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Visual Attention Intensifies Emotion: A Replication Study

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Authors' Note

We have no known conflict of interest to disclose.

Abstract

Recent studies have made clear that emotion plays a role in intensifying attention. Mrvka et al. 2019 set out to demonstrate that voluntary attention given to stimuli intensifies the emotion associated with it. In this paper, we report the results from a replication of the first experiment reported in Mrkva et al. (2019), in which participants' attention was directed toward a target image. In the original experiment, participants were asked to rate the emotional intensity of the target objects. The perceived distinctiveness and the degree to which participants liked each image were also examined to find out whether either parameter mediates the relationship between emotion and attention. In our replication, participants perceived target images as more emotionally intense than control images, corroborating the results of the original experiment and aligning with our expectations. Distinctiveness was also found to have a statistically significant effect on attention, indicating that it mediates the relationship between emotion and attention. Liking had no such significant effect. While recent work suggests that emotion intensifies attention and that attention in return intensifies emotion, further research is still necessary to determine the relative magnitude of the responses (What kinds of attention result in more intense emotional responses and vice versa?) and the specific context (Which neural processes do said kinds of emotion and attention trigger?) in which each process occurs.

Key terms: Valence: referring to the affective "goodness" or "badness" of a stimulus. Generally considered to be negative, neutral or positive (Citron et al. 2014); Endogenous attention: Intentional attention involving conscious expectation of specific stimuli (Brosch et al. 11); Exogenous attention: effects associated with low level physical properties (intensity, color, size) and involuntary bottom up attention process (Brosch et al. 11).

Visual Attention Intensifies Emotion: A Replication Study

Attention and emotion are two important psychological components that significantly shape our lives. Our emotional reactions to an object as well as the degree to which we attend to them influence our daily interactions. There is a broad consensus that emotion intensifies attention (Mrkva et al. 2019), but less research has been conducted on the reverse causal relationship(whether attention intensifies emotion). This new understanding of the relationship between attention and emotion can allow for the development of new procedures in a litany of fields. In therapy, better techniques can be devised to deal with emotional trauma. In education, appeals to emotion can allow educators to get a better hold of the attention of their students. Lastly, in medicine, nuanced understandings of the neural pathways that play a role in emotional and attentional processes could result in more effective drugs that may augment patients' ability to cope with emotional distress.

The origins of the effect of emotion on attention have been widely examined. For example, Ohman and colleagues (2001) attributed emotion's intensification of attention to the "pop-out effect," whereby we direct attention to objects that pose a threat to us (e.g., a snake in the grass), which may subsequently evoke fearful responses. This aligns with our understanding of the neural pathways that enable emotional and attentional processing which have also been extensively studied. Additionally, it is clear that the brain has limited bandwidth for processes related to conscious attention and not all stimuli can be processed at a level necessary for image recognition. As such, information is prioritized and processing of stimuli occurs in stages in various parts of the brain (Schupp et al., 2007). This explains why fear-inducing objects are prioritized in the pop-out effect, as humans likely had an evolutionary incentive to prioritize the processing of threat- or reward- related information. This is corroborated in earlier research that links objects with significant negative or positive valence to the brain's innate systems of motivation and avoidance, connecting the brain's processes for attention and emotion (Schupp et al. 2003).

Further, we also know that a significant locus for uniting these processes is the amygdala. This region has been known to independently augment the emotion-attention network in the brain, enhancing it in parallel to the original process (Taylor et al. 2005). For example, the amygdala can link the attentional processing that occurs in the dorso-lateral prefrontal cortex, to the limbic system, where emotional processing occurs. This process is generally strengthened via the amygdala's direct action on the parietal cortex, which primarily deals with sensory perception, in conjunction with attention processing systems in the frontal cortex (Vuilheumer et al. 2005). However these effects have largely been examined in the context of emotion's effect on attention.

The Present Study

This paper and our replication will examine these processes in the context of attention's effect on emotion. As such, our replication is particularly important because it approaches the relationship between emotion and attention in a new light while also helping alleviate the replication crisis in psychology for novel research. Experiment 1 examined the perceived emotional intensities of images selected as targets versus control images, facilitated by voluntary attention directed by visual search. Experiment 2 and 3 delve deeper into manipulating voluntary attention and isolating visual search effects. In this paper, we replicate results from Experiment 1.

Our replication of Experiment 1 uses the paper's dataset and codebook from the Open Science Framework (OSF | Experiment1(new_search).csv). Replication of data analysis was done in R, using linear mixed effects modeling.

