Estimating individual subjective values of emotion regulation strategies

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Abstract

Individuals have a repertoire of emotion regulation (ER) strategies at their disposal, which they can use more or less flexibly. In ER flexibility research, strategies that facilitate goal achievement are considered adaptive and therefore are subjectively valuable. Individuals are motivated to reduce their emotional arousal effectively and to avoid cognitive effort. Perceived costs of ER strategies in the form of effort, however, are highly subjective. Subjective values (SVs) should therefore represent a trade-off between effectiveness and subjectively required cognitive effort. However, SVs of ER strategies have not been determined so far. We present a paradigm that is suitable for determining individual SVs of ER strategies. Using a multilevel modelling approach, it will be investigated whether individual SVs can be explained by effectiveness (subjective arousal, facial muscle activity) and subjective effort. Relations of SVs to personality traits will be explored.

Keywords: emotion regulation, regulatory effort, effort discounting, registered report, specification curve analysis

Word count: XXXXX

Estimating individual subjective values of emotion regulation strategies

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1. Introduction

The ability to modify emotional experiences, expressions, and physiological reactions[1] to regulate emotions is an important cognitive skill. It is therefore not surprising that emotion regulation (ER) has substantial implications for well-being and adaptive functioning[2]. Different strategies can be used to regulate emotions, namely situation selection, situation modification, attentional deployment, cognitive change, and response modification[1], and, following the taxonomy of Powers and LaBar[3], individuals can implement ER strategies by means of different tactics. So called antecedent-focused strategies, e.g., attentional deployment and cognitive change, take effect early in the emotion generation process[1]. In contrast, response modification takes place late in the process and is therefore conceptualized as a response-focused strategy[1]. This postulated temporal sequence of ER strategies influences their effectiveness. Albeit it is meta-analytically proven that all mentioned strategies reduce subjective emotional experience, distraction as a tactic of attentional deployment and (expressive) suppression as a tactic of response modulation showed only small to medium effect sizes (distraction: $d_+ = 0.27$; suppression: $d_+ = 0.27$). In contrast, distancing as tactic of cognitive change showed the highest effectiveness with an effect size of $d_+ = 0.45$[4].

Psychophysiological measures provide further important information on the effectiveness of emotion regulation strategies (for an overview, see Zaehringer et al.[5]). Compared to cardiovascular, electrodermal, and pupillometric autonomic responses, facial electromyography has been reported consistently across studies to be influenced by emotion regulation with even medium effect sizes. For example, studies have shown that reappraisal of negative emotion is associated with reduced activity of the corrugator supercilii (associated with anger, sadness, and fear) with $d_{\_} = 0.32$[5]. In addition, the levator labii superioris (associated with disgust) has also been associated with reduced activity during reappraisal[6]. Similar effects have been reported for suppression[6], distancing[7], and distraction[8]. Importantly, results on electromyographic measures seem to be more consistent compared to other autonomic measures, likely because they are specific to emotional valence and its changes.

Similarly to the differences in short term effectiveness, these tactics from three different strategies are also related to different medium and long-term consequences. In particular, strategies that do not change the emotional content of the situation, for instance by taking a neutral perspective (i.e., distraction and suppression) are presumed to be disadvantageous in the longer term. Thus, the self-reported habitual use of suppression is associated with more negative affect and lower general well-being[9]. In addition, a number of ER strategies, e.g., rumination and suppression, have been associated with mental disorders (for meta-analytic review, see Aldao et al.[10]), which led to the postulation of *adaptive* (such as reappraisal, acceptance) and *maladaptive* (such as suppression, rumination) ER strategies. For example, it was shown that maladaptive ER strategies (rumination and suppression) mediate the effect between neuroticism and depressive symptoms[11].

The postulation of *adaptive* and *maladaptive* ER strategies has been challenged by the concepts of ER repertoire and ER flexibility. Within this framework, *maladaptive* refers to inflexible ER strategy use or use of strategies that are hindering goal achievement[12]. Adaptive flexible ER requires a large repertoire of ER strategies[12]. The term "repertoire" can be defined as the ability to utilize a wide range of regulatory strategies in divergent contextual demands and opportunities[13]. A growing number of studies report findings about the repertoire of emotion regulation strategies and its relationship to psychopathology[14–16]. Additionally, greater ER flexibility is related to reduced negative affect and therefore beneficial in daily life[17].

How do people choose strategies from their repertoire? Similarly to the expectancy-value model of emotion regulation[18] it could be assumed, that people also assign a value to an ER strategy reflecting the usefulness of this strategy for goal achieving. Evidence from other psychological domains (e.g., intertemporal choice[19]) shows that subjective values (SVs) are attributed to the choice options on the basis of which the decision is made. Research on ER choice has identified numerous factors that influence the choice of ER strategies, which can be seen as indirect evidence for factors influencing SVs[20]. For example, a study found that the intensity of a stimulus or situation plays a role in the choice[21]. Higher intensity of the (negative) stimulus lead to a choice of rather disengaging tactics of attentional deployment, like distraction[20,21]. ER choice was further influenced by, among others, extrinsic motivation (e.g., monetary incentives), motivational determinants (i.e., hedonic regulatory goals), and effort[20,22]. Nonetheless, there are only few studies to date that examined the required effort of several strategies in more detail and compared them with each other. Furthermore, the research on ER choice lacks information regarding the strategies that were *not* chosen in each case. It is unclear whether people had clear preferences or whether the choice options were similarly attractive.

We assume that people choose the strategy that has the highest value for them at the moment. The value is determined against the background of goal achievement in the specific situation: A strategy is highly valued if it facilitates goal achievement[12]. One certainly central goal is the regulation of negative affect. The effectiveness of ER strategies should therefore influence the respective SV. A second, intrinsic, and less obvious goal is the avoidance of effort[23]. When given the choice, most individuals prefer tasks that are less effortful[24]. Cognitive effort avoidance has been reported in many contexts, for example in affective context[25], the context of decision making[26], and executive functions[27], and is associated with Need for Cognition (NFC)[28], a stable measure of the individual pursuit and enjoyment of cognitive effort[29,30]. In the area of emotion regulation, too, there are initial indications that people show a tendency towards effort avoidance. Across two studies, we could show in previous work that the choice for an ER strategy is mainly influenced by the effort required to implement a given strategy[22]. In our studies, participants used the strategies distancing and suppression while inspecting emotional pictures. Afterwards, they choose which strategy they wanted to use again. Participants tended to re-apply the strategy that was subjectively less effortful, even though it was subjectively not the most effective one - in this case: suppression. Moreover, the majority of participants stated afterwards the main reason for their choice was effort. We assume therefore that, although individuals trade off both factors - effectiveness and effort - against each other, effort should be the more important predictor for SVs of ER strategies. In addition, perceived utility should have an impact on SVs. A strategy that is less effortful and can objectively regulate arousal (i.e., is effective), but is not subjectively perceived as useful, should have a low SV. SVs of ER Strategies could therefore be helpful to describe the ER repertoire[12] more comprehensively. Depending on the flexibility of a person, different patterns of SVs could be conceivable: A person with high flexibility would show relatively high SVs for a number of strategies. This would mean that all strategies are a good option for goal achievement. A second person with less flexibility, however, would show high SVs only for one strategy or low SVs for all of the strategies. This in turn would mean that there is only a limited amount of strategies in the repertoire to choose from. Subsequently, the ability to choose an appropriate strategy for a specific situation is also limited.

So far we have not seen any attempt in ER choice research to determine individual SVs of ER strategies. However, this would be useful to describe interindividual differences in the preference of ER strategies and the ER repertoire more comprehensively. To investigate this question, the individual SVs of each strategy available for selection would have to be determined. Promising approaches can be found in studies on difficulty levels of effortful cognitive tasks.

Individual SVs of effortful cognitive tasks have been quantified using the Cognitive Effort Discounting Paradigm (COG-ED)[29].

In the original study by Westbrook et al.[29], cognitive load was varied using the n-back task, a working memory task that requires fast and accurate responses to sequentially presented stimuli. Participants had to decide in an iterative procedure whether they wanted to repeat a higher n-back level for a larger, fixed monetary reward, or a lower level for a smaller, varying reward, with the implicit assumption that the objectively easiest n-back level has the highest SV. In the present study, we want to use this paradigm to determine SVs of ER strategies. In doing so, we need to make an important change: We have to adapt the assumption that the easiest n-back level has the highest SV. As we have shown in previous studies, there are large inter-individual differences in the preference and perceived subjective effort of ER strategies[22]. Moreover, there is nothing like an objectively easiest ER strategy. It could be assumed, that the antecedent-focused strategies, i.e. attentional deployment and cognitive change, require less effort, because according to Gross[1] these strategies apply when the emotional reaction has not fully developed, yet. In contrast, suppression would need ongoing effort, because it takes effect late in the emotion generating process and does not alter the emotion itself. A similar assumption has been made by Mesmer-Magnus et al.[31], who state that Surface Acting (the equivalent to expressive suppression in emotional labor research) is supposed to continuously require high levels of energy (hence effort). Deep Acting (which refers to reappraisal), in turn, only initially needs the use of energy. This would be in conflict with findings in our previous studies, that showed that many people choose expressive suppression because they evaluated it as less effortful, hence easy[22]. Others define emotion regulation on a continuum from explicit, conscious, and effortful to implicit, unconscious, automatic and effortless[32]. This would mean, that all explicit strategies that have been proposed by the process model of emotion regulation are similarly effortful[1]. Similarly, the flexibility approach of emotion regulation also states, that there is no “best” strategy[33]. An emotion regulation attempt is adaptive, when the intended, individual goal is reached. Those attempts could also consist of sequences of regulatory efforts using different strategies, which might be effective and effortless only in this specific context. Therefore, we have to add an additional step, which precedes the other steps and where the ER option with the higher subjective value is determined. In this step, the same monetary value (i.e., 1 €) is assigned to both options. The assumption is that participants now choose the option that has the higher SV for them. In the next step we return to the original paradigm. The higher monetary value (i.e., 2 €) is assigned to the option that was not chosen in the first step and therefore is assumed to have the lower SV. In the following steps, the lower value is changed in every iteration according to Westbrook et al.[29] until the indifference point is reached. This procedure will be repeated until all strategies have been compared. The SV of each strategy is calculated as the mean of this strategy's SV from all comparisons. In case a participant has a clear preference for one strategy, the SV of this strategy will be 1. But our paradigm can also account for the case that a person does not have a clear preference. Then no SV will be 1, but still, the SVs of all strategies can be interpreted as absolute values and in relation to the other strategy's SVs (see Figure 1). In a separate study, we will test our adapted paradigm together with a *n*-back task and explore whether this paradigm can describe individuals that do not prefer the easiest *n*-back option (see Zerna, Scheffel et al.[34]).

