sophisticated cognitive judgments of the self" (Koole et al., 2001, p. 670), such as the comparison of self to abstract standards for behavior. A central theoretical claim is that types of self-evaluation have corresponding types of outcomes: implicit self-evaluation processes affect implicit outcomes (e.g., implicit self-esteem), and explicit self-evaluation processes affect explicit outcomes (e.g., behavioral self-regulation, conscious moods, and explicit self-esteem; Koole and Pelham, 2003). Bosson et al. (2003) proposed a similar model: they suggest that implicit self-esteem comes from automatic processes, whereas explicit self-esteem comes from conscious introspection. In contrast to the self-awareness approach, which emphasizes generality and versatility in self-evaluative processes, the dual evaluation model proposes that implicit causes have implicit effects and explicit causes have explicit effects.

To date, only one experiment has compared implicit and explicit self-focus (Silvia and Phillips, in press, Experiment 2). In a behavioral study, people completed a cognitive task and were instructed that the standard was to be fast or to be accurate. Self-focus was manipulated with either a mirror or with masked first-name priming. Compared to a control condition, both the mirror and name-priming conditions had similar effects on self-evaluation, which was inferred from performance. When the standard was to be accurate, for example, both self-focus groups made fewer errors; when the standard was to be fast, both self-focus groups made more errors.

1.2. Motivational intensity and effort regulation

One way to evaluate the differing models of self-evaluation is to examine effort mobilization during self-regulation. Brehm's motivational intensity theory (Brehm and Self, 1989; Brehm et al., 1983) addresses factors that promote mobilizing and withholding effort. Wright (1996) integrated this model with Obrist's (1981) active coping approach, which yielded a model of effort dynamics that were linked to physiological outcomes. The model has been widely applied to understand how task difficulty (Wright et al., 1992), mood states (Silvestrini and Gendolla, 2009), individual differences (Capa, 2012), self-relevance (Gendolla and Richter, 2010), incentives (Richter, 2010, 2012; Richter and Gendolla, 2009), and fatigue (Wright and Stewart, 2012), to name a few, influence physiological markers of effort.

Motivational intensity theory proposes that effort is a function of two variables: the importance of the goal and the difficulty of the task. The goal's importance affects *potential motivation*, the maximum amount of effort that would be justified in light of the goal's value (Wright, 2008). The task's difficulty, in contrast, affects *actual motivation*, the level of effort actually mobilized. When a goal is easy to achieve, effort will be low—even if the goal's value would justify intense effort, such effort is unnecessary to achieve an easy goal. As the goal becomes harder to attain, effort increases proportionally. Eventually, however, people will disengage effort because (1) the goal is unattainable, so expending effort would be fruitless, or (2) the amount of effort needed exceeds the amount that is justified, so the goal is not important enough for the effort. Common measures of effort-related physiology are markers of beta-adrenergic sympathetic activity, such as higher systolic blood pressure (Wright and Kirby, 2001) or a smaller average pre-ejection period (Kelsey, 2012; Richter et al., 2008).

The theory identifies some notable exceptions to this pattern. First, some tasks are unfixed in difficulty. Known as self-paced tasks, piece-rate tasks, or do-your-best tasks, unfixed tasks allow people to work at their own pace and thus to achieve as much or as little as they wish (Brehm and Self, 1989; Wright et al., 2002). Such tasks lack a dimension of task difficulty, so effort is solely due to the importance of achieving the goal (Wright et al., 2002). Second, some tasks have an ambiguous level of difficulty. When people cannot appraise a task's level of challenge, they mobilize effort as a function of the goal's importance (Richter and Gendolla, 2006, 2007).

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To intersect motivational intensity theory and self-awareness theory, Gendolla et al. (2008) proposed that self-focused attention increases the importance of achieving a goal. This proposal is consistent with extensive research on how explicit self-focus makes goals more self-relevant (Hull et al., 1988) and amplifies the emotional consequences of goal attainment (Phillips and Silvia, 2005). Several experiments support this integration. First, for unfixed tasks, increasing self-focus with a video camera (Gendolla et al., 2008) or with first-name priming (Silvia et al., 2011a) significantly increases systolic blood pressure reactivity. Second, for fixed-difficulty tasks, self-focus increases the amount of effort people are willing to mobilize. People high and low in self-focus mobilize equally low effort for easy tasks, but people high in self-focus continue to mobilize effort as the task gets harder and require higher levels of difficulty before disengaging (Gendolla et al., 2008; Silvia et al., 2010). This pattern appears for several manipulations of explicit self-focus (mirrors, video cameras) and for individual differences in self-focused attention (Silvia et al., 2011b). Taken together, findings from both the unfixed and fixed tasks show that self-focus increases potential motivation, the level of justified effort.

1.3. The present research

In the present experiments, we evaluated how implicit and explicit self-focus affected effort-related cardiovascular reactivity. Each experiment had participants work on a cognitive task. In Experiment 1, the task was unfixed: people were told to “do their best” and could work at their own pace. In Experiments 2 and 3, the level of challenge was fixed at several difficulty levels ranging from easy to very challenging. The set of experiments thus tests motivational intensity theory’s predictions for both unfixed and fixed tasks. During the task, three self-focused attention conditions were created: a control condition, an implicit self-focus condition (manipulated by using rapid masked priming of people’s first names), and an explicit self-focus condition (manipulated by exposing people to their reflection in a large mirror). The design thus allows a comparison of the similarity of implicit and explicit self-focus.