Methods

Participants

Mrkva et al. recruited US adult participants via Clickworker, and participants were compensated $2.00 for their time. Of 100 participants (60 female, 40 male); mean age of participants was 35.2 years. Participants were told their task was to select images for a future study.

Materials and Procedures

The International Affective Picture System (IAPS) was used. More specifically, 3 sets of 10 images were selected, each with either positive, neutral, or negative valences. The images within each set were presented in random order.

Replication Study Design

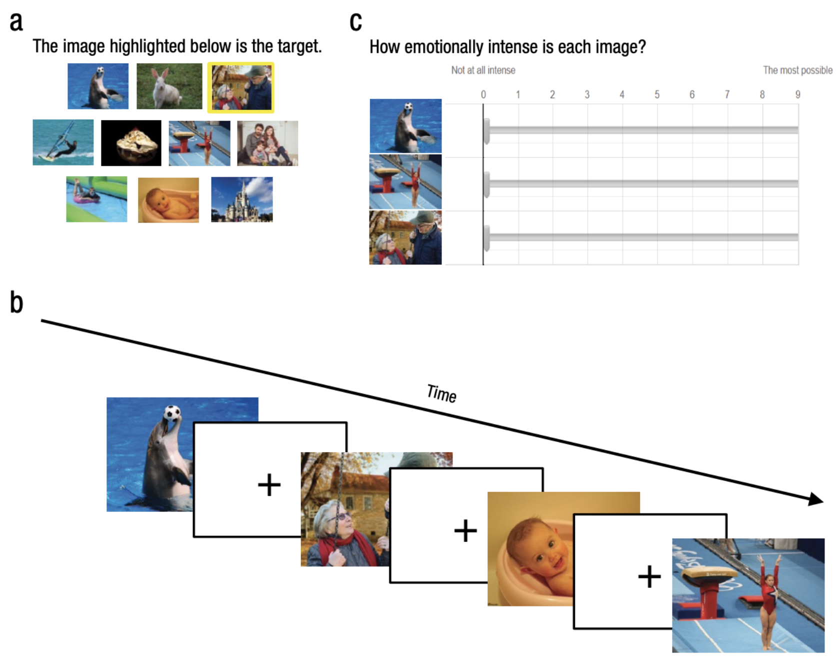
In the original study (Mrkva et. al, 2019) there were three experiments which aimed to investigate the effects of different manipulations of attention on perceived emotion. The present study focused on Experiment 1 and it's evaluation of the effects of voluntary attention on emotional intensity, liking, and distinctiveness.

Experiment 1

Experiment 1 followed three stages: target identification, image presentation, and image ratings. These stages are illustrated in the original paper, shown below as Figure 1 (taken from Mrkva et al., 2019). Ten images of either positive, negative, or neutral valence were presented on the screen simultaneously, with the target image highlighted (Figure 1, panel a). Each image was presented again one by one for a duration of 1 second (Figure 1, panel b). In between individual presentations of each image, there followed a fixation cross which remained on screen for a duration of 1 second. Participants were instructed to press the “J” key in response to the target image appearing on the screen and to press the “F” key when other (non-target) images appeared, excluding the fixation cross. Each valenced set of images was presented 10 times, with the image order randomized. Participants then rated images on perceived emotional intensity, liking, and distinctiveness (Figure 1, panel c). An image’s perceived emotional intensity score was the average of two questions rated on a 0 (not at all intense) to 9 (the most possible) scale: “How intense was your emotional reaction to each image?” and “How emotionally intense is each image?” Similarly, the self-reported measures of liking and distinctiveness were also on a 0 (not at all) to 9 (the most possible) scale: “How much do you like each image?” and “How distinct is each image?” Half of participants were randomly selected to provide baseline ratings of emotional intensity for all images prior to target identification (i.e., before all ten images were presented with a highlighted target image). The authors of the original paper (Mrkva et al. 2019) did not ask all participants to provide baseline ratings due to concerns that participants might anchor on initial ratings.

Figure 1

Outline of Procedure for Experiment 1



Note: Taken from the original paper, Figure 1 explains the 3 parts of Experiment 1 in Mrkva et al. 2019. Part 'a' shows 10 images of the same valence: 9 are control images; the target image is highlighted in yellow. Part 'c' illustrates an example of the sliding scale used to rate the emotional intensity of the images. Part 'b' depicts the randomized presentation sequence, with a fixation cross between images.

Experimenter demand and hypothesis awareness. Demand characteristics and hypothesis awareness were examined at the end of Experiment 1. To assess demand, participants were asked how they thought the experimenter wanted them to rate the emotional intensity of the target versus control images on a continuous scale: "to rate the target images as much less emotionally intense" (-2), "to rate the target images as much more emotionally intense" (2), with "to not let my emotional intensity ratings be influenced by whether an image was a target or not" (0) (p.

