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Does General Motivation Energize Financial Reward-Seeking Behavior? Evidence from an Effort Task

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Abstract

We aimed to predict how hard subjects work for financial rewards from their general trait and state reward-motivation. We specifically asked 1) whether individuals high in general trait ''reward responsiveness'' work harder 2) whether task-irrelevant cues can make people work harder, by increasing general motivation. Each trial of our task contained a 1 second *earning interval* in which male subjects earned money for each button press. This was preceded by one of three predictive cues: an erotic picture of a woman, a man, or a geometric figure. We found that individuals high in trait ''reward responsiveness'' worked harder and earned more, irrespective of the predictive cue. Because female predictive cues are more rewarding, we expected them to increase general motivation in our male subjects and invigorate work, but found a more complex pattern.

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Introduction

Several classical psychological theories assume that two basic brain systems motivate behavior: one responds to potential punishment/frustration, the other to potential reward/relief [1,2,3,4]. Despite recent variations to this idea [5], an underlying ''reward system'' is still widely thought to influence individual differences in behavior [6,7,8], neurophysiology [9], and personality [10]. A central property of this ''reward system'' is that it energizes reward-seeking behavior. We therefore measured the energy of reward-seeking behavior in terms of *the rate of work for financial rewards* and aimed to predict this from subjects' trait and state reward motivation. We measured the former with a standard questionaire measure of ''reward responsiveness'' [11].

Regarding the latter, our question was whether incidental cues could increase general motivation, driving subjects to work harder. Previous work has shown that incidental sexual cues alter people's goal-directed choice behavior [12,13,14]. We wondered whether task-irrelevant sexual cues could also influence general motivation to work for seperate financial rewards in a task *without* discrete choices. This question arises from classical empirical work [15] and recent theoretical work [16] which has documented two aspects of motivation. The first type is directed towards achieving a specific goal. The second, less intuitive, aspect is a general level of invigoration: such motivation should non-specifically increase work, even in a task without discrete choices, i.e. not a standard ''decision-making task''.

In our task, subjects main ''choice'' was not between discrete alternatives, but how vigorously to respond with a given, rewarded behavior [16]. Male subjects intermittently had the opportunity to earn money for each button press, approximately 5 US cents per press (0.05 CHF). This opportunity was signaled by predictive cue, which was incidentally a female erotic cue, male erotic cue or abstract shape, see Figure 1a. We have elsewhere shown that female cues are more subjectively rewarding. Here we asked whether they increase work-rate, as would be predicted if they were generally invigorating [15,16]. We further asked whether greater trait reward-responsiveness, as measured by questionaire, would predict greater of interference of incidental reward cues on instrumental responses for money.

Methods

0.1 Experiment

0.1.1 Subjects. The experiment was conducted in a computer laboratory at the University of Zurich. A total of 52 subjects (18–30 years old, all male) were tested in four sessions. The study was approved by the Human Subjects Ethics Committee, Dept. of Economics, Zurich. Subjects provided written consent according to a procedure approved by the Human Subjects Ethics Committee. Subjects were not deceived in any part of this study. Subjects' payments depended on their real performance and choices in the task.

0.1.2 Procedure. Subjects were welcomed into a reception hall. Having been identified and instructed of the ground rules (see below), they were conveyed *en masse* into a separate behavioral lab, where they were each randomly assigned to an isolated computer booth. Subjects could only see their own screen, and communication was prohibited. They were first given written and verbal instructions, as follows.

