Journal of Advertising

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ujoa20

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To cite this article: Tomer Bakalash & Hila Riemer (2021) I Feel It in My Brain: Understanding the Processes Underlying the Influence of Ad Affect on Memory Using fMRI, Journal of Advertising, 50:5, 639-655, DOI: 10.1080/00913367.2021.1973621

To link to this article: https://doi.org/10.1080/00913367.2021.1973621

JOURNAL OF ADVERTISING
2021, VOL. 50, NO. 5, 639–655
https://doi.org/10.1080/00913367.2021.1973621

I Feel It in My Brain: Understanding the Processes Underlying the Influence of Ad Affect on Memory Using fMRI

Tomer Bakalash and Hila Riemer

Ben-Gurion University of the Negev, Be'er Sheva, Israel

ABSTRACT

Using functional magnetic resonance imaging (fMRI), in our previous research (Bakalash and Riemer 2013) we explored the mechanisms involved in the relationships between ad affect and ad memorability and provided first-time neural evidence for the involvement of sociocognitive processes. We now extend that study as we disentangle the roles of the valence and arousal dimensions in the influence of ad affect on memory and investigate the neural processes involved. We also explore the role of gender, thereby shedding further light on underlying mechanisms. Our results demonstrate that of the two dimensions of affect it is valence, not arousal, that drives the effect. Specifically, we show memory advantage for negative over positive ad affect. Memory advantage was accompanied by activation in brain regions associated with social cognition. Exploratory examination of gender differences reveals similar memory patterns across genders in all ad affect conditions except sadness: Women, but not men, demonstrated a memory advantage of sad (versus neutral) ads. Such gender differences might be due to emotional regulation processes—a direction which requires further examination. This study reinforces the role of a sociocognitive process in affective memory, which has been neglected in past research; it adds insights into the processes by which ad affect enhances memorability and into the boundary conditions for this effect.

Research suggests that emotionally arousing ads are better remembered than neutral ones (Aaker, Stayman, and Hagerty 1986; Bolls, Lang, and Potter 2001; Zhao, Muehling, and Kareklas 2014; Thorson and Friestad 1989; Akram, McClelland, and Furnham 2018; Hartmann, Apaolaza, and Alija 2013; Kemp, Min, and Joint 2015; Poels and Dewitte 2019; Pavelchak, Antil, and Munch 1988). Integrating knowledge on affect and memory, Bakalash and Riemer (2013) proposed three routes by which affect influences memory: attention, elaboration, and social cognition. Bakalash and Riemer's (2013) conceptualization is based on theories and empirical research utilizing self-report measures, which are limited when studying the underlying mechanisms, particularly when people are unaware of the process.

Neuroscientific measures can address these limitations, yet only a few advertising studies have used these methods (Chang 2017). Bakalash and Riemer's (2013) study pioneered the use of neuroscience in examining affect and memory in advertising (Chang 2017). It demonstrated greater amygdala activation upon viewing memorable (versus unmemorable) ads and showed that amygdala activation was accompanied by activation in the superior temporal sulcus (STS), a brain region involved in social cognition (Allison, Puce, and McCarthy 2000; Park et al. 2010; Vander Wyk et al. 2009)—a process which had not been the focus of affect and memory research (Murty et al. 2010).

Sociocognitive processes occur when people attempt to appraise the social environment. Such processes include making judgments of the self and others, as well as assessing interactions between the self and the environment (Adolphs 2001). Emotional processing involves social cognition; when exposed to

CONTACT Hila Riemer hriemer@bgu.ac.il Guilford Glazer Faculty of Business and Management, Ben-Gurion University of the Negev, P.O. Box 653, Be'er Sheva, 84105, Israel

Supplemental data for this article is available online at https://doi.org/10.1080/00913367.2021.1973621.

Tomer Bakalash (PhD, Ben-Gurion University of the Negev) is an adjacent lecturer, Guilford Glazer Faculty of Business and Management, Ben-Gurion University of the Negev.

Hila Riemer (PhD, University of Illinois at Urbana–Champaign) is a senior lecturer, Guilford Glazer Faculty of Business and Management, Ben-Gurion University of the Negev.

emotionally arousing stimuli, people perform appraisal to generate meaning or to assess the significance of the emotional stimuli to their selves and to their well-being (Lazarus 1991). Emotional appraisal theories postulate that the experience of emotional arousal, in and of itself, requires sociocognitive processing, including processes such as perception, attention, recognition, and evaluation (Smith and Ellsworth 1985). In an advertising context, exposure to an emotional scene (in an ad) would lead to appraisal processing, which may elicit emotional arousal (Parkinson and Simons 2009).

Although Bakalash and Riemer's (2013) study provides support for the sociocognitive route in affective ad memory, it has a few limitations, which we address in the current study. First, the real ads used in that study had been previously broadcast, making it impossible to confidently determine whether the detected neural activity resulted from familiarity with the ads or caused the enhanced ad memory. Consequently, Bakalash and Riemer's (2013) study could establish merely an association between ad affect, social cognition, and memory for the ad, but not causal effects. The stimuli and design in the current study enable examination of causality.

Second, Bakalash and Riemer (2013) did not consider specific dimensions of affect. Research has long established three basic dimensions of affect: valance, arousal, and dominance (Bradley and Lang 1994; Holbrook and O'Shaughnessy 1984). Two of these dimensions—valence and arousal—explain most of the findings in affective neuroscientific research (Posner, Russell, and Peterson 2005). Thus, we focus on two dimensions of affect, disentangling arousal (the intensity of affect) and valence (the direction of affect). Evidence on the effect of valence on memory is mixed. Some studies demonstrate no effect (Bolls, Lang, and Potter 2001), but others suggest that valence negatively influences the depth of information processing (Cohen, Pham, and Andrade 2008). LaBar and Cabeza (2006) argue that the processing of negative and positive stimuli occurs through similar brain systems. These contradictions require further investigation, which we address.

Thus, our goal was to shed light on the influence of ad affect on ad memory and on the underlying process. We aimed to disentangle the roles of the valence and arousal dimensions, to replicate Bakalash and Riemer's (2013) findings indicative of sociocognitive processes, and to establish causality. Furthermore, relying on research suggesting gender differences in emotion-related processes (e.g., Ochsner and Gross 2008; Bradley and Wildman 2002), we explore gender differences in the memory of affective ads and the processes leading to such differences, which provides insights on the process underlying the effect of ad affect on memory.

Scientific Background and Research Questions

The Influence of Ad Affect and the Dimensions of Affect

Past research provides a basis for the prediction that ad affect will positively influence ad memory (Akram, McClelland, and Furnham 2018; Bolls, Lang, and Potter 2001; Hartmann, Apaolaza, and Alija 2013; Kemp, Min, and Joint 2015; Kroeber-Riel 1979; Pavelchak, Antil, and Munch 1988; Poels and Dewitte 2019). This prediction suggests that emotionally arousing ads will be more memorable than neutral ads, but it does not consider the specific role of each dimension of affect: valence and arousal.

Researchers have consistently shown that arousal enhances ad memory (Poels and Dewitte 2006). When focusing on the effect of valence, however, results are mixed. Some studies suggest that negative affect has greater influence on ad memory (Lang and Friestad 1993; Newhagen and Reeves 1992; Reeves et al. 1991; Poels and Dewitte 2019; Thorson and Friestad 1989), while others suggest that the influence of positive affect is greater (Lang, Dhillon, and Dong 1995).