Cardiovascular assessments were taken at baseline and throughout the task, thus allowing an estimate of reactivity from baseline to task. We measured systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR). Of the three, SBP reactivity is most closely linked to beta-adrenergic sympathetic activation and thus reflects effort the best (Wright, 1996). Many experiments have shown that SBP reactivity consistently captures effort during active coping (e.g., Bongard, 1995; Gerin et al., 1995; Light, 1981; Richter et al., 2008; Richter and Gendolla, 2009; Sherwood et al., 1990; Smith et al., 2000). Some studies of motivational intensity have found DBP effects (e.g., Al’Absi et al., 1997; Gendolla and Richter, 2005; Silvia et al., 2010, 2011b), but it is a less consistent marker of effort. HR rarely shows significant effects, with some exceptions (e.g., Eubanks et al., 2002), consistent with its control by both sympathetic and parasympathetic processes (Obrist, 1981).

2. Experiment 1: effort for an unfixed task

Experiment 1 examined how implicit and explicit self-focus affect effort during an unfixed-difficulty task. According to motivational intensity theory, effort during unfixed tasks is a function of potential motivation (Wright et al., 2002). If both implicit and explicit self-focus make success more important, then both should increase effort-related cardiovascular activity—particularly systolic reactivity—compared to a control condition.

2.1. Method

2.1.1. Participants and design—A total of 50 people (31 women, 19 men) enrolled in General Psychology at the University of North Carolina at Greensboro (UNCG) participated as part of a research participation option. Seven cases were excluded because of equipment or software issues or extensive missing self-report data, which left a final sample of 43 people (28 women, 15 men). The sample was approximately 65% European American, 26% African American, 5% Asian American, and 2% Hispanic or Latino, and age ranged from 18 to 30 (M = 19.3, SD = 2.06). People were randomly assigned to one of three between-subject conditions: a control condition, a name priming condition, and a mirror condition.

2.1.2. Cardiovascular assessment—We assessed SBP (mmHg), DBP (mmHg), and HR (bpm) with an automated Dinamap cardiovascular monitor (8100 or 1846sx; Critikon, USA) using the oscillometric method. Measurements were taken using a standard cuff on the brachial artery of the participant's non-dominant arm. There were four baseline assessments (one every 2 min) and five task assessments (one every minute).

2.1.3. Procedure—In all three experiments, participants first provided informed consent, and UNCG's Institutional Review Board approved the research. Each person participated individually. After participants provided informed consent, the experimenter explained that the research was about how the body responded during cognitive tasks. The experiment began with a baseline period: participants sat quietly and completed a questionnaire, and four cardiovascular assessments were taken at 2 min intervals.

2.1.3.1. The d2 task: After the baseline period, the experimenter introduced and described the "cognitive task," which was a computerized version of the d2 test of attention (Brickenkamp and Zillmer, 1998). Several recent studies of motivational intensity have used this task (Gendolla and Richter, 2005; Gendolla et al., 2008; Silvia et al., 2010, 2011a,b). For the d2 task, a *d* or a *p* is displayed on the screen. The *d* or *p* has zero, one, or two apostrophes above and below it, and people must decide whether it is a d2 (a *d* with two apostrophes above it, two apostrophes below it, or one above and one below it). Participants pressed a green button if the letter was a d2 and a blue button for all other items (*d*s with 1, 3, or 4 apostrophes and all *p*s). People responded with their dominant hand on a Cedrus RB-834 response pad (Cedrus, USA). The task was presented and controlled using SuperLab Pro 2.0.4 (Cedrus, USA).

2.1.3.2. Self-focus manipulations: We manipulated explicit self-focus using a mirror, which is probably the most common self-focus manipulation (Duval and Silvia, 2001; Duval and Wicklund, 1972). In all conditions, a 24 in. by 36 in. mirror was placed on the participant's desk, and the monitor was angled to the side. The mirror was covered with a green cloth. For participants in the mirror condition, the experimenter removed the cloth prior to the task. As a result, participants in the mirror condition could see their face and upper body in the mirror, whereas participants in the other conditions could see only the cloth.

We manipulated implicit self-focus using masked first-name priming. The priming procedures were based on our prior work (Silvia and Phillips, in press; Silvia et al., 2011a) and other work on name priming (Koole and Coenen, 2007; Macrae et al., 1998). We briefly presented the participant's first name before a trial. The trials began with a fixation cross (250 ms) followed by the person's first name (27 ms), a random letter mask (100 ms), and the d2 item. The items remained onscreen until participants gave a response. After a 100 ms pause, the next trial began. In the control and mirror conditions, all trials presented a random string of consonants for 27 ms instead of the person's first name. All letters were presented in 48 pt upper-case Tahoma in black against a white background. First names were primed for two-thirds of the trials. Because prior work indicated that prime frequency can sometimes influence effort-related physiology (Silvestrini and Gendolla, 2011), a prior study tested three frequency levels (33%, 67%, and 100%; Silvia et al., 2011a) but found that each level had similar effects.