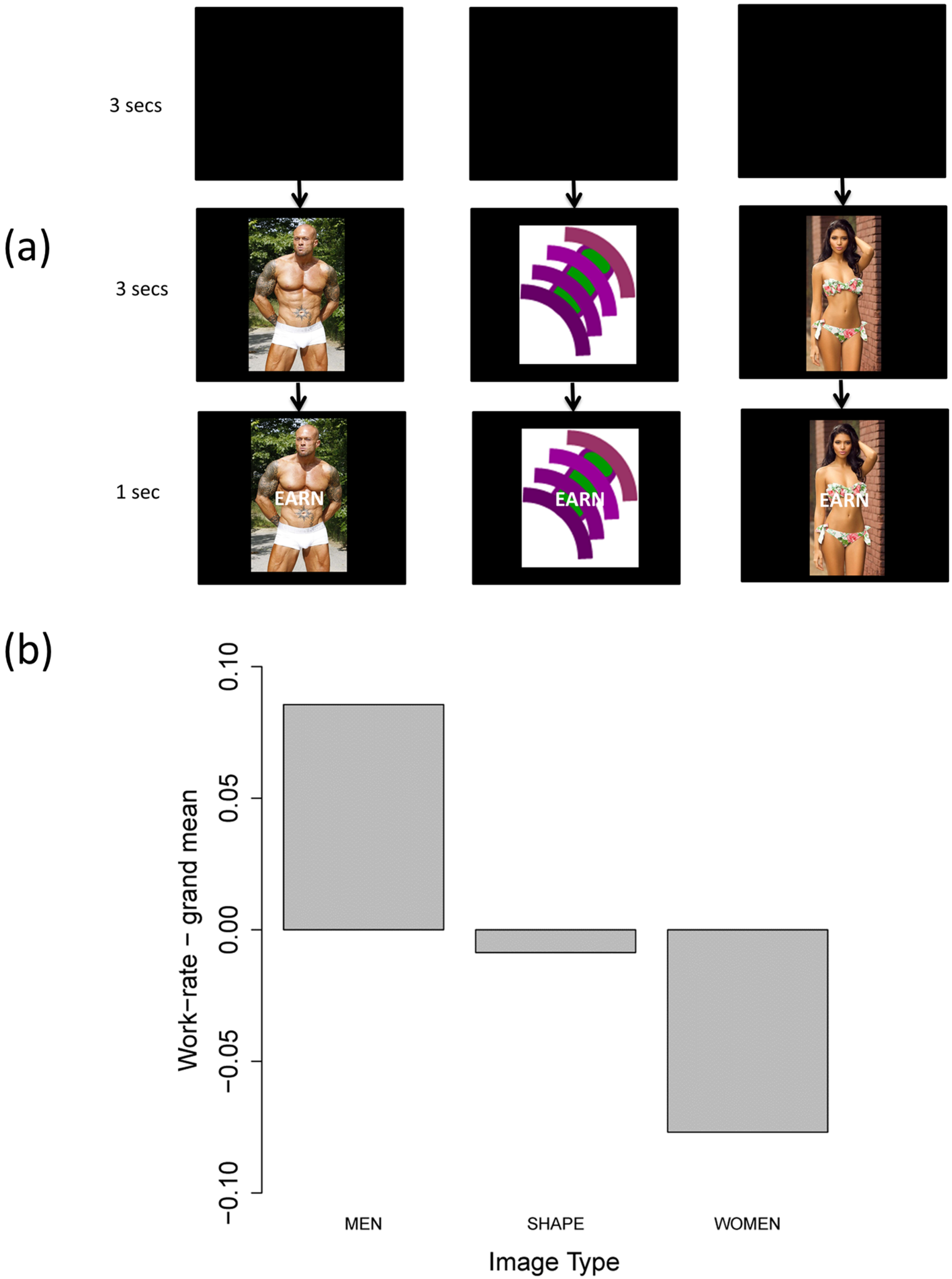
(a)
3 secs
3 secs
1 sec
EARN
EARN
EARN
(b)
Work−rate − grand mean
0.10
0.05
0.00
−0.05
−0.10
MEN
SHAPE
WOMEN
Image Type