Two theoretical perspectives may yield contradictory predictions regarding the influence of valence on memory. One perspective suggests that individuals allocate more attention to negative (versus positive) stimuli (Zajonc 1984). This is because negative stimuli contain information that is important for survival (Talarico, Berntsen, and Rubin 2009), and remembering such information may assist in planning for and avoiding reoccurrences of threatening events (LeDoux 1996). Consistently, people pay more attention to negative (versus positive) information (Vaish, Grossmann, and Woodward 2008) and tend to remember it better (Levine and Pizarro 2004). Another perspective suggests that people strive to maximize pleasure (Fiske and Taylor 1984), leading them to pay more attention to positive information, which should result in enhanced memory for positive information (Bohn and Berntsen 2007; Walker, Skowronski, and Thompson 2003). Thus, while it is reasonable to expect that arousing ads will be better remembered than neutral ads, the two perspectives produce opposite predictions regarding whether negative or positive stimuli are more memorable. This leads to the first research question, concerning the role of affect's valence in the memorability of ads:

> **RQ1:** Which ads will be better remembered compared to emotionally neutral ads: positive or negative affective ads?

The Neural Processes Underlying the Effect of Ad Affect on Memory

Neuroimaging research suggests that the positive effect of emotions on memory is due to neurohormonal changes caused by emotional arousal, which activate (β-adrenergic) receptors in the amygdala. Amygdala activation is accompanied by activation of other brain regions, such as the temporal pole, orbitofrontal cortex, insula, putamen, inferior and medial temporal gyri, frontal lobe regions, medial temporal lobe (hippocampus, entorhinal cortex, perirhinal cortex, parahippocampal cortex), and visual processing regions (middle temporal gyrus, fusiform gyrus, occipital cortex) (Dahlgren, Ferris, and Hamann 2020; Hamann 2001; Murty et al. 2010). Activation in these regions assists in memory consolidation, which eventually enhances memory (Hamann 2001; McGaugh 2003). Yet despite evidence on causal effect of amygdala and hippocampus activation on memory (Hamann 2001), it is unclear which of the other various areas listed account for emotional memory enhancement, either in general or specifically in advertising contexts.

Bakalash and Riemer's (2013) conceptualization suggests that the effect of ad affect on ad memory is due to either attention, elaboration, or sociocognitive processing. Two meta-analyses (Dahlgren, Ferris, and Hamann 2020; Murty et al. 2010) that looked at the regions associated with each type of process indicated that *attention processes* are linked to activation in the parietal cortex, in the ventral stream, in the visual cortex, and in the auditory cortex; *elaboration processes* are linked to activation in the prefrontal cortex; and *sociocognitive processes* are linked to activation in the prefrontal cortex and the STS (see Supplemental Online Appendix 1).

In the context of advertising, to the best of our knowledge, the only evidence so far on brain regions involved in affective ad memory is found in Bakalash and Riemer's (2013) exploratory study, which demonstrated that ad memorability is associated with amygdala activation accompanied by activation in the STS. These preliminary findings are consistent with other studies that reinforce the role of STS in enhancing memory (Bukowski and Lamm 2018; Spreng and Grady 2010).

In light of the evidence from past studies reviewed here, we can expect that exposure to affective ads would involve activation in brain regions linked to all emotional memory processes mentioned in Bakalash and Riemer's (2013) conceptualization, namely, brain regions whose activation correlates with attentional processes, elaboration, and sociocognitive processes. These areas are listed in Supplemental Online Appendix 1. The lack of specific evidence on neural activation involved in ad memorability limits our ability to specifically predict which brain regions would be involved in emotional ad memorability. Thus, our second research question concerns the neural processes involved in the effect of ad affect on memory:

> **RQ2:** What brain regions are activated during successful encoding of emotional ads? And what can we learn from such activation on the processes underlying the memory of affective ads?

Exploring the Role of Gender in the Effect of Ad Affect on Memory

Gender differences in emotional memory may occur due to two distinct processes: emotional regulation and optimal stimulation level. Emotional regulation is a process by which individuals monitor and modify their emotions (Gross 2002). Men and women differ in their tendency to use various emotional regulation strategies. Women are more likely to engage in cognitive reappraisal, that is, to interpret emotional experiences with a goal to reduce the intensity of the response. Men are more likely to engage in emotional suppression, that is, to decrease emotion-expressive behavior (Ochsner and Gross 2008). The various emotional regulation strategies may differentially influence memory: Cognitive reappraisal leads to better memory, while emotion suppression impairs memory (Dillon et al. 2007). Gender differences in emotional regulation should thus lead to gender differences in affective memory.

Another process that could lead to gender differences in affective memory is linked to optimal stimulation level, which refers to the ideal level of emotional activation preferred by an individual (Zuckerman, Eysenck, and Eysenck 1978). According to this concept, humans are motivated to attain satisfactory levels of stimulation, which vary across individuals (Berlyne 1960). High optimal stimulation level, also recognized as a sensation-seeking personality trait, is believed to have a biological basis that expresses a need for physiological arousal and a tendency to engage in actions to obtain such arousal (Stephenson 2003). Research shows that men have higher optimal stimulation levels than women (Byrnes, Miller, and Schafer 1999; Zuckerman, Eysenck, and Eysenck 1978). Individuals with a high optimal stimulation level tend to allocate more attention to stimulating information, leading them to remember such information better (Niederdeppe et al. 2007). Thus, gender differences in optimal stimulation levels may also lead to gender differences in affective ad memory.

The discussion so far suggests that emotional regulation predicts better emotional memory for women, while optimal stimulation level predicts better emotional memory for men. Each of these processes, however, would occur under distinct conditions. We argue that valence may determine the occurrence of these processes and consequently the gender differences in ad affect memorability. Individuals are more motivated to engage in emotional regulation to decrease negative (versus positive) emotions (Gross 2002). It is, therefore, reasonable that gender differences in the tendency to downregulate negative emotions will lead to gender differences in the memorability of negative, but not positive, affective ads. Yet research associated with optimal stimulation theory suggests that individuals are more likely to select positive situations and avoid negative ones (Gallagher, Diener, and Larsen 1989). Gender differences in optimal stimulation level may, therefore, lead to gender differences in memory of positive, but not of negative, affective ads.

> **RQ3:** What are the differences between men and women in the effect of ad affect on memory and in the processes underlying this effect?

Method

Overview

The study was conducted in two sessions. In the first session, participants underwent a functional magnetic resonance imaging (fMRI) scan while watching video ads with different levels of arousal and valence (determined by a pretest). Then, outside the scanner, participants completed scales measuring their optimal stimulation level (Zuckerman, Eysenck, and Eysenck 1978) and their tendency to engage in emotional regulation (Gross and John 2003). In the second session, one day later, participants completed memory measures.

Design and Participants

We used a 2 (ad affect valence: positive, negative) × 2 (ad affect arousal: low, high) × 2 (gender) mixed-design experiment. Valence and arousal were within-subjects factors, and gender was a between-subjects factor. Each participant viewed 24 ads: 20 ads communicating affective states of each of four arousal × valence conditions, resulting in five high arousal positive ads (happy, H), five low arousal positive ads (relaxed, R), five high arousal negative ads (fearful, F), and five low arousal negative ads (sad, S). Four additional ads were emotionally neutral.[1]

Twenty healthy students (50% women; $M_{age} = 25.3$) with normal or corrected-to-normal vision received $40 each for their participation. To reach a significant threshold ($p < 0.05$) in fMRI experiments, approximately 12 participants are required per group, for an 80% power at the voxel level of analysis (Desmond and Glover 2002). While this sample size is comparable to that of other fMRI studies (Button et al. 2013), the number of participants in our study is smaller for the gender analysis. We, therefore, consider the gender analysis as exploratory and stress that findings relating to gender must be treated with caution.