944). For hypothesis awareness, each participant was asked to select "the purpose of the study" from eight answer choices, which included the correct purpose.

Data Analysis

We first replicated the correlation between the average intensity of an image and the average perceived intensity of the image. Next, we calculated descriptive statistics (means and standard deviation) for image emotional intensity at baseline and post-experimental task by target status. We used the following packages in our replication and analysis:

Package used	**Purpose**
lme4	Creates and analyzes linear mixed effects models
lmerTest	Provides summary tables for linear mixed effects models
emmeans	Calculates estimated marginal means and confidence intervals
dplyr	Manipulates data, including filtering, mutating, selecting columns
ggplot2	Data visualization, creates figures

Multilevel model approach

We used the lmer package to create a series of multilevel linear models for each metric (intensity, liking and distinctiveness) from which we derived simple slopes for each valence type. Each baseline model started with a linear model with target status entered as the predictor and one of the 3 metrics entered as the output. We then grouped the data by participant and image. After each modification, the output values more closely mirrored Mrkva et al.'s (2019) paper's values.

To fine-tune our models for emotional intensity, liking, and distinctiveness, we next entered image valence and a target status by image valence interaction. Two different contrast codes for image valence were utilized: one that tested for effect differences between both types of emotional images vs. all neutral images (neutral images = 2/3, negative and positive images = -⅓) and a second that compared the effect of negative vs. positive images only (negative = -1, neutral = 0, positive = 1). Additionally, we added control parameters, and calculated confidence intervals using the "Wald" method from the original paper. Finally, for deriving the simple slopes for each valence type, we used three dummy codes in which each valence was re-coded as 1 and the other two were re-coded as 0.

Experimenter Demand and Hypothesis Awareness

Finally, we replicated mean and standard deviation for the experiment demand as well as calculated the percentage of correct guesses for the purpose of the experiment.

Results

Data Replication

Correlation Test

Our analysis showed a $r = 0.76$ correlation between the average intensity rating of (or emotional reaction to) an image and the average *perceived* intensity rating of the same image. This was similar to the paper's value of $r = 0.72$ (Mrkva et. al, 2019).

Multilevel Models

The following results are organized by variable. The variables measured in Experiment 1 were emotional intensity, liking and distinctiveness (Mrkva et al., 2019). For a quick overview of all models, fixed effects and simple slopes, see Table 1.

Table 1

Summary of Mixed Effects for Emotional Intensity, Liking and Distinctiveness.

Table 1. Multilevel Model Summary of Effects for Emotional Intensity, Liking and Distinctiveness

