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ORIGINAL ARTICLE

Induced affective states do not modulate effort avoidance

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Abstract

Recent research reveals that when faced with alternative lines of action, humans tend to choose the less cognitively demanding one, suggesting that cognitive control is intrinsically registered as costly. This idea is further supported by studies showing that the exertion of cognitive control evokes negative affective states. Despite extensive evidence for mood-induced modulations on control abilities, the impact of affective states on the avoidance of cognitive demand is still unknown. Across two well-powered experiments, we tested the hypothesis that negative affective states would increase the avoidance of cognitively demanding tasks. Contrary to our expectations, induced affective states did not modulate the avoidance of demand, despite having an effect on task performance and subjective experience. Altogether, our results indicate that there are limits to the effect of affective signals on cognitive control and that such interaction might depend on specific affective and control settings.

Introduction

Cognitive control allows humans to adjust their behavior to achieve current and long-term goals while overriding competing, perhaps preponderant, lines of action. This cognitive ability is particularly relevant when we have to perform an unpleasant or difficult cognitive task in the face of less demanding options that might provide immediate extrinsic and/or intrinsic rewards. Consider, for instance, the case of a student who has to decide to either study for an upcoming test or binge watch a favorite TV show. In such situations, the costs and benefits of each option must be compared and, potentially, the rewards of the unpleasant task might outweigh the incentives of less demanding ones (Westbrook & Braver, 2015).

In the absence of strong incentives, lines of action are primarily selected to minimize physical (Hull, 1943) and/or mental effort (Kool, McGuire, Rosen, & Botvinick, 2010). One prominent paradigm employed to measure cognitive effort avoidance was developed by Kool and colleagues (2010). In their demand selection task (DST), participants must choose between two decks of cards on every trial. Importantly, each deck is associated with high or low cognitive demand, manipulated in task settings that require high or low levels of cognitive control. For instance, the high control deck would demand frequent switches between two tasks (parity vs. magnitude judgments), while the low demand deck consists mostly of task repetitions. In such context, participants consistently tend to choose the less cognitively demanding deck (Kool et al., 2010), although some variables and individual differences can counteract this tendency (see below). Other studies have led to similar conclusions using related paradigms (Desender, Calderon, Van Opstal, & Van den Bussche, 2017; Gold et al., 2015; Schouppe, Demanet, Boehler, Ridderinkhof, & Notebaert, 2014). The results of these different investigations converge on the idea that avoidance of cognitive demand is a consistent and robust tendency in humans (Kool et al., 2010).

When trying to understand such avoidance, one common consideration is that cognitive control, as required in situations of cognitive conflict, is registered as aversive (Botvinick & Cohen, 2014). Therefore, if people can choose between two different cognitive tasks, the aversive outcomes

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of the high demand task can be a discouraging factor pushing towards effort avoidance. Recent evidence supports this view by showing that effort avoidance can be modulated. For instance, people tend to choose more demanding tasks if they entail external incentives (Kool et al., 2010; Westbrook & Braver, 2015). Moreover, personality traits, such as Need for Cognition, which reflects the likelihood of engaging in cognitively demanding activities as well as the pleasure associated with such activities, modulates the strength of avoidance patterns (Kool et al., 2010). Specifically, higher scores in Need for Cognition often correlate with less avoidance of demand in the DST. These results suggest that effort avoidance depends not only on task demands but also on a series of modulating factors. Crucial to the goal of the present study, the described impact of (internal and external) incentives in effort avoidance hints at a potentially important role of the current affective state in such situations.

The relationship between cognitive control and affective signals has been largely discussed in the literature (Okon-Singer, Hendler, Pessoa, & Shackman, 2015; Pessoa, 2009). On the one hand, cognitively demanding situations can influence the evaluation of affective content (Braem, King, Korb, Krebs, Notebaert & Egner 2017b; Dreisbach & Fischer, 2015; Fritz & Dreisbach, 2013). For example, Braem, De Houwer, Demanet, Yuen, Kalisch & Brass (2017a) found that the Anterior Cingulate Cortex (ACC) responded differently to emotional pictures depending on the congruency of the previous trial, revealing lower ACC activation for negative pictures when the previous trial in a cognitive task (either a conflict or task-switching condition) was incongruent. This study thus suggested that demanding cognitive situations induce negative affect that primes subsequent stimuli processing. In parallel, several studies indicate that control can be modulated by our affective state, or that control can be understood as an emotional process by itself (Inzlicht, Bartholow, & Hirsh, 2015). For instance, task switching abilities are impacted by the presentation of images with affective content (Demanet, Liefooghe, & Verbruggen, 2011), and task switching primes are evaluated as more negative than task repetition primes (Vermeylen, Braem, & Notebaert, 2019).

Still, although results strongly suggest a tight relationship between cognitive control and affective processing, the effect of current affective states on cognitive effort avoidance remains unknown. Previous research has proposed that cognitive demand is inherently registered as aversive and that precisely this negative experience and not conflict itself might serve as a down-regulatory mechanism of aversive signals (Dreisbach & Fischer, 2012, 2015). Moreover, such conflict registration is facilitated by motivational states that are congruent with the inherent negative valence of conflict (Botvinick, 2007), as suggested by the observation that negative affective states facilitate adaptations to cognitive conflicts (van Steenbergen, Band, & Hommel, 2010). Last, there is previous evidence that actions resulting in a high level of cognitive demand are preceded by an anticipatory skin conductance response, supporting the aversive tagging of cognitively effortful actions (Botvinick & Rosen, 2009). Under this account, we hypothesized that induced negative states would amplify the aversive registration of control and trigger a faster adjustment to task demands, enhancing in turn effort avoidance. In contrast, positive affective states incongruent with the aversive tagging of cognitive demand would reduce effort avoidance.

To address this question, we combined a DST paradigm with the induction of negative and positive affective states (via pictures with affective content) to investigate whether these modulated the pattern of demand avoidance. Based on the idea that cognitive control is usually registered as costly, we hypothesized that avoidance would be enhanced by a maintained negative mood, increasing the selection of low demand decks under this affective state, compared to positive and neutral states. Furthermore, we evaluated whether affective states impacted performance and self-reported subjective experience of the task. Last, we assessed the role of personality traits, task-switching abilities and awareness of the manipulation in the interaction of emotion with demand selection. Contrary to our predictions, the results of the two experiments show that whereas induced affective states impacted task performance and the subjective experience of participants, effort avoidance patterns remained unaltered.

Experiment 1

Methods

Participants

A sample of 72 undergraduate students (59 female, mean age = 19.31, SD = 2.11), with normal or corrected-to-normal vision from the University of Granada participated in exchange for course credits. All participants were native Spanish speakers. This sample size was estimated a priori (PANGEA; https://jakewestfall.shinyapps.io/pangea/) to detect a small effect size (0.20) with a power of 0.80 using six repeated measurements (three affective conditions [positive, negative and neutral] and two levels of task difficulty [high demand, low demand]). Participants signed a consent form before participating in the study, which was carried out in accordance with the Declaration of Helsinki and was approved by the local Ethics Committee. All data and materials from the experiment are available at https://osf.io/nesc8/.

