A Reversal of Roles: Effects of Visual Attention on Emotion

A replication of *Attention drives emotion: Voluntary visual attention increases perceived emotional intensity*.

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Abstract

Extant research has continually indicated that emotion moderates attention such that attention can be caught, maintained, and/or intensified towards a given emotional object (Mrkva, Westfall, & Van Boven, 2019). However, sparse research has investigated the reverse— whether attention can intensify emotion. To examine the bidirectionality of the relationship between emotional intensity and voluntary attention, we conducted a replication of the Mrkva et al. study on visual attention and emotional intensity. We hypothesized that participants would perceive target images as more emotionally intense than control images, and that their post-search ratings of emotional intensity for each target image would be higher than their pre-search ratings. Each participant was instructed to search for a specific image in a randomized sequence with varying emotional valence in separate trials per participant (Mrkva et al., 2019). Our primary outcome measures were the participants' self-reported intensity of their emotional reaction to each image as well as their perception of the inherent emotional intensity of each image. Additionally, our secondary measures included ratings of the extent to which participants liked each image and how distinct they perceived the images to be. Our results ultimately supported our hypothesis, suggesting that directed attention towards an image enhances its perceived emotional intensity and distinctiveness. Examining whether attention can affect emotions poses practical significance, as it will allow us to better explore and understand how the objects that we pay attention to can impact our emotions in day-to-day life.

Keywords: emotional intensity, voluntary attention, distinctiveness, valence

Introduction

Attention is the catch-all term for how the brain controls information processing by selectively focusing on objects, prioritizing concentration on specific stimuli while ignoring other stimuli (Öhman, Flykt, & Esteves, 2001). Large amounts of stimuli are present in our environments; thus, the brain— with its limited capacity for information processing— relies on attention to aid it in determining what to focus on (Krajbich & Rangel, 2011). This function of attention is integral to its classification, which is defined by: the problem, or the amount of information to process; the challenge, or maintaining attention over long periods of time; and, the solution, or choosing relevant information that pertains to behavior (Chun, Golomb, & Turk-Browne, 2011). In its solution, attention can be further distinguished between external and internal attention. External attention is the processing of external stimuli from the environment, such as a nearby conversation or the information shown on a computer screen (Chun et al., 2011). On the other hand, internal attention is the processing of internally generated thoughts and memories, as illustrated when an individual contemplates a conversation or attempts to remember information from a lecture (Chun et al., 2011).

Attention can also be further broken down into two types: voluntary attention and involuntary attention. Voluntary attention is a goal-oriented form of attention that is used to focus on completing tasks, such as a student focused on studying a textbook to do well on a test (American Psychological Association, APA Dictionary of Psychology). In contrast, involuntary attention is dependent on the salience of the stimulus and is not deliberately applied (APA, APA Dictionary of Psychology). For example, a loud background noise is likely to draw the involuntary attention of a student focused on studying.

One factor that can influence attention is emotion. Evidence of this includes work demonstrating that emotional stimuli can not only attract and hold more attention than neutral stimuli, but also alter performance on tasks (Raymond, 2009). Additionally, individuals are evolutionarily adapted to more rapidly draw their attention towards fear-inducing and threatening images of snakes and spiders than neutral images (Öhman et al., 2001). Emotional intensity is a measure of the degree of emotional arousal an individual has towards a stimulus, which can influence which specific emotional stimuli the individual attends to. For example, researchers have established that stimuli that elicit high emotional intensity capture attention more effectively than those that elicit low emotional intensity (Öhman et al., 2001).

Just as Öhman et al. (2001) depicted that emotion drives attention, attention can furthermore be a driving force for emotion. If certain aspects of a stimuli are more distinctive, people tend to focus on these distinctive aspects. This increased attention may lead certain features to be weighed more heavily, and then they would have a greater influence on emotion. For example, when rating whether people would be happier in the Midwest or California, a distinctive difference between the two locations is weather. Participants then cited weather as an important factor for happiness even when they said that weather was not personally important to them. Thus, the increased attention towards weather led to it having a greater influence on perceived emotion, so participants said that the weather in California would make the people there happier than those in the Midwest (Schkade & Kahneman, 1998).