[INSERT FIGURE 1 HERE]

The aim of the present study is to evaluate whether this paradigm is suitable for determining SVs of ER strategies. As a manipulation check, we first want to investigate whether the valence of the pictures is affecting subjective and physiological responding, resulting in lower subjective arousal ratings after and lower EMG activity during neutral compared to negative pictures. Second, we want to check whether the ER strategies distraction, distancing, and suppression effectively reduce subjective arousal and physiological responding compared to the active viewing condition. Third, we want to see whether the strategies subjectively require more cognitive effort than the active viewing condition, and whether participants re-apply the for them least effortful strategy. Furthermore, we want to investigate whether subjective effort, arousal ratings, subjective

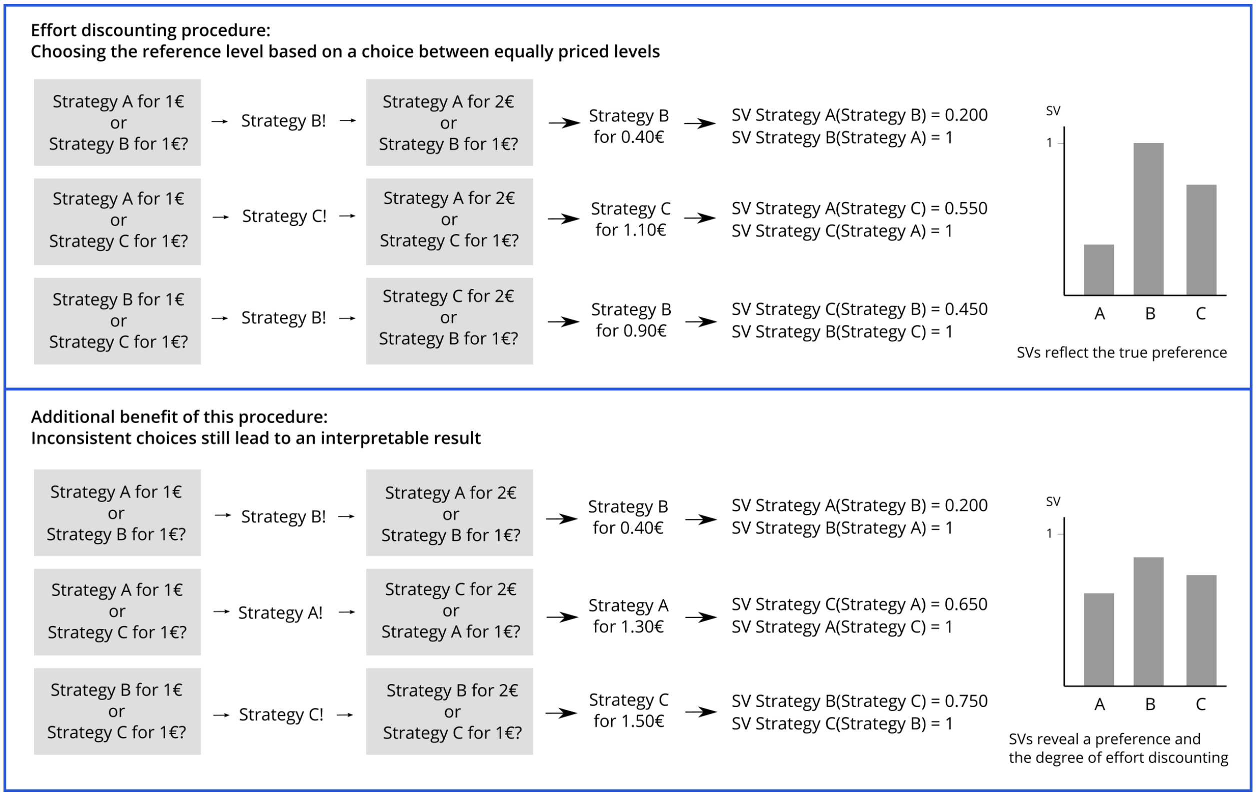

Figure 1. Exemplary visualization of two response patterns. In the top half, the person has a clear preference for one of the three strategies. In the lower half, they have no clear preference and therefore show an inconsistent response pattern. This pattern can be represented by our paradigm. Figure available at https://osf.io/vnj8x/, under a CC-BY4.0 license.

utility, and EMG activity predict individual subjective values of ER strategies. And lastly, we want to check whether the SV of a strategy is associated with its likelihood of being chosen again, and whether SVs reflect participants' self-reported ER flexibility. All hypotheses are detailed in the design table. Exploratorily, we want to investigate whether individual SVs are related to personality traits and how individual SVs of ER strategies relate to SVs of other tasks with different demand levels, namely *n*-back.

2. Method

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study[35]. The paradigm was written and presented using *PsychoPy*[36]. We used *R* with *R Studio*[37,38] with the main packages *afex*[39] and

BayesFactor[40] for all analyses. The R Markdown file used to analyze the data and write this document, as well as the raw data and the materials are freely available at https://github.com/ChScheffel/CAD. A complete list of all measures assessed in the study can be found at OSF (https://osf.io/vnj8x/) and GitHub (https://github.com/ChScheffel/CAD).

2.1 Ethics information

The study protocol complies with all relevant ethical regulations and was approved by the ethics committee of the Technische Universität Dresden (reference number EK50012022). Prior to testing, written informed consent was obtained. Participants received 24 € in total or course credit for participation.

2.2 Pilot data

The newly developed ER paradigm was tested in a pilot study with $N = 16$ participants (9 female; age: $M = 24.1 \pm SD = 3.6$). Regarding self-reported arousal, results showed significant higher subjective arousal for active viewing of negative compared to neutral pictures. However, ER strategies did not lead to a reduction of subjective arousal compared to active viewing of negative pictures. Regarding physiological responses, ER strategies were associated with reduced facial muscle activity of the *corrugator* and *levator* compared to active viewing of negative pictures. In accordance with our previous study[22], we found that the use of ER strategies compared to active viewing was associated with increased subjective effort. All results are detailed in the OSF repository (https://osf.io/vnj8x/).

2.3 Design

Young healthy participants (aged 18 to 30 years) were recruited using the software *ORSEE*[41] at the Technische Universität Dresden. Participants were excluded from participation if they do not fluently speak German, had current or a history of psychological disorders or neurological trauma, or reported to take medication. Participants were invited to complete an online survey containing different questionnaires to assess broad and narrow personality traits and measures of well-being. The study consisted of two lab sessions, which took place in a shielded cabin with constant lighting. Before each session, participants received information about the respective experimental procedure and provided informed consent. In the first session participants filled out a demographic questionnaire and completed an n-back task with the levels one to four. Then, they completed an effort discounting (ED) procedure regarding the n-back levels on screen, followed by a random repetition of one n-back level[34]. The second session took place exactly one week after session one. Participants provided informed consent and received written instructions on the ER paradigm and ER strategies that they should apply. A brief training ensured that all participants were able to implement the ER strategies. Next, electrodes to measure facial EMG were attached and the ER task was conducted, followed by an ED procedure regarding the ER strategies. After that, participants chose one ER strategy to repeat one more time. Study data were collected and managed using REDCap electronic data capture tools hosted at Technische Universität Dresden[42,43].

2.3.1 Psychometric measures. The online survey contained a number of questionnaires. In the focus of the current project was the Flexible Emotion Regulation Scale (FlexER)[44].

It assesses flexible use of ER strategies with items such as “If I want to feel less negative emotions, I have several strategies to achieve this.”, which we define as ER flexibility. The items were rated on a 4-point scale ranging from “strongly agree” to "strongly disagree".

Further psychological constructs were assessed but had no clear hypotheses in the present work and are therefore investigated only exploratory: General psychological well-being was assessed using the German version of the WHO-5 scale[45,46]. To measure resilience, the German version 10-item-form of the Connor-Davidson resilience Scale (CD-RISC)[49] was used. Habitual use of ER will was assessed using the German version of the Emotion Regulation Questionnaire (ERQ)[9,50]. Implicit theories of willpower in emotion control was assessed using the implicit theories questionnaire from Bernecker and Job[51]. To assess Need for Cognition, the German version short form of the Need for Cognition Scale[28,52] was used. To assess self-control[53], sum scores of the German versions of the following questionnaires were used: the Self-Regulation Scale (SRS)[54], the Brief Self-Control Scale (BSCS)[55,56], and the Barratt Impulsiveness Scale (BIS-11)[57,58]. Attentional control were assessed using the Attentional Control Scale (ACS)[59]. For more detailed information on psychometric properties of the questionnaires, please see supplementary material.

2.3.2 Emotion regulation paradigm. The ER paradigm consisted of three parts that will be described in the following.

Part one: ER task. Part one was a standard ER task in a block design (see Figure 2), similar to paradigms previously used by our group[22]. Participants were told to actively view neutral and negative pictures (see 2.3.3) or to regulate all upcoming emotions by means of distraction, distancing, and expressive suppression, respectively. Every participant first had the condition "active viewing-neutral" that served as a baseline condition. During this block, 20 neutral pictures were presented. Participants were asked to "actively view all pictures and permit all emotions that may arise." In the second block, participants actively viewed negative pictures. During the third, fourth, and fifth block, participants saw negative pictures and were asked to regulate their emotions using distraction, distancing, and suppression. In order to achieve distraction, participants were asked to think of a geometric object or an everyday activity, like brushing their teeth. During distancing, participants were asked to "take the position of a non-involved observer, thinking about the picture in a neutral way." Participants were told not to re-interpret the situation or attaching a different meaning to the situation. During suppression, participants were told to "suppress their emotional facial expression." They should imagine being observed by a third person that should not be able to tell by looking at the facial expression whether the person is looking at an emotional picture. Participants were instructed not to suppress their thoughts or change their facial expression to the opposite[22]. All participants received written instruction and completed a training session. After the training session, participants were asked about their applied ER strategies to avoid misapplication. The order of the three regulation blocks (distraction, distancing, and suppression) were randomized between participants. Each of the blocks consisted of 20 trials showing neutral (Block 1) and negative (Blocks 2, 3, 4, 5) pictures. Each trial began with a fixation cross that lasted 3 to 5 seconds (random uniform distributed). It was followed by neutral or negative pictures for a total of 6 seconds. After each block, participants retrospectively rated their subjective emotional arousal ("not at all aroused" to "very highly aroused"), their subjective effort ("not very exhausting" to "very exhausting"), and - after the regulation blocks - the utility of the respective strategy ("not useful at all" to "very useful") on a continuous scale using a slider on screen.