Affective stimuli

A total of 63 images [21 positive (e.g. kids playing or landscapes), 21 negative (e.g. attacks or wars), and 21 neutral (e.g. household utensils)] were extracted from the International Affective Picture System (IAPS) database (Lang, Bradley, & Cuthbert, 1997) validated by Moltó et al. for the Spanish population (1999). Two additional neutral images were used for the practice session. Pictures were selected according to their scores in valence and arousal dimensions as follows: (1) Positive [valence = 7.46, SD = 1.64; arousal = 6.18, SD = 2.20]; (2) Negative [valence = 2.13, SD = 1.38; arousal = 5.89, *SD* = 2.11]; (3) Neutral [valence = 4.54, SD = 1.30; arousal = 3.78, SD = 1.92]. Post-hoc Bonferroni analyses showed that all affective sets differed in valence (all $ps < 0.001$). In addition, whereas positive and negative sets did not differ in terms of arousal ($p = 0.51$), they differed in this scale when compared with the neutral condition (both $ps < 0.001$).

Scales

- The Scale for Mood Assessment (Escala de Valoración de Estado de Ánimo [EVEA]; Sanz, 2001; Sanz, Gutiérrez, & García-Vera, 2014) evaluates four self-referenced affective factors on a Likert scale ranging from 0 ("nothing") to 10 ("very much") with four items each: joy (e.g. "I feel optimistic"), anxiety (e.g. "I feel nervous"), hostility (e.g. "I feel angry"), and depression (e.g. "I feel sad"). In the present study, the EVEA was administered four times (see below).
- Self-Assessment Manikins (SAM; Bradley & Lang, 1994). This self-report instrument evaluates affective experiences in valence and arousal dimensions through continuums composed of five figures and four points located between them. In the valence dimension, figures fluctuated from a happy (9) to a sad person (1). In the arousal dimension, pictures oscillated between a stressed (9) and a relaxed picture (1). As with the EVEA questionnaire, this instrument was administered four times (see below).
- Need for Cognition questionnaire (NFC; Cacioppo, Petty, & Feng Kao, 1984). This self-report assesses the tendency to engage in and enjoy tasks and situations that require high thinking abilities (e.g. "I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought") through 18 items on a Likert scale from 1 ("extremely uncharacteristic") to 5 ("extremely characteristic").
- Self-Control Scale (SCS; Tangney, Baumeister, & Boone, 2004). This is a 36-item instrument to evaluate individual differences in self-control (e.g. "I never allow myself to lose control") on a Likert scale ranging from 1 ("not at all") to 5 ("very much").
- Subjective effort and fun scales. We introduced two sliding scales with which participants could answer to the questions "How much mental effort did you experience performing the tasks associated with this cue?" for a subjective effort variable, and "How much fun did you find the tasks associated with this cue to be?" for a subjective fun variable. The sliding scales were 200 pixels long and the middle pixel was assigned a value of 0. Any pixel to the left of 0 was assigned negative values [− 1 to − 100] and pixels to the right of zero were assigned positive values [+ 1 to + 100]. These scales had shown to be sensitive to cognitive demand manipulations in unpublished pilot data.

Procedure

The study was individually carried out in a weakly illuminated and soundproof room. All tasks and questionnaires were presented to participants in Matlab, using the Psychtoolbox Toolbox extensions (Kleiner, Brainard, & Pelli, 2007).

To obtain an independent measure of task-switching abilities, participants first performed a preliminary task-switching block (126 trials; Kool et al., 2010). At the beginning of each trial, a number (from one to nine, excluding five) appeared in a circle centered on the screen. This number could be colored in blue or yellow, indicating whether a parity or a magnitude evaluation of the number should be performed. In the magnitude task, participants had to report whether the number was lower or higher than five, while the parity task required participants to report whether the number was odd or even. In both cases, participants used the left and right buttons of the mouse to respond. They were instructed to perform the task as fast and as accurately as possible. Response mappings were counterbalanced across participants.

After the preliminary task-switching block and before the main task, participants filled the EVEA and SAM questionnaires. Then, they performed the main task of the study, which resembled Experiment 5 of Kool et al., (2010). On each trial, two cues appeared on the screen in a random position within the perimeter of an imaginary circle and separated 45 degrees from each other. To make cues distinguishable, they were surrounded by a different colored border. The position and color of the cues remained fixed during each block but changed across blocks over the course of the whole experiment, mimicking the procedure in Kool et al., (2010). In each trial, participants were told to freely choose

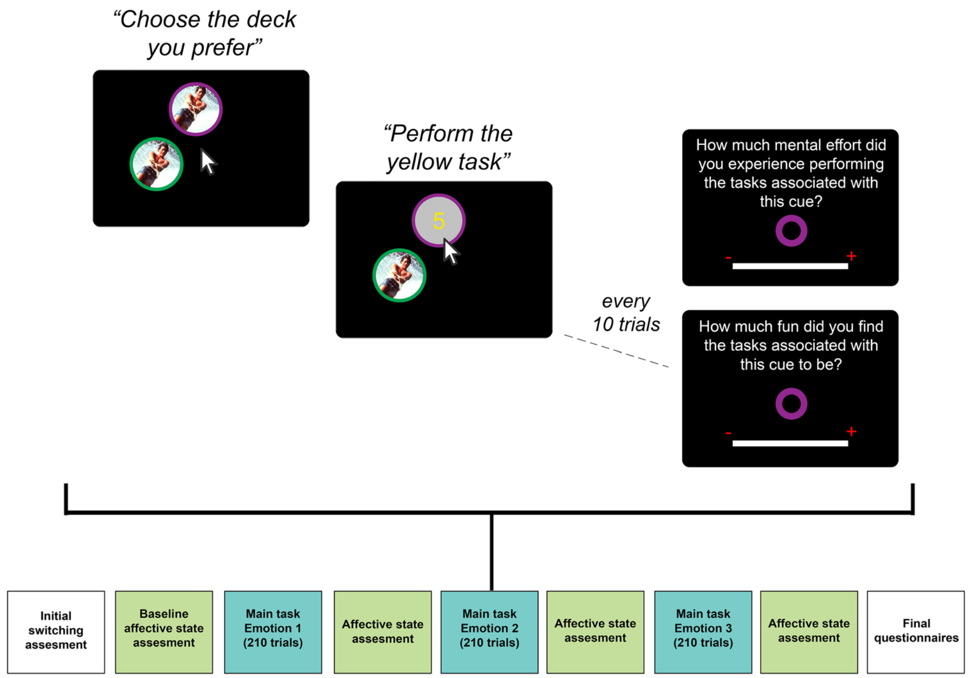

Fig. 1 General flow of events and trial procedure in "Experiment 1". Before and after each block of the main task, the affective state of the participants was assessed. In the main task, at the beginning of each trial, participants were presented with two cues that contained an affectively tagged image (same image in both decks). They were instructed to choose of the two decks by hovering the mouse over it. This revealed a number that could be painted in blue or yellow, asking participants to perform either a parity or a magnitude judgment. After ten trials, participants had to answer with a sliding scale to two questions about each deck (one regarding subjective effort, another regarding subjective fun)