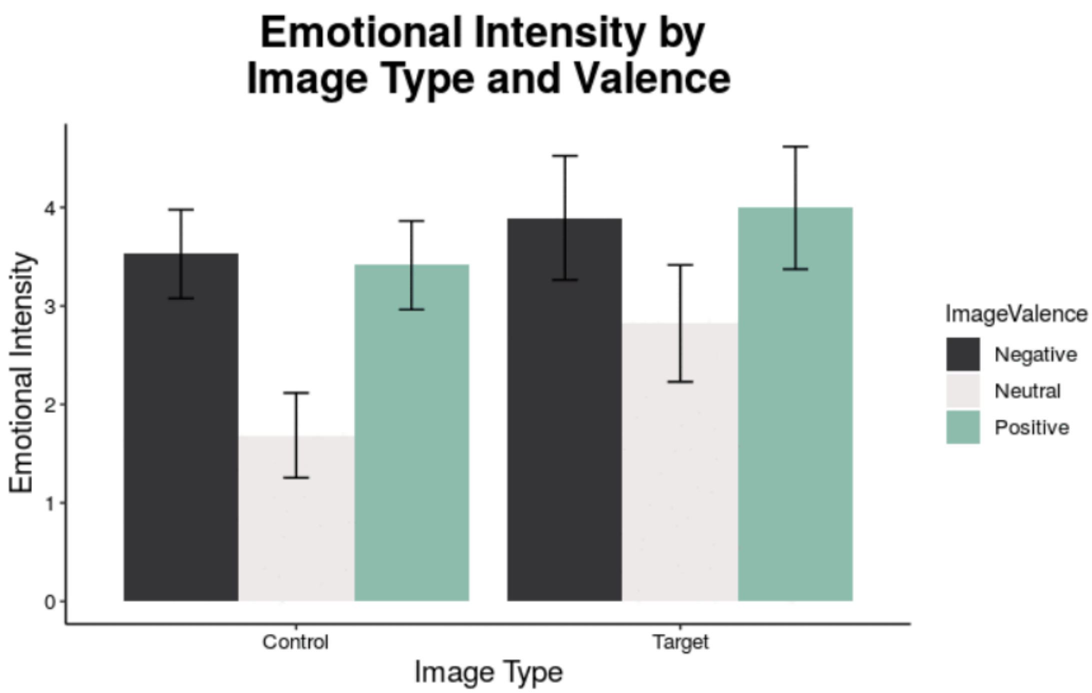
Category	*IV(s)*	*DF & t-value*	*Slope*	*95% Confidence Interval*	*p value*	*Model # in Code*
Emotional Intensity	target	$t(39.72) = 4.41$	$b = 0.70$	[0.39, 1.00]	$p < .001$	m1_paper
	target x neutral	$t(18.15) = 2.59$	$b = 0.66$	[0.16, 1.16]	$p = .018$	m1_paper
	target x valence	$t(18.12) = 0.73$	$b = 0.22$	[-0.36, 0.79]	$p = .476$	m1_paper
	neutral images	$t(25.71) = 5.93$	$b = 1.15$	[0.77, 1.53]	$p < .001$	m1e
	positive images	$t(41.83) = 2.66$	$b = 0.60$	[0.16, 1.04]	$p = .011$	m1d
	negative images	$t(26.82) = 1.58$	$b = 0.37$	[-0.09, 0.82]	$p = .125$	m1c
	baseline target	$t(52.28) = 3.94$	$b = 0.79$	[0.40, 1.19]	$p < .001$	m1a
	baseline control	$t(57.15) = -0.77$	$b = -0.07$	[-0.24, 0.11]	$p = .445$	m1b
Liking	target	$t(103.15) = 1.26$	$b = 0.15$	[-0.08, 0.39]	$p = .209$	m2
	target x neutral	$t(273.08) = 0.21$	$b = 0.05$	[-0.40, 0.50]	$p = .836$	m2
	target x valence	$t(95.71) = -1.02$	$b = -0.31$	[-0.89, 0.28]	$p =.310$	m2
Distinctiveness	target	$t(44.62) = 4.70$	$b = 0.98$	[0.57, 1.38]	$p < .001$	m3
	target x neutral	$t(17.37) = 3.22$	$b = 1.06$	[0.42, 1.71]	$p = .005$	m3
	target x valence	$t(17.17) = -0.31$	$b = -0.12$	[-0.84, 0.61]	$p = 0.760$	m3
	neutral images	$t(24.66) = 4.86$	$b = 1.68$	[0.77, 1.53]	$p < .001$	Model 15
	positive images	$t(21.47) = 1.58$	$b = 0.56$	[-0.14, 1.25]	$p = .129$	Model 16
	negative images	$t(29.64) = 2.27$	$b = 0.68$	[0.92, 1.27]	$p = .031$	Model 17

Emotional Intensity. Averages and standard deviations were successfully replicated with our final models for emotional intensity of target and control images (target: $M = 3.58$, $SD = 2.72$; control: $M = 2.87$, $SD = 2.61$; $t(39.72) = 4.41$, $b = 0.70$, 95% CI = [0.39, 1.00], $p < .001$. Further, the effect for target x neutral interaction was $t(18.15) = 2.59$, $b = 0.66$, 95% CI = [0.16, 1.16], $p = .018$. In line with Mrkva et. al's original findings, neutral images showed the largest effect: $t(25.71) = 5.93$, $b = 1.15$, 95% CI = [0.77, 1.53], $p < .001$, while the simple slope for positive images was $t(41.83) = 2.66$, $b = 0.60$, 95% CI = [0.16, 1.04], $p = .011$ and $t(26.82) = 1.58$, $b = 0.37$, 95% CI = [-0.09, 0.82], $p = .125$ for negative images. Target x valence interaction was $t(18.12) = 0.73$, $b = 0.22$, 95% CI = [-0.36, 0.79], $p =.476$.