Stimuli

The ads were selected based on a pretest, in which 58 undergraduate students were randomly assigned to view 10 out of 40 ads taken from an international advertising pool (AdForum). All ads were nonverbal (with background music). To ensure that all ads and brands were unfamiliar to the participants, we presented only ads for brands not distributed on the national market. We eliminated ads that were familiar to participants. After viewing each ad, pretest participants completed scales to measure two dimensions of their affective response to the ad, valence and arousal, using the respective six semantic differential 9-point items (Mehrabian and Russell 1974).

Based on the pretest, we identified ads with distinct valence (V) and arousal (A) values: five ads in each category across the V × A conditions and four neutral ads. Within the affective ads, the interactions between the valence and arousal conditions on either the valence or arousal scores were insignificant (on valence: F (1, 16) = 3.548, $p = 0.078$; on arousal: F (1, 16) = .181, $p = 0.311$). Valence scores differed significantly between the positive and negative valence ads ($V_{positive} = 6.95$, $V_{negative} = 3.07$, F (1, 16) = 275.03, $p < 0.01$, on a 9-point scale where low scores indicate negative affect and high scores indicate positive affect) but did not differ significantly between low and high arousal ads, F (1, 16) $= 0.001$, $p = 0.97$. Arousal scores differed significantly between the low and high arousal ads ($A_{low\ arousal} = 4.255$, $A_{high\ arousal} = 6.695$, F (1, 16) $= 127.54$, $p < 0.01$, on a 9-point scale where low scores indicate low arousal and high scores indicate high arousal) but did not differ significantly between negative valence and positive valence ads, F (1, 16) $=$ 1.094, $p = 0.311$. Further, the scores of the neutral ads did not differ significantly from the middle scores of the valence and arousal scales (5), which represent neutral emotion ($A_{neutral} = 4.87$, $A_{difference} = -0.135$, t (3) $= -1.027$, $p = 0.38$; $V_{Neutral} = 4.99$, $V_{difference} = -0.125$, t (3) $= 0.143$, $p = 0.895$). For all ads in affective conditions, arousal and valence scores differed significantly from the middle scores of the scales (for ad details, see Supplemental Online Appendix 2).

Procedure

Participants of the main experiment underwent fMRI scanning while viewing the ads. MRI acquisition imaging data were collected on a 3T Philips MRI scanner. The experiment used a 32-channel phased-array head coil. Blood oxygenation level-dependent (BOLD) contrast was obtained with a gradient echo-planar T2* sequence; 35 oblique axial slices were acquired parallel to the anterior commissure-posterior commissure line; 96×96 matrix; FoV $= 251 \times 251$ mm; $2.61 \times 2.61 \times 3.00$ mm voxel resolution; gap thickness $= 0$ mm; TR $= 2550$ ms; TE $= 0$ ms; flip angle $= 90$ degrees; and sound pressure level $= 5.3$.

The order of ad presentation was counterbalanced, with a 10-second black screen between ads (which was used as a neural baseline). The total stimuli time was 27 minutes and 19 seconds. After exiting the MRI scanner, participants completed the emotional regulation and optimal stimulation level scales described in the next section. They were requested to return to the lab 24 hours later. The following day, participants completed a surprise memory measure.

Emotional Regulation and Optimal Stimulation Level

Participants completed the Emotion Regulation Questionnaire (Gross and John 2003) to measure their tendency to use different emotional regulation strategies: emotional suppression (ES) and cognitive reappraisal (CR). They also completed the Sensation Seeking Scale (Zuckerman, Eysenck, and Eysenck 1978) to assess their optimal stimulation level. Four items measured emotional suppression ($\alpha = .86$), six items measured cognitive reappraisal ($\alpha = .77$), and 40 items measured optimal stimulation level ($\alpha = .86$).

Memory

To measure memory, we used a day-after recall test, which is well established and frequently employed in advertising research (Rossiter and Percy 2017; Walker and von Gonten 1989). Participants were told: "In the MRI scanner we presented a series of ads. One of the ads advertised [a product]. Please write all the details you remember from this ad, including its narrative, brand name, ad claim, or any other information you remember."

Two independent coders, unfamiliar with the hypotheses, provided memory scores. Scores were given from 0 to 5 (0 = *Not at all*, 5 = *Very much*), based on a key indicating the "correct answer." Disagreements between coders were resolved by discussion. An intraclass correlation coefficient (ICC) indicated a high degree of interrater reliability (0.87).

fMRI Analysis

To analyze the fMRI data we used BrainVoyager software (Brain Innovation, Masstricht, Netherlands) along with a custom MATLAB program. For each scan, we discarded the first two images and superimposed all other images on two-dimensional anatomic images, which were then integrated into three-dimensional data sets using trilinear interpolation. For each participant, we reconstructed the cortical surface using a Talairach coordinate system (Talairach and Tournoux 1988) with three-dimensional spoiled gradient scan. Prior to data processing we performed three-dimensional motion correction for low frequencies (up to two cycles per condition) and used Gaussian filter (with maximum values of 4 mm) to spatially smooth all data. For the analysis we utilized a general linear model with a regressor for each condition (Friston et al. 1994). The duration for the purpose of the analysis was the whole ad, with TR of 2,550 ms, and average ad length of 57 seconds. Boxcar functions were used to convolve hemodynamic response upon all repressors, assuming a 5-second hemodynamic lag, which was verified for each participant. Independent analysis was performed for each voxel (threshold < 0.05), and multisubject analysis used random-effect generalized linear model (GLM)