Part two: ER effort discounting. In the second part, ER effort discounting took place. The procedure of the discounting will follow the COG-ED paradigm by Westbrook et al.[29] with a major change. We used the following adaption that allowed the computation of SVs for different strategies without presuming that all individuals would inherently evaluate the same strategy as the easiest one: For each possible pairing (distraction vs. distancing, distraction vs. suppression, and distancing vs. suppression), each of the two strategies were presented with a monetary reward. Because there is no strategy that is objectively more difficult, we added initial comparisons asking the participants to choose between “1 € for strategy A or 1 € for strategy B”. They decided by clicking the on-screen button of the respective option. Each of the three strategy pairs were presented three times in total, in a randomized order and randomly assigned which strategy appeared on the left or right side of the screen. For each pair, the strategy that was chosen at least two out of three times was assigned the flexible starting value of 1 €, the other strategy was assigned the fixed value of 2 €. After this, comparisons between strategies followed the original COG-ED paradigm[29]. Each pairing was presented six consecutive times, and with each decision the reward of the strategy with the starting value of 1 € was either lowered (if this strategy was chosen) or raised (if the strategy with the fixed 2 € reward was chosen). The adjustment started at 0.50 € and each was half the adjustment of the previous step, rounded to two digits after the decimal point. If a participant always chose the strategy with the fixed 2 € reward, the other strategy's last value on display was 1.97 €, if they always choose the lower strategy, its last value was 0.03 €. The sixth adjustment of 0.02 € was done during data analysis, based on the participants' decision in the last display of the pairing. Participants were instructed to decide as realistically as possible by imagining that the monetary reward was actually available for choice.

Part three: ER choice. After the discounting part, participants chose which one of the three ER strategies (distraction, distancing or suppression) they wanted to re-apply. Importantly, there was no further instruction on what basis they should make their decision. Participants should make their decision freely, according to criteria they consider important for themselves. However, participants were asked to state the reasons for the decision afterwards in RedCap using a free text field. As soon as they have decided, they saw the respective instruction and the block with another 20 negative pictures started.

[INSERT FIGURE 2 HERE]

2.3.3 Stimuli. Pictures that were used in the paradigm were selected from the Emotional Picture Set (EmoPicS)[60] and the International Affective Picture System (IAPS)[61]. The 20 neutral pictures (Valence (V): $M \pm SD = 4.81 \pm 0.51$; Arousal (A): M

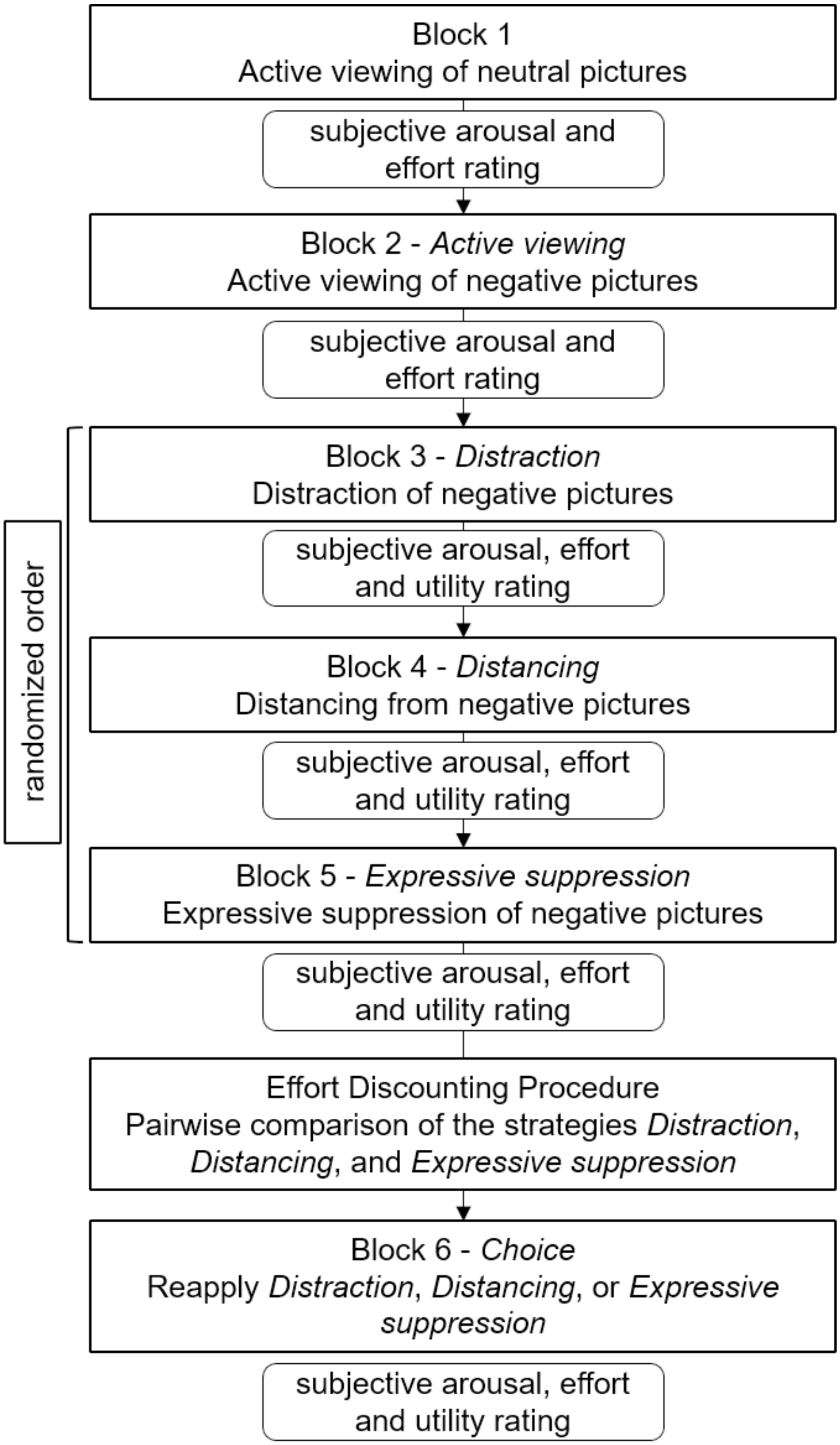

Figure 2. Block design of the paradigm. Every participant starts with two "active viewing" blocks continaing neutral (Block 1) and negative (Block 2) pictures. Order of the regulation blocks (Blocks 3, 4, and 5) was randomized between participants. After, the discounting procedure took place. All three regulation strategies were compared pairwise. Before the last block, participants could decide which regulation strategy they wanted to reapply. Subjective arousal and effort ratings were assessed after each block using a slider on screen with a continuous scale. Figure available at https://osf.io/vnj8x/, under a CC-BY4.0 license.

$\pm$ $SD = 3 \pm 0.65$) depicted content related to the categories persons, objects, and scenes. Further, 100 negative pictures, featuring categories animals, body, disaster, disgust, injury, suffering, violence, and weapons, were used. An evolutionary algorithm[62] was used to cluster these pictures into five sets with comparable valence and arousal values (set one: V: $M \pm SD = 2.84 \pm 0.57$, A: $M \pm SD = 5.62 \pm 0.34$; set two: V: $M \pm SD = 2.64 \pm 0.46$, A: $M \pm SD = 5.58 \pm 0.35$; set three: V: $M \pm SD = 2.82 \pm 0.62$, A: $M \pm SD = 5.60 \pm 0.39$; set four: V: $M \pm SD = 2.65 \pm 0.75$, A: $M \pm SD = 5.61 \pm 0.41$; set five: V: $M \pm SD = 2.74 \pm 0.70$, A: $M \pm SD = 5.63 \pm 0.37$). A complete list of all pictures and their classification into sets can be found in supplementary material table S1. The five sets of negative pictures were assigned randomly to the blocks.

2.3.4 Facial electromyography. Bipolar facial electromyography (EMG) were measured for *corrugator supercilii* and *levator labii* as indices of affective valence[63], similar to previous work by our group[7]. Two passive surface Ag/AgCl electrodes (8 mm inner diameter, 10 mm distance between electrodes) were placed over each left muscle according to the guidelines of Fridlund and Cacioppo[64]. The ground electrode was placed over the left *Mastoid*. Before electrode placement, the skin was abraded with Every abrasive paste, cleaned with alcohol, and filled with Lectron III electrolyte gel. Raw signals were amplified by a BrainAmp amplifier (Brain Products Inc., Gilching, Germany). Impedance level were kept below 10 $k\Omega$. Data were sampled at 1000 Hz, filtered, rectified and integrated. A 20 Hz high pass (order 8), a 300 Hz low pass (order 8), and a 50 Hz notch filter was applied to both signals. *Corrugator* and *levator* EMG was analyzed during the 6 s of picture presentation. EMG data were baseline-corrected using a time window of 2 s prior to stimulus onset[63]. Last, the sampling rate was changed to 100 Hz, and EMG data were averaged for each condition and each participant.

2.4 Sampling plan

Sample size calculation was done using *G*Power*[65,66]. In a meta-analysis of Zaehringer and colleagues[5], effect sizes of ER on peripheral-physiological measures were reported: To find an effect of $d = -0.32$ of ER on *corrugator* muscle activity with $\alpha = .05$ and $\beta = .95$, data of at least $N = 85$ have to be analyzed. Power analyses of all other hypotheses yielded smaller sample sizes. However, if participants withdraw from study participation, technical failures occur, or experimenter considers the participant for not suitable for study participation (e.g., because the participant does not follow instructions or shows great fatigue), respective data will also be excluded from further analyses. Therefore, we aimed to collect data of $N = 120$ participants, about 50 more data sets, than necessary. Detailed information on power calculation for each hypothesis can be found in the design table.

2.5 Analysis plan

Data collection and analysis were not performed blind to the conditions of the experiments. Data of whole participants were excluded from analysis if participants withdraw their consent or they stated that they did not follow experimental instructions. EMG data of subjects were excluded from analysis if errors occured during recording. No further data exclusions were planned. The level of significance was set to $\alpha = .05$. For hypotheses H1-4, repeated measures analysis of variance (rmANOVA) were conducted and estimated marginal means were computed using the *afex* package[39]. Greenhouse-Geisser-corrected degrees of freedom and associated p-values were reported when the assumption of sphericity was violated. If the within-subjects factor of interest was significant, pairwise contrasts were calculated using Bonferroni adjustment for multiple testing. Proportion of explained variance η_p^2 was reported as a measure of effect size.