Baseline emotional intensity averages and standard deviations for all valence types were also accurately replicated: (positive images: $M = 3.69$, $SD = 2.46$; neutral images: $M = 1.55$, $SD = 1.92$; negative images: $M = 3.50$, $SD = 2.62$), and the data showed higher intensity ratings for positive and negative images. In comparing target and control baseline ratings, target images were perceived as more intense than control images. Participants who had been a part of both the experimental and baseline groups, rated target images as more intense when they were presented in the experimental condition (target: *M* = 3.71, *SD* = 2.68) compared to baseline (baseline: *M* = 2.92, *SD* = 2.59; Note that baseline target values were approximated, but came very close to the original paper's baseline of *M* = 2.96, *SD* = 2.65) and had an effect of $t(52.28) = 3.94$, $b = 0.79$, 95% CI = [0.40, 1.19], $p < .001$). Further, for these participants, there was not a significant difference between how control images were rated at baseline (control: *M* = 2.85 , *SD* = 2.62; $t(57.15) = -0.77$, $b = -0.07$, 95% CI = [-0.24, 0.11], $p = .445$) and how they were rated in the experiment condition (see Figures 2a, 2b). Overall, data shows higher emotional intensity ratings across all valence types for images in the target condition (see Figure 2a, 2b). Thus the data reflects evidence for the effect of voluntary attention (experimental target condition) on emotional intensity.

Figure 2a.

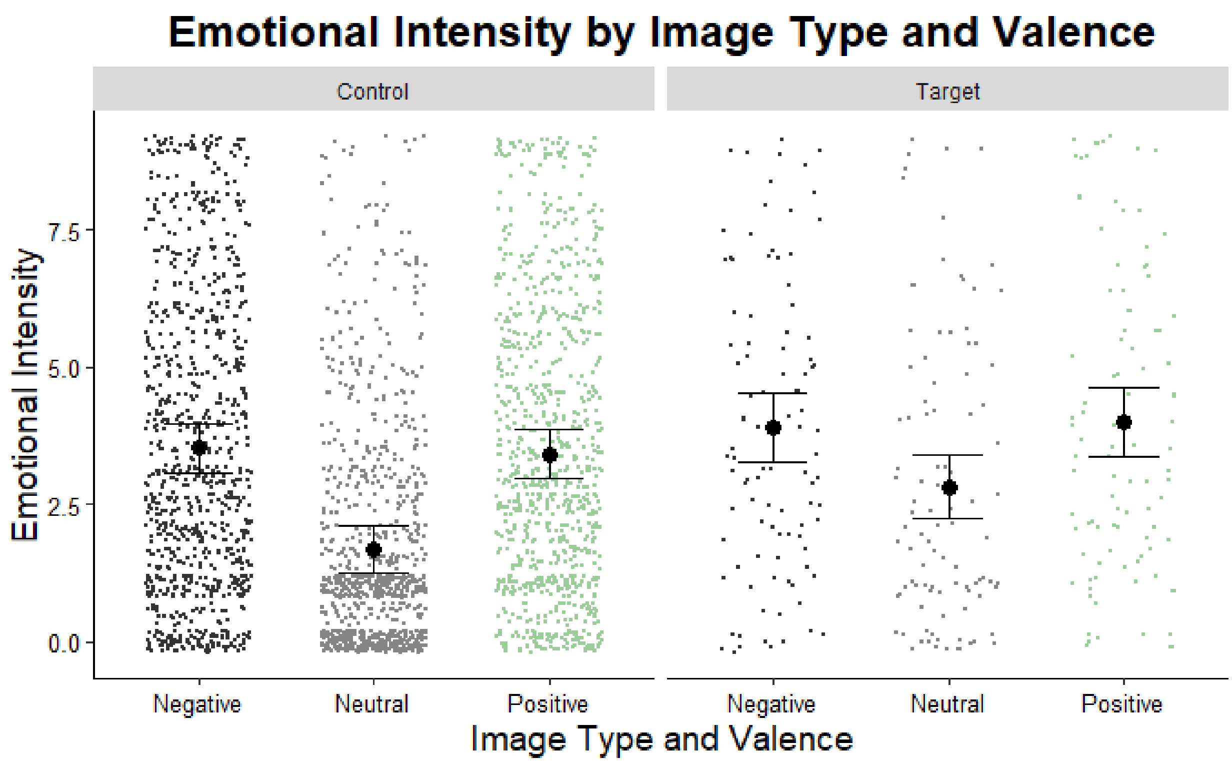
Comparison of emotional intensity ratings for control images and target images, grouped by valence.



Note: Negative, neutral and positive images were presented in both target and control conditions.

Figure 2b.

Comparison of emotional intensity ratings for control images and target images, grouped by valence.