one of the cues by hovering the mouse cursor over it, which revealed a number. The mouse course was locked as soon as it hovered over one of the cues, and thus participants were not able to switch back and forth before the two cues before making a choice. Participants then had to perform the previously described magnitude-parity task with the revealed number, depending on its color (see Fig. 1). The selection of the cue and the response to the number were self-paced, but participants were instructed to respond as fast and as accurately as possible. In every block, one of the cues was associated with high switching probability (i.e. a different task in the current trial compared to the previous one with a probability of 90%; high-demand condition), while in the other cue, tasks switched with a probability of 10% (low-demand condition). After responding to the number, both cues disappeared and the cursor moved back to the center of the screen, ensuring that participants started each trial with the cursor equidistant from the two cues.

Critically, both cues contained the same image, which could be positive, negative or neutral. This was done to ensure that any potential effect of affective state was due to the overall internal mood rather than the contextual affective tagging of each cue (Dreisbach, Reindl, & Fischer, 2018). Participants were told that the aim of the photographs was to hide the target before hovering over one of the cues. The affective condition was blocked (three consecutive blocks of the same affective content), with each block containing seven images. The same picture was presented in both cues during ten consecutive trials. After these ten trials, two sliding scales prompted participants to rate their subjective effort and fun associated with each cue. In total, participants performed nine blocks (three for each affective condition) of 70 trials each, resulting in a total of 630 trials. The order of the affective blocks, as well as the response mappings, were counterbalanced across participants. Furthermore, to compare the affective state of participants during the main task, they completed EVEA and SAM self-reports after each affective manipulation (after each of the three blocks). After the main task, NFC and SCS questionnaires were administered. Participants were allowed to take short breaks between each block and before the administration of the NFC and SCS. The whole session lasted approximately 60 min.

Design

A within-participant factorial design was employed: 3 (Affective Condition; Positive vs. Negative vs. Neutral) × 2 (Demand; High vs. Low). Reaction Times (RT), which were divided into Decision RT and Task RT (see below), and accuracy were used as dependent variables. To assess the effectiveness of the affective induction, we performed an ANOVA with one factor (Affective Condition; Positive vs. Negative vs. Neutral) and used SAM (valence and arousal scores) and EVEA (joy, anxiety, hostility and depression subscales) scores as dependent variables.

The analysis plan was as follows: (1) First, to check the effectiveness of the affective manipulation, repeated measures ANOVAs were carried out for each dependent measure of the affective questionnaires. (2) The overall cue selection was first assessed with a paired Wilcoxon test against 50 (chance level); (3) the effect of Affective Condition on Selection was assessed through repeated measures ANOVAs. (4)

Table 1 Mean (M) and Standard Deviation (SD) of the effect of moods on variables of "Experiment 1"

Measure	Positive mood		Negative mood		Neutral mood	
	M	SD	*M*	SD	*M*	SD
Fear/anxiety	2.36	2.28	3.19	2.68	2.68	2.44
Anger	1.31	2.08	4.12	1.83	1.49	2.12
Sadness	1.59	1.7	2.15	2.25	1.65	1.76
Joy	4.59	2.22	4.11	2.36	4.28	2.32
Valence	5.77	1.77	5.01	1.92	5.58	1.74
Arousal	5.26	2.15	4.53	2.1	4.87	2.14
Low-demand selection (%)	53	16	52	17	52	19
Decision RTs (ms)	476	134	515	190	492	66
Task RTs (ms)	1098	286	1154	353	1091	294
Task accuracy	0.95	0.04	0.95	0.04	0.95	0.04
Subjective effort	−38.8	39.07	−39.06	40.2	−40.8	39.1
Perceived fun	−27.5	48.6	−43.28	44	−32.9	44

RT and accuracy data from the main selection task were analyzed depending on the Affective Condition and Demand. (5) Repeated measures ANOVAs were performed to assess participants' subjective experience of effort and fun. (6) Correlations were performed to assess potential modulations of selection by cognitive and personality traits.

Results

Descriptive statistics of all dependent variables across affective states are described in Table 1 (see Supplementary Table 1 to see descriptive statistics separately for task-repetition and task-switch trials).

Manipulation check–affective measures

Repeated-measures ANOVAs revealed significant changes in the affective state of participants during the different blocks of the task. The Fear/Anxiety scale of EVEA showed a significant effect of the Affective condition ($F_{142,2}=9.24$, $p<0.001$, $\eta^2_p=0.12$), with higher values of fear/anxiety after negative ($M=3.19$, SD = 2.68) than after positive blocks ($M=2.36$, SD = 2.28; $p<0.001$), and intermediate values after neutral blocks ($M=2.68$, SD = 2.44; not differing from negative nor positive, all $ps>0.06$). Similar patterns were found for Anger ($F_{142,2}=6.11$, $p<0.001$, $\eta^2_p=0.08$) and Sadness ($F_{142,2}=8.42$, $p<0.001$, $\eta^2_p=0.1$) scales. This pattern was reversed for the Joy scale ($F_{142,2}=4.47$, $p<0.01$, $\eta^2_p=0.06$), which showed higher values after positive ($M=4.59$, SD = 2.22) than after negative blocks ($M=4.11$, SD = 2.36; $p<0.01$). Moreover, the Valence scale of the SAM (Supplementary Fig. 1) revealed a significant effect of the affective manipulation ($F_{142,2}=7.09$, $p<0.001$, $\eta^2_p=0.09$), with higher valence after positive ($M=5.77$, SD = 1.77) than after negative blocks ($M=5.01$, SD = 1.92; $p<0.01$). The affective effect on the Arousal scale was also significant ($F_{142,2}=5.38$, $p<0.01$, $\eta^2_p=0.07$), revealing higher arousal after positive ($M=5.26$, SD = 2.15) than negative blocks ($M=4.53$, SD = 2.1; $p=0.005$).

