ERP Evidence for Rapid Hedonic Evaluation of Logos

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Abstract

■ We know that human neurocognitive systems rapidly and implicitly evaluate emotionally charged stimuli. But what about more everyday, frequently encountered kinds of objects, such as computer desktop icons and business logos? Do we rapidly and implicitly evaluate these more prosaic visual images, attitude objects that might only engender a mild sense of liking or disliking, if at all? To address this question, we asked participants to view a set of unfamiliar commercial logos in the context of a target identification task as brain electrical responses to these objects were recorded via event-related potentials (ERPs). Following this task, participants individually identified those logos that were most liked or disliked, allowing us to then compare how ERP responses to logos varied as a function of hedonic evaluation—a procedure decoupling evaluative responses from any normative classification of the logos themselves. In Experiment 1, we found that visuocortical processing manifest a specific bias for disliked logos that emerged within the first 200 msec of stimulus onset. In Experiment 2, we replicated this effect while dissociating normative- and novelty-related influences. Taken together, our results provide direct electrophysiological evidence suggesting that we rapidly and implicitly evaluate commercial branding images at a hedonic level. ■

INTRODUCTION

Modern electronic advertising bombards our visual worlds with fleeting symbolic images such as logos, images designed to engender rapid and automatic hedonic responses despite the passive viewing conditions under which they are typically observed (Wheeler, 2006). The premise of advertisers that logos can trigger such responses is by no means unfounded. Cognitive theory stipulates that valuation judgments are integral to normal human behavior—so much so that they are generated without conscious intent (e.g., Dijksterhuis & Aarts, 2003; Chen & Bargh, 1999; Glaser & Banaji, 1999; Eagly & Chaiken, 1998; Bargh, Chaiken, Raymond, & Hymes, 1996; Fazio, Sanbonmatsu, Powell, & Kardes, 1986) and can bias cognitive–affective function in even the briefest of circumstances (e.g., Barrett, 2006). However, whether these rapid and implicit responses generalize to liking or disliking everyday images such as logos remains unclear.

That stimulus processing is sensitive to at least some forms of implicit evaluative responding is well known. For example, behavioral evidence indicates that people rapidly and automatically evaluate the valence of visual images having a strong positive or negative emotional content (e.g., Herr & Page, 2004; Giner-Sorolla, Garcia, & Bargh, 1999; Hermans, de Houwer, & Eelen, 1994), even for unfamiliar stimuli observed with no overt evaluative goals (e.g., Duckworth, Bargh, Garcia, & Chaiken, 2002). Consistent with these findings, event-related potential (ERP) data have shown that the late positive potential (LPP, beginning around 400 msec poststimulus) and the earlier visual P2 component (beginning around 200 msec poststimulus) are both strongly sensitive to the emotional valence of a stimulus, regardless of whether evaluations are implicit or explicit (e.g., Codispoti, Ferrari, & Bradley, 2006; Herbert, Kissler, Junghöfer, Peyk, & Rockstroh, 2006; Cuthbert, Schupp, Bradley, Bierbaumer, & Lang, 2000; Ito & Caccippo, 2000; Ito, Larsen, Smith, & Cacioppo, 1998; Cacioppo, Gardner, & Berntson, 1997; Cacioppo, Crites, & Gardner, 1996; Crites et al., 1995; Cacioppo & Berntson, 1994).

Yet whether implicit hedonic evaluations are manifest in an analogous manner is less than certain. To the point, studies of implicit affective evaluations have predominately relied on using stimuli—such as pictures and words—deliberately selected for having strongly positive or negative emotional valence as identified via normative ratings (e.g., Codispoti et al., 2006; Herbert et al., 2006; Duckworth et al., 2002; Cuthbert et al., 2000; Ito et al., 1998; Cacioppo et al., 1997; Cacioppo & Berntson, 1994). The nature of visual evaluative processing is then inferred by comparing behavioral and/or brain responses to stimuli drawn from these positive versus negative valence categories. Although this methodology has been successful in elucidating core aspects of affect-related visual evaluative responses, it is also limited in that (i) it only captures evaluative responding as it relates to normative and polarized emotional valence and (ii) it does not account for individual variability in the actual

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evaluative response that may be ascribed to an attitude object.