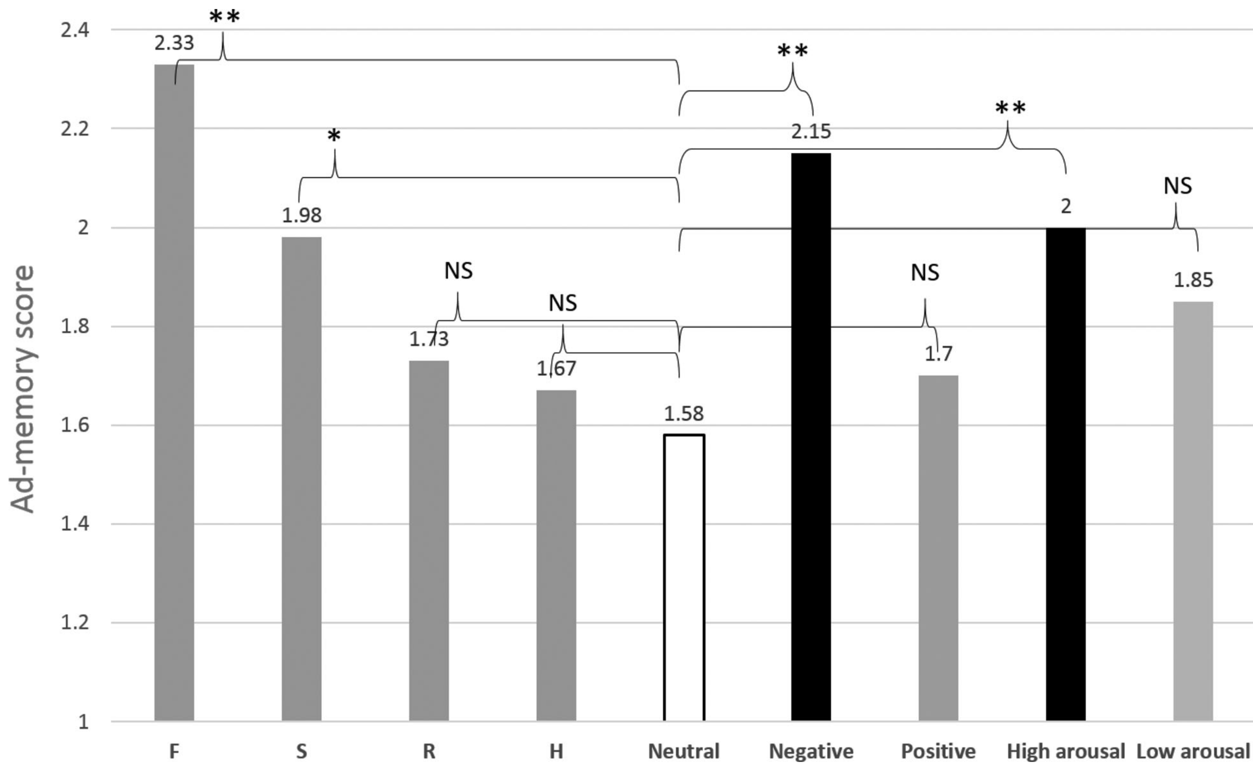


Figure 1. Memory results for the different ad conditions: ** = significant difference; * = marginally significant difference; NS = nonsignificant difference.

(Friston et al. 1999). On the unfolded Talairach normalized map, we projected the multisubject functional maps. For any given cluster, calculation of significance levels considered the probability of a false detection and the minimum cluster size. This was done using Monte-Carlo simulation (AlphaSim by B. Douglas Ward) along with individual voxel probability thresholding. The probability of a false-positive detection was based on cluster size frequency within the cortical surface and was corrected to $p < 0.05$. Statistical level is indicated by color scales from $p < 0.05$ (darker colors) to at least $p < 2.92e^{-07}$ (brighter colors).

Results and Discussion

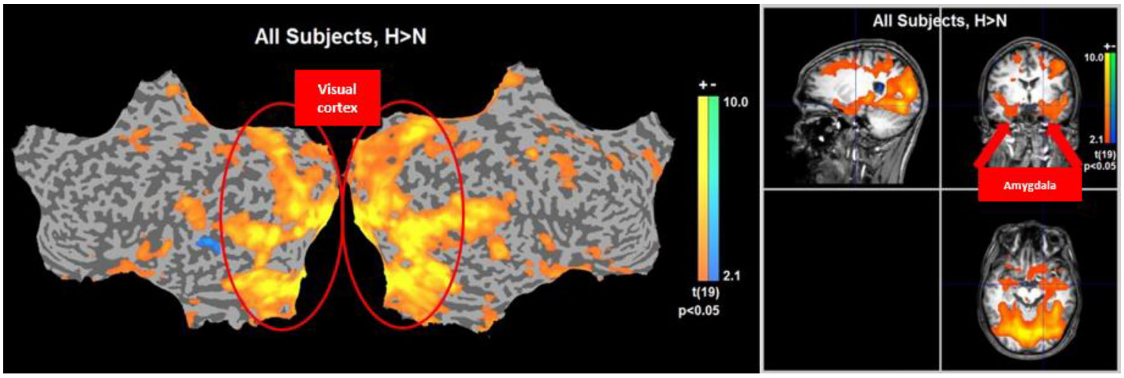
The Effect of Ad Affect on Ad Memory

Results reveal a marginally significant difference between memory for neutral ($M_{neutral}$ = 1.58) and sad ads (M_{sad} = 1.98, F (6, 133) = 0.393, p = 0.094), a significant difference between neutral and fearful ads (M_{fear} = 2.33, F (6, 133) = 0.743, $p < 0.05$), an insignificant difference between neutral and happy ads (M_{happy} = 1.67, F (6, 133) = 0.083, p = 0.781), and an insignificant difference between neutral and relaxing ads (M_{relax} = 1.73, F (6, 133) = 0.150, p = 0.614; Figure 1). These findings provide an answer to research question 1: Which ads will be better remembered when compared to emotionally neutral ads—positive or negative affective ads? Our results indicate a memory advantage for negative ads over positive ads when each is compared to neutral ads, which is in line with the perspective predicting an advantage for negative rather than positive stimuli (Zajonc 1984).

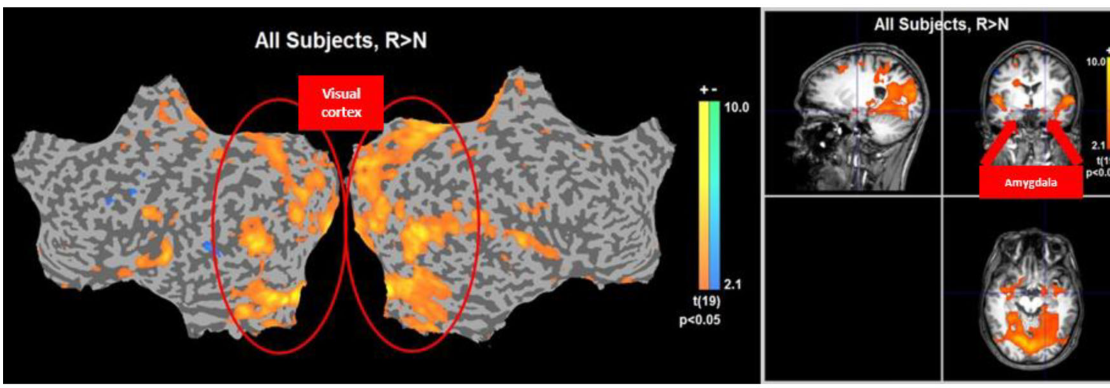
To further disentangle the influences of valence and arousal, we calculated for the affective conditions a memory gap score that equals the average memory score on that condition subtracted by the memory score for neutral ads. The interaction between valence and arousal on memory was insignificant (F (1, 19) = 2.589, $p = 0.124$), with a significant effect of valence (F (1, 19) = 10.122, $p < 0.01$), and an insignificant effect of arousal (F (1, 19) = 1.045, $p = 0.320$). These findings suggest that it is valence, not arousal, that dominates the influence of ad affect on memory. Our remaining analyses, therefore, focus on valence.

Brain Activity

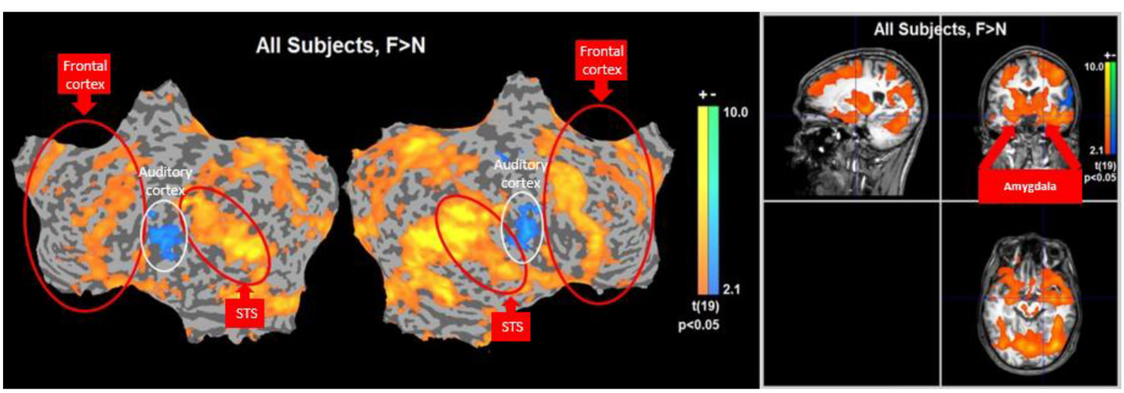
We first contrasted the neural activation during the different affective conditions (H, R, F, S) versus the neutral condition (N). Results are presented both on a flattened cortical map (left-hand in Figure 2) and at the subcortical level on the amygdala's Talairach