Main task

The analysis of Cue selection (Wilcoxon test, since scores significantly deviated from normality, $p<0.001$) revealed an overall preference for the Low Demand cue (53%; $W_{71,1}=869$, $p=0.01$, effect size [matched rank biserial correlation] = 0.34). However, this preference was not modulated by the affective condition ($F<1$; see Fig. 2). To determine the reliability of this non-significant finding, we performed a Bayesian ANOVA with Affective condition as

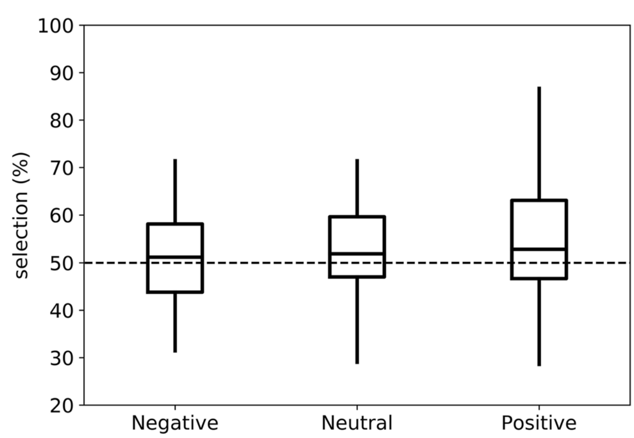

Fig. 2 Selection scores in "Experiment 1", for each affective state. The thick line inside box plots depicts the second quartile (median) of the distribution. The bounds of the boxes depict the first and third quartiles of the distribution. Whiskers denote the 1.5 interquartile range of the lower and upper quartile. The dashed line denotes chance level

a factor (using the methodology proposed in Rouder, Morey, Speckman, & Province, 2012). The BF_{01} (evidence in favor of H_0 against evidence for H_1) for the effect of Affective condition was 16.39. This constitutes strong evidence for the null hypothesis (Jeffreys, 1998) that the affective state did not modulate selection patterns. Given that we manipulated affect within participants, one could argue that the impact of the affective induction could be reduced over the course of the experiment and, therefore, that any potential differences between affective states might wash out after the initial blocks of the task. To explore this possibility, we performed an additional ANOVA to test if the selection of Low and High demand cues in the first three blocks was modulated by the affective state (in this analysis thus working as a between-subject factor). The results of this ANOVA revealed that the effect of Demand in the first three blocks was not modulated by the Affective state factor ($F<1$, $BF_{01}=8.34$). Last, we explored if demand selection was influenced by trial history. We observed that participants overall tended to pick the same cue as in the previous trial ($M=79\%$, $SD=21\%$; significantly higher than chance level: $t_{71}=11.83$, $p<0.001$, Cohen's $d=1.4$), regardless of whether this was a task switch or a task repetition trial ($F_{71,1}=1.95$, $p=0.17$), and this was not modulated by the affective state ($F_{142,2}=1.19$, $p=0.31$). Similarly, cue selection was not modulated by the congruency of the previous trial ($F<1$) nor its interaction with the affective state ($F_{142,2}=1.7$, $p=1.18$).

Regarding task performance, a repeated-measures ANOVA revealed a main effect of Demand on decision RTs (i.e. time between cues onset and hovering over one of them; $F_{66,1}=6.36$, $p<0.02$, $\eta^2_p=0.09$; Supplementary Fig. 2), with longer RTs when choosing the High ($M=508.33$ ms, $SD=185.33$ ms) compared to the Low Demand condition ($M=479.67$ ms, $SD=127.67$ ms). Despite the absence of a main effect of Affective Condition ($F_{132,2}=1.81$, $p=0.17$; $BF_{01}=2.78$), the Demand x Affective Condition interaction was significant ($F_{132,2}=3.46$, $p<0.04$, $\eta^2_p=0.05$), revealing a difference between High ($M=548$ ms, $SD=254$ ms) and Low Demand ($M=482$ ms, $SD=125$ ms) only during Negative blocks ($F_{66,1}=6.77$, $p=0.011$), but not during Neutral ($F=2.43$, $p=0.12$) nor Positive blocks ($F<1$).

Regarding Task RTs (i.e. time between hovering over one of the cues and responding to the number), a repeated-measures ANOVA yielded again a main effect of Demand ($F_{66,1}=51.14$, $p<0.001$, $\eta^2_p=0.44$; Supplementary Fig. 3), with longer RTs in the High ($M=1203$ ms, $SD=353$ ms) compared to the Low Demand condition ($M=1025$ ms, $SD=268.66$ ms). The main effect of Affective Condition was also significant ($F_{132,2}=3.56$, $p<0.04$, $\eta^2_p=0.05$), revealing longer RTs during the negative blocks ($M=1154$ ms, $SD=353$ ms) compared to neutral ($M=1090.5$ ms, $SD=293.5$ ms; $p=0.025$) and positive blocks ($M=1097.5$ ms, $SD=286$ ms; $p=0.039$).

In addition, we performed another ANOVA to assess whether Demand and Affective State had an effect on switch costs (RTs of task switches – RTs of task repetitions). As expected for a context with a low switch probability, switch costs were significantly larger in the Low Demand condition ($M=330.34$ ms, $SD=591.68$ ms) than in the High Demand one ($M=42.3$ ms, $SD=522.67$ ms; $F_{63,1}=17.19$, $p<0.001$, $\eta^2_p=0.21$). Neither the Affective State factor nor its interaction with Demand modulated switch costs (all Fs < 1).

Regarding accuracy scores, we found a clear effect of Demand ($F_{66,1}=33.49$, $p<0.001$, $\eta^2_p=0.34$), with more accurate responses in the Low ($M=0.96$, $SD=0.02$) than in the High Demand condition ($M=0.94$, $SD=0.04$). Neither the affective state ($F<1$) nor its interaction with Demand ($F_{132,2}=1.36$, $p=0.26$) were significant. A Bayesian ANOVA provided support for the null effect of the affective condition and its interaction with the demand (all $BFs_{01}>3$).

Finally, a repeated-measures ANOVA on the subjective effort scores with Affective Condition and Demand as factors, revealed a significant effect of Demand ($F_{71,1}=7.31$, $p=0.07$, $\eta^2_p=0.045$), with higher effort perceived for High ($M=-37$, $SD=40$) than for Low Demand cues ($M=-41$, $SD=39$). In contrast, the main effect of Affective Condition, and its interaction with the Demand factor were not significant (Fs < 1; $BFs_{01}>3$). Last, the same ANOVA with the Perceived Fun scores showed that the affective state influenced participants' subjective experience of the task. This analysis revealed main effects of Affective Condition ($F_{142,2}=10.31$, $p<0.001$, $\eta^2_p=0.13$), with higher perceived fun after positive ($M=-24.48$, $SD=48.52$) and neutral ($M=-33$, $SD=44$) than after negative blocks ($M=-43.28$, $SD=44$, all ps < 0.005). In addition, there was a main effect of Demand ($F_{71,1}=7.13$, $p=0.009$, $\eta^2_p=0.09$), with higher perceived fun for Low ($M=-31$, $SD=44$) compared to High ($M=-34$, $SD=45$) demand cues. The Affective x Demand interaction was marginally significant ($F_{142,2}=2.63$, $p=0.076$, $\eta^2_p=0.03$), revealing higher perceived fun in the Low vs. High demand cues in Positive blocks ($F_{71,1}=7.68$, $p=0.007$), but only a marginal difference in Negative blocks ($F_{71,1}=2.9$, $p=0.09$) and no differences in Neutral blocks ($F<1$).