Effect of valence on arousal and facial EMG. To examine the impact of valence of emotional pictures on subjective arousal ratings (H1a), a rmANOVA with the factor valence (neutral and negative) for the strategy active viewing was conducted. To examine the impact of valence on physiolocigal responding (H1b and H1c), a rmANOVA with the factor valence (neutral and negative) for the strategy active viewing was conducted for EMG *corrugator* and *levator* activity.

Effects of emotion regulation on arousal, facial EMG, and effort. To investigate the effects of the three ER strategies on subjective arousal (H2a), another rmANOVA with the factor strategy (active viewing - negative, distraction, distancing, and suppression) for subjective arousal ratings was conducted. To examine the effects of the three ER strategies on physiological responding (H3a and H3b), another rmANOVA with the factor strategy (active viewing - negative, distraction, distancing, and suppression) for EMG *corrugator* and *levator* activity was conducted. To examine the effect of ER strategies on subjective effort (H4a), a rmANOVA with the factor strategy (active viewing - negative, distraction, distancing, and suppression) for subjective effort ratings was conducted.

Subjective values of emotion regulation strategies. For each ER strategy, SVs were calculated as follows: first, the value 0.02 € was added to or subtracted from the last monetary value of the flexible strategy, depending on the participant's last choice. Second, to obtain the SV of the fixed strategy (the minimum relative reward required for participants to choose the flexible over the fixed strategy), the last value of the flexible strategy was divided by 2 €. Therefore, the SVs of the flexible strategies were 1, because they were chosen in the initial comparison of each pairing in which the same value was offered for both strategies, so they were the preferred strategy of each pairing. The SVs of the fixed strategies lay between 0 and 1, with lower values indicating that the participant would need a much higher monetary incentive to choose this strategy over the other one in the pairing. The final SV per strategy for each participant was computed by averaging the SVs of each strategy across pairings.

To explore the association between subjective effort (H5a), subjective arousal (H5b), subjective utility (H5c), and physiological responding (H5d,e) on SVs, a multilevel model (MLM) was specified using the *lmerTest* package[67]. First, ER strategies were recoded and centered for each subject according to their individual SVs: The strategy with the highest SV will be coded as -1, the strategy with the second highest SV 0, and the strategy with the lowest SV will be coded as 1. Restricted maximum likelihood (REML) was applied to fit the model. A random slopes model of SVs including subjective effort (effort ratings), subjective arousal (arousal ratings), utility (utility ratings), and physiological responses (*corrugator* and *levator* activity) as level-1-predictors was specified.

$$SV \sim strategy\ + \text{effort rating} + \text{arousal rating} + \text{utility rating} + corrugator \text{ activity} \\ + levator \text{ activity} + (strategy|subject)$$

Level-1-predictors were centered within cluster[68]. Residuals of the final model were inspected visually. Intraclass correlation coefficient (ICC), ρ, was reported for each model (null model, as well as full model). The presented MLM followed the conceptualization of Zerna, Scheffel, et al.[34]

To investigate whether individual SVs predict ER choice (H7a), a $\chi 2$ test with predicted choice (highest SV of each participant) and actual choice was computed. Furthermore, an ordinal logistic regression with the dependent variable choice and independent variables SVs of each strategy was computed.

The association between flexible ER and SVs of ER strategies (H7b) was investigated with a linear regression using the individual *intercept* and *slope* of each participants' SVs to predict their FlexER score. To this end, for each participant, SVs were sorted by magnitude in descending order and entered as dependent variable in a linear model, with strategy (centered, i.e., -1, 0, 1) as independent variable. The resulting *intercept* informs about the extent to which an individual considers any or all of the ER strategies as useful for regulation their emotion, while the *slope* informs about the flexibility in the use of emotion regulation strategies. The individual intercepts and slopes were entered as predictors in a regression model with the FlexER score as dependent variable. A positive association with the predictor *intercept* would indicate that overall higher SVs attached to ER strategies predicts higher scores on the FlexER scale. A positive association with the predictor *slope* would indicate that less negative slopes, i.e., a smaller preference for a given ER strategy, would be associated with a higher score of the FlexER scale.

The influence of personality traits on SVs were investigated exploratorily. Therefore, the MLM specified above was extended by the level-2-predictors NFC and self-control.

For each result of the analyses, both p-values and Bayes factors $BF10$, calculated using the *BayesFactor* package[40], were reported. Bayes factors were calculated using the default prior widths of the functions *anovaBF*, *lmBF* and *regressionBF*.

Data availability

The data of this study can be downloaded from osf.io/vnj8x/.

Code availability

The paradigm code, as well as the R Markdown file used to analyze the data and write this document is available at our Github repository.

3. Results

3.1 Participants and descriptive statistics

Data collection took place between 2022-08 and 2023-02. A total of $N = 151$ participants completed the online survey and were invited to participate in the two lab sessions. Of these, $N = 125$ participated in the first laboratory session[34] and $N = 121$

completed the second laboratory session. Of these, $n = 1$ person had to be excluded from analyses because they did not follow the instructions. The final sample consisted of $N = 120$ participants (100 female ; age: $M = 22.5 \pm SD = 3.0$). Please note that sample size for individual calculations may be smaller due to failure of EMG recording ($n = 1$) and failure to record utility ratings ($n = 18$).

3.2. Confirmatory analyses

Manipulation checks.

Subjective arousal and physiological responding. To explore whether negative pictures evoke emotional arousal and physiological responding, we conducted separate ANOVAs for the active viewing condition with predictors subjective arousal, *Corrugator*, and *Levator* activity. We found a highly significant main effect of valence for subjective arousal ($F(1, 119) = 399.95$, $p < .001$, $\hat{\eta}^2_G = .589$, 90% CI $[.498, .659]$, $\mathrm{BF}_{10} = 1.47 \times 10^{44}$), *Corrugator* activity ($F(1, 117) = 27.73$, $p < .001$, $\hat{\eta}^2_G = .111$, 90% CI $[.037, .206]$, $\mathrm{BF}_{10} = 8.67 \times 10^{16}$), and *Levator* activity ($F(1, 117) = 8.87$, $p = .004$, $\hat{\eta}^2_G = .039$, 90% CI $[.002, .111]'$, $\mathrm{BF}_{10} = 188.72$), indicating that negative pictures successfully evoked emotional arousal and physiological responding.

To investigate whether ER strategies reduce emotional arousal and physiological respoindng, we conducted separate rmANOVA comparing subjective arousal, *Corrugator*, and *Levator* activity of four strategies (active viewing, distraction, distancing, suppression). We found a significant effect of strategy for subjective arousal ($F(2.71, 322.55) = 7.39$, $p < .001$, $\hat{\eta}^2_G = .015$, 90% CI $[.000, .036]$, $\mathrm{BF}_{10} = 0.21$), *Corrugator* activity ($F(1.76, 206.02) = 13.70$, $p < .001$, $\hat{\eta}^2_G = .056$, 90% CI $[.019, .094]$, $\mathrm{BF}_{10} = 6.16 \times 10^{7}$), and *Levator* activity ($F(1.54, 180.41) = 19.95$, $p < .001$, $\hat{\eta}^2_G = .089$, 90% CI $[.043, .134]$, $\mathrm{BF}_{10} = 3.22 \times 10^{17}$), indicating that regulation strategies reduced subjective arousal and physiological responding. For detailed information on post-hoc tests, please see supplementary material.

Subjective effort of ER strategies. To investigate whether ER strategies require cognitive effort, we conducted an rmANOVA comparing the subjective effort ratings of four strategies (active viewing, distraction, distancing, suppression). We found a significant effect of strategy ($F(2.92, 347.65) = 128.47$, $p < .001$, $\hat{\eta}^2_G = .327$, 90% CI $[.261, .384]$, $\mathrm{BF}_{10} = 1.84 \times 10^{37}$). Post-hoc test showed significant higher subjective effort for distraction ($t(357) = -17.92$, $p_{\mathrm{Tukey}(4)} < .001$, $\mathrm{BF}_{10} = 3.61 \times 10^{30}$), distancing ($t(357) = -15.82$, $p_{\mathrm{Tukey}(4)} < .001$, $\mathrm{BF}_{10} = 1.60 \times 10^{28}$), and suppression ($t(357) = -12.26$, $p_{\mathrm{Tukey}(4)} < .001$, $\mathrm{BF}_{10} = 1.27 \times 10^{19}$) compared to active viewing. Moreover, we found significantly lower effort during suppression compared with distraction ($t(357) = 5.66$, $p_{\mathrm{Tukey}(4)} < .001$, $\mathrm{BF}_{10} = 1.61 \times 10^{6}$) and distancing ($t(357) = 3.55$, $p_{\mathrm{Tukey}(4)} = .002$, $\mathrm{BF}_{10} = 29.19$).

[... WAHLVERHALTEN FEHLT NOCH ...]

Subjective values of ER strategies. Individual SVs could be determined for 120 participants for all three ER strategies. SVs ranged between 0.005 and 1.00. In sum, $n =$ 119 had a SVs of 1.0, indicating a clear preference for one ER strategy. Highest SV for distraction was reported by $n = 41$, for distancing by $n = 36$, and for suppression by $n =$ 36.

To investigate, which variables can predict individual SVs of ER strategies, a multilevel model approach was chosen. The ICC of the null model was $ICC = 0.19$, indicating that level-2 predictor subject accounted for 19.10 percent of total variance. The preregistered model showed a correlation of $r = 0.95$ of the random effects subjects and recoded strategy ($BF10$ of the variable strategy: $\mathrm{BF}_{10} = \infty$). Our model explained 0.90 percent of variance and thus we assumed our model was overfitted due to including recoded strategy as random slope. We therefore set a new model without the recoded strategy as random slope factor to estimate the influence of predictors on SVs more precisely. The second model followed the specification:

$$SV \sim \text{effort rating} + \text{arousal rating} + \text{utility rating} + \textit{corrugator} \text{ activity} \\ + \textit{levator} \text{ activity} + (1|\textit{subject})$$

The second model explained 0.41 percent of variance. All results of the second model are in table 1.

[INSERT TABLE 1 HERE]

Table 1
Results of multilevel model predicting subjective values of ER strategies.