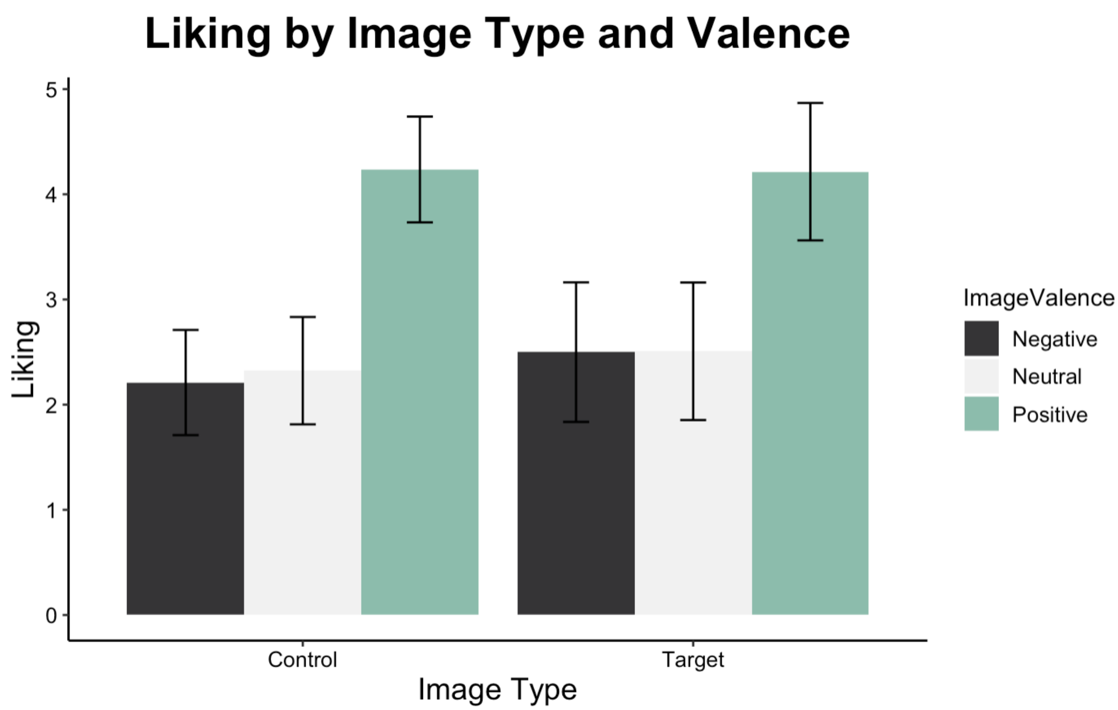


Note: Control image ratings are presented in the left panel, and target image ratings are presented in the right panel. Bars represent 95% confidence interval, and black point represents mean.

Liking. Participants also evaluated how much they liked the images. Averages and standard deviations of liking were thus replicated as well (target images: $M = 3.06$, $SD = 2.77$; with control images: $M = 2.92$, $SD = 2.78$) and successfully matched to original results (Mrkva et al., 2019). Little difference was observed between ratings of liking for control images and target images: $t(103.15) = 1.26$, $b = 0.15$, 95% CI = [-0.08, 0.39], $p = .209$. Negative images and neutral images were rated approximately the same (Target x neutral interaction was $t(273.08) = 0.21$, $b = 0.05$, 95% CI = [-0.40, 0.50], $p = .836$; however, positive images were rated significantly higher for liking in both control and target conditions. Target x valence interaction similarly showed no significant effects: $t(95.71) = -1.02$, $b = -0.31$, 95% CI = [-0.89, 0.28], $p = .310$). Thus, for liking, voluntary attention did not have a significant effect (see Figure 3).

Figure 3

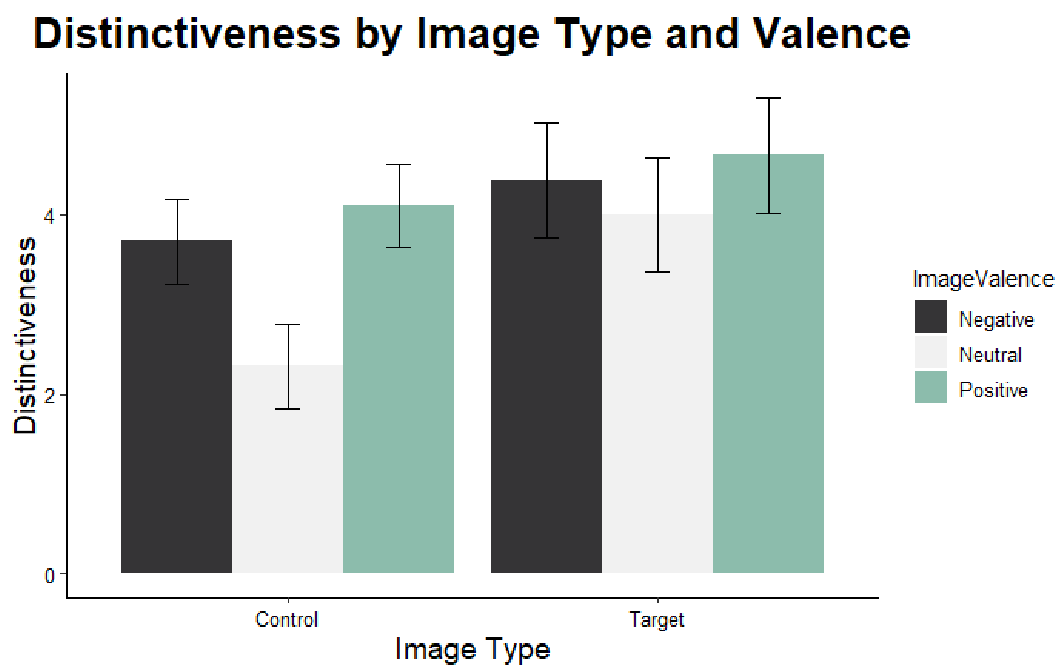
Differences between ratings of liking for control images and target images across valence categories.



