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The effect of choice on the physiology of emotion: An affective startle modulation study

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ABSTRACT

The affective startle modulation task has been an important measure in understanding physiological aspects of emotion and motivational responses. Research utilizing this method has relied primarily on a 'passive' viewing paradigm, which stands in contrast to everyday life where much of emotion and motivation involves some active choice or agency. The present study investigated the role of choice on the physiology of emotion. Eighty-four participants were randomized into 'choice' ($n=44$) or 'no-choice' ($n=40$) groups distinguished by the ability to choose between stimuli. EMG eye blink responses were recorded in both anticipation and stimulus viewing. Results indicated a significant attenuation of the startle magnitude in choice condition trials (relative to no-choice) across all picture categories and probe times. We interpret these findings as an indication that the act of choice may decrease one's defensive response, or conversely, lacking choice may heighten the defensive response. Implications for future research are discussed.

1. Introduction

A robust literature has consistently demonstrated that the startle response is modulated by foreground stimulus. Specifically, when viewing affectively negative stimuli, participants' startle responses are potentiated relative to neutral, and while viewing positive pictures, startle responses are attenuated relative to neutral. This task, termed the affective startle modulation (ASM), has been a particularly helpful tool in both basic research on the processes of emotion and motivation (Dichter et al., 2002; Gard et al., 2007; Sabatinelli et al., 2001) and in research with a variety of clinical populations, including schizophrenia, depression, and specific phobias (e.g. Curtis et al., 1999; Grillon, 2008; Kring et al., 2011; Patrick, 1994; Pissiota et al., 2003; Schlenker et al., 1995; Taiminen et al., 2000; Volz et al., 2003).

To our knowledge, research using ASM has only utilized a 'passive' viewing paradigm, in which the emotional foreground stimulus is chosen randomly for participants. Participants in ASM studies have not had choice or control over the stimuli they experience. In contrast to this, much of the emotion experienced in daily life has an inherent element of choice. Basic experiences of success, failure, goal-attainment, frustration, interpersonal conflict, and intimacy often have an element of choice or agency. In fact, very few emotional experiences are devoid of agency or choice in some way.

Research in social psychology and behavioral economics has highlighted the importance of choice on important psychological factors including motivation, performance, and satisfaction. For example, Self-determination theory has long posited that the availability of choice results in positive motivational and performance outcomes (Deci, 1980; Deci and Ryan, 1985; Ryan and Deci, 2000). When an individual feels some sense of control over his or her environment there is a related increase in the experience of intrinsic motivation (Patall et al., 2008). Studies on employee work-place autonomy and self-determination have found a significant relationship with task-related motivation (Deci et al., 1989). Conversely, more rigorously controlled work environments (i.e., limited choice) resulted in decreased levels of employee motivation. Related work on learned helplessness has demonstrated that motivation and learning suffer when a perceived lack of control exists (Seligman, 1975). The existence of choice has also been shown to moderate the experience of subjectively aversive stimuli. In studies involving eating unappetizing foods or administering electrical shock, participants with an element of choice reported experiencing these events as less unpleasant than their no-choice counterparts (Zimbardo et al., 1965). Additionally, findings of increased effort (Becker, 1997), perceived competence (Kernan et al., 1991), and enjoyment of tasks (Swann and Pittman, 1977) are all moderated by the presence of personal choice. In sum, these findings illustrate the importance of investigating the relationship between choice and the experiences of emotion and motivation.

Our goal with the current study design was to investigate the moderating effect of choice on the emotion experience of affective

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stimuli utilizing the ASM as a physiological measure. We created 'choice' and 'no-choice' conditions in a typical ASM design and defined choice as the participant's ability to have a measure of control over the picture stimuli presented. We also included an anticipatory period, utilized in other ASM designs, to investigate whether the effect of choice would impact the anticipation of the stimulus (e.g. Dichter et al., 2002; Patrick and Berthot, 1995; Sabatinelli et al., 2001). We added this condition in order to investigate the temporal course of emotion as it relates to choice (Davidson, 1998), and anticipation (Knutson et al., 2007, 2008). Our hypotheses were as follows: 1) During picture viewing the startle response in both choice and no-choice conditions will replicate the pattern reported in previous studies, with potentiation in trials of negative stimuli and attenuation in trials of positive stimuli. Although no previous studies have used choice as a variable in ASM designs, we have no reason to believe that approach and avoidance motivation systems will not be active in the choice condition (as they are in no choice conditions). 2) During anticipation of stimuli, the startle response in both the choice and no-choice conditions will replicate previous research with potentiation in anticipation of both positive and negative pictures. 3) We predict a general dampening of the startle response in the choice condition compared to the no-choice condition. Our rationale for this hypothesis is that previous research has found that the intensity of the startle response is negatively associated with approach motivation activation (e.g. Bradley et al., 2001a; Gard et al., 2007). As images become more approach related, the startle response diminishes. Recent research has shown that choosing behavior and anticipation of choice activates neural substrates implicated in approach motivation (Knutson et al., 2007, 2008). Thus, we believe having choice may decrease one's startle response. Related to this, one interpretation of the social–psychological research reviewed above is that choice is generally associated with increased approach motivation, and thus, we would expect a decreased startle response in the choice condition.