Parameter	Beta	SE	p-value	f^2	Random Effects (SD)
Intercept	8.03×10^{-1}	0.01	0.00		0.11
Effort	-6.85×10^{-4}	0.00	0.00	0.03	
Arousal	-7.84×10^{-5}	0.00	0.32	0.00	
Utility	1.42×10^{-3}	0.00	0.00	0.15	
Corrugator activity	7.45×10^{-3}	0.00	0.04	0.00	
Levator activity	5.32×10^{-3}	0.00	0.07	0.00	

The predictors effort rating ($\hat{\beta} = 0.00$, 95% CI $[0.00, 0.00]$, $t(5, 618.96) = -13.98$, $p < .001$), utility rating ($\hat{\beta} = 0.00$, 95% CI $[0.00, 0.00]$, $t(5, 618.96) = -13.98$, $p < .001$), and *Corrugator* activity ($\hat{\beta} = 0.01$, 95% CI $[0.00, 0.01]$, $t(5, 618.96) = 2.09$, $p = .037$) showed a significant association with SVs. The values were relatively small, so the respective effect size f^2 was calculated as the explained variance. Interestingly, utility rating showed the greatest effect size of all predictors ($f^2 = 0.155$), indicating that utility rating explained 15.5 percent of variance in SVs. Effort rating showed an effect size of $f^2 =$ 0.035. The effect sizes of all other predictors were negligibly small ($f^2 < 0.01$).

Associations between subjective values and flexible ER. To investigate the ecological validity of the subjective values of ER strategies we calculated, we looked to see if SVs were associated with the actual choice of participants in the choice block. Therefore, a χ^2 test with predicted choice (i.e., the strategy with the highest SV of each participant) and actual choice was computed. There was a significant association between predicted choice and actual choice ($\chi^2(4, n = 120) = 115.40$, $p < .001$, $\mathrm{BF}_{10} = 1.62 \times 10^{21}$). We then conducted a ordinal regression with the dependent variable "choice" and the individual SVs of all three strategies as independent variables. Overall model fit was fair with $R^2 = 0.27$. The predictor SV of strategy distraction was found to contribute to the model ($b = -6.29$, 95% CI $[-10.81, -3.02]$, $z = -3.21$, $p = .001$, $BF10 = 2.00$). The estimated odds ratio indicated a higher chance of choosing strategy distraction, when SV of that strategy is higher. Additionally, the predictor SV of strategy suppression was found to contribute to the model ($b = 2.70$, 95% CI $[0.83, 4.84]$, $z = 2.67$, $p = .008$, $BF10 = 1.99$). The estimated odds ration indicated that is more likely to later choose suppression, when SV of strategy suppression is higher.

Last, we investigated whether SVs are associated with ER flexibility. We conducted a logistic regression to inspect whether participants' individual *slopes* and *intercepts* of ordered SVs could predict their ER flexibility score. We found neither a significant associations between *slopes* of SVs and FlexER score ($b = -0.36$, 95% CI $[-1.28, 0.56]$, $t(117) = -0.77$, $p = .444$, $\mathrm{BF}_{10} = 0.72$), nor between *intercepts* and FlexER score ($b = 1.32$, 95% CI $[-1.38, 4.02]$, $t(117) = 0.97$, $p = .336$, $\mathrm{BF}_{10} = 0.85$). However, model fit was relatively low ($R^2 = .03$, $F(2, 117) = 1.93$, $p = .150$).

3.3. Exploratory analyses

We exploratory wanted to investigate the influence of self-control and the investment trait Need for Cognition (NFC) on individual SVs of ER strategies. The starting point for this was the model reported before. Only predictors that had previously shown a significant association with SVs were included in the model together with level 2 predictors self-control and NFC. The third model followed the specification:

$$\begin{aligned} SV \sim & \text{ effort rating} + \text{utility rating} + \textit{corrugator} \text{ activity} \\ & \text{self-control} + \text{NFC} + (1|subject) \end{aligned}$$

As one would expect, the predictors effort rating ($\hat{\beta} = 0.00$, 95% CI $[0.00, 0.00]$, $t(5, 620.93) = -14.26$, $p < .001$), utility rating ($\hat{\beta} = 0.00$, 95% CI $[0.00, 0.00]$, $t(5, 620.93) = -14.26$, $p < .001$), and *Corrugator* activity ($\hat{\beta} = 0.01$, 95% CI $[0.00, 0.01]$, $t(5, 620.93) = 2.12$, $p = .034$) showed a significant association with SVs. In addition, a positive association was also found between self-control and SVs ($\hat{\beta} = 0.02$, 95% CI $[0.00, 0.05]$, $t(97.97) = 2.04$, $p = .044$). However, effect size of self-control was negligibly small ($f^2 = 0.002$). Detailed information can be found in the supplementary material.

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Acknowledgements

This research is partly funded by the German Research Foundation (DFG) as part of the Collaborative Research Center (CRC) 940. Additionally, we have applied for funding of the participants' compensation from centralized funds of the Faculty of Psychology at Technische Universität Dresden. Applications for the centralized funds will be reviewed in May. Regardless of whether or not this additional funding will be granted, the study can commence immediately. The funders have/had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript.

Competing Interests

The authors declare no competing interests.

Figures and figure captions

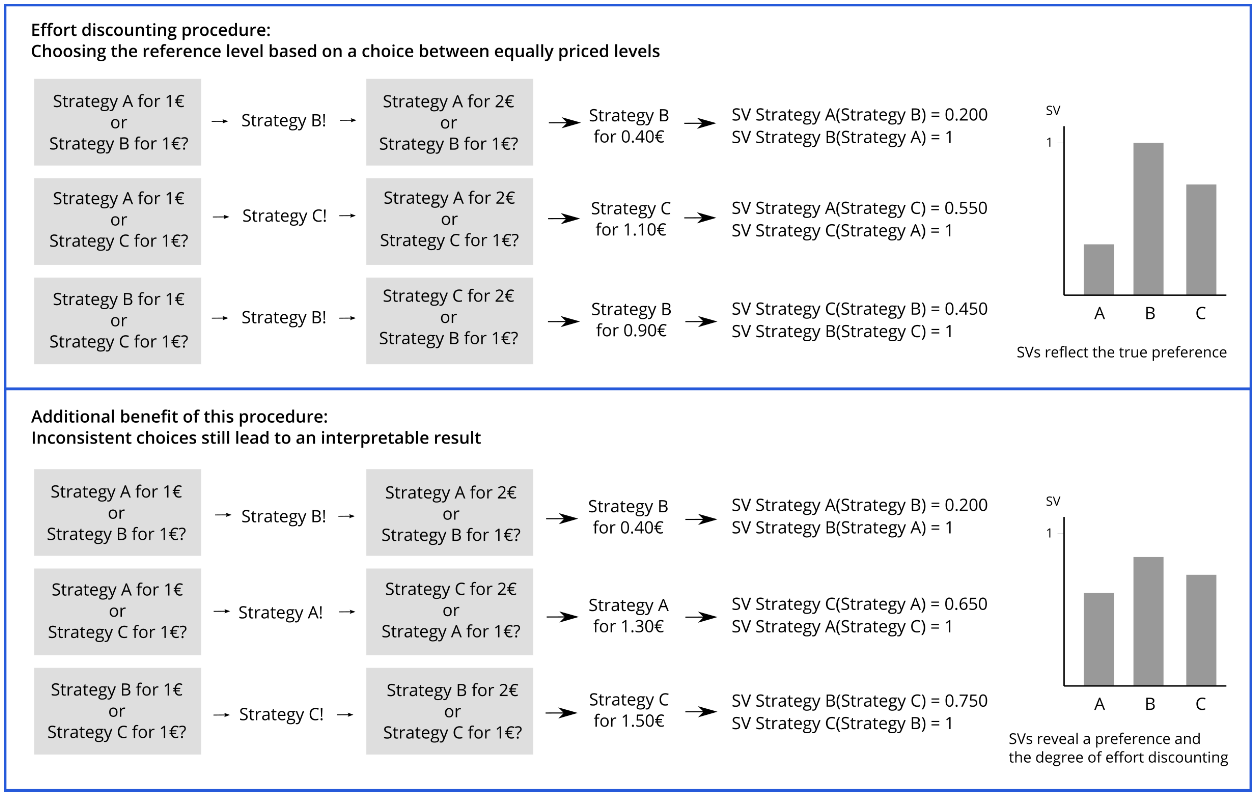

Figure 1

Figure 1. Exemplary visualization of two response patterns. In the top half, the person has a clear preference for one of the three strategies. In the lower half, they have no clear preference and therefore show an inconsistent response pattern. This pattern can also be represented by our paradigm.

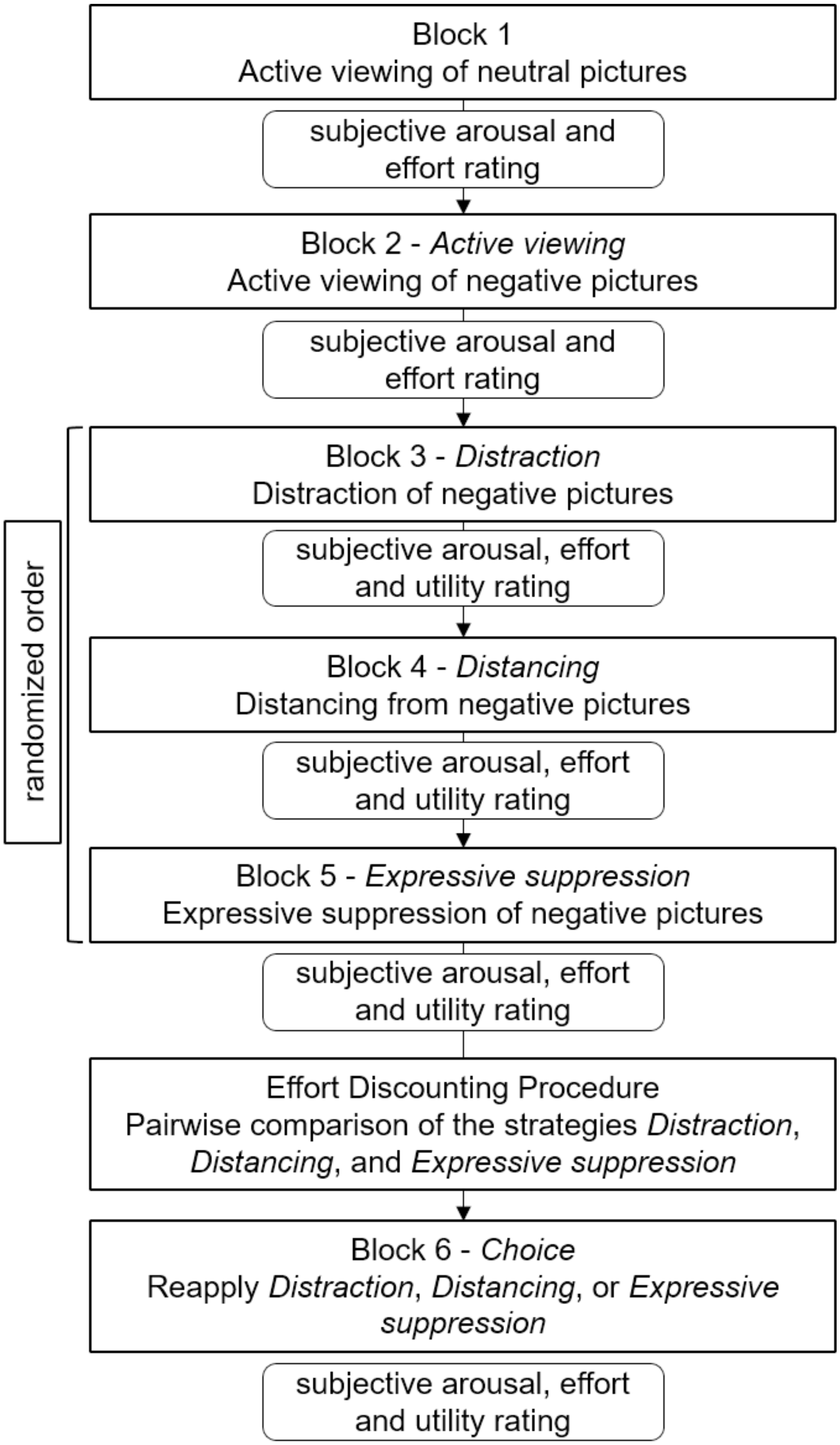
Block 1
Active viewing of neutral pictures
subjective arousal and effort rating
Block 2 - Active viewing
Active viewing of negative pictures
subjective arousal and effort rating
Block 3 - Distraction
Distraction of negative pictures
subjective arousal, effort and utility rating
Block 4 - Distancing
Distancing from negative pictures
subjective arousal, effort and utility rating
Block 5 - Expressive suppression
Expressive suppression of negative pictures
subjective arousal, effort and utility rating
randomized order
Effort Discounting Procedure
Pairwise comparison of the strategies Distraction, Distancing, and Expressive suppression
Block 6 - Choice
Reapply Distraction, Distancing, or Expressive suppression
subjective arousal, effort and utility rating