Accounting for biases in spatial compatibility, previous research has shown that target images that participants were instructed to search for were rated as more emotionally intense compared to images that participants were not required to search for (Fitts & Seeger, 1953; Mrkva, Westfall, & Van Boven, 2019). Researchers have also shown that voluntary attention—

when tested with colored patches of varying contrast— increases the perceived contrast of a stimulus, resulting in an increase in the perceived distinctiveness of the stimulus (Liu et al., 2009). Since the hue, saturation, and brightness of color also affect perceived emotional intensity, this suggests a relationship between the emotional intensity inherent to certain colors and the voluntary attention that was being manipulated (Valdez & Mehrabian, 1994). Such findings further support the notion that voluntary visual attention has the capacity to enhance the general features of an image, essentially amplifying its perceived emotional intensity.

The theory that attention drives emotion is described in Chun's "A Taxonomy of External and Internal Attention," which also brings forth the idea that attention influences emotional evaluation (2011). This, in a sense, is comparable to the tendency of individuals to visually fixate on favorable objects (Krajbich, & Rangel, 2011). Whether it is a fixation on a distinct target image or an object of choice, attention sets this point of focus apart from other stimuli, which differentiates the target as emotionally intense or dissimilar from the stimuli that are not receiving as much attention. The tendency to perceive greater emotional intensity and distinctiveness of a stimulus may be evolutionarily advantageous, as the brain is able to detect the particular features of a point of focus, which potentially has high survival value.

In addition to the notion of evolutionary adaptation as a potential impelling cause for the greater perceived emotional intensity of attended stimuli, the Biased Attention via Norepinephrine Model (BANE) may be another driving force (Markovic, Anderson, & Todd, 2014). The BANE model incorporates the brain's mechanistic activation of brain regions such as the amygdala, a region of the brain that is key to the processing of threatening and fear-inducing stimuli (Markovic et al., 2014). The activation of the amygdala may account for the enhancement of participants' "subjective vividness" towards attended emotional stimuli, such as positive or

negative images (Markovic et al., 2014). Norepinephrine, in turn, functions as an excitatory neurotransmitter that improves attentiveness, thus mediating the enhancement of the subjective vividness of stimuli (Markovic et al., 2014). Therefore, the BANE model helps explain why there is often more attention directed towards emotionally salient events, which are then perceived as more emotionally intense and distinctive.

With current research, there is an understanding about how emotion affects attention, but there is less research about how attention affects emotion. For this replication paper, we observed whether attention, specifically voluntary attention, affects perceived emotional intensity by having participants search for an image. Based on previous research, we hypothesized that greater attention would result in greater perceived emotional intensity and distinctiveness while there would be no significant effect on liking.

When analyzing emotional intensity, we looked at three variables in regards to image perception: emotional intensity, liking, and distinctiveness. We also looked at how these variables may be affected: 1) whether actively searching for and attending to a stimulus would affect perceived emotional intensity, liking, and distinctiveness 2) whether the effect varied depending on the valence of the stimulus (positive, negative, or neutral). We expected that our results would demonstrate that images that were searched for and attended to would be reported as more emotionally intense than other images. For distinctiveness, the data should also show that images that were searched for and attended to would be reported as more distinct.

Beyond its focus on the effect of voluntary attention on the perceived emotional intensity of a target image, our hypothesis also emphasizes that participants' interpretations of an image's emotional intensity are heightened by the action of searching for the image, as illustrated by

previous studies.To assess this prediction, a subset of participants provided baseline ratings of all stimuli prior to the experimental task.

Methods of Replication

We focused on Experiment 1 to replicate the authors' statistical analysis using the data that the researchers had collected from the Mrkva, K., Westfall, J., & Van Boven, L. study. This particular experiment manipulated attention by asking 100 participants to search for an image; the remaining experiments confirmed that it is the manipulation of voluntary attention that affects emotional reactions, and not some other aspect of the experimental design or searching process.

Participants

Participants were chosen through Clickworker, a service that uses an online platform for data collection, and received $2.00 compensation for their participation (Mrkva, Westfall, & Van Boven, 2019). There were 105 participants recruited, however 5 participants were excluded after either not completing the study or being duplicate recruited participants. The data we used consisted of a sample size N=100 participants (60 females; 40 males; mean age 35.12 years) (Mrkva, Westfall, & Van Boven, 2019).

Procedure

Participants were told to select images from three sets of 10 International Affective Picture System (IAPS) images (Lang, Bradley, & Cuthbert, 1999) that they were told would be used in a future study. The 10 images were displayed at the same time and participants were asked to provide two ratings on the perceived emotional intensity of each image by providing ratings (ranging from 0 = not at all to 9 = the most possible) for the questions "How intense was

your emotional reaction to each image?" and "How emotionally intense is each image" (Mrkva, Westfall, & Van Boven, 2019). Each individual searched among ten images for a target image and repeated this ten times. After and before the rounds, people rated the emotional intensity.