2. Materials and methods

2.1. Participants

Participants were 84 undergraduate students (68 female; mean age = 25.4 years) randomly assigned into the choice ($n = 44$, 33 female, mean age = 26.61, SD = 10.64) and no-choice ($n = 40$, 35 female, mean age = 23.97, SD = 6.58) conditions. Neither age differences ($F(1,82) = 1.8$ *ns*) nor gender distribution ($x^2 = 1.39$, *ns*) was significantly different between the two groups. Participants received course credit for their efforts.

2.2. Materials

One hundred eighty digital images were selected from the International Affective Picture System (IAPS, Lang et al., 2008). Thirty-six pictures for each of the five stimulus categories (threat, victim, erotic, action, and neutral[1]) used in previous studies (e.g. Bradley et al., 2001a; Dichter et al., 2010; Gard et al., 2007) were selected based upon published self-report arousal values. Categorization of threat images was defined as images depicting an imminent threat to the viewer (e.g., barking dog, coiled snake, aimed weapon). Victim images were defined as depicting injuries and the aftermath of violence committed upon others. Action images were of exhilarating physical activities (e.g., sky-diving, skiing). Erotic images depicted intimate scenes of nude and semi-nude heterosexual couples. Consistent with previous research, primary analyses were conducted on valence categories (negative, neutral, positive), with threat and victim stimuli composing the negative image set and action and erotic composing the positive image set.

Visual and auditory stimuli were controlled by E-Prime v1.2 (Psychological Software Tools, Pittsburgh, PA) installed on a Pentium III class desktop PC, and displayed on a 15 in. LCD at a viewing distance of approximately 0.5 m. All behavioral responses, including picture selection and self-report data, were captured using the PC keyboard and recorded by the E-Prime software.

Acoustic startle probes were digitally generated white noise bursts 50 ms in duration, with instantaneous rise and fall times, amplified to 105 dB and presented binaurally through Sennheiser HD 490 headphones.

2.3. Design

During each trial participants were presented with a screen containing three thumbnail pictures (small, low-resolution preview images) numbered 1 through 3, all from the same picture category (e.g., threat, action, etc.). A between-subject design was utilized to ensure enough trails were presented within each cell of the study while minimizing subject burden and fatigue. Participants in the choice condition used the corresponding number keys to select the picture they preferred to view in full-screen size. Participants in the no-choice condition were asked to look at the three picture options for four seconds, but were not able to choose between them. The term 'chosen picture' shall be used throughout this description to refer to either the picture selected by the participant in the choice condition, or the picture randomly selected in the no-choice condition. Presented thumbnail pictures were 4 cm by 6 cm.

Following the thumbnail screen, participants viewed a blank screen for 4 s (the anticipation period) followed by the full sized chosen image, presented for 6 s. Two digital versions of the Self-Assessment Manikin (SAM) scale (Lang, 1980) were used to assess self-reported valence and arousal experience of the chosen picture. A 5 s inter-trial interval followed each trial.

Each session consisted of 63 individual trials. The first three trials for each participant were identical habituation trials included to allow the subjects to habituate to the aversive startle probe, and were therefore excluded in the data analysis. Each of the remaining 60 trials presented the participant with three images from one of the five image categories. The image category changed from trial to trial, but the images within any single trial were all compiled from the same image category. The image sets were predetermined based upon published valence and arousal scores (Lang et al., 2008) and their presentation order was randomized during each session. The position of the pictures on the screen was randomized during each trial. No pictures were repeated at any point during the session.