Figure 1. Different cue types and how they influenced work-rate. Figure 1a. This gives an example trial for each of the three types of cue: female, male and shape cues. Figure 1b. Work-rate following male, female and shape anticipatory cues, relative to average work-rate. Source: Bbpics, ShareAlike 3.0 Unported, https://commons.wikimedia.org/wiki/File:Male_Model_John_Quinlan_in_Calvin_Klein_Low-Rise_Boxer_Briefs.JPG Source: earthlydelights, Bandeau Bikini adjusted, CC-BY 2.0, https://www.flickr.com/photos/earthlydelights/4423552169/.
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- Whenever you see the word "EARN" on the screen, you can earn 5 centimes simply by pressing the space bar. You can press as often as you want whenever "EARN" is on the screen: you will always earn.
- You will not earn anything for pressing the space bar when the word "EARN" is not on the screen. You will never lose money.
- Try to earn as much money as possible.
- You will see photographs and images on the screen about this task, but these are not relevant to the task and you should ignore them.

The experimenter then left the room.

We independently varied the type of images across trials. There were 3 types of images: 10 MEN, 10 WOMEN and 10 FRACTALS. Pictures of men and women were cropped from head to thigh and featured semi-nude models (in underwear) posing in provocative body postures. Pictures of fractals were abstract, meaningless shapes. To obtain copies of these images, please contact the corresponding author. In previous work, we have shown that male subjects on average find female images more rewarding: they express a preference for viewing female images. Each image was presented four times, giving 120 trials. The order of presentation was randomized across subjects. Each image was presented for exactly 4 seconds per trial. After 3 seconds, the word "EARN" was presented, for exactly 1 second. There was then a inter-trial interval of 3 seconds. Subjects then completed the ARES personality questionnaire [11], before being payed and dismissed.

To characterize subjects self-reported "reward responsiveness", we used a sub-scale from a widely used personality measure, ARES BIS/BAS [11]. Please see Materials S1 for details on reliability of ARES and validity of BAS more generally. In general, this personality questionnaire aims to measure two behavioral systems that are tightly coupled to subjective emotional experience [11]: a behavioral inhibition system (BIS) and a behavioral activation system (BAS). BIS I measures anxiety and BIS II, frustration. BAS I contains questions evaluating the drive behind goal-directed behavior. BAS II measures the responses to reward attainment. We used the short version of the ARES-scales which contains 20 items from [11]. The English version is provided in the Materials S1. BAS I and BAS II resemble "drive" and "reward responsiveness" respectively, in Carver & White's BAS scales [17,18]. This questionnaire does not include a scale corresponding to "fun seeking", which is less straightforward to derive from biobehavioral models of animal reinforcement sensitivity and may relate more to impulsivity [18].

The BAS II subscale quantifies reward responsivity with five items (the final two are scored in reverse). This resembles BAS II – "reward responsiveness" – in Carver & White's BAS scales [17,18]. These five items are…

- Even small things make me really happy.
- I am easily delighted.
- It makes me very happy to achieve a goal I strove for.
- I get rather seldom really excited about something.
- I rarely get excited, even when I get something that I really wanted.

0.1.3 Statistical analysis. Our analysis asked whether work depended on subjects' BAS II "reward responsiveness" R_s (between-subject) and incidental cue type (within-subject). To jointly address these within- and between-subject hypotheses, we used a multilevel, generalized linear mixed model to explain the number of button-presses on each trial. Let Y_{si} be this button-press count on trial i for subject s. Because the earning interval was 1 sec, this is simply the work-rate in hertz. Because Y_{si} takes non-negative integer values, we assume that it follows a Poisson distribution. We captured within-subject variation in work-rate with the linear model $\beta_{0,s}+\beta_{1,s}F+\beta_{2,s}S$. Here F and S are dummy variables which equal 1 on any female or shape trial, respectively, and equal 0 otherwise. Thus $\beta_{0,s}$ reflects the average work-rate of subject s in the presence of male cues. To see this, note that the presence of male cues implies the absence of female/shape cues, i.e. $FEMALE=SHAPE=0$, so the equation above yields $\beta_{0,s}$. In turn, $\beta_{1,s}$ quantifies additive deviations from this (male) baseline due to the presence of female cues. Analogously, $\beta_{2,s}$ represents deviations from this baseline in the presence of shape cues. To quantify between-subject variation in these effects $(\beta_{0,s},\beta_{1,s},\beta_{2,s})$ as a function of "reward responsiveness" R_s, we again used linear regression with the form $\beta_{i,s}=\tau_{i,1}+\tau_{i,2}R_s$. Equation 2 uses standard matrix notation to capture these three, between-subject linear regressions on R_s