To justify the mirror and the masking procedures, the experimenter explained that the study was interested in how mild distractions can influence performance. Participants were told that each session could involve one or more distractions: flashes of random letters during the task, exposure to the mirror, or listening to jazz music on a set of headphones. No participants actually listened to music, but this third “possible distraction” was used to make the study’s cover story more credible.

The experimenter explained that the task’s goal was to get as many d2 trials right during the 5 min task period. Because the task was self-paced—making a response ended the trial and started the next one—people could work at their own pace, i.e., the task was unfixed in difficulty (Wright et al., 2002). People completed 22 practice trials to familiarize themselves with the task. The practice trials were not scored, and no priming occurred during the practice period.

In all conditions, people worked on the d2 task for 5 min. Cardiovascular assessments were taken 5 times, once per minute, starting with the task’s onset. Afterward, participants were probed about the priming manipulation, debriefed, thanked, and given the opportunity to ask questions about the research.

2.2. Results and discussion

2.2.1. Data reduction and analysis strategy—We averaged the four baseline assessments to form baseline scores for SBP (α = .93), DBP (α = .89), and HR (α = .98). Table 1 displays the baseline values. The five task assessments were averaged to form overall task scores for SBP (α = .99), DBP (α = .96), and HR (α = .98). Cardiovascular reactivity scores were created by computing difference scores between the baseline and task values. To test for initial-value or carry-over effects, we tested whether the baseline scores covaried with the difference scores. The correlation for SBP was not significant ($r(43) = -.04$, $p = .781$), but the correlations for DBP ($r(43) = -.35$, $p = .021$) and HR ($r(43) = -.29$, $p = .059$) were, so DBP and HR analyses were conducted using baseline-residualized difference scores (Llabre et al., 1991). Table 2 displays the difference scores for each condition.

We used regression models to estimate the effects of self-focus. Because we expected that implicit and explicit self-focus would have similar effects, we estimated a focused comparison that contrasted the no-priming control condition (weight = −2) with the two self-focus conditions (weights = 1). This contrast compares the control condition with the average of the two self-focus conditions. The regression analyses were conducted in Mplus 6.1 using maximum likelihood with robust standard errors. All regression weights are unstandardized.

2.2.2. Cardiovascular reactivity

2.2.2.1. SBP reactivity: For SBP reactivity, the contrast was significant, $b = 1.81$, $SE = .74$, $Z = 2.46$, $p = .014$, and the model R^2 was 12.0%. Table 2 shows the pattern of means. As expected, both the mirror condition and name priming condition differed significantly from the control condition, according to 95% confidence intervals around the means (see Table

2), and they did not differ from each other. This pattern supports our prediction: implicit and explicit self-focus had similar effects on SBP reactivity.

2.2.2.2. DBP reactivity: For DBP reactivity, the contrast was significant, $b = 1.58$, $SE = .76$, $Z = 2.07$, $p = .038$, and the model R^2 was 8.1%. Table 2 shows the pattern of means. Both the mirror condition and name priming condition differed significantly from the control condition, according to 95% confidence intervals around the means (see Table 2), and they did not differ from each other.

2.2.2.3. HR reactivity: For HR reactivity, the contrast was not significant, $b = .22$, $SE = .56$, $Z = .39$, $p = .692$, and the model R^2 was 0.2%. Table 2 shows the pattern of means. According to 95% confidence intervals around the means (see Table 2), no condition differed from any other condition.

2.2.3. Task performance—Response times and errors for the d2 task were examined to explore effects of self-focus on behavioral performance. Similar regression contrasts were estimated. For response times, the contrast was not significant, $b = -9.36$, $SE = 8.96$, $Z = 1.04$, $p = .296$, and the model R^2 was 2.3%. For errors, the contrast was not significant, $b = 1.33$, $SE = 1.03$, $Z = 1.29$, $p = .198$, and the model R^2 was 2.1%. The descriptive statistics are displayed in Table 2.

2.3. Discussion

As expected, implicit and explicit self-focus had similar effects on effort-related cardiovascular activity. SBP reactivity, the parameter most closely linked to effort in past work, was significantly higher in both self-focus conditions than in the control condition. A similar significant effect was found for DBP reactivity: both self-focus conditions had significantly higher DBP reactivity than the control condition. No effects were found for HR reactivity. The significant effort effects were not mirrored in behavioral performance, a common pattern that we will consider in Section 5.

3. Experiment 2: effort for a fixed difficulty task

Experiment 2 examined how implicit and explicit self-focus influence effort-related cardiovascular reactivity during a fixed-difficulty task. People worked on a cognitive task that varied in difficulty, and they were told that the performance standard was to get 90% of the trials correct. According to our application of motivational intensity theory to self-focused attention, both implicit and explicit self-focus should make meeting the standard more important. As a result, both should increase the amount of effort people are willing to expend. This would appear as an increase in effort as the task becomes harder, so long as success is seen as feasible. As a result, we would expect the self-focus and control conditions to be similar when a task is easy—even though success is more important for the self-focused groups, high effort is unnecessary—but to diverge as the task becomes increasingly hard.