The randomization and blocking methods employed ensured the following: (a) participants encountered exactly three sets of each picture category during each quarter of the study session, (b) The order of sets within each block was randomized for each participant, (c) The presentation order of the three pictures within each set was randomized for each trial, (d) participants encountered exactly six occurrences of each startle probe condition (anticipatory, picture presentation, and no-startle—so that participants would not begin to predict the probe) during each quarter of the study session, and (e)

[1] IAPS image slide numbers used in this study organized by image category. Positive-Action: 8030, 8185, 8179, 8160, 8186, 8178, 8370, 8490, 8080, 8400, 8180, 5629, 8475, 8341, 8200, 8034, 8190, 8191, 8300, 8170, 5626, 8161, 8499, 8251, 8193, 8192, 5470, 8116, 8210, 5460, 8260, 5450, 8340, 8496, 8090, 8021. Positive-Erotic: 4800, 4659, 4670, 4664, 4681, 4810, 4652, 4683, 4695, 4660, 4687, 4608, 4658, 4694, 4656, 4607, 4651, 4672, 4647, 4689, 4677, 4669, 4666, 4676, 4690, 4611, 4680, 4643, 4649, 4770, 4653, 4599, 4645, 4650, 4609, 4641. Neutral: 7009, 5500, 7030, 7234, 5520, 7053, 7205, 7140, 7100, 5530, 7235, 5510, 7224, 7233, 7050, 5731, 7059, 7025, 7040, 7035, 7705, 7090, 7150, 7041, 5740, 7060, 7217, 7000, 7490, 7006, 7080, 7020, 7031, 7004, 7010, 7175. Negative-Threat: 6230, 6350, 6510, 6313, 1120, 6260, 2811, 1050, 1931, 1300, 1321, 6250, 1052, 1525, 1932, 6370, 1930, 6315, 6312, 1201, 1114, 6360, 1040, 1070, 1113, 1200, 1022, 6212, 1302, 1310, 6243, 1110, 1051, 6410, 1090, 6213. Negative-Victim: 3000, 3005, 3080, 3170, 3010, 3060, 6550, 9410, 3069, 3500, 3130, 3053, 3400, 3071, 3120, 6540, 3530, 3266, 3068, 3030, 3110, 9252, 3102, 3150, 9635, 6560, 9921, 3100, 3064, 3140, 3063, 3250, 6530, 6022, 9405, 6021.

participants would encounter one of each startle probe condition in all picture categories during each quarter of the study session.

For each trial, there existed three possible startle probes: (a) an anticipation probe presented 3.5 s into the anticipatory period (anticipatory condition), (b) a presentation probe presented 3 s into the display of the 'chosen' picture (viewing condition), or (c) a no probe condition in which there was no startle probe presented (no-startle condition). There was no more than one probe per trial and the specific pictures associated with each probe condition were randomized.

2.4. Startle EMG recording and quantification

In line with current startle guidelines (Blumenthal et al., 2005), raw electromyographic (EMG) data was recorded using two Ag–AgCl mini (4.2 mm sensor) Beckman-style reusable electrodes filled with electrode gel. The first electrode was placed directly below the left pupil in forward gaze, and the second approximately 1.5 cm lateral to the first, toward the subject's left-hand side. A third mini ground electrode was applied to the center of the participant's forehead. In order to minimize movement artifact all electrode leads were secured to the participant's body by medical tape and a hair clip was used to supply enough lead slack such that slight body movement did not result in tugging on the electrodes. Mean impedance measurements were 17.6 kΩ.

A Biopac MP150 Data Acquisition Unit was used to sample the raw EMG signal at 1000 Hz and amplify using a 5000 gain. The EMG signal was then displayed and recorded using the Acqknowledge software package installed on a separate Pentium III class desktop PC located in the adjacent observation room.

Raw EMG signals were filtered using a 13–1000 Hz passband and rectified online such that all measurements appeared as absolute values. The signal was then smoothed using a 30 ms averaging constant. The 300 ms scoring window used in analysis began 50 ms prior to each startle probe and ended 250 ms after the probe.

To quantify the EMG measurements, raw and smoothed EMG data from scoring windows defined by the startle probe were loaded into a visual scoring program based upon the Balaban algorithm (Balaban et al., 1986; Gard et al., 2007; Germans Gard and Kring, 2007). Startle responses with a base latency less than 20 ms or more than 100 ms after the startle probe were not considered in analysis as these responses are thought to be unrelated to the startle stimulus (Balaban et al., 1986).