All Subjects, H>N
Visual cortex
+ -
10.0
2.1
t(19)
p<0.05
All Subjects, H>N
10.0
2.1
t(19)
p<0.05
Amygdala

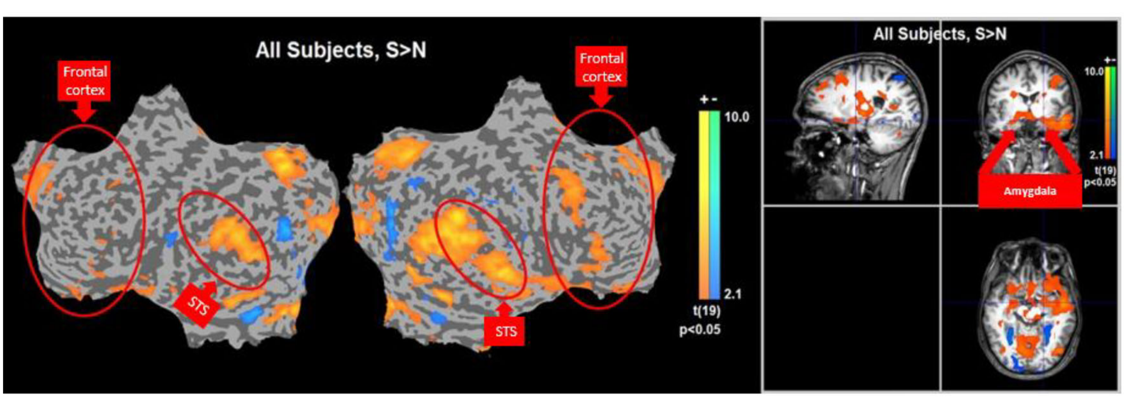
A


All Subjects, R>N
Visual cortex
+ -
10.0
2.1
t(19)
p<0.05
All Subjects, R>N
10.0
2.1
t(19)
p<0.05
Amygdala

B


All Subjects, F>N
Frontal cortex
Frontal cortex
Auditory cortex
Auditory cortex
STS
STS
+ -
10.0
2.1
t(19)
p<0.05
All Subjects, F>N
10.0
2.1
t(19)
p<0.05
Amygdala

C


All Subjects, S>N
Frontal cortex
Frontal cortex
STS
STS
+ -
10.0
2.1
t(19)
p<0.05
All Subjects, S>N
10.0
2.1
t(19)
p<0.05
Amygdala

D

coordinates (right-hand maps). Consistent with past studies (Hamann 2001), results demonstrate enhanced neural activation in the amygdala in all affective ads compared to the neutral ads. Figure 2A shows that the processing of happy ads (H versus N) involves greater coactivation in the primary visual cortex. A similar pattern of neural differences, though to a lesser degree, is evident when contrasting relaxed and neutral ads (R versus N; Figure 2B). Recall that neither happy ads nor relaxing ads were more memorable than neutral ads. Thus, neural activation in the visual cortex, indicative of the attentional process (Dahlgren, Ferris, and Hamann 2020; Bowen, Kark, and Kensinger 2018; LaBar and Cabeza 2006; Vuilleumier et al. 2004; Vuilleumier and Driver 2007), did not lead to memory improvement. This surprising finding is interesting and will be discussed further. Figure 2C shows that the processing of fearful ads (F versus N) involves greater coactivation in the STS and in widespread frontal cortical regions. Interestingly, the neutral ads (N) produce higher activation in the auditory cortex than fearful ads. This is also surprising, considering that the soundtracks in the neutral ads were calmer than in the fearful ads and that the neutral ads were less memorable than the fearful ads. Figure 2D shows that sad ads (S versus N) also produced higher activation in the STS and in the frontal cortex.

Next we contrasted the high arousal positive ads (H) with the high arousal negative ads (F)—the most unmemorable and memorable ads, respectively (see Supplemental Online Appendix 3). Happy ads (H) produce stronger activations in the visual cortex and in the auditory cortex, while fearful ads (F) produce stronger neural activations in the STS and in widespread frontal cortical regions. A similar pattern emerges in Supplemental Online Appendix 4, contrasting all positive ads and negative ads. These findings resemble the neural patterns presented in Figure 2, when contrasting both H and F with N.

Integrating these findings with memory data suggests that amygdala activation is not sufficient to enhance memory. The greater memory effect of negative versus positive ads (compared to neutral ads) is associated with neural activation in the STS and various frontal cortical regions. These regions are associated with sociocognitive processes (Adolphs 2001, 2002; Beer et al. 2006; Dolcos et al. 2017a, 2017b; Narumoto et al. 2001).

The STS was also linked to ad memorability in Bakalash and Riemer's (2013) exploratory study. Moreover, the fact that the STS was activated in negative ad affect conditions is consistent with a recent research linking the STS to memorability in avoidance (negative) rather than approach (positive) context (Marrero et al. 2020). The fact that neural sociocognitive processing is demonstrated to a larger extent when viewing fearful ads (significantly more memorable than neutral ads) compared to sad ads (only marginally more memorable than neutral ads) reinforces the link between the STS and emotional ad memorability.

The greater neural activation in the visual cortex upon viewing happy ads (and to a lesser degree in relaxing ads), as well as the greater activation in the auditory cortex while viewing neutral ads (compared to fearful ads), may be indicative of the attentional processing involved in emotional memory (Dahlgren, Ferris, and Hamann 2020; Bowen, Kark, and Kensinger 2018; LaBar and Cabeza 2006; Vuilleumier et al. 2004; Vuilleumier and Driver 2007). Nevertheless, these neural activations did not enhance memory—neither for positive over neutral ads, nor for neutral over negative ads. This implies either that the occurrence of attentional process may have been insufficient for memory enhancement or that social cognition (Allison, Puce, and McCarthy 2000; Park et al. 2010; Vander Wyk et al. 2009) may dominate the effect of ad affect on memory.

To reinforce the effect of valence on neural activation we also conducted a parametrical analysis based on the valence scores of each ad (i.e., an analysis that considers the continuum of valence scores of the various ads). This analysis aimed to validate that the neural patterns of the positive-negative ad contrast are indeed due to differences in valence rather than to other ad characteristics. The valence scores for this analysis were derived from the ad pretest. Thus, this analysis tested the correlation between the ads' valence scores and the activation of the various brain regions. Supplemental Online Appendix 5 presents the cortical neural activity correlated with the valence scores of the ads. Orange color indicates regions that are significantly correlated with positive-valence ads; blue

Figure 2. Generalized linear model (GLM) results for the different affective ad conditions contrasted by neutral ads: (A) contrast between happy ads (H) and neutral ads (N); (B) contrast between relaxing ads (R) and neutral ads (N); (C) contrast between fearful ads (F) and neutral ads (N); (D) contrast between sad ads (S) and neutral ads (N).

color indicates regions that are significantly correlated with negative-valence ads. Again, processing of positive affective ads is significantly correlated with enhanced activation in the primary visual cortex and the auditory cortex; processing of negative affective ads is correlated with neural activation in the STS and in the frontal cortex. These findings strengthen the premise that the frontal-cortical activation that accompanies STS activation is derived from the negativity of the ads' emotional valence, implying involvement of social cognition in ad affect memory (Bakalash and Riemer 2013).