The issue here as it relates to more affectively benign hedonic evaluations is that these judgments are, by their very nature, idiosyncratic to the given observer—as the old proverb goes, ''Beauty is in the eye of the beholder.'' In other words, it is the subjective appraisal of an attitude object that drives an individual's hedonic response to that object, not the physical features of the object itself (e.g., Silvia, 2005). To be sure, there are any number of factors that may contribute to how a given individual hedonically evaluates a given attitude object (e.g., Berlyne, 1971), including those intrinsic to the object itself—such as symmetry and complexity (e.g., Jacobsen, Schubotz, Höfel, & von Cramon, 2006) and perceptual fluency (e.g., Reber et al., 2004; Winkielman & Cacioppo, 2001). However, there are also key factors intrinsic to the observer himself or herself that will also impact how an attitude object is hedonically evaluated, such as age, sex, culture, personal experience, and so on. While identifying these myriad factors and how they interact is beyond the scope of our study, it nevertheless stands to reason that our understanding of how normative emotion-related evaluative responses bias visuocortical processing may not generalize to more multifactored and implicit evaluations such as hedonic ones (e.g., Silvia, 2005). Indeed, unlike judgments of affectively polarized stimuli, recent ERP evidence suggests that aesthetic judgments of ''beauty'' bias visuocortical processing only when these evaluations are made explicitly (Höfel & Jacobsen, 2007a, 2007b). Taken together, the available evidence thus suggests that although visuocortical processing is susceptible to at least some forms of implicit evaluative analysis, whether this includes implicit hedonic analysis of everyday visual images like logos, remains an open question.

To address this issue, we recorded ERPs from participants as they viewed a serial stream of unfamiliar visual objects (logos) in the context of a target identification task. The task required a manual response whenever a predetermined target logo was shown, and importantly, no specific instructions were given to think about or aesthetically evaluate the logos per se. Instead, following completion of this task, participants were asked to identify the three logos they liked the most and the three logos they disliked the most. This methodology was premised on the assumption that an explicit hedonic evaluation of the logos taken after ERP data collection would provide a valid and reliable measure of any implicit hedonic responses to those logos that were evoked at the time of ERP recording. In this manner, we took advantage of the fact that there is a strong correspondence between implicit and explicit evaluations under conditions such as those in the current study, where the stimuli have little emotional intensity and the social pressure to respond in a specific way to any given image is negligible (e.g., Nosek, 2005, 2007). For each participant, ERP waveforms were then derived for three specific groupings of logos: the three logos that the participant self-reported to like the most (''liked_logos''), the three self-reported to be disliked the most (''disliked_logos''), and—as a baseline comparison condition—all 25 nontarget logos (''all_logos'').

If implicit hedonic evaluative responses can bias visuocortical processing, it predicted that effects should be manifest in one or more ERP time windows that have been shown to be sensitive to other forms of visual evaluative responding: 150–200 msec and 200–400 msec windows associated with more perceptually driven aspects of visual–sensory evaluation (e.g., Höfel & Jacobsen, 2007a, 2007b; Näätänen, 1992), and the 400–600 msec window capturing the LPP, an index of deeper or more contemplative aspects of evaluative analysis (e.g., Cuthbert et al., 2000; Ito & Caccippo, 2000; Cacioppo et al., 1996; Crites et al., 1995; Cacioppo & Berntson, 1994). Given this general mapping between the timing of an evaluative effect and the level of evaluative analysis involved, not only could we identify whether implicit hedonic evaluations actually bias visuocortical processing, but we could also gain insight into what levels of processing may be affected.

EXPERIMENT 1

Methods

Participants

Thirty-two right-handed volunteers (16 men, 16 women) were paid $20 to participate. All had normal or corrected-to-normal vision, and reported no neurological abnormalities. All testing procedures were approved by the University of British Columbia Clinical Review Ethics Board.

Stimuli

A total of 25 nontarget logos were used as the primary stimulus set; the logos were drawn from sources publicly available on the Internet and can be viewed and downloaded from (www.psych.ubc.ca/~tchandy/logos). Criteria for inclusion in this set included that the logo contained no verbal/lexical information (i.e., no words or letters) and that it was not a widely known or familiar image (e.g., such as the Nike ''swoosh''). Initial pretesting of the stimulus set was conducted to confirm the likelihood of individual variability in positive/negative preference ratings. We asked 20 people to rate each logo on two different metrics using 7-point scales: hedonic preference (like vs. dislike) and visual ''complexity'' (complex vs. simple). This initial testing confirmed that explicit hedonic judgments were highly uncorrelated with visual ''complexity'' judgments (r = .007, p = .88). Finally, for the 32 participants in the ERP experiment reported here, postexperiment debriefing was used to determine whether any of the logos were previously familiar or known; one participant reported that one logo was familiar, and it was removed from her dataset.