3.1. Method

3.1.1. Participants and design—A total of 166 people enrolled in General Psychology at UNCG participated as part of a research participation option. Seventeen cases were excluded (primarily due to intensive exercise prior to the experiment and to equipment or software issues), leaving a final sample of 149 people (113 women, 36 men). Based on self-reported race and ethnicity, the sample was approximately 65% European American, 27% African American, 6% Asian American, and 5% Hispanic or Latino. Age ranged from 18 to 36 ($M = 19.4$, $SD = 2.85$). People were randomly assigned to one of nine between-person conditions, based on a 3 (Self-Focus: Control, Name Priming, Mirror) by 3 (Task Difficulty: Easy, Medium, Hard) between-person factorial design.

3.1.2. Cardiovascular assessment—We measured SBP (mmHg), DBP (mmHg), and HR (bpm) using the same equipment (Dinamap 8100) and methods as in Experiment 1. Like Experiment 1, there were four baseline assessments (one every 2 min) and five task assessments (one every minute).

3.1.3. Procedure—The procedures and task were the same as in Experiment 1, but with a few exceptions. First, we manipulated task difficulty by fixing the response window during the d2 task. Each trial was presented for a fixed amount of time—2500 ms in the Low condition, 1250 ms in the Medium condition, and 750 ms in the High condition—and the participants had to respond within that time. Giving a response did not terminate the trial: the item remained on screen until the response window had passed, so people were unable to work at their own pace. This method of manipulating task difficulty, and the specific windows, have been used in several past experiments (Gendolla et al., 2008; Silvia et al., 2010, 2011b). As before, people completed 22 practice trials to familiarize them with the task. The practice trials contained no name priming and were presented using the main task's difficulty level.

Second, people completed a brief "pre-task questionnaire" following the 22 practice trials but prior to the task. This questionnaire assessed people's subjective appraisal of the task's difficulty. People were asked "How confident are you that you can get 90% correct?" (1 = *not confident*, 7 = *very confident*), "Are you optimistic about your ability to meet the standard of 90% correct?" (1 = *no, not at all*, 7 = *very optimistic*), and "Do you expect to meet this standard?" (1 = *no, not at all*, 7 = *yes, definitely*). These items have been used in our past research (Silvia et al., 2010, 2011b).

Finally, the timing parameters of the first-name priming were changed slightly: the first name (or random consonant string) was presented for 22 ms (rather than 27 ms in Experiment 1, due to acquiring monitors with faster refresh rates), and first names were presented on 100% of the trials (rather than 67% in Experiment 1, for the sake of replication across varying conditions).

3.2. Results and discussion

3.2.1. Data reduction and analysis strategy—We averaged the four baseline assessments to form baseline scores for SBP (α = .91), DBP (α = .94), and HR (α = .98). Table 3 displays the baseline values. The five task assessments were averaged to form overall task scores for SBP (α = .96), DBP (α = .96), and HR (α = .98). Cardiovascular reactivity was scored by computing difference scores. As before, we examined if the baseline scores covaried with the difference scores. The correlations for SBP ($r(149) = -.27$, $p < .001$), DBP ($r(149) = -.40$, $p < .001$), and HR ($r(149) = -.21$, $p = .010$) were significant, so analyses were conducted using residualized scores (Llabre et al., 1991).

As in Experiment 1, we used regression models to estimate the effects of task difficulty, self-focus, and their interaction. Task difficulty was modeled with a linear contrast (easy = −1, medium = 0, hard = 1), and self-focus was modeled with the same 2 versus 1 contrast used in Experiment 1 (control = −2, name priming = 1, mirror = 1). The contrasts were multiplied to create an interaction term. The analyses were conducted in Mplus 6.1 using maximum likelihood with robust standard errors. All regression weights are unstandardized. The means are displayed in Table 4.

Self-reported expectations of success suggested that the manipulation of task difficulty was successful. People in the easy condition (*M* = 5.78, *SE* = .15, 95% CI = 5.48, 6.07) had significantly more positive expectancies than people in the medium condition (*M* = 5.42, *SE* = .16, 95% CI = 5.10, 5.73), who in turn had significantly more positive expectancies than people in the hard condition (*M* = 4.45, *SE* = .19, 95% CI = 4.06, 4.84).

3.2.2. Cardiovascular reactivity

3.2.2.1. SBP reactivity: For SBP reactivity, there was a significant main effect of the 2 versus 1 contrast, *b* = .64, *SE* = .33, *Z* = 1.93, *p* = .053, a significant main effect of task difficulty, *b* = 1.53, *SE* = .55, *Z* = 2.79, *p* = .005, and a marginal interaction between self-focus and task difficulty, *b* = .57, *SE* = .41, *Z* = 1.41, *p* = .158. The model R^2 was 7.8%. Table 4 shows the pattern of means. Although the interaction between self-focus and task difficulty was not significant, the task difficulty slopes were examined within each self-focus condition to understand the pattern more thoroughly. In the control condition, task difficulty had a non-significant effect on SBP reactivity, *b* = .39, *SE* = 1.03, *Z* = .38, *p* = .703, 95% CI = −1.63 to 2.41. In the self-focus condition, however, task difficulty significantly increased SBP reactivity, *b* = 2.11, *SE* = .65, *Z* = 3.27, *p* = .001, 95% CI = .843 to 3.37. The confidence intervals around the slope in the self-focus condition exclude the slope in the control condition, but not vice versa, consistent with the marginal interaction.