Startle magnitudes for each trial were calculated as the difference between the electrical amplitude at peak and base. Trials in which EMG activity indicated that the participant did not blink were classified as 'no response', given a value of 0, and were considered in all analyses. Alternatively, if on a given trial EMG noise artifact made it impossible to accurately identify blink onset and/or peak, trials were classified as immeasurable and excluded. The present study's non-response rate (9% of trials) falls within published ASM guidelines (Blumenthal et al., 2005).

2.5. Data analysis strategy

Data analyses included three independent variables: (a) a between-subjects choice variable (choice, no-choice), (b) a two level within-subjects probe time variable (anticipatory, picture viewing), and (c) a three level within-subjects picture category variable (positive, neutral, and negative). Additionally, analyses were conducted using the self-report scores of picture valence and arousal collected after each trial to explore image category by choice condition differences.

A 2 × 2 × 3 repeated-measures mixed ANOVA with Agency × Startle Time × Picture Category was performed first to identify omnibus main effects. Independent samples t-tests were performed to compare startle magnitude means within picture categories between the choice and no-choice conditions for both the anticipatory and viewing periods. Post-hoc analyses were conducted to explore gender effects in image ratings and further investigate the significant main effect findings of startle modulation within image categories.

3. Results

3.1. Self-report of image arousal and valence

A significant main effect of picture content on arousal ratings was found across all probe times and choice conditions, $F(2,166) = 221.83$, $p < .001$, indicating that picture category moderated the participant's experience of arousal. Although there were no significant differences in gender, $F(1,82) = 0.9$ *ns*, when subdivided into component image categories there was a significant content × gender interaction, $F(4,410) = 3.1$, $p < .05$. Further analysis indicated that women as a group reported erotic stimuli as less arousing (means: 5.16 < 6.09, $t(82) = 1.99$, $p < .05$). This result is in line with well replicated findings that male participants generally rate erotic images as more pleasurable and arousing than their female counterparts (e.g. Bradley et al., 2001b; Koukounas and McCabe, 1997; Steinman et al., 1981).

When choice condition effects were analyzed there was no significant main effect of choice in arousal ratings, $F(1,82) = 0.3$ *ns*, and no significant picture content × choice interaction, $F(4,410) = 0.2$, *ns*. These results are interpreted as an indication that participants in both choice and no-choice conditions found the pictures equally arousing, and suggest that differences in startle modulation are unlikely to be caused by differential arousal to the picture content based on the choice condition manipulation.

A significant main effect of picture content on self-report valence scores was found, $F(2,166) = 486.2$, $p < .001$. These results indicate that the picture choices succeeded in representing significantly different levels of emotional experience. Specifically, valence ratings for positive images were greater than neutral (means: 6.2 > 4.9, $t(83) = 12.3$, $p < .001$) and negative images were lower than neutral (means: 2.5 < 4.9, $t(83) = 20.5, p < .001$). As with the arousal scores, no main effect of gender on valence was found, $F(1,82) = 0.1$ *ns*, but when subdivided into component image categories there was a significant content × gender interaction, $F(4,328) = 2.3$, $p < .05$, with women reporting significantly lower valence levels for erotic images (means: 6.06 < 6.69, $t(82) = 2.04$, $p < .05$).

When valence scores were analyzed by choice condition there was no significant interaction found of content × choice, $F(4,328) = 0.4$, *ns*. However, there was a significant main effect of choice condition found, $F(1,82) = 7.4, p < .01$. Independent samples t-tests of self-report valence scores revealed a significant result for the threat, $t(82) = 2.142$, $p < .05$, and neutral, $t(82) = 2.512$, $p < .05$, categories, such that individuals in the choice condition preferred these pictures compared to the no-choice group.