Regarding individual differences in cognitive and personality traits, switch costs (indexed as Switch versus Non-switch RTs during the preliminary task-switching task),[1] NFC and SCS scores did not correlate with selection rate (all ps > 0.17; all $BFs_{01}>2.78$).

[1] A paired Wilcoxon test (a Saphiro-Wilk test of normality revealed a significant deviation from normality, $p<0.001$) was performed on RTs of correct switch ($M=1593$ ms, $SD=435$ ms) and non-switch trials ($M=1111$ ms, $SD=269$ ms), revealing a significant effect of switching ($W_{71,1}=75$, $p<0.001$, effect size = 0.94). An analysis of accuracy scores also revealed a switching effect ($W_{71,1}=1683$, $p=0.002$, effect size = 0.28).

Discussion

Results from "Experiment 1" replicated the effect of effort avoidance described in previous studies (Kool et al., 2010; Schouppe et al., 2014), showing a general tendency to choose the less demanding option, which involved a lower number of task switches. This indicates that the paradigm was effective in manipulating the load of cognitive control and in biasing behavioral choices. However, the induced affective state did not modulate effort avoidance. Contrary to our expectations, we found consistent evidence towards a null effect of the affective state on demand selection ($BF_{01} > 16$, which indicates strong evidence for the null hypothesis (Jeffreys, 1998)). Still, the affective induction was successful, and it influenced participants' task performance. Specifically, our results revealed an overall slower performance in Negative blocks, but similar switching costs across affective states, replicating previous results (Demanet et al., 2011). The affective state also influenced participants' subjective experience of the task, reducing the fun perceived during Negative blocks. In sum, our results suggest that the affective induction impacted performance on the parity and magnitude tasks but had no direct influence on cognitive demand avoidance.

Several reasons might underlie this lack of effect. A first possibility is that our affective manipulation, despite significantly modulating EVEA and SAM scores, was not strong enough to influence demand selection. Given that images were task-irrelevant, participants could have strategically decided to ignore them, which in turn could have reduced their impact on selection. Also, the same picture was presented several times in a row, which could have enhanced habituation and reduced the impact of their affective content on task decisions. Last, the complex and changing nature of the location of the cues and targets could have impaired participants' ability to detect the differences in demand between the two cues, making the effect of Demand relatively small (Desender et al., 2017) and in turn, masking any potential effects of the affective condition. In "Experiment 2", we sought to replicate results from "Experiment 1" while increasing the salience of the affective manipulation and making the demand manipulation more evident.

Experiment 2

Method

Participants

A sample of 72 undergraduate students (56 female, mean age = 22, SD = 1.5) from the University of Granada participated in exchange for course credits. All participants were native Spanish speakers and had normal or corrected-to-normal vision. The same sample size as in "Experiment 1" was used. The study was carried out in accordance with the Declaration of Helsinki and was approved by the local Ethics Committee. All data and materials from the experiment are available at https://osf.io/nesc8/.

Materials, procedure, and design

Materials and procedure were similar to those in "Experiment 1", except in the following: (1) To enhance the power of the affective manipulation, we sought to reduce habituation by increasing the number of images per affective state and randomizing the presentation order of images within each block. Thus, each image was presented 6 times instead of ten, and these presentations did not occur in consecutive trials. A total of 105 images (35 positive, 35 negative, and 35 neutral) were extracted from the IAPS. Two extra neutral images were used for the practice session. Pictures were selected depending on their scores in valence and arousal dimensions: Positive [valence = 7.42, SD = 0.35; arousal = 6.16, SD = 0.64]; Negative [valence = 2.26, SD = 0.20; arousal = 6.12, SD = 0.24]; Neutral [valence = 4.57, SD = 0.18; arousal = 3.77, SD = 0.69]. As in "Experiment 1", Post-hoc Bonferroni analyses showed that all affective sets differed in valence (all $ps < 0.001$). To analyze effects depending on the valence dimension, we controlled arousal scores for affective conditions. Therefore, while the neutral condition was different compared to positive and negative sets (all $ps < 0.001$), the last two conditions did not differ ($p = 1$). (2) To further increase the impact of the affective manipulation, we presented the same image contained in the cues before cue onset as well, in full screen, during 1 s. In contrast to "Experiment 1", here participants were told that they had to pay attention to the affective content of the pictures and that their recollection of the images would be evaluated at the end of the session. In addition, to further strengthen the affective state, before the first block of each affective condition they were told to write down, during 3 min, an autobiographical memory associated with positive, negative or neutral affective states. (3) To assess the degree of processing of the images as well as participants' awareness of the critical manipulation, a memory task and a debrief were conducted at the end of the study, after the main task. The memory task consisted of 30 previously seen images (10 per affective state) and 30 new images (catch trials, 10 per affective state), presented

Table 2 Mean (M) and Standard Deviation (SD) of the effect of moods on variables of "Experiment 2"

Measure	Positive mood		Negative mood		Neutral mood	
	M	SD	*M*	SD	*M*	SD
Fear/anxiety	2.38	1.93	2.91	2.89	2.62	2.42
Anger	1.34	1.77	2.18	2.16	1.52	1.86
Sadness	1.86	1.53	2.99	1.87	2.104	1.72
Joy	4.66	2.32	3.79	2.3	4.14	2.38
Valence	5.69	1.7	4.29	1.72	5.14	1.74
Arousal	5.7	2	5	2.23	5.68	2.24
Low-demand selection (%)	54	17	54	16	55	15
Decision RTs (ms)	510	207	546	253	509	202
Task RTs (ms)	887	190	924	205	884	212
Task accuracy	0.92	0.06	0.93	0.05	0.93	0.05
Subjective effort	−29.9	40	−21.8	41.9	−29.5	38.3
Perceived fun	−4.89	45.7	−59.4	36.5	−29.9	37.1

in random order.[2] On each trial of the memory task, participants had to report whether the image was old or new by pressing *Z* or *M* keys, respectively, as fast and as accurately as possible. (4) Given the significant but small effect of control demands on selection, we sought to reduce task complexity to make the differences between the low and high demand cues more evident. We reasoned that the fact that colors had two functions in "Experiment 1" (signaling the high/low demand cue as well as the parity/magnitude task) could be misleading to participants. Thus, we removed the colored border of the cues and fixed their position in the screen across the entire experiment (e.g. low demand on upper and high demand on the lower half of the screen; counterbalanced across participants). (5) Due to the main task being slightly longer and the minimal role of the SCS measure in "Experiment 1" data, this questionnaire was not administered in "Experiment 2". The approximate total task duration was 70 min.

Results

Descriptive statistics of all dependent variables across affective states are described in Table 2 (see Supplementary Table 2 to see descriptive statistics separately for repetition and switch trials).