3.2.2.2. DBP reactivity: For DBP reactivity, there was a marginal main effect of the 2 versus 1 contrast, *b* = .49, *SE* = .27, *Z* = 1.80, *p* = .071, a non-significant main effect of task difficulty, *b* = .70, *SE* = .50, *Z* = 1.39, *p* = .16, and a non-significant interaction, *b* = .36, *SE* = .36, *Z* = .99, *p* = .320. The model R^2 was 4.0%. Table 4 shows the pattern of means. As before, we explored the task difficulty slopes within each self-focus condition. Task difficulty had a non-significant effect on DBP reactivity in the control condition, *b* = −.01, *SE* = .88, *Z* = .01, *p* = .990, 95% CI = −1.74 to 1.71, and a marginal effect in the self-focus conditions, *b* = 1.06, *SE* = .61, *Z* = 1.72, *p* = .085, 95% CI = −.15 to 2.26.

3.2.2.3. HR reactivity: For HR reactivity, there was a marginal main effect of the 2 versus 1 contrast, *b* = .46, *SE* = .29, *Z* = 1.57, *p* = .117, a non-significant main effect of task difficulty, *b* = .73, *SE* = .54, *Z* = 1.34, *p* = .181, and a non-significant interaction, *b* = .02, *SE* = .38, *Z* = .04, *p* = .969. The model R^2 was 2.7%. Table 4 shows the pattern of means. Exploring the task difficulty slopes within each self-focus condition revealed non-significant slopes in both the control condition, *b* = .69, *SE* = .91, *Z* = .77, *p* = .443, 95% CI = −1.08 to 2.47, and the self-focus conditions, *b* = .74, *SE* = .68, *Z* = 1.09, *p* = .274, 95% CI = −.58 to 2.06.

3.2.3. Task performance—To examine effects of self-focus and task difficulty on behavioral performance, we examined response times and errors using similar regression models. The descriptive statistics are displayed in Table 4. For response times, there was a significant main effect of self-focus (*b* = 8.82, *SE* = 4.51, *Z* = 1.96, *p* = .050), a significant main effect of task difficulty (*b* = −96.69, *SE* = 8.68, *Z* = 11.14, *p* < .001), and a significant interaction (*b* = −15.34, *SE* = 6.07, *Z* = 2.53, *p* = .011). The model R^2 was 51.0%. The difficulty slopes were significant in both the control condition (*b* = −66.02, *SE* = 14.69, *Z* = 4.49, *p* < .001, 95% CI = −94.82 to 37.22) and the self-focus conditions (*b* = −112.03, *SE* = 10.75, *Z* = 10.42, *p* < .001, 95% CI = −133.10 to −90.96), but the slope in the self-focus conditions was significantly more negative. As Table 4 shows, both self-focus conditions were slower than the control condition when the task was easy. Because the standard was an accuracy standard—get 90% correct—slower responding is consistent with trying to make fewer mistakes.

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For errors, there was a non-significant main effect of self-focus ($b = .69$, $SE = 1.11$, $Z = .62$, $p = .535$), a significant main effect of task difficulty ($b = 15.44$, $SE = 2.08$, $Z = 7.43$, $p < .001$), and a non-significant interaction ($b = -1.49$, $SE = 1.54$, $Z = .97$, $p = .332$). The difficulty slopes were significant in both the control condition ($b = 18.41$, $SE = 3.91$, $Z = 4.70$, $p < .001$, 95% CI = 10.74 to 26.08) and the self-focus conditions ($b = 13.95$, $SE = 2.43$, $Z = 5.75$, $p < .001$, 95% CI = 9.14 to 18.70), but the slopes did not differ from each other.

3.3. Discussion

Experiment 2 found good support for the predicted pattern. For SBP reactivity, our central outcome, there was some evidence for a joint effect of self-focus and task difficulty: the difficulty slope was significant in the self-focus conditions and non-significant in the control condition, but the slopes' confidence intervals were not reciprocally exclusive, consistent with the marginal interaction effect. The findings were specific to SBP reactivity. One performance effect appeared: people in the self-focus conditions were significantly slower when the task was easy. This pattern appeared in a prior experiment that manipulated easy and hard levels of task difficulty (Silvia et al., 2010). Because the task's standard was to be accurate (get 90% of the trials correct), slowing down is an effective way to meet the standard. It is easy to slow down in the easy condition, given the 2500 ms response window, but as the window shrinks it is difficult to slow down and still respond within the allotted time.

4. Experiment 3: within-person effort trends for a fixed-difficulty task

Experiment 3 sought to replicate and extend Experiment 2. On balance, Experiment 2 supported our predictions regarding how implicit and explicit self-focus influence effort-related cardiovascular reactivity during a fixed challenge. Some important effects, however, were only marginally significant, particularly for SBP reactivity, our key outcome. As a result, Experiment 3 was designed to examine the interaction of self-focus and difficulty more closely. Experiment 3 differed in two key respects. First, task difficulty was manipulated within-subjects rather than between subjects. Second, there were two levels of task difficulty: a 750 ms response window and a 500 ms response window. We discarded the easy condition and focused on the higher end of task difficulty—motivational intensity theory would not predict differences for an easy task and no studies to date have found such differences (Gendolla et al., 2008; Silvia et al., 2010, 2011b).