To examine our evidence vis-à-vis findings from Bakalash and Riemer (2013), in Supplemental Online Appendix 6 we overlaid a contour of the cortical neural activation patterns found in Bakalash and Riemer's (2013) study (contrasting memorable with unmemorable ads) onto the map produced in the current study contrasting negative ads (most memorable) with positive ads (least memorable). These maps indicate a considerable overlap in the activation of the STS region, reinforcing the premise that STS activation is associated with affective response to the ad, along with ad memorability. This strengthens the association between ad affect, sociocognitive processing, and ad memorability.

To gain further insights about the meaning of the observed neural activity, we rely on Lieberman's (2007) review of core sociocognitive neural processes identified across neuroscientific research. Lieberman presents a map of the regions associated with various types of sociocognitive processing, distinguishing between automatic and controlled processes (i.e., processes that differ in awareness, intention, controllability, and efficiency; Bargh 1989; Hasher and Zacks 1979; Moors and De Houwer 2007). The regions associated with the automatic system are the amygdala, basal ganglia, ventromedial prefrontal cortex (VMPFC), lateral temporal cortex (LTC), and dorsal anterior cingulate cortex (dACC). The regions associated with the controlled system are the lateral prefrontal cortex (LPFC), medial prefrontal cortex (MPFC), lateral parietal cortex (LPAC), medial parietal cortex (MPAC), medial temporal lobe (MTL), and rostral anterior cingulate cortex (rACC).

In Supplemental Online Appendix 7a we projected these sociocognitive regions on a flattened cortical map; Supplemental Online Appendix 7 b-d overlaid these highlighted cortical regions onto the maps displaying the contrasts between the various conditions. Supplemental Online Appendix 7b presents the sociocognitive network overlaid onto the contrast between the negative (F + S) and positive (H + R) conditions. This reveals that the neural patterns correlated with the processing of negative affective ads (colored orange) overlap with various regions involved in sociocognitive processing. Moreover, regions correlated with processing of positive affective ads (colored blue) do not overlap with regions that are part of the sociocognitive network. This can serve as a further indication for the involvement of the sociocognitive route in the memory of negative ads. It appears, therefore, that negative ads activate an excessive portion of the sociocognitive neural network. Similarly, Supplemental Online Appendix 7c presents the highlighted sociocognitive cortical regions overlaid onto the map of negative ads (F + S) contrasted with neutral ads (N). Here again, processing negative ads involves activation of a widespread portion of the sociocognitive neural system. In fact, almost all regions associated with sociocognitive processing are activated when viewing negative ads, and none of these regions are activated when viewing neutral ads (although neutral ads do show enhanced activation in the auditory cortex, colored blue). Thus, memory enhancement of negative (versus neutral) ads involves activation in most of the sociocognitive neural network. These regions include the VMPFC, STS, LPFC, MPFC, MPAC, and DMPFC. Finally, Supplemental Online Appendix 7d presents the highlighted sociocognitive cortical regions overlaid onto the map contrasting the processing of fearful ads (F; the most memorable ads) with that of neutral ads (N; the least memorable ads). This reveals that compared to neutral ads (N), fearful ads (F) activate the same cortical regions that were evident in the contrast between negative ads (F + S) and neutral ads (N) (Supplemental Online Appendix 7c) but to a greater extent. These regions include the VMPFC, lateral LTC, STS, LPFC, MPFC, MPAC, and DMPFC. Further, unlike the analysis of all negative affect ads (F + S), fearful ads (F only) activate an additional cortical region termed lateral parietal cortex (LPAC), thus expanding the neural activation patterns across the majority of the sociocognitive neural network.

For a general assessment of the specific functions in the activated versus nonactivated areas, Supplemental Online Appendix 8 presents both kinds of areas alongside their functions. For exploratory assesment, we identified the functions that are linked only to the activated areas. This assessment reveals that the activated areas are linked to processes of theory of the mind, dispositional attribution, and affect labeling (Lieberman 2007). These findings possibly point to specific processes that should be further explored in the future.

The findings presented in this section provide answers to research question 2: What brain regions are activated during successful encoding of emotional ads, and what can we learn from such activation on the processes underlying the memorability of affective ads? Our findings demonstrate that memory advantage of affective ads was accompanied by neural activation in brain regions associated with social cognition, and not with those regions associated with attention or elaboration processes.

Exploring Gender Differences in Affective Ad Processing

Emotional Regulation, Optimal Stimulation Level, and Memory of Affective Ads across Genders

As expected, women have a higher tendency than men to use the emotion regulation strategy of cognitive reappraisal (M_{men} = 5.07, M_{women} = 5.77, t (18) = 2.12, p < .05; Ochsner and Gross 2008). Men were found to have a higher tendency than women to use the emotion regulation strategy of emotional suppression (M_{men} = 3.85, M_{women} = 2.35, t (18) = 2.86, p < .01; Ochsner and Gross 2008). Men were also found to have a higher level of optimal stimulation than women (M_{men} = 66.4, M_{women} = 61.3, t (18) = 1.76, p < .05; Byrnes, Miller, and Schafer 1999; Zuckerman, Eysenck, and Eysenck 1978).

The comparison between the memory of positive ads (H + R) and of neutral ads (N) reveals insignificant difference both in men ($M_{positive\text{-}men}$ = 1.64, $M_{neutral\text{-}men}$ = 1.68, t (9) = 0.117, p = 0.909) and women ($M_{positive\text{-}women}$ = 1.77, $M_{neutral\text{-}women}$ = 1.50, t (9) = −1.692, p = 0.125). Insignificant memory difference was also found, in men and women, when comparing separately each positive affective ad (H or R) with the neutral ads (N) ($M_{happy\text{-}men}$ = 1.64, $M_{neutral\text{-}men}$ = 1.68, t (9) = 0.210, p = 0.838; $M_{relax\text{-}men}$ = 1.68, $M_{neutral\text{-}men}$ = 1.68, t (9) = 0.000, p = 1.000; $M_{happy\text{-}women}$ = 1.74, $M_{neutral\text{-}women}$ = 1.50, t (9) = −1.383, p = 0.200; $M_{relax\text{-}women}$ = 1.80, $M_{neutral\text{-}women}$ = 1.50, t (9) = −1.450, p = 0.181). The comparison between the memory of negative ads (F + S) and of neutral ads (N) reveals insignificant difference in men ($M_{negative\text{-}men}$ = 2.14, $M_{neutral\text{-}men}$ = 1.68, t (9) = −1.641, p = 0.135), but a significant difference in women ($M_{negative\text{-}women}$ = 2.14, $M_{neutral\text{-}women}$ = 1.50, t (9) = −4.390, p < 0.01). Comparing separately each negative ad (F or S) with the neutral ad (N) shows that in men there was a significant memory difference between fearful and neutral ads ($M_{fear\text{-}men}$ = 2.48, $M_{neutral\text{-}men}$ = 1.68, t (9) = −2.854, p < 0.05) but an insignificant memory difference between sad and neutral ads ($M_{sad\ men}$ = 1.80, $M_{neutral\ men}$ = 1.68, t (9) = −0.383, p = 0.711). In women, however, results show a significant memory difference both between fearful and neutral ads ($M_{fear\text{-}women}$ = 2.18, $M_{neutral\text{-}women}$ = 1.50, t (9) = −4.163, p < 0.01) and between sad and neutral ads ($M_{sad\text{-}women}$ = 2.16, $M_{neutral\text{-}women}$ = 1.50, t (9) = −2.571, p < 0.05). The findings imply that for women, valence alone makes a difference in the influence of ad affect on memory. By contrast, for men it is the combination of valence and arousal that matters. Thus, the patterns of the effect of ad affect on memory are similar across genders, except for the case of sadness; happy and relaxed ad affect did not influence ad memorability in either men or women, fearful ad affect enhanced ad memory in both genders, and sad ad affect enhanced ad memory in women but not in men. The additional analyses described in the next sections will attempt to shed light on this pattern of results.