Manipulation check–affective measures

The Fear/Anxiety scale of EVEA showed a significant effect of the Affective condition ($F_{142,2}=3.56$, $p=0.031$, $\eta^2_p=0.05$), with higher values of fear/anxiety after negative ($M=2.9$, SD = 2.28) than after positive blocks ($M=2.37$, SD = 1.93; $p<0.05$). A similar effect was also found for Anger ($F_{142,2}=6.83$, $p<0.001$, $\eta^2_p=0.08$) and Sadness ($F_{142,2}=27.13$, $p<0.001$, $\eta^2_p=0.27$) scales. This pattern was reversed for the Joy scale ($F_{142,2}=17.7$, $p<0.001$, $\eta^2_p=0.2$), which showed higher values after positive ($M=4.66$, SD = 2.32) than after negative blocks ($M=3.79$, SD = 2.3; $p<0.001$). The Valence scale of the SAM revealed a significant effect of the affective manipulation ($F_{142,2}=24.05$, $p<0.001$, $\eta^2_p=0.25$), with higher valence after positive ($M=5.69$, SD = 1.7) than after negative blocks ($M=4.29$, SD = 1.72; $p<0.001$, $\eta^2_p=0.19$). The affective effect on the Arousal scale was also significant ($F_{142,2}=5.91$, $p=0.003$, $\eta^2_p=0.07$), revealing higher arousal after positive ($M=5.63$, SD = 2) than after negative blocks ($M=5$, SD = 2.24; $p=0.005$).

To assess whether valence scores increased with respect to "Experiment 1", we performed a repeated measures ANOVA with all participants from "Experiments 1 and 2", Affective Condition as within-participants factor, and Experiment as between-participants factor. This analysis revealed that the between-participants factor significantly modulated the effect of the Affective condition (Affective state X Experiment interaction; $F_{426,3}=3$, $p=0.029$, $\eta^2_p=0.02$; Supplementary Fig. 1). Specifically, valence scores after negative blocks were significantly lower in "Experiment 2" ($M=4.23$, SD = 1.76), compared to "Experiment 1" ($M=5.01$, SD = 1.92; $F=5.68$, $p=0.019$). Scores did not significantly differ for neutral ($F=2.35$, $p=0.12$) or positive ($F<1$) scores.

[2] The 30 new images were selected to match the valence and arousal values of those presented during the experiment. Specifically, the scores for each dimension of the new images were: Positive [valence = 6.84, SD = 0.35; arousal = 6.42, SD = 0.89]; Negative [valence = 2.44, SD = 0.65; arousal = 6.01, SD = 0.75]; Neutral [valence = 4.73, SD = 0.46; arousal = 3.77, SD = 0.54].

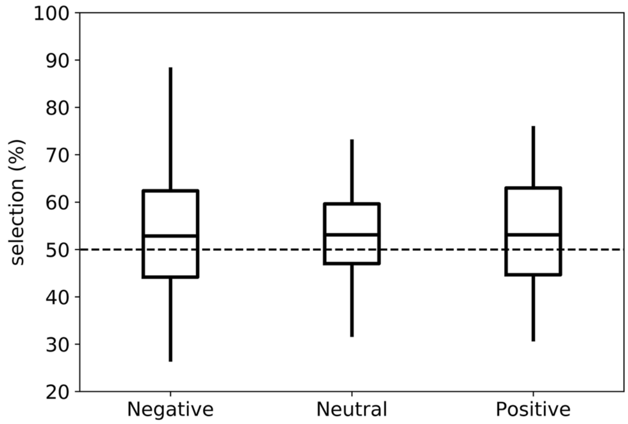

Fig. 3 Selection scores in "Experiment 2", for each affective state. The thick line inside box plots depicts the median of the distribution. The bounds of the boxes depict the first and third quartiles of the distribution. Whiskers denote the 1.5 interquartile range of the lower and upper quartile. The dashed line denotes chance level

Main task

A one-sample Wilcoxon test (scores deviated from normality, $p < 0.001$) revealed that participants performed the low demand task more frequently (54.8%; $W_{71,1} = 893$, $p = 0.009$, effect size = 0.32), to a similar extent as in "Experiment 1" (an independent samples t-test revealed a null effect of Experiment [Experiment 1 vs. Experiment 2] on the selection rate, $p = 0.435$, $BF_{01} = 4.17$). Crucially, replicating results from "Experiment 1", selection was not modulated by the affective state ($F < 1$; see Fig. 3). Rather, strong evidence was found towards a null effect of emotion on selection ($BF_{01} = 16.67$). To assess whether awareness of the demand manipulation influenced the role of emotion on selection, we split our sample according to whether or not participants had detected the manipulation during the task, assessed by a debriefing questionnaire. The questionnaires were evaluated by three independent observers and participants were tagged as aware if two or more observers agreed on this evaluation. Following this procedure, 22 out of 72 participants were identified as aware of the demand manipulation. We carried out a repeated-measures ANOVA with the selection rate under the three affective states as a within-subject factor, and awareness as a between-subject factor. This ANOVA showed that the null effect of emotion was not modulated by awareness (Demand x Affective State x Awareness, $F < 1$, $BF_{01} > 3$). The between-subject factor was not significant either (Main effect of Awareness, $F < 1$, $BF_{01} = 2$). Moreover, as in "Experiment 1", we explored the effect of the affective state on selection during the first three blocks of the task, where the impact of the induction could be strongest. However, similar to "Experiment 1", the Affective State did not modulate demand patterns ($F < 1$, $BF_{01} > 3$). To compensate for the loss of power of using only one-third of the trials, we repeated the analysis combining participants from both experiments, with a total sample size of 144, allowing us to detect subtle effects (minimal detectable effect size of $d = 0.26$, with a power of 0.80). This analysis, again, yielded a null effect of Affective State on Demand ($F < 1$, $BF_{01} > 3$). Last, we explored if demand selection was influenced by trial history. We observed that participants overall tended to pick the same cue as in the previous trial ($M = 56\%$, SD = 22%; significantly higher than chance level: $t_{71} = 2.38$, $p = 0.02$, Cohen's $d = 0.28$), regardless of whether this was a task switch or a task repetition trial ($F_{71,1} = 2.6$, $p = 0.11$), and this was not modulated by the affective state ($F < 1$). Similarly, cue selection was not modulated by the congruency of the previous trial nor its interaction with the affective state (all Fs < 1).