$$Y_{si}\sim Poisson(g^{-1}(\beta_{0,s}+\beta_{1,s}F+\beta_{2,s}S))\ t =1,2;\ \ s=1,\ldots,52;\ \ i=1,\ldots,120 \tag{1}$$

$$\begin{pmatrix}\beta_{0,s}\\ \beta_{1,s}\\ \beta_{2,s}\end{pmatrix}\sim Normal\left(\begin{pmatrix}\tau_{11} & \tau_{12}\\ \tau_{21} & \tau_{22}\\ \tau_{31} & \tau_{32}\end{pmatrix}\begin{pmatrix}1\\ R_s\end{pmatrix},\Sigma\right) \tag{2}$$

where $X\sim Normal(\Theta,\Sigma)$ means X follows a multivariate Gaussian distribution governed by mean Θ and variance-covariance matrix Σ, $X\sim Poisson(\mu)$ means X follows a Poisson distribution governed by mean μ and $g(\cdot)=log(\cdot)$ is the 'canonical' link function for the Poisson distribution in the context of generalized linear models. The 'group-level' parameters $\tau_{l,k}$ quantify baseline and differential work-rate *on average in the population* and are therefore the object of statistical inference. The estimated $\tau_{l,k}$ are reported below. This model accommodates subject-wise repeated-measures by affording each subject their own (random) effects [19].

Results

Subjects button-pressed 7.47 times on average during the earning interval. Statistical inference is based on Equations 1,2. In particular, parameters $\tau_{12},\tau_{22},\tau_{32}$ respectively quantify how well reward responsiveness R predicts baseline work-rate – in the presence of male cues – and the effect of female and shape cues (relative to male cues). This analysis revealed that self-reported