In order to test whether our image selection process successfully achieved presentation of chosen images with equivalent valence and arousal in both choice conditions we conducted *t*-test comparisons on published ratings. No differences were found between choice and no-choice groups in the scores of chosen images across all images categories (Valence: $t(118) = 0.14$, $p = 0.89$; Arousal: $t(118) = 0.02$, $p = 0.98$), or in the individual picture categories for Valence (Threat, $t(21) = 0.14$, $p = 0.89$; Victim, $t(21) = 0.30$, $p = 0.77$; Neutral, $t(21) = 0.15$, $p = 0.88$; Action, $t(21) = 0.15$, $p = 0.88$; Erotic, $t(21) = 0.71$, $p = 0.49$) and Arousal (Threat, $t(21) = 0.01$, $p = 0.89$; Victim, $t(21) = 0.03$, $p = 0.98$; Neutral, $t(21) = 0.03$, $p = 0.97$; Action, $t(21) = 0.06$, $p = 0.95$; Erotic, $t(21) = 0.07$, $p = 0.95$). These null findings appear to indicate that both groups (choice versus no-choice) viewed similarly valenced and arousing images.

3.2. Startle eyeblink response

Omnibus analysis of the within subject startle magnitudes found no significant main effect of probe time, $F(1,82) = 1.4$ *ns*, or probe time × choice interaction, $F(1,82) = 1.4$ *ns*, indicating that there was no overall difference in startle response during the anticipation and picture viewing periods. As predicted by previous research (Bradley et al., 2001a; Gard et al., 2007; Levenston et al., 2000) there was a significant main effect for picture content, $F(2,166) = 8.49$, $p < .001$, indicating that regardless of probe time there existed a significant difference in startle response magnitudes based upon picture content.

As predicted by hypothesis 1, trials with startle probes during picture viewing demonstrated a significant linear relationship ($F(1,83) = 25.28$, $p < .01$), with startle responses that were significantly higher for negative images when compared to positive images in both the choice, $t(43) = 3.47$, $p < .01$, and no-choice, $t(39) = 3.91$, $p < .01$, conditions (see Fig. 1). Similarly, during anticipatory probe trials we observed a significant linear relationship ($F(1,83) = 21.87$, $p < .01$), with potentiation of startle responses for negative images compared to positive images in both the choice, $t(43) = 3.06$, $p < .01$, and no-choice, $t(39) = 3.56$, $p < .01$, conditions. This finding is contrary to previous studies in which anticipatory startle modulation resembles a quadratic function, with potentiation in both negative and positive image categories. Further analysis confirmed this discrepancy and revealed a non-significant quadratic component, $F(1,83) = 2.44$, $p = .122$. As elaborated below, we believe the absence of this quadratic component may be due to an 'offset' effect caused by the initial thumbnail images (i.e., the 'anticipation' period may be seen as a period after the images were presented, albeit in smaller form), in which the startle magnitude is driven by stimulus valence, as in the image viewing period.

Analysis of the between groups choice variable was found to be significant, $F(1,82) = 7.7$, $p < .01$, indicating that the participant's ability to actively choose the picture stimuli was an important factor in startle response. Analysis of choice condition effect size indicated a moderate-large eta squared effect size of .075 (Cohen, 1988). In addition there was a trend for a content × choice interaction, $F(2,160) = 2.1$, $p = .087$, indicating that the relationship between startle magnitude and image category differed between the choice conditions. Analyses were re-conducted using a four factor ANOVA that included a participant gender variable and all reported effects remained unchanged.

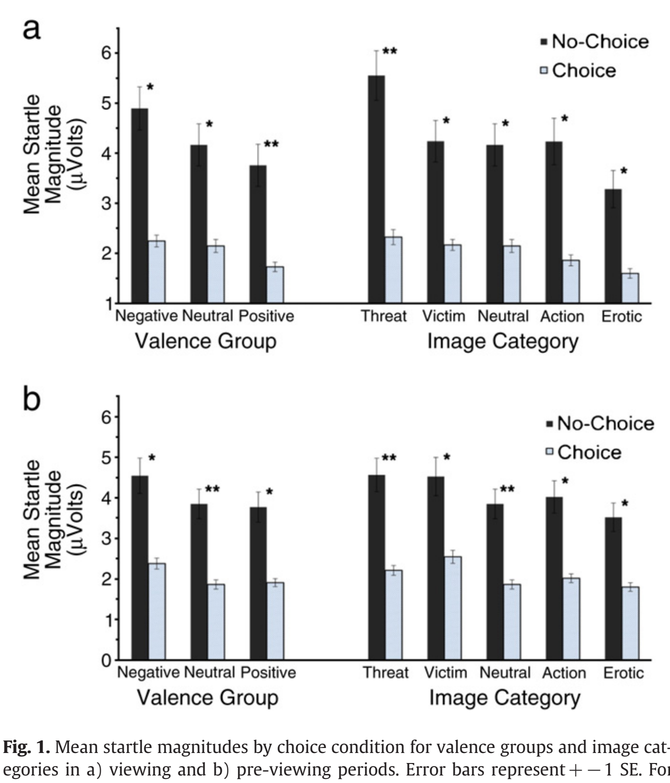

Fig. 1. Mean startle magnitudes by choice condition for valence groups and image categories in a) viewing and b) pre-viewing periods. Error bars represent + − 1 SE. For choice versus no-choice group comparisons, * indicates $p < .05$, ** indicates $p < .01$.