Regarding task performance, in Decision RTs (Supplementary Fig. 2), neither main effects of Demand and Affective condition nor the interaction were significant (all ps > 0.2; all $BF_{01} > 2.38$). Regarding Task RTs (Supplementary Fig. 3), we found a significant effect of Demand ($F_{68,1} = 53.1$, $p < 0.001$, $\eta^2_p = 0.44$) and a marginal effect of Affective state ($F_{142,2} = 2.62$, $p = 0.077$, $\eta^2_p = 0.04$), while the interaction remained not significant ($F < 1$; $BF_{01} = 18.18$). In addition, we performed another ANOVA to assess whether Demand and Affective State had an effect on switch costs (RTs of task switches – RTs of task repetitions). As expected for a context with low switch probability, switch costs were significantly larger in the Low Demand condition ($M = 330.34$ ms, SD = 591.68 ms) than in the High Demand one ($M = 42.3$ ms, SD = 522.67 ms; $F_{67,1} = 22.6$, $p < 0.001$, $\eta^2_p = 0.25$). In contrast, neither the Affective State factor nor its interaction with Demand modulated switch costs (all ps > 0.26).

Last, on the accuracy scores, we found an effect of Demand ($F_{68,1} = 19.45$, $p < 0.001$, $\eta^2_p = 0.22$), with more accurate responses in the Low ($M = 0.93$, SD = 0.04) than in the High Demand condition ($M = 0.92$, SD = 0.06). In contrast, neither the affective state ($F = 2.79$, $p = 0.07$; $BF_{01} = 2.08$) nor the interaction of Affective Condition and Demand ($F < 1$; $BF_{01} = 20$) were significant.

Regarding the self-reported subjective experience of the task, the perceived effort varied across affective states ($F_{71,1} = 6.47$, $p = 0.002$, $\eta^2_p = 0.08$), revealing less perceived effort in positive blocks ($M = -29.86$, SD = 39.94) and neutral (M = -29.52, SD = 38.33) compared to negative blocks ($M = -21.81$, SD = 41.93; $p = 0.009$ and $p = 0.004$, respectively). The cue demand had no effect ($F < 1$, $BF_{01} > 3$). The affective state also modulated the perceived fun ($F_{142,2} = 58.66$, $p < 0.001$, $\eta^2_p = 0.45$), being the task perceived as less fun on negative ($M = -58.35$, SD = 36) compared to neutral ($M = -29.94$, SD = 37; $p < 0.001$) and positive blocks ($M = -4.89$, SD = 45.61; $p < 0.001$). Perceived fun was also significantly higher in positive blocks compared to neutral blocks ($p < 0.001$). The effect of affective state interacted with the demand of the cue ($F_{142,2} = 4.24$, $p = 0.016$, $\eta^2_p = 0.056$), revealing a larger impact of the affective state in the low ($F_{71,1} = 60.82$, $p < 0.001$) compared to the high demand cue ($F_{71,1} = 54.84$, $p < 0.001$). Furthermore, switching abilities[3] and NFC score did not correlate with Selection (all ps > 0.1; all $BFs_{01} > 1.92$).

Memory task

Last, to ensure that participants attended to the affective stimuli we calculated *d*' values for images of each valence during the memory task. We then compared these values against 0, which yielded significant differences in all cases (scores deviated from normality, $p < 0.001$; all effect sizes > 0.82), suggesting high discrimination of images presented during the main task regardless of their affective valence. In addition, differences of d' values among affective states did not reach significance (average $d' = 4.21$; $F = 2.66$, $p = 0.07$; $BF_{01} = 2$).

Discussion

Results of "Experiment 2" show a similar tendency for an effect of the affective state on task performance and participants' subjective experience of the task, as well as an overall preference for the low demand option. However, data again showed consistent evidence for a null effect of affective state on demand selection. Furthermore, in this second experiment, we ruled out some potential alternative explanations. First, the effect of the affective manipulation in the EVEA and SAM scores was enhanced, and participants could reliably remember previously presented images, which indicates that they thoroughly processed the images and, in addition, that the lack of effect on selection is not due to shallow processing of the images. Second, by reducing the complexity of the task, we sought to make the distinction of low and high demand cues more evident and test for an effect of the affective state in those conditions. However, our results show that even in those participants that were explicitly aware of the manipulation, the affective induction had no effect on demand selection. In sum, these results suggest that under the current setting, induced affective states can impact task performance as well as the subjective experience of the task, but they do not modulate the avoidance of cognitive demand.

General discussion

In the current study, we assessed the impact of phasic affective states on the voluntary choice between two lines of action associated with high vs. low cognitive demand, manipulated by the probability of switching between a magnitude and a parity judgment. Given that previous research had suggested a tight link between control demands and negative affective state, we predicted that the latter would impact effort avoidance and, in turn, selection patterns. Specifically, we hypothesized that negative affective states would increase the intensity of the aversive signals associated with cognitive demand, enhancing its avoidance in comparison with a positive and a neutral control condition. However, contrary to this prediction, in two experiments with an accumulated sample of 144 participants, our results revealed that the induction of positive and negative affective states had no effect on demand avoidance, which was reinforced by a Bayesian analysis revealing strong evidence for the null hypothesis ($BFs_{01} > 16$). Rather, participants consistently chose the least demanding line of action to a similar extent, regardless of the induced affective state. In contrast, the affective state modulated task performance and self-reported subjective experience of the task. Overall, the current study suggests a limited influence of the induction of affective states on effort avoidance.

Across the two experiments, affective signals impacted task performance, primarily in "Experiment 1". Affective states generally slowed down responses to targets and decision reaction times during negative states blocks (in "Experiment 1", and a similar trend in "Experiment 2"). This is consistent with previous research revealing a tight relationship between emotion and cognitive processes (Pessoa, 2009), with some accounts proposing the conception of cognitive control as an emotional process itself (Inzlicht et al., 2015). Our results are thus in line with several studies that have repeatedly reported either performance modulation in cognitive tasks via induction of affective states (Okon-Singer et al., 2015; Pessoa, 2009), or the impact of cognitive task components on participants' affective states (Braem et al., 2017b; Vermeylen et al., 2019). Based on previous proposals that congruent motivational states might facilitate conflict registration (Botvinick, 2007), we predicted that affective states would also modulate choices that lead to more or less demanding lines of action. Prominent cognitive control models, such as the Expected

[3] A paired Wilcoxon test (a Saphiro-Wilk test of normality revealed a significant deviation from normality, $p < 0.001$) was performed on the reaction times (RTs) of correct switch ($M = 1407$ ms, SD = 348 ms) and non-switch trials ($M = 1000$ ms, SD = 209 ms), revealing a significant effect of switching ($W_{71,1} = 75$, $p < 0.001$, effect size = 1). An analysis of accuracy scores also revealed a switching effect ($W_{71,1} = 1842$, $p < 0.001$, effect size = 0.4).

Value of Control (Shenhav, Botvinick, & Cohen, 2013), propose that the allocation of control depends critically on a costs-benefits analysis that assigns a particular expected value to different control signals. Such models provide a computational solution that accommodates the consistent finding (also replicated in the present study) that, when faced with two lines of (cognitive) action, humans tend consistently towards the less demanding one (Kool et al., 2010). Given that negative affective states amplify the aversive registration of control signals, we predicted that induced negative states would trigger a faster adjustment to task demands, generating larger demand avoidance as a consequence. In other words, we reasoned that negative states would induce a faster detection and adaption to task demands, enhancing effort avoidance. In contrast, positive states incongruent with the aversive tagging of control would hinder conflict registration, attenuating avoidance strategies. Additionally, one could expect an important role of interpersonal variability in such avoidance strategies, for instance, depending on switching abilities or traits such as Need for Cognition. However, in both experiments, we found compelling evidence ($BF_{01} > 16$) for a null effect of induced affective states on demand avoidance.