Figure 2

Figure 2. Block design of the paradigm. Every participant starts with two "active viewing" blocks containing neutral (Block 1) and negative (Block 2) pictures. Order of the regulation blocks (Blocks 3, 4, and 5) is randomized between participants. After, the discounting procedure takes place. All three regulation strategies are pairwise compared. Before the last block, participants can decide which regulation strategy they want to reapply. Subjective arousal and effort ratings are assessed after each block using a slider on screen with a continuous scale.

Design Table

Question	Hypothesis	Sampling plan (e.g. power analysis)	Analysis Plan	Interpretation given to different outcomes
1.) Do negative pictures (compared to neutral pictures) evoke subjective arousal and physiological responding? (Manipulation check)	1a) Subjective arousal (arousal rating) is lower after actively viewing neutral pictures compared to actively viewing negative pictures.	F tests - ANOVA: Repeated measures, within factors Analysis: A priori: Compute required sample size <u>Input:</u> Effect size f = 1.59 (η_p^2 = 0.716) (Scheffel et al., 2021) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of groups = 1 Number of measurements = 2 Corr among rep measures = 0.5 Nonsphericity correction ε = 1 <u>Output</u>: Noncentrality parameter λ = 40.3380260 Critical F = 10.1279645 Numerator df = 1.0 Denominator df = 3.0 Total sample size = 4 Actual power = 0.9789865	Repeated measures ANOVA with two linear contrasts, comparing the subjective arousal ratings of two blocks (active viewing – neutral and active viewing - negative). ANOVA is calculated using aov_ez() function of the afex-package, estimated marginal means are calculated using emmeans() function from the emmeans-package: if the factor Block is significant, pairwise contrasts are calculated using pairs() with Bonferroni adjustment for multiple testing. Bayes factors are computed for the ANOVA and each contrast using the BayesFactor-package.	ANOVA yields $p < .05$ is interpreted as subjective arousal (arousal ratings) changing significantly with blocks. Values of arousal ratings are interpreted as equal between blocks if $p > .05$. Each contrast yielding $p < .05$ is interpreted as arousal ratings being different between those two blocks, magnitude and direction are inferred from the respective estimate. Values of arousal ratings are interpreted as equal between blocks if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
	1b) Physiological responding (EMG *corrugator* activity) is lower while actively viewing neutral pictures compared to actively viewing negative pictures.	F tests - ANOVA: Repeated measures, within factors Analysis: A priori: Compute required sample size <u>Input:</u> Effect size f = 0.5573293 (η_p^2 = 0.237) (Pilot Study) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of groups = 1 Number of measurements = 2	Repeated measures ANOVA with two linear contrasts, comparing the EMG *corrugator* activity of two blocks (active viewing – neutral and active viewing - negative). ANOVA is calculated using aov_ez() function of the afex-package, estimated marginal means are calculated using	ANOVA yields $p < .05$ is interpreted as physiological responding (EMG *corrugator* activity) changing significantly with blocks. Values of EMG *corrugator* activity are interpreted as equal between blocks if $p > .05$. Each contrast yielding $p < .05$ is interpreted as EMG *corrugator* activity being different between those two blocks, magnitude and direction are

		Corr among rep measures = 0.5 Nonsphericity correction ε = 1 <u>Output</u>: Noncentrality parameter λ = 16.1520293 Critical F = 4.7472253 Numerator df = 1.0 Denominator df = 12.0 Total sample size = 13 Actual power = 0.9573615	emmeans() function from the emmeans-package: if the factor Block is significant, pairwise contrasts are calculated using pairs() with Bonferroni adjustment for multiple testing. Bayes factors are computed for the ANOVA and each contrast using the BayesFactor-package.	inferred from the respective estimate. Values of EMG *corrugator* activity are interpreted as equal between blocks if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
	1c) Physiological responding (EMG *levator* activity) is lower while actively viewing neutral pictures compared to actively viewing negative pictures.	F tests - ANOVA: Repeated measures, within factors Analysis: A priori: Compute required sample size <u>Input:</u> Effect size f = 0.4396788 (η_p^2 = 0.162) (Pilot Study) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of groups = 1 Number of measurements = 2 Corr among rep measures = 0.5 Nonsphericity correction ε = 1 <u>Output</u>: Noncentrality parameter λ = 14.6921260 Critical F = 4.4138734 Numerator df = 1.0 Denominator df = 18.0 Total sample size = 19 Actual power = 0.9517060	Repeated measures ANOVA with two linear contrasts, comparing the EMG *levator* activity of two blocks (active viewing – neutral and active viewing - negative). ANOVA is calculated using aov_ez() function of the afex-package, estimated marginal means are calculated using emmeans() function from the emmeans-package: if the factor Block is significant, pairwise contrasts are calculated using pairs() with Bonferroni adjustment for multiple testing. Bayes factors are computed for the ANOVA and each contrast using the BayesFactor-package.	ANOVA yields $p < .05$ is interpreted as physiological responding (EMG *levator* activity) changing significantly with blocks. Values of EMG *levator* activity are interpreted as equal between blocks if $p > .05$. Each contrast yielding $p < .05$ is interpreted as EMG *levator* activity being different between those two blocks, magnitude and direction are inferred from the respective estimate. Values of EMG *levator* activity are interpreted as equal between blocks if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.

2.) Do ER strategies reduce emotional arousal? (Manipulation check)	2a) Subjective arousal (arousal rating) is lower after using an emotion regulation strategy (distraction, distancing, suppression) compared to active viewing.	F tests - ANOVA: Repeated measures, within factors Analysis: A priori: Compute required sample size <u>Input:</u> Effect size f = 0.50 (η_p^2 = 0.20) (Scheffel et al., 2021) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of groups = 1 Number of measurements = 4 Corr among rep measures = 0.5 Nonsphericity correction ε = 1 <u>Output</u>: Noncentrality parameter λ = 20.0 Critical F = 2.9603513 Numerator df = 3.0 Denominator df = 27.0 Total sample size = 10 Actual power = 0.95210128	Repeated measures ANOVA comparing the subjective arousal ratings of four blocks (active viewing, distraction, distancing, suppression). ANOVA is calculated using aov_ez() function of the afex-package, estimated marginal means are calculated using emmeans() function from the emmeans-package: if the factor Block is significant, pairwise contrasts are calculated using pairs() with Bonferroni adjustment for multiple testing. Bayes factors are computed for the ANOVA and each contrast using the BayesFactor-package.	ANOVA yields $p < .05$ is interpreted as arousal ratings changing significantly with blocks. Values of arousal ratings are interpreted as equal between blocks if $p > .05$. Each contrast yielding $p < .05$ is interpreted as arousal ratings being different between those two blocks, magnitude and direction are inferred from the respective estimate. Values of arousal ratings are interpreted as equal between blocks if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
3.) Do ER strategies reduce physiological responding? (Manipulation check)	3a) Physiological responding (EMG *corrugator* activity) is lower after using an emotion regulation strategy (distraction, distancing, suppression) compared to active viewing.	F tests - ANOVA: Repeated measures, within factors Analysis: A priori: Compute required sample size <u>Input:</u> Effect size f = 0.1605 (Zaehringer et al., 2020) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of groups = 1 Number of measurements = 4 Corr among rep measures = 0.5 Nonsphericity correction ε = 1	Repeated measures ANOVA comparing the *corrugator* muscle activity of four blocks (active viewing, distraction, distancing, suppression). ANOVA is calculated using aov_ez() function of the afex-package, estimated marginal means are calculated using emmeans() function from the emmeans-package: if the factor Block is significant, pairwise contrasts are calculated using	ANOVA yields $p < .05$ is interpreted as *corrugator* muscle activity changing significantly with blocks. Values of *corrugator* muscle activity are interpreted as equal between blocks if $p > .05$. Each contrast yielding $p < .05$ is interpreted as *corrugator* muscle activity being different between those two blocks, magnitude and direction are inferred from the respective estimate. Values of *corrugator* muscle activity