4.1. Participants and design

A total of 47 people enrolled in General Psychology at UNCG participated as part of a research participation option. Four cases were excluded (one person did not understand the d2 task, one person was excluded due to pregnancy, and two cases had equipment or software issues), leaving a final sample of 43 people (26 women, 17 men). Based on self-reported race and ethnicity, the sample was approximately 58% European American, 21% African American, 9% Asian American, and 7% Hispanic or Latino. Age ranged from 18 to 28 ($M = 19.7$, $SD = 2.08$). People were randomly assigned to one of three between-person conditions: control, name priming, or mirror. Task difficulty was manipulated within-subjects (medium, high).

4.2. Cardiovascular assessment

We measured SBP (mmHg), DBP (mmHg), and HR (bpm) using the same equipment (Dinamap 8100) and methods as in Experiment 2. There were four baseline assessments (one every 2 min) and four task assessments (one every minute).

4.3. Procedure

The procedures and task were the same as in Experiment 2, but with a key exception. Task difficulty was manipulated within-subjects. After a baseline period, people completed a 4 min version of the d2 task. They were told that the task would become harder midway through the task, and the software signaled them when the more challenging phase was about to begin. During the first 2 min, the task was fixed at a medium level of difficulty by imposing a response window of 750 ms. During the last 2 min, the task was fixed at a high level of difficulty by imposing a response window of 500 ms. The priming methods and parameters were the same as in Experiment 2.

4.4. Results and discussion

4.4.1. Data reduction and analysis strategy—We averaged the four baseline assessments to form baseline scores for SBP (α = .94), DBP (α = .88), and HR (α = .97). Table 5 displays the baseline values. The medium and high difficulty periods each consisted of two assessments, which were averaged to form scores for SBP (αs = .92 and .93), DBP (αs = .91 and .88), and HR (αs = .94 and .96). The correlations between the cardiovascular baselines and their respective difference scores ranged from $r = -.18$ to $r = -.30$, so each difference score was residualized with regard to its respective baseline value (Llabre et al., 1991).

The data were analyzed using repeated-measures ANOVAs, with self-focus as a between-subjects factor and task difficulty as a within-subjects factor. As in Experiments 1 and 2, we modeled self-focus with a 2 versus 1 contrast (control = −2, name priming = 1, mirror = 1). Table 6 displays the descriptive statistics for all conditions and outcomes.

4.4.2. Cardiovascular reactivity

4.4.2.1. SBP reactivity: For SBP reactivity, there was a significant main effect of self-focus $F(1, 41) = 4.51$, $p = .040$, no main effect of task difficulty, $F < 1$, and no interaction, $F < 1$. As expected, the self-focus conditions significantly increased SBP reactivity for both the medium, $t(41) = 1.99$, $p = .053$, and high levels of difficulty, $t(41) = 2.04$, $p = .048$ (see Table 6).

4.4.2.2. DBP reactivity: For DBP reactivity, there was a significant main effect of self-focus $F(1, 41) = 8.85$, $p = .005$, no main effect of task difficulty, $F < 1$, and no interaction, $F < 1$. The self-focus conditions significantly increased DBP reactivity for both the medium, $t(41) = 2.94$, $p = .005$, and high levels of difficulty, $t(41) = 2.32$, $p = .025$ (see Table 6).

4.4.2.3. HR reactivity: For HR reactivity, there were no significant main effects or interactions, all Fs < 1 (see Table 6).

4.4.3. Task performance—To examine effects of self-focus and task difficulty on behavioral performance, we examined response times and errors using similar repeated-measures ANOVAs. The descriptive statistics are displayed in Table 6. For response times, there was a significant main effect for task difficulty, $F(1, 41) = 503.52$, $p < .001$, no main effect for self-focus ($F < 1$), and no interaction ($F < 1$). Similarly, for errors, there was only a significant main effect for task difficulty, $F(1, 41) = 403.84$, $p < .001$, and no other effects, both Fs < 1. Not surprisingly, the main effects for task difficulty reflect faster response times and more errors when the response window shifted to 500 ms from 750 ms.

4.5. Discussion

Experiment 3 found that implicit and explicit self-focus had similar effects on effort: SBP reactivity was significantly higher at both levels of task difficulty. A similar effect appeared for DBP; no effects appeared for HR. As in Experiment 1, changes in effort were divorced from task performance, which was due solely to task difficulty.

5. General discussion

Focusing attention on the self is central to self-regulation. The present experiments examined how both implicit and explicit self-focus influenced effort regulation. Intersecting Brehm's motivational intensity theory (Brehm and Self, 1989) with self-awareness theory (Duval and Silvia, 2001) yielded predictions about how self-focus would affect effort-related cardiovascular responses. Specifically, self-focus makes success more important, so it should influence the potential motivation parameter in Brehm's model.

The pattern of cardiovascular effects strongly supported the predictions. Both implicit and explicit self-focus increased SBP reactivity for an unfixed task (Experiment 1), consistent with the view that self-focus increases potential motivation (Wright et al., 2002). When difficulty was fixed, both implicit and explicit self-focus increased SBP reactivity as task difficulty increased (Experiments 2 and 3), which again shows that self-focus increases the amount of justifiable effort. DBP reactivity largely paralleled SBP reactivity in the three experiments, which is commonly found in motivational intensity research (e.g., Silvia et al., 2010, 2011a,b) and consistent with sympathetic contributions to DBP. HR reactivity showed no effort-related differences, which is consistent with the literature on motivational intensity.