A first plausible explanation for such lack of an effect could be that our mood manipulation was not strong enough to induce sustained affective states. Indeed, although the content of the images modulated valence and arousal scales, the absolute scores observed in EVEA and SAM questionnaires are not extremely high. Still, induced states had an impact on several different levels. First, affect significantly modulated questionnaire results and also task performance. In "Experiment 1", the choice between high and low demand cues slowed down in Negative blocks. Execution RTs in negative blocks were also slower in the first experiment, and a tendency in the same direction was found in the second one. Second, the affective state influenced the subjective perception of fun. In both experiments, reported fun was lower during negative compared to positive blocks. Similarly, perceived effort was higher during negative blocks in the second experiment. Last, in "Experiment 2" we introduced some changes to enhance the effect of the affective induction. This was confirmed by directly comparing valence scores across experiments, which revealed an increase in the strength of negative affective states compared to "Experiment 1". Altogether, our results indicate that the affective induction was successful. Moreover, given the within-participants nature of our affective manipulation, it is plausible that the strength of the induced affect diminishes over the course of the experiment, washing out its potential effect on effort avoidance. However, in both experiments, we found compelling evidence for a null effect of affective state on demand when only considering the first three blocks of the task, which argues against this possibility.

A second alternative explanation could be that participants strategically decided not to pay attention to the images. Additionally, in "Experiment 1", they might have habituated to the images, since the same ones were presented several times in a row. However, in "Experiment 2", we showed that participants explicitly recognized previously presented images (d' of 4.21, close to the effective limit of $d' = 4.65$ with hit rate = 0.99 and false alarm rate = 0.01), even if an even larger number of images were shown in this experiment, and their order was randomized. Thus, an argument regarding shallow processing of the images does not accommodate the current set of results either. Last, another potential explanation for such a lack of an effect could be that the relatively complex setting of the task in "Experiment 1" (e.g. cues changing color and location every few trials) reduced participants' ability to detect the differences between high and low demand cues. However, similar choice patterns were found in "Experiment 2" with a simpler setting, and, crucially, even those participants that were explicitly aware of the manipulation did not show an effect of affective state on demand selection. The fact that these confounds are ruled out, together with a Bayesian analysis providing strong evidence for a null effect (all $BF_{01} > 3$), point to the idea that sustained affective states induced by pictorial content does not influence selection in a Demand Selection Task.

An important aspect to consider is the fact that our affective manipulation was irrelevant to the task. Since our goal was to induce affective states sustained during the duration of a block, low and high demand choices were concomitant to induced affect. Therefore, it is possible that although internal moods do not influence effort avoidance, other affect manipulations might succeed in modulating avoidance patterns. In this regard, previous research has revealed opposing effects of internal moods (van Steenbergen et al., 2010) and affective context (Dreisbach, Fröber, Berger, & Fischer, 2019; Dreisbach et al., 2018) in control adaptations. Future studies should thus explore the possibility that transient affective signals predictive of either low or high demand might modulate the degree of avoidance. One possibility is to manipulate the content of each cue, making a particular affective valence (e.g. negative) contingent with a particular level of demand (e.g. high), and test if the contingency of negative valence and high demand increases demand avoidance when compared with the reversed contingency (negative valence-low demand).

In accordance with our results, recent research suggests that there might be limits to the relationship between affective states and cognitive control. For instance, Dignath, Janczyk, & Eder (2017) embedded a phasic affect induction procedure in a spatial Simon task. Similar to our rationale, these authors reasoned that if conflict is registered as an aversive signal that increases conflict monitoring, negative affect should facilitate to an even larger extent this monitoring process. In contrast to their hypothesis, they found strong evidence for a null effect of phasic affect in post-conflict adjustment. In another study, Nusbaum, Wilson, Stenson, Hinson, & Whitney (2018) induced positive, negative or neutral affective states in participants performing a reversal learning task to assess whether positive mood improved cognitive flexibility. In this task, two decks were presented, and each of them was associated with either economic gains or losses. Despite the mood induction was successful, affective states did not modulate deck selection, in a similar fashion to our demand selection results. Overall, these and our results suggest that the interaction of induced affective states and cognitive control may depend on the task dimension on which control processes operate (Hefer & Dreisbach, 2018). For instance, it has been proposed that affective processes might be especially influential in cognitive control in situations that entail stimulus conflict, but irrelevant in other instances of control (Dignath et al., 2017). The current findings suggest that voluntary demand selection might be primarily guided by cognitive processes. In line with this reasoning, previous research has shown that negative symptoms of schizophrenic patients, which could be conceived as an extreme case of mood alteration, do not correlate with greater effort avoidance on the Demand Selection Task (Gold et al., 2015), despite inducing greater switching costs compared to a control group.

The current study has some limitations. First, we used exclusively self-reported measures of affective induction, which might be less sensitive to mild modulations in affective state. Future studies could add to the current set of results by making use of psychophysiological measures, such as skin conductance. Moreover, despite the strong evidence for a null effect of affective states on effort avoidance, our affective induction was relatively mild, although well within the range of effects observed in studies using similar induction procedures (e.g. Bäuml & Kuhbandner, 2007; Hefer & Dreisbach, 2018; Mirandola & Toffalini, 2016; Xie & Zhang, 2018). In future studies, it would be interesting to explore ways of potentially inducing more intense affective states, such as using newer images, short videos or songs with highly affective content (Uhrig et al., 2016; Zhang, Yu, & Barrett, 2014), or modulating fear with mild electric shocks (Braem et al., 2017a). Another potential avenue is to study demand avoidance in populations with different affective traits, although previous research in this direction suggests results similar to the ones reported here (Gold et al., 2015).

To summarize, across two highly-powered experiments, we found and replicated a null effect of induced affective states on voluntary demand selection, which highlights the relevant contribution of null findings to psychological science (Johnson, Payne, Wang, Asher, & Mandal, 2017). In both experiments, a Bayesian analysis provided strong evidence for a null modulation of positive and negative affective induction on effort avoidance. Despite this lack of mood influence on demand avoidance, the affective state did modulate task performance as well as participants' subjective effort perception of the task. This inconsistency in the modulation of subjective reports, on the one hand, and lack of effect of induction on demand selection is hard to reconcile with theories where subjective perception is at the core of effort avoidance (Kurzban, Duckworth, Kable, & Myers, 2013). Overall, our results suggest that there are limits to the effects of mood on cognitive control and that these might be highly dependent on specific affective and cognitive settings.

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