Distinctiveness. Compared to control images, target images were rated as more distinctive by participants (Mrkva et al., 2019). Results supported this finding (target images: $M = 4.34$, $SD = 2.94$, control images: $M = 3.37$, $SD = 2.77$; $t(44.62) = 4.70$, $b = 0.98$, 95% CI = [0.57, 1.38], $p < .001$) and were accurately replicated (effect's degrees of freedom were approximated). For each category, some increase was observed for distinctiveness across valence types (target x valence interaction: $t(17.17) = -0.31$, $b = -0.12$, 95% CI = [-0.84, 0.61], $p = 0.760$. However, only neutral images saw a significant increase in distinctiveness in the target images when compared to control images (target x neutral interaction: *t*(17.37) = 3.22, *b* = 1.06, 95% CI = [0.42, 1.71], *p* = .005). For both Control and Target images, images with positive and negative valence were rated higher for distinctiveness than neutral images (simple slope for neutral images: *t*(24.66) = 4.86, *b* = 1.68, 95% CI = [0.77, 1.53], *p* < .001), with images with positive valence being slightly more distinct (positive images: *t*(21.47) = 1.58, *b* = 0.56, 95% CI = [-0.14, 1.25], *p* = .129). The simple slope for negative images was *t*(29.64) = 2.27, *b* = 0.68, 95% CI = [0.92, 1.27], *p* = .031. Across valence categories, voluntary attention resulted in an increase in distinctiveness ratings (see Figure 4).

Figure 4

Distinctiveness increased across all valence categories when the image was a target.



Brief Summary of Findings. As part of the replication, we reconfirmed that voluntary attention would increase emotional intensity and distinctiveness but liking. On the other hand, more exposure of certain images would increase liking but not intensity. In general, effects of attention on perceived emotional intensity were larger for neutral images than for images with significant valence (see Figures 2a, 2b and Figure 2c in Appendix I). Notably, the original paper used 95% confidence intervals (Mrkva et al., 2019). Figure 2b incorporates this confidence interval directly. It also shows a higher concentration of data points for control images; this is due to the same 30 images being used as both control and target images: recall the method for Experiment 1 highlights a target image among a group of control images (see Figure 1, Mrkva et.al, 2019). Thus, despite the higher number of control images, the effect of voluntary attention is clear across valence types. Although the data does not support this effect for the liking variable (See Figure 3), this pattern exists for both the emotional intensity and distinctiveness variables (See Figures 2a, 2b, Figure 2c in Appendix I and Figure 4).

Experimenter Demand and Hypothesis Awareness

Finally, we replicated results for experimenter demand and hypothesis awareness. Mrkva et al. (2019) addressed potential demand characteristics by examining two extraneous variables, which they called experimenter demand and hypothesis awareness. These are specific to the design of Experiment 1. Data on these demand characteristics serve to highlight potential bias that may have been present in the original experiment. Our replication found demand intensity for the experimenter demand data returned an average of 0.29, with a standard deviation of 0.97, which matched Mrkva et al.'s findings (M = 0.29, SD = 0.97), as did replication of correct hypothesis awareness which averaged 0.16%.

Discussion

Based on our background research, we expected negative and positive images to have higher ratings of emotional intensity than neutral images after the task. We also expected target images to be rated higher in emotional intensity than non-target images since we know from Vuilleumier et al. (2005) that search (and therefore attention) is facilitated by emotion and is qualified by the extent of emotional arousal. We learned that attention can in fact intensify the experience of emotion, as indicated by the fact that individuals perceive images to be more emotionally intense when they are actively attended to vs. simply viewed. Vuilleumier et al. (2005) corroborates this, as in general emotional valence of an image is more significant when it is attended to.