Neural Activations Elicited by Affective Ads across Genders

To shed light on the processes underlying affective ads memory across genders, we followed Kret and Gelder's (2012) recommendations and conducted a series of whole brain statistical analyses, employing multiple statistical comparisons using Monte Carlo simulations in both men and women. Due to the sample size in each gender (10 men, 10 women), the statistical power was not sufficient for statistical comparisons of gender differences in neural activation across the different ad affect conditions versus the neutral ads. Consequently, for exploratory purposes, we descriptively compared the statistical neural activation maps of men to those of women, highlighting noticeable gender differences evident in widespread neural regions. This method is conventional in similar neural research (Salomon, Levy, and Malach 2014) but should be treated as exploratory.

Recall that gender differences in the effect of ad affect on memory were found in sad (versus neutral) ads and in all negative (versus neutral) ads together; women, but not men, had significantly better memory for sad (versus neutral) ads. Thus, Supplemental Online Appendix 9 contrasts various negative affect conditions with neutral conditions for women and men separately. Results reveal somewhat distinct patterns in four main neural regions: the STS, LPFC, MPAC, and the insula. According to Lieberman (2007), the first three regions are associated with a

Table 1. Correlation analyses between memory scores and measures of optimal stimulation level and emotion regulation tendencies.

	$M_{positive\ minus\ neutral}$	$M_{negative\ minus\ neutral}$	$M_{fear\ minus\ neutral}$	$M_{sad\ minus\ neutral}$	$M_{happy\ minus\ neutral}$	$M_{relax\ minus\ neutral}$
Optimal stimulation level (OSL)	$r = -.92$ $p = .701$	$r = -.235$ $p = .319$	$r = -.062$ $p = .794$	$r = -.306$ $p = .190$	$r = -.105$ $p = .660$	$r = -.059$ $p = .804$
Emotional suppression (ES)	$r = .225$ $p = .337$	$r = -.156$ $p = .512$	$r = .203$ $p = .309$	$\mathbf{r = -.387}$ $\mathbf{p = .092}$	$r = .179$ $p = .450$	$r = .225$ $p = .340$
Cognitive reappraisal (CR)	$r = -.169$ $p = .477$	$r = -.161$ $p = .498$	$r = -.334$ $p = .150$	$r = .011$ $p = .964$	$r = .256$ $p = .276$	$r = -.048$ $p = .840$

number of sociocognitive processes, including reappraisal, impulse control, affect labeling, attitude processes, and social reasoning (see Lieberman 2007; Satpute and Lieberman 2006). The insula (also known as the insular cortex) is a portion of the cerebral cortex folded deep within the lateral sulcus. It is involved in functions usually linked to emotion, including compassion and empathy. Studies have demonstrated that during cognitive reappraisal, neural activity increases in a widespread network of cortical frontal regions, as it simultaneously decreases in the insula, an area critical for emotional elicitation (Banks et al. 2007; Goldin et al. 2008; Kim and Hamann 2007; Ochsner et al. 2002; Ochsner et al. 2004). The seeming decrease in insula activation (i.e., inhibition) under negative ad conditions in women, but not in men, may be indicative of women's tendency to engage in cognitive reappraisal during exposure to negative valance ads. Altogether these findings may imply that gender differences in the influence of ad affect on memory, when established, could be attributed to differences in the tendency to engage in social cognition and possibly in cognitive reappraisal, which is in line with Ochsner and Gross (2008).

It is noteworthy that sociocognitive processes, which may include interpretation, may be involved in the affective experience elicited by the ads. This raises the question of whether the seeming gender differences in the influence of ad affect on memory are derived from the experience of affect or from its expression. That is, it may be that the distinct effects across genders are due to distinct emotional responses elicited by the ad. To explore this explanation, we used fMRI scans of the subcortical brain, and specifically amygdala activation, as an indication of the emotional response in the various conditions. We were interested in examining whether amygdala activation patterns differ across genders. Supplemental Online Appendix 10 contrasts between men and women in the subcortical activation during exposure to each of the affective ad conditions. These maps demonstrate that in all cases there seem to be insignificant gender differences in amygdala activation, suggesting that the ads may have elicited similar levels of affective response across genders. If this is the case, then the findings could imply that men and women possibly apply different processes upon experiencing similar affect, which may eventually result in distinct effects on memory.

The Role of Optimal Stimulation Level and Emotion Regulation Tendencies

To further investigate the underlying process, we ran a series of exploratory analyses to examine the association between optimal stimulation level or emotional regulation tendencies and ad memorability in the various conditions, as well as between these tendencies and neural acivation. These analyses were conducted across all participants, disregarding the gender variable.

First, we looked at the correlation between participants' memory gap score in the various ad affect conditions (the average memory score on that condition subtracted by the memory for neutral ad) and their scores of optimal stimulation level (OSL), emotional suppression (ES), or cognitive reappraisal (CR). Results reveal insignificant correlations in all cases (Table 1). In only one case did we find a marginally significant correlation: between scores of tendency for ES and the memory score of sad ads. This marginally signifcant correlation possibly points to a moderate negative association between ES tendency and memory for sad (versus neutral) ads. Recall that this was the only case where the gender comparisons of memorability effects suggested differences between women and men (i.e., women, but not men, showed memory advantage for sad ads over neutral ads). In addition, recall that men and women exhibited differences in the tendency for emotion suppression. A combination of these findings suggests that emotion suppression could play a role in the effect of ad affect on ad memory. Another point to consider is the preliminary indication of gender differences in activation found in brain regions associated with sociocognitive processes under the negative ad affect condition. Our discussion proposed that cognitive reappraisal processes might be involved. Future research should be devoted to systematic examination of the role of these various processes in ad memorability.

We also looked at neural activity using optimal stimulation, emotional suppression, or emotional reappraisal variables as continuous variables (Supplemental Online Appendix 11). As can be seen in the maps, the neural data do not demonstrate any pattern of activation, perhaps due to low power.

In these two types of analyses, it is impossible to determine whether the null effect resulted from low power or from these tendencies not playing a role in affective memory. More research, using larger samples, is needed to further examine these aspects. In future research, it would also be beneficial to consider looking at stronger indications for the processes, relying on temporary rather than chronic tendencies. Put differently, instead of looking at chronic disposition toward high stimulation, it might be worthwhile to look at temporal (perhaps motivational) manipulations or measurement of sensation seeking and emotion regulation (Millgram et al. 2019). Additional strategies of emotional regulation, such as distraction, should also be examined (Sheppes and Meiran 2007), as well as the possibility of co-occurrence of multiple processes.

The findings described in this section provide answers to research question 3: What are the differences between men and women in the effect of ad affect on memory and in the processes underlying this effect? Men and women exhibited similar patterns of effect on memory in all affective conditions except for sadness: sad ad affect enhanced ad memory in women but not in men. This gender difference could be attributed to differences in the tendency to engage in emotional regulatory processes (Ochsner and Gross 2008), which reinforces our premise that sociocognitive processes play an important role in the memory of affective ads.