Procedures

Each trial block began with the presentation of the target logo for 2 sec as a reminder of which logo required a manual response to be made; the same logo was used as the target across all trial blocks and participants. Within each trial block, this target was presented 10 times and each of the 25 nontarget logos was presented four times, with the order of presentation randomly varied between blocks. The duration of each stimulus was 200 msec, and the interstimulus interval was randomly varied between 1300 and 1500 msec. Each participant performed a total of 10 trial blocks. Stimuli were presented on a VGA monitor controlled by a Pentium PC using the VAPP stimulus presentation system (http://nilab.psychiatry.ubc.ca/vapp/), and manual responses to the target were made by pressing a button with the thumb on a hand-held joystick, with the thumb of response (left vs. right) counterbalanced between participants.

Initial instructions to the participants asked them to simply observe the logos on the screen and make a manual response as fast as possible whenever the target logo was presented. No instructions were given to think about or explicitly evaluate the nontarget logos. Following completion of this task and the removal of the EEG/EOG recording equipment, each participant was then asked to rate each of the 25 nontarget logos in terms of how much they liked or disliked each one. To make these ratings, each participant was given a sheet of paper containing all 25 nontarget logos, with a space underneath each to mark his or her rating on a 7-point scale (1 = strongly disliked, 7 = strongly liked); participants were encouraged to use the entire scale range. Once ratings were made for all 25 logos, we then asked participants to specifically mark which three logos they liked the most and which three logos they disliked the most (see Table 1). Importantly, this instruction was specifically given after subjective ratings were performed in order to ensure that all logos were hedonically evaluated before our "liked_logos" and "disliked_logos" categories were identified. To make sure that the arrangement/order of logos on the rating sheet did not bias ratings, four different ratings sheets were used across participants, with each sheet presenting the logos in a different arrangement/order.

Table 1. Logo Selection Preferences for Experiment 1

Logo no.	*Liked*	*Disliked*
1	6	5
2	5	2
3	7	0
4	5	2
5	3	11
6	4	5
7	9	0
8	3	3
9	3	3
10	6	2
11	5	6
12	3	6
13	2	4
14	1	7
15	3	10
16	0	1
17	5	4
18	1	4
19	6	0
20	1	3
21	3	3
22	4	5
23	2	3
24	6	3
25	3	4

Shown are how many participants rated each logo as one of his or her three "most liked" versus "most disliked."

Electrophysiological Recording

Scalp potentials were recorded from 24 tin electrodes mounted in a custom elastic cap, with an electrode spatial configuration approximately consistent with standard sites in the "10–20" location system. All EEG activity was recorded relative to the left mastoid, amplified (Grass Instruments, Model 12 Neurodata Acquisition System) with a bandpass of 0.1–30 Hz (1/2 amplitude cutoffs), and digitized on-line at a sampling rate of 256 samples-per-second. To ensure proper eye fixation, vertical and horizontal EOGs were also recorded, the vertical EOG from an electrode inferior to the right eye, and the horizontal EOG from an electrode on the right outer canthus. All electrode impedances were kept below 5 kΩ. Off-line, computerized artifact rejection was used to eliminate trials during which detectable eye movements ($>1°$), blinks, muscle potentials, or amplifier blocking occurred. For each subject, ERPs were then derived, algebraically re-referenced to the average of the left and right mastoid signals, and filtered with a low-pass Gaussian filter (25.6 Hz half-amplitude cutoff) to eliminate residual high-frequency artifacts in the waveforms. The resulting single-subject ERPs were then used to derive the group-averaged waveforms for display and analysis.

Results

Behavior

The number of times each logo was selected as ''liked'' or ''disliked'' across all participants is reported in Table 1. Mean reaction time to the targets was 437 msec (*SD* = 74 msec), and the mean target detection rate was 0.995 (*SD* = 0.014). In terms of logo ratings, the mean rating for liked_logos was 6.58 (out of 7), the mean for disliked_logos was 1.39, and the mean for all_logos was 3.99.