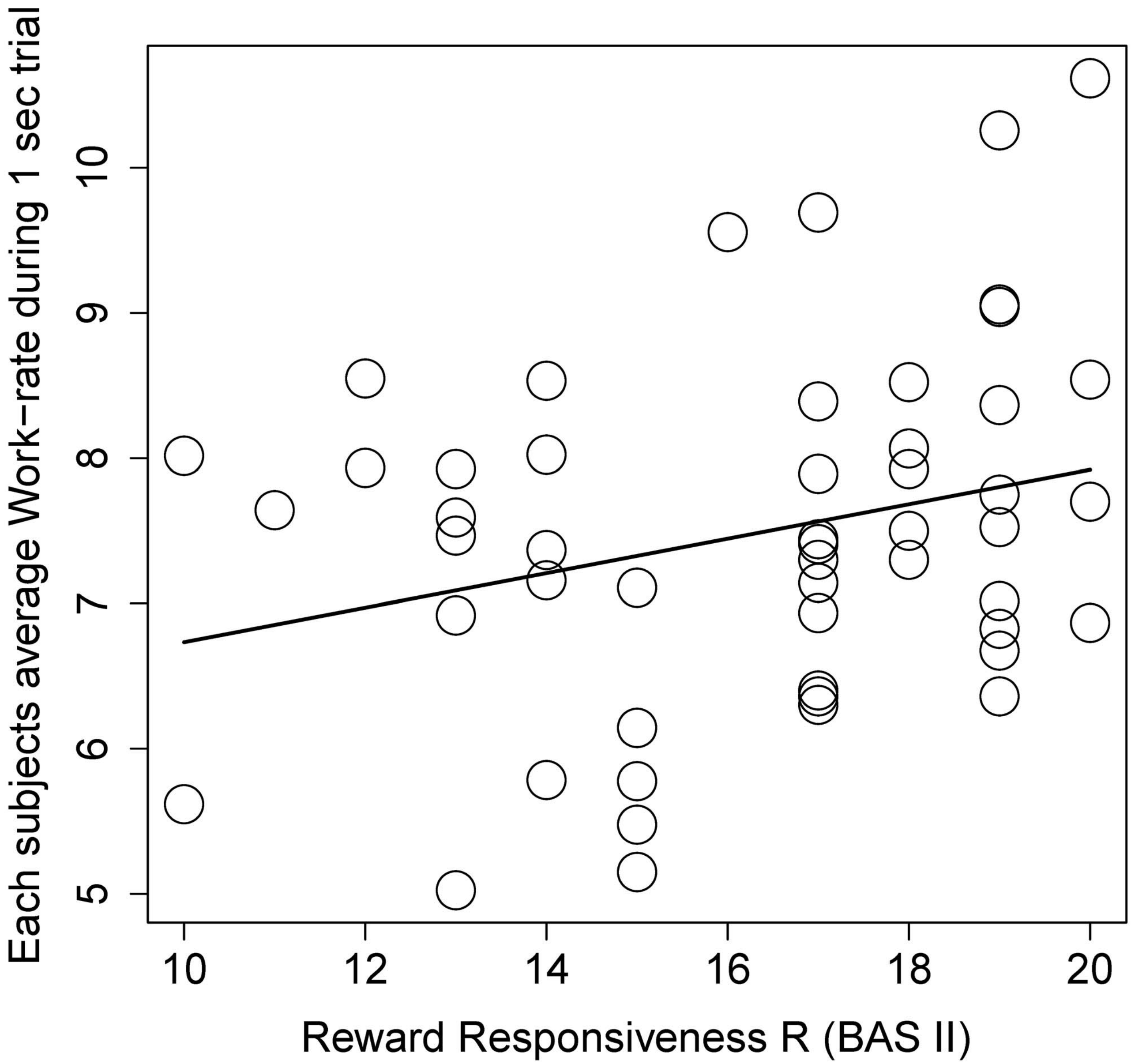

Figure 2. This scatter plot gives the relationship between self-reported reward responsiveness (BAS II) and work-rate, i.e. the number of button presses per one second earning interval.
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"reward responsiveness" significantly predicted higher baseline work-rate ($p=0.04$, $\hat{\tau}_{12}=0.04$, $n=52$), but not their differential work-rate faced with different cues.

Our second question was whether cue-type affected work-rate, independently of subjects' personality. This is quantified by the remaining three parameters, $\tau_{11},\tau_{21},\tau_{31}$. Figure 1 shows how work-rate differed following the presentation of male, female, and shape cues on average over all subjects. By hypothesis (see the introduction), female cues are more invigorating and our subjects should work harder in their presence. In contrast, we observed a statistically significant reduction in work-rate following female cues relative to male cues ($p=0.04$, $\hat{\tau}_{21}=-0.023$, $n=52$). To ask whether work-rate differed between female and shape cues, we simply redefined the baseline condition in Equation 1 to be "shape cues" and re-estimated this model. This revealed no significant difference between work-rate under female-cue versus shape-cue baseline, nor between work-rate under male-cue versus shape-cue baseline.

Because our task and hypotheses directly relate to behavioral reward responsivity, i.e. the tendency for immediate consumable rewards to invigorate behavior, we have focused on BAS II, which operationalizes self-reported reward responsivity. For completeness, we also report post-hoc analysis for the other three sub-scales, BAS I, BIS I, and BIS II. In particular, we re-estimated the model specified in Equations 1,2 three more times, each time replacing the BAS II (R_s) with one of the other sub-scales: BAS I, BIS I, and BIS II. As before, we found a lower work-rate in the presence of female versus male pictures at the 0.05 significance level in every analysis. Also as before, these sub-scales did not predict the effect of erotic reward cues on work-rate at the 0.05 significance level. In contrast to BAS II, BIS I (anxiety) predicted significantly lower baseline work-rate ($p = 0.0178$). There was a similar trend for BIS II ($p = 0.0684$), but no observable effect of BAS II ($p = 0.691$).