In order to ensure that the observed difference was not due to higher individual startle reactivity in any one group, we scored and assessed the three habituation trials presented identically to both groups at the beginning of each study session. Analysis revealed no significant difference in general startle reactivity between the choice conditions ($t(78) = -0.36$, $p = .72$ *ns*), furthering confidence that the choice manipulation was responsible for the observed main effect.

Independent sample t-tests were conducted to compare the mean startle magnitudes of each picture valence group and probe time combination in the choice and no-choice conditions. For each of the possible combinations of content and probe time (e.g., positive/anticipation, positive/viewing, neutral/anticipation, etc.) we compared the mean startle magnitude in the two choice conditions. Each of the six analyses indicated a significant dampening of the startle response in choice condition trials compared to those without choice (Fig. 1). Further, we divided the positive and negative valence groups into their component image categories (positive—action and erotic, negative—threat and victim) and performed similar between choice group t-tests. These eight additional comparisons also all yielded significant startle attenuation in choice condition trials (Fig. 1). These findings indicate that having a choice over a stimulus affects motivational system activation, regardless of whether the stimulus is positive or negative.

4. Discussion

The present study investigated the impact of choice on motivational system activation in the presence of emotionally evocative stimuli, using the affective startle modulation (ASM) paradigm. Results indicate a significant attenuation of startle magnitude for participants afforded a measure of choice over their stimuli compared to those participants that had the emotional stimuli chosen for them. Since the startle response during online experience of stimuli is thought to be a reliable measure of defensive response, we interpret this finding as an indication that perceived agency may dampen the natural defensive (avoidance) response. Having choice over a given situation may lower one's defenses and decrease vigilance to one's surroundings. Conversely, not having choice of an upcoming emotional stimulus or experience may heighten one's vigilance to environmental cues, resulting in an increased startle response to abrupt stimuli. Interestingly, the startle attenuation in the choice condition was not limited to negatively valenced trials, suggesting that the effect of choice is not restricted to making negative stimuli less aversive, but instead appears to be an overall effect of the act of choosing the stimuli regardless of valence. In other words, motivational state activation per se did not appear to be affected by choice, but rather the overall defensive response appeared to be dampened through the act of choosing.

As mentioned, the findings of decreased startle response in the choice condition were consistent in both the anticipation and picture viewing periods, indicating that choice impacted both the anticipation and experience of the images. However, it is important to note that the attenuated startle response in anticipation of positively valenced pictures is in contrast to results of previous studies (e.g. Dichter et al., 2002; Sabatinelli et al., 2001). This attenuation of the startle response in anticipation of the positively valenced full-sized pictures is likely a reflection of the study design, given that the attenuation occurred in both the choice and no-choice groups. The most likely explanation for this finding is that the small thumbnail pictures viewed prior to the 'anticipation' period elicited an approach response to the positively valenced content. After the thumbnails were viewed, the attenuated startle response (normally seen in the viewing period) persisted in the 'anticipation' period. The anticipation period in this study was likely similar to an 'offset' period used in other studies, during which a startle probe will elicit a valence dependent response even after the image is removed (e.g. Germans Gard and Kring, 2007). Alternatively, it is possible that during the anticipation period participants were actively imagining the image content of the thumbnail images they had just seen, thus influencing startle reactivity measured during this time frame. Interestingly, this lack of a potentiation to an approach image was still diminished in the choice condition relative to the no-choice condition, indicating that although this was not a true 'anticipation' period, the findings of diminished startle in the choice condition existed nonetheless. In short, it appears that this type of design (with the thumbnail pictures) is effective for assessing the impact of choice, but is not effective for the measurement of anticipation.