To assess whether attention did indeed increase intensity for images after they were searched for, half of the participants became the baseline for comparison and rated images before knowing the target images to ensure that participants were not sticking with only their first rating. Participants rated the images at baseline in order for us to assess whether target images did in fact increase in intensity after searching for them, while control images did not increase in intensity. Then, each individual searched among ten images for a target image and repeated this ten times. After and before the rounds, people rated the emotional intensity.

Analytic Approach

We used R on the data provided, which was in a CSV format (R Core Team, 2018). The data analysis showed whether or not directing attention towards a target image has an effect on three different variables: perceived emotional intensity, liking, and distinctiveness of the image. For each of these variables, we also tested the interaction effect, or whether the relationships between our independent and dependent variables are moderated by positive, negative, or neutral image valence.

Similar to the original paper, our replication of the data analysis included the functions "lmer," "glmer," and "summary." Our coded script also utilized "dyplr" (Wickham H., François R., Henry L. & Müller K., 2021), "lme4" (Bates D., Maechler M., Bolker B. & Walker S., 2015), "lmerTest" (Kuznetsova A., Brockhoff P., Christensen R., 2017) packages within R for utilizing the "lmer" and "summary" functions. The "ggplot2" (Robinson D., Hayes A. & Couch S., 2021), "ggpubr" (Mazerolle M.J., 2020), "tidyverse" (Lenth R.V., 2021), "broom" (Wickham H., 2011),

"AICcmodavg" (Mazerolle M.J., 2020), "emmeans" (Lenth R.V., 2021), and "plyr" (Wickham H., 2011) packages allowed us to explore the dataset and create plots for visualization of distribution and results. After this preparation, we defined the dataset under the "About the Dataset" headline and explored it under "Exploration" and carried out the replication process under the "Replication" title.

Each participant (N = 100) has a corresponding 30 rows labeled with a unique ID number creating 3000 rows with 33 columns of information. An anova test revealed that there was a relationship between emotional intensity and target images; however, this does not reveal the direction of the relationship. Running a T Test revealed a positive correlation between emotional intensity and target images. In short, participants rated target images as more emotionally intense than the control images they viewed. To further our understanding, means, standard deviations and confidence intervals were calculated.

For our result analysis, we used the "lmer" function to gather a readout of the iterations of data. Then, we gathered a summary of these iterations using "summary," ultimately creating a linear mixed model. This process was repeated many times for comparisons of different models and data for a comprehensive review of the authors' dataset. Visuals were created to demonstrate the distribution of the data based on distinctiveness, liking and valence.

Results

As seen in Table 1, our analysis for emotional intensity matched our expected results as participants perceived target images (target: M = 3.58, SD = 2.72) to be more emotionally intense than control images (control: M = 2.88, SD = 2.61). This is displayed through Table 2 which shows the interaction between control and target images to be significant ($t(39.72) = 4.41$,

b = 0.70, 95% CI = [2.88, 4.27], p = 7.6e-5). Table 2 also displays that the effect of target status on emotional intensity was significantly higher for neutral relative to positive and negative images (t(18.15) = 2.59, b = 0.66, 95% CI = [2.91, 4.24], p = 0.02). Additionally, this effect did not vary between positive and negative images (t(18.12) = 0.73, b = 0.21, 95% CI = [3.36, 3.79], p = .48). To see if directing attention towards an image increased the perceived emotional intensity of the image, we first looked at the baseline ratings, collected before target images were assigned at the beginning of the experiment, of images of different valences in Table 1. These numbers showed that positive and negative images (positive: M = 3.69, SD = 2.46; negative: M = 3.50, SD = 2.62) were rated as more emotionally intense than neutral images (neutral: M = 1.55, SD = 1.92). Then, of the participants that provided both baseline and targeted ratings, target images were rated as more emotionally intense compared to their baseline, from (M = 2.96, SD = 2.65) to (M = 3.71, SD = 2.68). In comparison, the emotional intensity for control images didn't significantly change from the initial baseline ratings (baseline: M = 2.96, SD = 2.65; control: M = 2.85, SD = 2.62).

Table 1

Mean and Standard Deviations for Different Categories and Types.