On the whole, increased effort did not translate into better performance. In Experiment 2, high self-focus predicted slowing down when the task was easy, presumably to meet the accuracy standard of 90%. No effect was found for the harder levels of task difficulty. A prior experiment found this effect, too: people in a mirror condition slowed down for an easy task (Silvia et al., 2010). Beyond this one effect, self-focused attention had no consistent effects on response times or errors in the three experiments. This pattern broadly fits past psychophysiological work on self-focus, which has found either no effects (Gendolla et al., 2008, Experiment 2; Silvia et al., 2011b), mixed effects (Silvia et al., 2011a), or a few isolated effects (Gendolla et al., 2008, Experiment 1). In the motivational intensity literature more generally, some studies find performance effects and others do not. Effort is but one contributor to performance: abilities and task strategies are important as well, and for many tasks trying harder is unlikely to enhance performance. For example, effort probably has a bigger effect on cognitive tasks with a large speed component (e.g., simple matching and cancelation tasks) relative to tasks with a large executive or inhibitory component (e.g., the d2 task). Furthermore, effort's effects on performance can be non-linear and negative. Under conditions of fatigue, stress, and sleep deprivation, for example, people will often mobilize high effort to compensate for deteriorating performance (e.g., Hockey, 1997; Schmidt et al., 2010; Wright and Stewart, 2012).

5.1. Implications for models of self-evaluation

Contemporary theories disagree about the relation between implicit and explicit processes. Theories of self-awareness, which emphasize the generality and versatility of goal comparison processes (Carver and Scheier, 1998; Duval and Silvia, 2001), contend that self-evaluation can be initiated by both implicit and implicit processes. Other models, particularly the dual evaluation model (Dijksterhuis, 2004; Koole et al., 2001), contend that implicit and explicit self-evaluative processes differ qualitatively (e.g., associative versus comparative) and are yoked to different classes of outcomes (e.g., implicit versus explicit self-esteem). The results of the present research are more consistent with theories of self-awareness: implicit and explicit self-focus had similar effects on the self-regulation of effort in response to a performance challenge. This is consistent with the claim that comparing the self to goals is a fundamental self-regulatory process that can be initiated by many things and that can influence behavior across multiple levels (Carver, 2003; Carver and Scheier, 1998). We certainly would not conclude that implicit and explicit self-processes are alike in all respects, but they seem to share an underlying motivational architecture and are thus unlikely to be qualitatively different.

5.2. Implications for implicit processes and effort regulation

The present findings contribute to the growing interest in how implicit processes influence the psychophysiology of effort. Most research on motivational intensity theory examined manipulations that were conscious, explicit, and obvious, such as manipulations of task difficulty, incentives, fatigue, and mood. In recent years, several studies have shown that implicit influences on effort can be understood within Brehm's theory. For example, rapid masked priming of positive and negative faces can influence effort-related physiology by influencing appraisals of task difficulty (Gendolla and Silvestrini, 2011). In other cases, pairing conscious positive words with non-conscious goal primes increases cardiovascular markers of effort (Capa et al., 2011), and primes associated with action versus rest appear to mobilize effort directly (Gendolla and Silvestrini, 2010). The present experiments reveal an implicit influence on potential motivation: masked first-name primes apparently made success more important, leading to higher effort on an unfixed task (Experiment 1) and higher effort as a task become more challenging (Experiments 2 and 3). Brehm's model of motivational intensity was developed prior to psychology's interest in implicit processes, but it appears to be sufficiently general to organize and explain many of the routes by which implicit processes affect the mobilization and withdrawal of effort.

5.3. Limitations and future directions

Future work could build upon the present experiments in several ways. One strength of the present work is that it tested motivational intensity theory's predictions for both fixed and unfixed tasks. At the same time, the task itself—the d2 task—did not vary, and the lack of performance effects suggests that it would fruitful to examine alternative tasks and to clarify when changes in effort correspond to changes in task performance. Moreover, the present studies found reliable effects for SBP reactivity, consistent with much past research (Gendolla and Richter, 2010). SBP has been favored in tests of motivational intensity theory because it reflects beta-adrenergic sympathetic activity. Alternative measures, such as PEP, are more pure markers of sympathetic impact on the heart and offer better temporal resolution (Kelsey, 2012; Richter and Gendolla, 2009). Finally, motivational intensity theory makes predictions about withdrawing effort and disengaging from goals, such as when the difficulty of attaining a goal exceeds the goal's importance (Brehm and Self, 1989). Examining the role of implicit and explicit self-focus in the disengagement of effort awaits future research.

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Table 1

Cardiovascular baseline values: Experiment 1.

	Control	Mirror	Name priming
SBP	118.03 (2.53)	115.98 (2.69)	117.77 (3.73)
DBP	69.92 (2.72)	63.82 (2.43)	66.88 (2.81)
HR	82.08 (3.58)	73.79 (3.52)	84.48 (3.57)

Note: Standard errors are in parentheses. SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate. SBP and DBP are in mmHg; HR is in beats per minute. $n = 14$ in the Control and Name priming conditions; $n = 15$ in the Mirror condition.

Table 2

Effects of self-focused attention on cardiovascular reactivity and task performance: Experiment 1.