General Conclusions

This study contributes to our understanding of the dominant dimensions in the influence of ad affect on memory and sheds light on the mechanism that drives the effect. We demonstrate that of the two dimensions of affect it is valence, not arousal, that drives the influence of ad affect on memory. Our results show memory advantage for negative over positive ad affect. In addition, evidence from fMRI in the current research reinforces findings by Bakalash and Riemer (2013) that sociocognitive processes are involved in memory of affective ads. Such evidence is consistent with another fMRI study of advertising effectiveness, demonstrating that social cognition also enhances behavioral changes promoted in the ad (Falk et al. 2015). Our evidence is insufficient for determining which specific sociocognitive processes were involved. However, the fact that passive viewing of ecological advertising stimuli activates widespread brain regions associated with sociocognitive processing is noteworthy and deserves future research to uncover the specific mechanisms involved.

Our study provides no evidence for the involvement of either the attention or the elaboration routes in affective ad memory. Moreover, our neuroscientific evidence demonstrates that attentional processes (discussed in emotional memory theorizing; Easterbrook 1959; Kahneman 1973), when they occur, do not lead to memory enhancement (but see Casado-Aranda, Van der Laan, and Sánchez-Fernández 2018, which used fMRI to support the contribution of attentional process to *attitude* toward the ad). Such findings point to the need to examine boundary conditions for the various routes to emotional memory in general and in advertising context specifically.

Although preliminary, the examination of gender differences suggests that gender might serve as a moderator in the role of sociocognitive processing in the memory for negative affect ads, particularly those communicating sadness. Future research should systematically examine these gender differences with a focus on the processes involved.

In addition to the theoretical contribution, our study offers practical implications. It suggests not only that emotional appeals are more effective than neutral ones but also that negative affective ads have a memory advantage over positive affective ads (with fear displaying the strongest effect). The memory advantage of sad (versus neutral) ad affect in women but not in men may suggest that when targeting female audiences, designing sad ads may improve memorability. Yet Riemer and Noel (2020) recently found that although affective arousal enhances long-term ad memory, it decreases immediate memory, and that when the level of arousal is irrelevant for the claim of the ad, ad arousal has no effect on memory. These boundary conditions should be combined with our current findings when designing advertising.

The exploratory evidence on the role of gender might offer implications beyond merely understanding gender differences in responses to ads; it may also inform us about the processes involved. Such insights, once established, may assist in developing interventions to control these processes. For example, the greater tendency of women to engage in cognitive reappraisal, which may have led to enhanced memory for negative ads, suggests that the effect on memory may be absent when alternative emotional regulation strategies are available (e.g., distraction; Sheppes and Meiran 2007). Similarly, introducing a cognitive reappraisal strategy in conditions where people do not usually employ it may enhance memory. Including instructions for such processes in ads might serve as a technique to enhance memorability. These instructions may include, for example, sentences such as "Think about what this means to you" or "How would this [–] relate to you?" Future research should examine these directions.

The centrality of sociocognitive processes may have broad implications in the era of social media. As the use of social media as an advertising platform has been increasing (Gavilanes, Flatten, and Brettel 2018), the involvement of sociocognitive processes during exposure to advertising may be enhanced because of the social nature of the context in which consumers are exposed to the ads. The enhancing effect of sociocognitive processes on ad memorability suggests that despite the overload of information and stimulation associated with social media, advertising memorability may in fact be enhanced in this medium, as it usually involves not only passive exposure to ads but also some sort of social interaction. Future research is needed to examine this direction and its boundaries.

Several methodological issues merit attention. First, examination of the content of the ads reveals that the negative affective ads in our study seemed to largely be about social awareness, whereas most positive affect ads were intended to sell goods. Indeed, research suggests that social campaigns increasingly use negative emotions (Brennan and Binney 2010), which may account for this difference. It is thus possible that the sociocognitive processes demonstrated in the study result from the content of the ads rather than, or in addition to, their affect. Future research needs to address this issue.

Second, gender differences in affective processing may be stimuli dependent. Proverbio et al. (2009), for example, found that men and women differed in their neural responses to emotional pictures portraying humans compared to natural or urban scenarios. Thus, gender differences in brain response to affective ads might depend upon the presence (or absence) of humans in the stimuli. Our study did not control for this variable and thus cannot assess this alternative explanation. Further, Fine, Semrud-Clikeman, and Zhu (2009) investigated gender differences in response to emotional human photographs versus emotional human naturalistic videos. They found that although more complex neural circuitry was activated in social processing when using video vignettes, men and women appear to process the videos similarly, whereas photo processing generated larger gender variation (Fine, Semrud-Clikeman, and Zhu 2009). In the context of our research, it might be that greater neural gender differences would have been found in response to printed (versus video) ads. Other ad characteristics may also play a role in gender differences—for example, the content of the ad, the product, and whether it is stereotypically or commonly linked to one gender. All of this is worth further research.

Third, previous studies on gender differences in response to advertising usually conceptualized these differences along sociocultural dimensions (Brunel and Nelson 2000; Eisend 2019; Eisend, Plagemann, and Sollwedel 2014; Fisher and Dubé 2005; Meyers-Levy 1988). The common finding is that men and women respond more favorably to ads that use emotional appeals consistent with their gender roles. Moreover, Fisher and Dubé (2005) found that when viewed privately, men reported the same level of pleasure as women did in response to ads that emphasized themes related to love, warmth, tenderness, and sentimentality (stereotype-incongruent emotions). However, when ads were viewed in the presence of others, gender differences in emotionality and pleasure were significant. Cultural stereotypes and social desirability may thus produce variations in the response of men and women. Such variations can be partially explained by the use of either individual-based or group-based data collection (Fisher and Dubé 2005). In our experiments, participants viewed ads in the fMRI scanner, which can be characterized as individual based, and therefore may have generated more gender similarities than gender differences. Future research should identify situations and contexts in which neural gender differences in response to affective ads emerge or disappear.

Fourth, our research provides evidence for the role of arousal and valence in the processing of affective ads. Yet knowledge on the effects of specific emotions on memory is limited. Future research should be devoted to investigating such effects, specifically in advertising contexts.

Fifth, the ads in the various conditions vary in low level features as well as in their content. Our method does not enable separating the effects of these factors from those of the affect itself. It may very well be that those features are involved in eliciting the affective response to the ad. Yet because past research suggests that such low level features can also initiate a wide variety of neural processes (Casado-Aranda, Van der Laan, and Sánchez-Fernández 2018; Chang et al. 2016), more research should be devoted to isolating the effects of these factors.

Sixth, Pozharliev, Verbeke, and Bagozzi (2017) stressed that to fully understand brain responses to advertising, the social context should be taken under methodological consideration (Chang 2017). Our participants viewed the ads while in the fMRI scanner, and therefore the methodology did not permit social facilitation. Future research should address this factor as well.

Finally, our research demonstrated only the socio-cognitive processes underlying the influence of ad affect on memory. The integrative framework proposed in Bakalash and Riemer's (2013) article suggests three processes underlying emotional memory: attention, elaboration, and social cognition. Yet our current study is consistent with Bakalash and Riemer's (2013) study in that both provide evidence only for the social cognition route and not for the other routes. More research is needed to examine the boundary conditions for all possible processes that perhaps underlie the effect in certain conditions but do not play a role in others.

Note

1. We used four rather than five neutral ads because our pretests could identify only four ads that fit the requirement.

Acknowledgments

This research is part of a doctoral dissertation of the first author, supervised by the second author. The article is dedicated to the memory of Ayala Malach-Pines, who served as a cochair of the doctoral committee.

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