Category	Type	Mean	SD
Emotional Intensity	Control	2.875	2.613
	Target	3.575	2.716
Baseline:	Positive (+)	3.694	2.596
	Neutral	1.551	1.917
	Negative (-)	3.500	2.624
Liking	Control	2.924	2.776
	Target	3.063	2.769
Distinctiveness	Control	3.370	2.767
	Target	4.334	2.941

Table 2

T-values, Confidence Intervals, P-values, and Degrees of Freedom for Categories and Target x Interactions

Category	Target x	T-Value	95% CI	P-Value	DF
Emotional Intensity	Control	4.413	[2.879, 4.271]	7.6e-51	39.724
	Neutral	2.592	[2.913, 4.237]	0.0183	18.148
	Valence	0.727	[3.361, 3.789]	0.476	18.120
Liking	Control	1.264	[2.912, 3.215]	0.209	103.153
	Neutral	0.207	[3.016, 3.111]	0.836	273.084
	Valence	-1.020	[3.370, 2.757]	0.310	95.713
Distinctiveness	Control	4.696	[3.369, 5.318]	2.55e-5	44.624
	Neutral	3.222	[3.280, 5.407]	0.005	17.370
	Valence	-0.311	[4.459, 4.228]	0.760	17.170

For distinctiveness, target images were perceived as more distinctive than control images (target: M = 4.34, SD = 2.94; control: M = 3.37, SD = 2.77; $t(44.62) = 4.70$, b = 0.98, 95% CI = [3.37, 5.32], p = 2.55e-5). Similar to emotional intensity, Table 2 shows that the effect of target status with distinctiveness demonstrated a statistically significant interaction for neutral images relative to positive or negative images ($t(17.37) = 3.22$, b = 1.06, 95% CI = [3.28, 5.41], p = 0.01) while the Target x Valence interaction wasn't significant meaning that this effect did not vary between positive and negative images ($t(17.17) = -0.31$, b = -0.12, 95% CI = [4.46, 4.23], p = .76).

Discussion

Overall, our replication demonstrated that directing attention towards an image increased the participants' perceived emotional intensity and distinctiveness of the image. Previous research has established that emotion affects attention, and our results depicted that the reverse—that is, that attention affects emotion— is also true. Specifically, enhanced attention towards an image increased its perceived emotional intensity, particularly for neutral images (Figure 1). In contrast to neutral images, participants exhibited minimal differences between their emotional responses for the positive and negative images for both the control and target images (Figure 1).This may be because valenced images are already emotionally intense, thus when they are targeted, it is hard to make an already intense reaction even more intense. Additionally, our analysis showed that target images were perceived by participants to be more distinct than control images (Figure 2), and the extent to which participants liked the image was not significantly affected by the act of directing attention towards the given image (Figure 3).