		<u>Output</u>: Noncentrality parameter λ = 17.5169700 Critical F = 2.6404222 Numerator df = 3.0 Denominator df = 252 Total sample size = 85 Actual power = 0.9509128	pairs() with Bonferroni adjustment for multiple testing. Bayes factors are computed for the ANOVA and each contrast using the BayesFactor-package.	are interpreted as equal between blocks if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
	3b) Physiological responding (EMG *levator* activity) is lower after using an emotion regulation strategy (distraction, distancing, suppression) compared to active viewing.	F tests - ANOVA: Repeated measures, within factors Analysis: A priori: Compute required sample size <u>Input:</u> Effect size f = 0.1605 (Zaehringer et al., 2020) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of groups = 1 Number of measurements = 4 Corr among rep measures = 0.5 Nonsphericity correction ε = 1 <u>Output</u>: Noncentrality parameter λ = 17.5169700 Critical F = 2.6404222 Numerator df = 3.0 Denominator df = 252 Total sample size = 85 Actual power = 0.9509128	Repeated measures ANOVA comparing the *levator* muscle activity of four blocks (active viewing, distraction, distancing, suppression). ANOVA is calculated using aov_ez() function of the afex-package, estimated marginal means are calculated using emmeans() function from the emmeans-package: if the factor Block is significant, pairwise contrasts are calculated using pairs() with Bonferroni adjustment for multiple testing. Bayes factors are computed for the ANOVA and each contrast using the BayesFactor-package.	ANOVA yields $p < .05$ is interpreted as *levator* muscle activity changing significantly with blocks. Values of *levator* muscle activity are interpreted as equal between blocks if $p > .05$. Each contrast yielding $p < .05$ is interpreted as *levator* muscle activity being different between those two blocks, magnitude and direction are inferred from the respective estimate. Values of *levator* muscle activity are interpreted as equal between blocks if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
4.) Do ER strategies require cognitive effort? (Manipulation check)	4a) Subjective effort (effort rating) is greater after using an emotion regulation strategy (distraction,	F tests - ANOVA: Repeated measures, within factors Analysis: A priori: Compute required sample size <u>Input:</u>	Repeated measures ANOVA comparing the subjective effort ratings of four blocks (active viewing, distraction, distancing, suppression).	ANOVA yields $p < .05$ is interpreted as effort ratings changing significantly with blocks. Values of effort ratings are interpreted as equal between blocks if $p > .05$.

	distancing, suppression) compared to active viewing.	Effect size f = 0.2041241 (η_p^2 = 0.04) (Scheffel et al., 2021) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of groups = 1 Number of measurements = 4 Corr among rep measures = 0.5 Nonsphericity correction ε = 1 <u>Output</u>: Noncentrality parameter λ = 17.6666588 Critical F = 2.6625685 Numerator df = 3.0 Denominator df = 156.0 Total sample size = 53 Actual power = 0.95206921	ANOVA is calculated using aov_ez() function of the afex-package, estimated marginal means are calculated using emmeans() function from the emmeans-package: if the factor Block is significant, pairwise contrasts are calculated using pairs() with Bonferroni adjustment for multiple testing. Bayes factors are computed for the ANOVA and each contrast using the BayesFactor-package.	Each contrast yielding *p* < .05 is interpreted as effort ratings being different between those two blocks, magnitude and direction are inferred from the respective estimate. Values of effort ratings are interpreted as equal between blocks if *p* > .05. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
	4b) Majority of participants reuse the strategy that was least effortful for them.	-	Subjects are asked about the reasons for their choice in the follow-up survey. These answers are classified into categories and counted.	The percentage choice of strategies is described descriptively.
5.) Which variables can predict individual subjective values of ER strategies?	5a) Subjective effort (effort ratings) negatively predict subjective values of ER strategies.	t tests - Linear multiple regression: Fixed model, single regression coefficient Analysis: A priori: Compute required sample size <u>Input</u>: Tail(s) = One Effect size f² = 0.34 (Since there are no findings in this respect yet,	Multilevel model of SVs with level-1-predictors subjective effort, subjective arousal, subjective utility, *corrugator*, and *levator* muscle activity using subject specific intercepts and allowing random slopes for ER strategies.	Fixed effects yield *p* < .05 are interpreted as subjective values are related to subjective effort. Subjective values are interpreted as not being related to subjective effort if *p* > .05. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.

	5b) Subjective arousal (arousal ratings) negatively predict subjective values of ER strategies.	we have inferred from the effect size in the closest-similar model: Westbrook et al., 2013) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of predictors = 4 <u>Output</u>: Noncentrality parameter δ = 3.4 Critical t = 1.6991270 Df = 29 Total sample size = 34 Actual power = 0.9529571	The null model and the random slopes model are calculated using lmer() of the lmerTest-package. Bayes factors are computed for the MLM using the BayesFactor-package.	Fixed effects yield *p* < .05 are interpreted as subjective values are related to subjective arousal. Subjective values are interpreted as not being related to subjective arousal if *p* > .05. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
	5c) Subjective utility (utility ratings) positively predict subjective values of ER strategies.			Fixed effects yield *p* < .05 are interpreted as subjective values are related to subjective utility. Subjective values are interpreted as not being related to subjective utility if *p* > .05. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
	5d) Physiological responding (EMG *corrugator* activity) negatively predict subjective values of ER strategies.			Fixed effects yield *p* < .05 are interpreted as subjective values are related to *corrugator* activity. Subjective values are interpreted as not being related to *corrugator* activity if *p* > .05. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
	5e) Physiological responding (EMG *levator* activity) negatively predict subjective values of ER strategies.			Fixed effects yield *p* < .05 are interpreted as subjective values are related to *levator* activity. Subjective values are interpreted as not being related to *levator* activity if *p* > .05.

				The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
6.) Is the effort required for an ER strategy the best predictor for subjective values of ER strategies?	6a) Subjective values decline with increasing effort, even after controlling for task performance (subjective arousal ratings), utility (subjective utility ratings), and physiological responding (EMG *corrugator* and *levator* activity).	t tests - Linear multiple regression: Fixed model, single regression coefficient Analysis: A priori: Compute required sample size <u>Input</u>: Tail(s) = One Effect size $f^2 = 0.34$ (Since there are no findings in this respect yet, we have inferred from the effect size in the closest-similar model: Westbrook et al., 2013) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of predictors = 4 <u>Output</u>: Noncentrality parameter $\delta = 3.4$ Critical t = 1.6991270 Df = 29 Total sample size = 34 Actual power = 0.9529571		Fixed effects yield $p < .05$ are interpreted as subjective values changing significantly with ER strategy. Subjective values are interpreted as equal between ER strategies if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.
7.) Are subjective values related to flexible emotion regulation?	7a) The higher the subjective value, the more likely the respective strategy is chosen.	1) χ^2 tests – Goodness-of-fit tests_ Contingency tables Analysis: A priori: Compute required sample size <u>Input:</u> Effect size $\omega = 0.5$ (Based on our theoretical considerations, we assume a large effect) α err prob = 0.05	1) Chi-squared test with the variables "predicted choice" (= highest SV of each participant) and "choice" (Strategy 1, 2, or 3) 2) Ordinal regression with dependent variable "Choice" (Strategy 1, 2, or 3) and independent variables "SV	1) χ^2 yields $p < .05$ is interpreted as predicted choice (highest SV of each participant) and actual choice show significant consistency. Predicted choice and actual choice are interpreted as independent if $p > .05$.

		Power (1-β err prob) = 0.95 Df = 1 Output: Noncentrality parameter λ = 19.8 Critical χ^2 = 11.0704977 Total sample size = 52 Actual power = 0.9500756 2) z tests –Logistic regression Analysis: A priori: Compute required sample size Input: Tails: One Pr(Y=1|X=1) H1 = 0.80 (Based on our theoretical considerations, that a higher SVs should lead almost certainly to the choice of the respective strategy) Pr(Y=1|X=1) H0 = 0.333 (Based on theoretical considerations: if all SVs are equal, choice is on chance level) α err prob = 0.05 Power (1-β err prob) = 0.95 R^2 other X = 0 X distribution: normal X param μ = 0 X param σ = 1 Output: Critical z = 1.6448536 Total sample size = 25 Actual power = 0.9528726	strategy 1", "SV strategy 2" and "SV strategy 3".	The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence. 2) Ordinal logistic regression yields $p <$ .05 is interpreted as the respective subjective value has a significant influence on the OR of the choice of a strategy. Respective SV is interpreted as not related to choice if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.

	7b) Subjective values are lower and decline stronger when ER flexibility is lower.	t tests – Linear multiple regression: Fixed model, single regression coefficient Analysis: A priori: compute required sample size <u>Input:</u> Tail(s) = One Effect size $f^2 = 0.15$ (as there is no evidence in the literature, we assume a medium sized effect) α err prob = 0.05 Power (1-β err prob) = 0.95 Number of predictors = 2 <u>Output:</u> Noncentrality parameter δ = 3.316662 Critical t = 1.69665997 Df = 71 Total sample size = 74 Actual power = 0.95101851	SVs will be sorted by magnitude in descending order. Values will be fitted in a linear model to estimate the individual intercept (i.e., the extent to which an individual considers any of the ER strategies useful) and slope (i.e., the extent to which one strategy is preferred over others, indicating less flexibility). A linear regression will be computed with individual intercepts and slopes as predictors and FlexER score as criterion.	β yield $p < .05$ are interpreted as significant association between predictor (intercept, slope) and ER flexibility. The direction of effect is interpreted according to sign (negative or positive). p – values > .05 are interpreted as no association between predictor and ER flexibility. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.

Exploratory: Are individual subjective values of ER strategies related to personality traits?			Multilevel model of SVs with level-1-predictors subjective effort, subjective arousal, *corrugator*, and *levator* muscle activity and level-2-predictors NFC and self-control using subject specific intercepts and allowing random slopes for ER strategies. The null model and the random slopes model are calculated using lmer() of the lmerTest-package. Bayes factors are computed for the MLM using the BayesFactor-package.	Fixed effects yield $p < .05$ are interpreted as subjective values are related to NFC and self-control. Subjective values are interpreted as not being related to subjective effort if $p > .05$. The Bayes factor *BF10* is reported alongside every *p*-value to assess the strength of evidence.

Supplementary Material

Supplementary Material 1

Table S1

List of IAPS (Lang, Bradley, and Cuthbert, 2008) and EmoPicS (Wessa et al., 2010) used in the ER paradigm.