As part of the replication, we confirmed that voluntary attention would increase emotional intensity for both search and spatial cuing. That is, if we look for something or direct attention towards something, we deem the perceived object to be more intense. In general, effects of attention on perceived emotional intensity was larger for neutral images than for images with positive valence.

At the same time, we expected images to be liked more as people pay more attention to those images. We predicted that the increase of attention would increase the perceived liking of the images, and as a result people would attend these images quicker. However, based on Vuilleumier et al. (2005), this correlation between liking and attention would not be as strong as that of arousal to attention. Further, we expected images that are perceived as more distinctive to also be attended quicker as spotting threats is a function of emotional arousal, which is in turn a function of attention (Vuilleumier et al., 2005). We did not find a strong correlation between the valance type and the emotional intensity. But it is interesting to note that for both liking and distinctiveness, the images with positive valence were rated the highest.

We interpreted that smaller effects on emotional intensity among negative and positive images likely occur because they are more distinctive to us. It is worth questioning why they are inherently more distinctive to us. We suspect that it might depend on many cultural factors. As Soares et al 2014 argues that effects of IAPS images vary significantly across gender, sex, and culture. Similar thoughts are shared in Schupp et al. 2007, which mentions valenced stimuli are flagged for "preferential processing," which may come at the expense of other processing (such as determining liking). One limitation to note is that it may also be possible that experiments with ratings and attentional manipulations have smaller effects because images with highly negative or positive valence have less place to move on a rating scale.

Limitations

It's important to note that there are many limitations on the study including cultural interpretation of the images and different individual interpretation of things. An image of a snake might be alarming for a person while someone else might interpret it as an image of a pet. Further research can be done by looking at different cognitive processing patterns when people look at these images and we can also look into whether attention increases the amount of information people acquire about attended objects and therefore influencing the choices they make. Significant research still needs to take place in the realm of attention and emotional intensity in order for us to get a better understanding between them and potentially start applying the knowledge in our daily lives.

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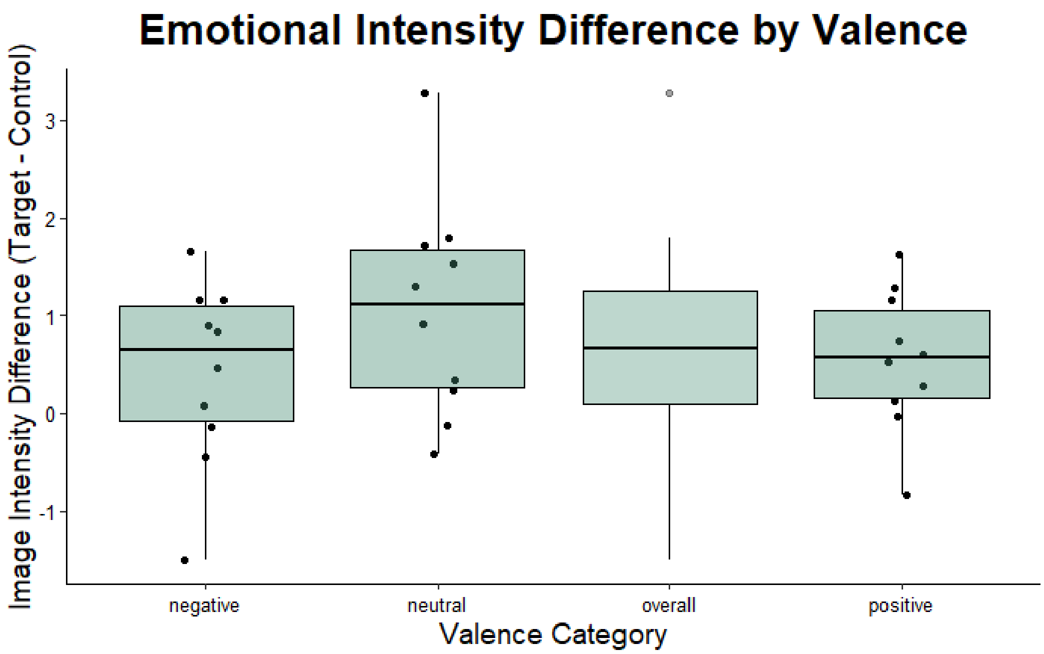
Appendix I. Supplemental Materials

Figure 2c.

Comparison of emotional intensity ratings per image, both within valence categories and between them.



Note: Each dot represents a specific image and illustrates how it was rated by all participants in the target vs. control conditions. Images above 0 on the y-axis were rated as more emotionally intense in the target condition.