Discussion

We found that subjects with higher self-reported "reward responsiveness" worked harder for money at baseline, but incidental reward cues did not have a greater influence on their work rate. We expected female erotic reward cues to increase work but found that subjects worked about the same under these cues and shape cues: they actually worked less hard under female cues than male cues. This suggests that sexual cues might sometimes have an arresting rather than invigorating action. This is puzzling from the perspective of theories of general motivation or drive [15,16] or the notion that reward cues might cause a greater urgency to consume anything rewarding [12].

If our effect is indeed attributable to the greater reward value of female cues, it may relate to other literature on reward-dependent performance impairments [20]. This work has proposed various psychological mechanisms to explain the apparent paradox that high reward-motivation can sometimes compromise performance. Most obviously, conscious attention to rewards is thought to disrupt the automatic or overlearned nature of the execution. In classical psychology, "Yerkes-Dodson law" states that either increasing or decreasing motivation beyond an optimal level can compromise learning and performance by affecting arousal [21]. Work from behavioral economics shows that a simple increase in financial incentives can compromise subjects' performance in diverse tasks, including motor learning and cognitive skill [22]. Yet it is important to recall that our task purposefully measured vigor in the absence of such learning or cognitive/executive skill. It remains possible that the lower work-rate on female trials reflected reward-dependent slowing of reaction time [23], meaning that there was less of the one second earning interval left to exploit. Future work should collect specific RTs to explore test this possibility. It is feasible that female images are more salient or distracting, and that this somehow property interferes with subjects' motor response during the effort task, reducing their work-rate. It would be a true testimony to the salience of these images if they could impair performance in a task as cognitively undemanding as ours. Alternatively, the difference that we observed between work-rate under male versus female cues, might reflect a specific motivating feature of *male* cues, either because these muscular images prime exertion or competitiveness. These possibilities should be addressed in future work.

Interestingly, in post-hoc analysis we found that BIS I (anxiety) predicted significantly lower baseline work-rate. We can speculate that anxious subjects were more reluctant to draw attention to themselves by audibly striking the space bar for money and/or were more concerned about damaging the keypad.

We now discuss specific features of our task which might limit the generality of our conclusions. First, as Figure 2 illustrates, our task produced relatively low variability in the dependent measure (work-rate), which plausibly reduced statistical power to detect between-trial/subject effects. In retrospect, we believe that a longer "earning interval" might increase this variability, thereby helping us to separate highly motivated conditions/subjects from less motivated conditions/subjects. Second, it is possible that cross-trial generalization effects may obscure trial-specific motivational effects, thereby also reducing our statistical sensitivity. For example, it is possible that images have a temporally sustained impact on behavioral vigor that can obscure trial-by-trial dynamics of vigor [24,25,16]. As one reviewer pointed out, this latter possibility might be assessed with an additional between-subject experimental factor, in which subjects perform our effort task in the absence of any cues. This would address two interesting questions: 1) do images affect performance at a contextual level (across trials) and 2) do non-instrumental, contextual motivates differentially based on trait measures like BAS?

Our main result is that self-reported reward-responsiveness predicts the vigor with which subjects pursue instrumental rewards. Paradigms such as ours may have utility in the study of psychiatrically disordered motivation. For example, clinically depressed subjects show substantial impairments in cognitive and motor tasks that require sustained effort [26]. Our task provides one way to assess whether such effects derive from generalized anhedonia or impaired reward responsiveness [27].

Supporting Information

Materials S1
(PDF)

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Author Contributions

Conceived and designed the experiments: JC. Performed the experiments: JC. Analyzed the data: JC. Contributed reagents/materials/analysis tools: EF. Wrote the paper: JC.

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