	Control	Mirror	Name priming
SBP			
M	−2.26	3.62	2.68
SE	1.85	1.98	1.78
95% CI	−6.26, 1.75	−.63, 7.87	−1.18, 6.53
DBP			
M	−3.20	.88	2.26
SE	1.83	2.33	1.91
95% CI	−7.15, −.74	−4.11, 5.87	−1.86, 6.38
HR			
M	−.45	.23	.20
SE	.75	2.92	.91
95% CI	−2.07, 1.17	−6.03, 6.50	−1.76, 2.16
Response time			
M	625	595	599
SE	22	25	22
95% CI	577, 674	542, 648	552, 648
Errors			
M	6.71	5.67	16.07
SE	1.32	1.29	5.51
95% CI	3.85, 9.57	2.88, 8.45	4.16, 27.98

Note: SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate. SBP and DBP are in mmHg; HR is in beats per minute. n = 14 in the Control and Name priming conditions; n = 15 in the Mirror condition. The means for DBP and HR are baseline-residualized difference scores (see text). Mean response times are rounded to the nearest millisecond.

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Table 3

Cardiovascular baseline values: Experiment 2.

	Control			Mirror			Name priming		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
SBP	119.69 (2.96)	117.43 (2.45)	116.78 (1.79)	119.36 (2.70)	122.08 (2.17)	111.69 (2.31)	120.89 (1.99)	112.88 (2.15)	114.68 (1.78)
DBP	64.91 (2.79)	67.31 (2.23)	65.79 (1.92)	64.81 (2.51)	66.36 (2.47)	61.16 (2.24)	66.62 (1.80)	61.50 (1.67)	60.85 (2.26)
HR	78.96 (2.87)	83.06 (3.08)	80.95 (2.59)	77.00 (3.27)	82.52 (3.15)	79.88 (2.21)	85.72 (2.95)	76.21 (2.37)	79.11 (3.58)

Note: Standard errors are in parentheses. SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate. SBP and DBP are in mmHg; HR is in beats per minute.

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Table 4

Effects of self-focused attention and task difficulty on cardiovascular reactivity and task performance: Experiment 2.

	Control			Mirror			Name priming		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
SBP	−1.40 (1.67)	−1.71 (1.31)	−.61 (1.30)	−1.34 (1.24)	1.85 (1.84)	1.79 (1.44)	−2.11 (1.02)	.83 (1.57)	3.19 (1.56)
DBP	−1.06 (1.51)	−.77 (.94)	−1.09 (.99)	1.15 (.96)	−.59 (1.16)	.50 (1.19)	−2.21 (.98)	1.92 (1.22)	2.57 (1.68)
HR	−1.60 (1.46)	−.87 (1.04)	−.21 (1.16)	−.85 (1.67)	1.98 (1.26)	.69 (1.41)	−.67 (1.30)	1.01 (1.33)	.70 (1.10)
Response time	666(28)	641(13)	533(9)	742(32)	609(16)	534(7)	779(27)	629(16)	544(10)
Errors	.59 (.17)	5.82 (1.93)	37.69 (7.99)	15.01 (.73)	7.44 (3.02)	38.59 (6.65)	2.00 (.97)	4.38 (1.13)	33.07 (6.39)
Sample size	17	17	16	16	16	17	18	17	15

Note: Standard errors are in parentheses. Mean response times are rounded to the nearest millisecond. SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate. SBP and DBP are in mmHg; HR is in beats per minute. Means for SBP, DBP, and HR are baseline-adjusted difference scores.

Table 5

Cardiovascular baseline values: Experiment 3.

	Control	Mirror	Name priming
SBP	117.83 (2.15)	118.11 (3.49)	116.17 (1.95)
DBP	62.27 (1.92)	62.47 (1.85)	62.22 (2.00)
HR	79.23 (2.07)	82.84 (4.40)	85.18 (2.13)

Note: Standard errors are in parentheses. SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate. SBP and DBP are in mmHg; HR is in beats per minute. $n = 15$ in the Control and Name priming conditions; $n = 13$ in the Mirror condition.

Table 6

Effects of self-focused attention and task difficulty on cardiovascular reactivity and task performance: Experiment 3.

	Control		Mirror		Name priming	
	Medium	**High**	**Medium**	**High**	**Medium**	**High**
SBP	−2.45 (1.68)	−2.99 (1.56)	1.75 (1.89)	.62 (2.47)	.92 (1.13)	2.45 (1.59)
DBP	−3.79 (1.11)	−2.71 (1.14)	3.83 (2.44)	2.21 (1.93)	.48 (1.21)	.79 (1.41)
HR	−.62 (.124)	−.49 (1.49)	−.66 (1.29)	−.92 (1.49)	1.19 (2.28)	1.29 (2.21)
Response time	534 (11)	415 (6)	543 (13)	416 (5)	537 (11)	422 (4)
Errors	12.47 (1.87)	61.80 (4.93)	9.92 (2.17)	60.08 (5.69)	10.00 (1.61)	62.67 (5.31)

Note: Between-group standard errors are in parentheses. Mean response times are rounded to the nearest millisecond. SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate. SBP and DBP are in mmHg; HR is in beats per minute. Means for SBP, DBP, and HR are baseline-adjusted difference scores. $n = 15$ in the Control and Name priming conditions; $n = 13$ in the Mirror condition.