Figure 1

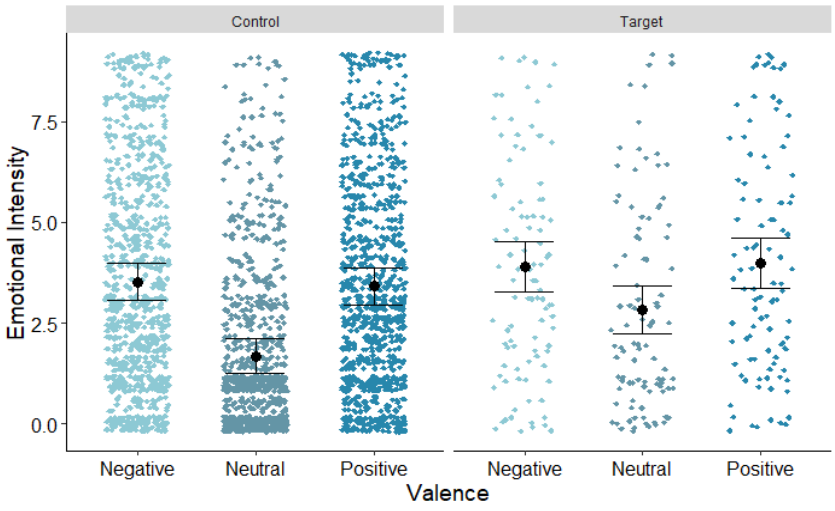


Figure 2

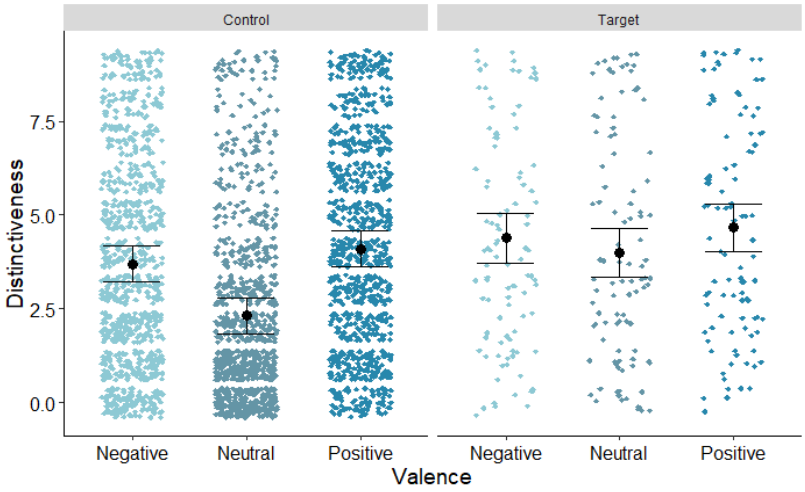
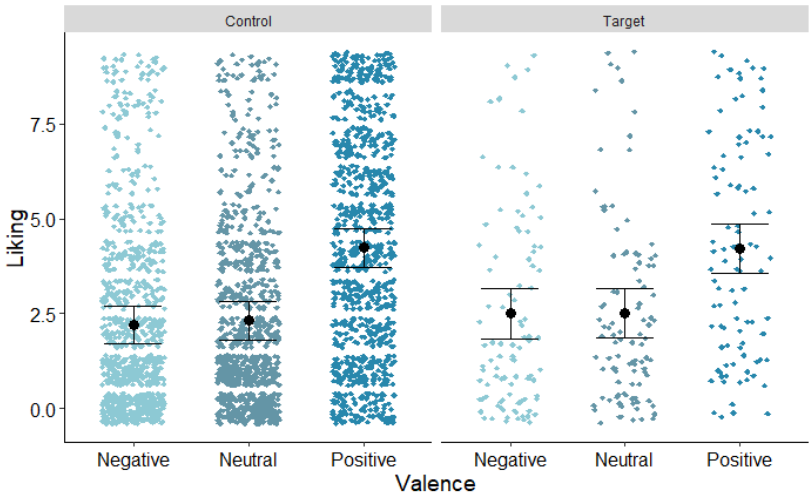


Figure 3



Future research may want to consider possible new relationships and moderating effects of other unmeasured variables. Our analysis showed that targeting an image increases its perceived distinctiveness and emotional intensity (Figures 1 and 2), and there may be a relationship between these two factors, in which increased distinctiveness is hypothesized to lead

to an increase in perceived emotional intensity (Valdez & Mehrabian, 1994). This may have significant effects in contexts of highly homogeneous or highly heterogeneous stimuli that may override or moderate the effects of voluntary attention on emotional intensity. We also found that the increase of perceived emotional intensity after labeling an image as the target was greater for neutral images compared to valenced images (Figure 1). This may be because valenced images are already emotionally intense, thus when they are targeted, it is hard to make an already intense reaction even more intense. This may also be due to experimental design, where the usage of a rating scale makes it so that there are smaller measured effects on valenced images because they had less room to move on the rating scale. Finally, future research may also want to consider the use of different types of stimuli such as auditory and tactile rather than purely visual stimuli which has been shown to have certain limited effects which can be moderated by high anxiety vs low anxiety participants.

The results of our research have significant implications for human behavior as well as the field of psychology and cognitive science. Emotion is an important motivator, helping drive our actions and push us forward in learning, creating, expressing, and other activities that create a society. Attention is also important as it plays a central evolutionary role in our survivability by allowing us to focus on aspects of our environment that have a high survival value (appearance of a threat) and filtering out stimuli that have low survival value. In our modern society, the interaction between emotions and attention can have even more widespread ramifications. That is, if more attention leads to greater emotional intensity, especially for neutral stimuli that may not have previously drawn such an emotional response, the degree of media exposure that certain events have can greatly influence the emotional response the public has for that event. In response, greater emotionality may result in more polarization or reckless behavior based on

emotions' influence on decision making. Additionally, our results support many extant findings in psychology. For example, peoples' tendency to overestimate the intensity and duration of future emotional events is thought to be due to the voluntary attention given to these focal events which, as our research shows, increases their emotional intensity. Meanwhile, in the attentional-drift-diffusion model, attention influences choices by increasing the relative weight that people give to the evidence about the attended stimuli. Our results suggest that people may weigh attended options more heavily, not just because of greater information, but also because their voluntary attention results in a stronger emotional reaction.

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Contributions

All authors contributed to every section, spent time writing/editing in every aspect, and approved of the final submission.

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