Although the primary finding of ASM group differences was significant, it is important to note that we are unable to rule out the possibility that participants in the choice condition were systematically selecting stimuli that are inherently more positively valenced (i.e., something distinct about certain images, beyond the self-reported experience), and that these differences may be related to the attenuation of the startle response. We attempted to control for this potential confound by tightly grouping stimulus pictures by published valence scores, so that there was limited variance (by valence) in the choice of the three thumbnail pictures. Indeed, there were only two content categories where participants rated the stimuli as more positively valenced in the choice condition (threat and neutral) compared to those in the no-choice condition. Furthermore, the differences in startle magnitude were not limited to these two content categories, but were found in all stimulus categories in both anticipation and viewing periods. In other words, even for content where there were no self-report differences, there were significant differences in startle magnitude. Future research may control for these differences by matching the specific pictures seen for the choice and no-choice group (for example, using a matched control group where individual participants in the no-choice group see the chosen pictures from a previous 'choice' group participant). Additionally, the viewing time of the three picture thumbnail screen may have differed in the two choice conditions. Participants without choice viewed the thumbnails for 4 s, while choice condition participants viewed the images only until they indicated their choice on the keyboard. Nonetheless, it should be noted that the pattern of results (i.e., the linear effect) did not differ by group. An alternative interpretation of the stated findings might posit uncertainty as a factor, which potentiates startle response in no-choice relative to choice trials, as opposed to the attenuating effect of agency offered previously. The current design does not allow us to disentangle the two possibilities and should be explored in future studies.

Our interpretation of the decreased startle response in the choice condition as an indication of decreased defensive response could be thought to contradict research on some of the negative consequences of having increased choices over stimuli in the environment. Schwartz and colleagues have produced a compelling body of research in decision making that has demonstrated a negative association between increased choice options and overall satisfaction (e.g. Schwartz, 2004). An important distinction between those studies and the one currently being reported is the number of options made available to study participants. It should be noted that the choice in this study was limited to three options, compared to studies where participants' options are more numerous (e.g., up to 30 options in studies by Iyengar and Lepper (2000)). From this study it is unclear what the effect of making a choice from many more options would be. Further study is necessary to identify an optimal number of choices necessary to provoke the most positive emotional experience of stimuli.

Although our interpretation is that choice may be decreasing the defensive startle response overall, there are other potential interpretations. For example, we are referring to the independent variable as 'choice'—however, depending on how you define it, this may also be thought of as a difference between expectancy (for review see Eerde and Thierry, 1996). That is, in the choice condition participants know what is coming after their choice, while individuals in the no choice condition do not. Another explanation is that participants in the choice condition may be paying more attention to a specific thumbnail image, and ignoring the remaining two, potentially habituating to the image that is focused on (whereas the no choice group may be spreading their attention to all three images). However, this alternative explanation seems unlikely as previous research has indicated that repeated viewing of affective images (i.e., habituation) removes the expected linear effect (Larson et al., 2000), which is not what occurred here. A third alternative explanation might posit emotion regulation strategies as a causal factor in the observed startle modulation. It is known that motivated up-regulation and down-regulation strategies can potentiate and attenuate startle magnitudes respectively (Bernat et al., 2011; Dillon and LaBar, 2005). However, the current finding of generalized attenuation independent of valence, present even in the neutral category, makes this alternative appear less likely. Finally, cognitive resources may be impacting the choice condition trials more than the no-choice condition trials, resulting in a diminished startle response (Anthony and Graham, 1985; Lang, 1995). However, the fact that the diminished startle response continues after the anticipation condition and several seconds into the viewing condition, argues against this alternative hypothesis.

In addition to implications for basic science research in emotion and motivation, we believe these findings represent an important opportunity for research in psychopathology. The presence of personal agency and choice has been identified as important predictive factors in a number of clinical disorders. Reker (1997) investigated the role of a number of factors in the development of depression in the elderly and found that "the freedom to choose and being responsible for those choices is the most salient existential predictor of the absence of depression" (p. 714). Research in anxiety has likewise found choice to be a powerful predictor of symptom occurrence. In a study of treatment options for cancer patients a significantly higher percentage of patients not offered a choice of surgery experienced clinical levels of anxiety related to their illness (Morris and Royle, 1988). A better understanding of the underlying mechanisms of motivational systems will make it possible to more clearly define the abnormal activation and processing that may occur in various disorders. Disruption of normal emotional processing is a common aspect of many psychiatric disorders (Barlow, 2004; Moses and Barlow, 2006), and the role of choice (or lack thereof) may provide important insights into symptoms, and ultimately their treatment.

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