	Neutral	Negative 1	Negative 2	Negative 3	Negative 4	Negative 5
	083†	225†	210†	208†	227†	223†
	107†	230†	218†	219†	252†	238†
	124†	255†	222†	226†	1051*	245†
	140†	327†	228†	253†	2800*	2981*
	143†	1111*	246†	254†	3061*	3016*
	7000*	3017*	251†	326†	3230*	3101*
	7002*	3022*	2703*	1301*	6561*	3181*
	7004*	3180*	3051*	3350*	6838*	3215*
	7006*	3280*	3160*	6242*	9120*	3220*
	7009*	6190*	3185*	6410*	9181*	3225*
	7021*	6244*	3301*	6555*	9185*	6020*
	7025*	6836*	6562*	6825*	9230*	6571*
	7041*	9180*	9031*	6940*	9254*	6831*
	7100*	9182*	9040*	8230*	9295*	8231*
	7150*	9253*	9042*	9041*	9332*	9373*
	7185*	9300*	9043*	9140*	9411*	9400*
	7211*	9326*	9145*	9340*	9420*	9402*
	7224*	9424*	9160*	9409*	9421*	9403*
	7233*	9425*	9184*	9570*	9599*	9405*
	7235*	9920*	9904*	9800*	9905*	9423*
Valence	4.86 ± 0.49	2.84 ± 0.57	2.64 ± 0.46	2.82 ± 0.62	2.65 ± 0.75	2.74 ± 0.70
Arousal	3.01 ± 0.61	5.62 ± 0.34	5.58 ± 0.38	5.60 ± 0.39	5.61 ± 0.41	5.63 ± 0.37

Note. * Pictures taken from the IAPS (Lang, Bradley, and Cuthbert, 2008); † Pictures taken from the EmoPicS (Wessa et al., 2010).

Detailed information on psychometric measures

WHO-5. General psychological well-being is assessed using the WHO-5 scale[45,46]. 5 Items such as "Over the past 2 weeks I have felt calm and relaxed." are rated on a 6-point Likert scale raning from 0 (at no time) to 5 (all of the time). The german version of the scale showed a high internal consistency (Cronbach's $\alpha = .92$)[46].

Connor-Davidson Resilience Scale. Resilience is assessed using the Connor-Davidson Resilience Scale (CD-RISC)[47–49]. 10 items such as "I am able to adapt to change." are rated on a scale from 0 (not true at all) to 4 (true nearly all the time). The 10-item version showed a high internal consistency (Cronbach's $\alpha = .84$) and a satisfactory retest-reliability of $r_{tt} = .81$ across 6 month[48].

Emotion Regulation Questionnaire. Habitual use of reappraisal and suppression is measured using the 10-item Emotion Regulation Questionnaire (ERQ)[9,50]. The scale has items such as "I keep my emotions to myself" (ERQ-suppression - 4 items) and "When I'm faced with a stressful situation, I make myself think about it in a way that helps me stay calm" (ERQ-reappraisal - 6 items), which are answered on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), and has acceptable to high internal consistency (Cronbach's $\alpha > .75$)[69].

FlexER Scale. Flexible use of ER strategies is assessed using the FlexER Scale[44] with items such as "If I want to feel less negative emotions, I have several strategies to achieve this.", which are answered on a 4-point scale ranging from "strongly agree" to "strongly disagree". Psychometric properties are currently under investigation.

Implicit Theories Questionnaire. Implicit theories of willpower in emotional control are assessed using the Implicit Theories Questionnaire of[51]. 4 items such as "Having to control a strong emotion makes you exhausted and you are less able to manage your feelings right afterwards." are rated on a 6-point scale ranging from 1 (fully agree) to 6 (do not agree at all). The questionnaire showed an internal consistency of Cronbach's $\alpha = .87$[51].

Need for Cognition Scale. Need for Cognition (NFC) is assessed with the 16-item short version of the German NFC scale[52]. Responses to each item (e.g., "Thinking is not my idea of fun", recoded) are recorded on a 7-point Likert scale ranging from -3 (completely disagree) to +3 (completely agree) and are summed to the total NFC score. The scale shows comparably high internal consistency (Cronbach's $\alpha > .80$)[52,70] and a retest reliability of $r_{tt} = .83$ across 8 to 18 weeks[71].

Self-Regulation Scale. As one measure of self-control, the Self-Regulation Scale (SRS)[54] is used. The scale has 10 items (e.g., "It is difficult for me to suppress thoughts that interfere with what I need to do.", recoded) on a 4-point scale ranging from 1 (not at all true) to 4 (exactly true). It has high internal consistency [Cronbach's $\alpha > .80$;[54]].

Brief Self-Control Scale. As a second measure of self-control, the Brief Self-Control Scale (BSCS)[55,56] is used. It comprises 13 items (e.g., "I am good at resisting temptations") with a 5-point rating scale ranging from 1 (not at all like me) to 5 (very much like me). The scale shows acceptable internal consistency (Cronbach's $\alpha = .81$)[56] .

Barratt Impulsiveness Scale. As a third measure of self-control, the Barratt Impulsiveness Scale (BIS-11)[57,58] is used. Responses to each item (e.g., "I am self-controlled.", recoded) are assessed on a 4-point scale ranging from 1 (never/rarely) to 4 (almost always/always). An internal consistency of Cronbach's $\alpha = .74$ and a retest reliability of $r_{tt} = .56$ for General Impulsiveness and $r_{tt} = .66$ for Total Score across 6 month were reported[58].

Attentional Control Scale. Attentional control is measured using the Attentional Control Scale (ACS)[59] with items such as "My concentration is good even if there is music in the room around me". The 20 items are rated on a 4-point scale ranging from 1 (almost never) to 4 (always). An internal consistency of Cronbach's $\alpha = .88$ was reported[59].

Test for normal distribution of predictor variables

Table S.2
Results of Shapiro-Wilk test for normal distribution of subjective arousal and effort ratings for all strategies.

	M	*SD*	*W*	*p*
Arousal View Neu	26.63	39.12	0.68	0.00
Arousal View Neg	187.78	87.31	0.98	0.06
Arousal Distraction	158.13	92.49	0.97	0.01
Arousal Distancing	168.62	95.75	0.98	0.04
Arousal Suppression	163.96	87.17	0.98	0.07
Effort View Neu	18.15	27.37	0.65	0.00
Effort View Neg	49.40	62.26	0.74	0.00
Effort Distraction	208.46	96.15	0.98	0.13
Effort Distancing	158.26	99.50	0.97	0.01
Effort Suppression	189.80	92.34	0.98	0.12

Table S.3
Results of Shapiro-Wilk test for normal distribution of Corrugator and Levator activity for all strategies.

	M	*SD*	*W*	*p*
Corrgator View Neu	0.04	6.99	0.05	0.00
Corrgator View Neg	1.03	7.21	0.19	0.00
Corrgator Distraction	0.00	7.67	0.04	0.00
Corrgator Distancing	0.07	3.78	0.08	0.00
Corrgator Suppression	0.25	1.92	0.35	0.00
Levator View Neu	0.09	1.84	0.38	0.00
Levator View Neg	0.58	3.20	0.43	0.00
Levator Distraction	-0.05	1.16	0.52	0.00
Levator Distancing	-0.03	0.92	0.48	0.00
Levator Suppression	0.01	1.00	0.55	0.00

Post-hoc tests of strategies for effects of ER on subjective arousal and physiological responding

Table S.4
Post-hoc tests for effects of ER strategies on subjective arousal ratings.

Contrast	Estimate	SE	df	t	p	$BF10$	η_p^2	$95\%CI$
$View_{neg} - Distraction$	29.65	6.68	357.00	4.44	0.00	168.48	0.05	[0.02, 1.00]
$View_{neg} - Distancing$	23.82	6.68	357.00	3.57	0.00	62.99	0.03	[0.01, 1.00]
$View_{neg} - Suppression$	19.16	6.68	357.00	2.87	0.03	1.97	0.02	[0.00, 1.00]
$Distraction - Distancing$	-5.83	6.68	357.00	-0.87	1.00	0.18	2.13e-03	[0.00, 1.00]
$Distraction - Suppression$	-10.49	6.68	357.00	-1.57	0.70	0.31	6.86e-03	[0.00, 1.00]
$Distancing - Suppression$	-4.66	6.68	357.00	-0.70	1.00	0.14	1.36e-03	[0.00, 1.00]

Table S.5
Post-hoc tests for effects of ER strategies on Corrugator activity

Contrast	Estimate	SE	df	t	p	$BF10$	η_p^2	$95\%CI$
$View_{neg} - Distraction$	0.18	0.04	351.00	4.79	0.00	21,919.73	0.06	[0.03, 1.00]
$View_{neg} - Distancing$	0.19	0.04	351.00	5.09	0.00	139,814.01	0.07	[0.03, 1.00]
$View_{neg} - Suppression$	0.21	0.04	351.00	5.67	0.00	1.84×10^7	0.08	[0.04, 1.00]
$Distraction - Distancing$	0.01	0.04	351.00	0.30	1.00	3.77×10^{-2}	2.61e-04	[0.00, 1.00]
$Distraction - Suppression$	0.03	0.04	351.00	0.88	1.00	8.02×10^{-2}	2.21e-03	[0.00, 1.00]
$Distancing - Suppression$	0.02	0.04	351.00	0.58	1.00	4.79×10^{-2}	9.51e-04	[0.00, 1.00]

Table S.6
Post-hoc tests for effects of ER strategies on Levator activity

Contrast	Estimate	SE	df	t	p	$BF10$	η_p^2	$95\%CI$
$View_{neg} - Distraction$	0.34	0.05	351.00	6.73	0.00	2.02×10^{11}	0.11	[0.07, 1.00]
$View_{neg} - Distancing$	0.28	0.05	351.00	5.66	0.00	3.99×10^7	0.08	[0.04, 1.00]
$View_{neg} - Suppression$	0.32	0.05	351.00	6.37	0.00	8.60×10^{10}	0.10	[0.06, 1.00]
$Distraction - Distancing$	-0.05	0.05	351.00	-1.07	1.00	0.22	3.26e-03	[0.00, 1.00]
$Distraction - Suppression$	-0.02	0.05	351.00	-0.36	1.00	3.91×10^{-2}	3.70e-04	[0.00, 1.00]
$Distancing - Suppression$	0.04	0.05	351.00	0.71	1.00	9.86×10^{-2}	1.44e-03	[0.00, 1.00]

778 **Exploratory analysis: Association between SVs and self-control and NFC**

Table S.7

Exploratory analysis: Results of MLM predicting SVs of ER strategies with level 2 predictors self-control and NFC.

Parameter	Beta	SE	p-value	f^2	Random Effects (SD)
Intercept	8.03×10^{-1}	0.01	0.00		0.11
Effort	-6.93×10^{-4}	0.00	0.00	0.04	
Utility	1.44×10^{-3}	0.00	0.00	0.20	
Corrugator activity	7.54×10^{-3}	0.00	0.03	0.00	
Self-Control	2.44×10^{-2}	0.01	0.04	0.00	
NFC	7.58×10^{-4}	0.00	0.44	0.00	