Electrophysiology

Grand-averaged ERP waveforms for liked_logos, disliked_logos, and all_logos are shown in Figure 1, and mean amplitudes across scalp locations and conditions are reported in Table 2. Statistical analyses of ERP data were based on repeated measures ANOVAs that used unpooled error terms in order to (1) return probability estimates that remain robust to violations of multisample sphericity common in repeated measures ERP data (e.g., Keselman, Wilcox, & Lix, 2003) and (2) that control for family-wise Type I error rates in a manner that does not inflate the Type II error rate, such as occurs with Bonferonni-type corrections (e.g., Vasey & Thayer, 1987). In addition to a factor of liking/disliking (or L/D) that had three levels (liked_logos vs. disliked_logos vs. all_logos), each ANOVA included a scalp-wide grid of 12 electrodes divided into four anatomical subgroupings: a frontal group (F3, Fz, F4), a central group (C3, Cz, C4), a parietal group (P1, Pz, P2), and an occipital group (OL, Oz, and OR). This allowed for analysis of scalp location (frontal vs. central vs. parietal vs. occipital) as a factor potentially interacting with L/D. Separate ANOVAs were run on each of three poststimulus time windows: (1) a 150–200 msec window capturing the frontal/central/parietal P1 and occipital N1 ERP components, (2) a 200–400 msec window capturing the frontal/central N2 and parietal/occipital P2 components, and (3) a 400–600 msec window capturing the LPP. Within each time window, ANOVAs within each scalp location were planned to follow-up any significant interactions between L/D and scalp location, and to dissociate how any significant L/D effects were manifest (i.e.,

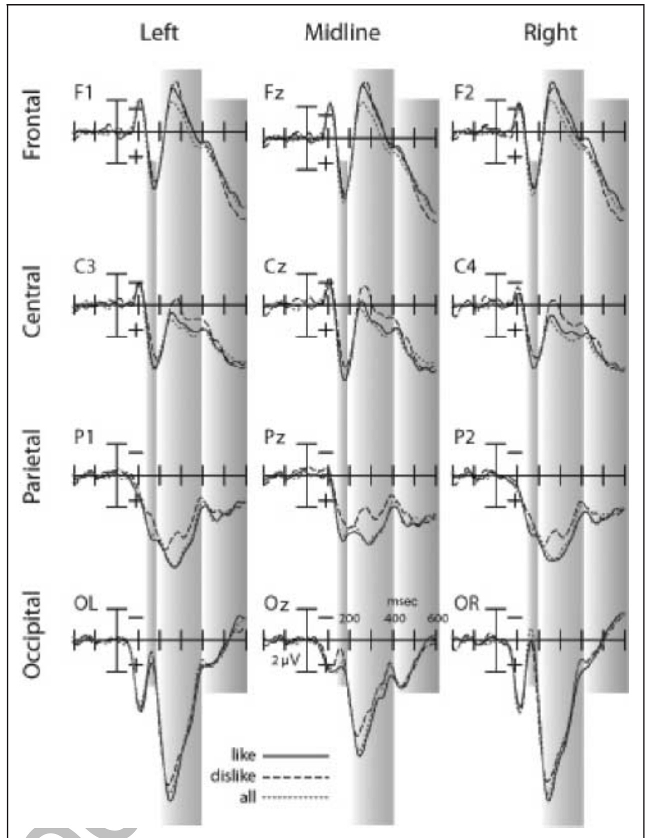

Figure 1. ERP responses to nontarget logos from Experiment 1. Data are shown as a function of hedonic evaluation of logos (liked vs. disliked), along with the response across all logos. In the 150–200 msec (left gray shaded bars), there was a significant decrease in P1 amplitude for disliked_logos at central and parietal locations. In the 200–400 msec time window (middle gray shaded bars), there was a significant increase in N2 amplitude for disliked_logos at central locations and a significant decrease for disliked_logos at parietal and occipital locations. There were no significant effects of hedonic evaluation in the LPP time range (400–600 msec window, right gray shaded bars).

Table 2. Mean Amplitude (μV) of Group-averaged ERPs for Liked, Disliked, and All Logos from Experiment 1

	Time Window								
	150–200 msec			*200–400 msec*			*400–600 msec*		
Scalp Location	*Like*	*Dislike*	*All*	*Like*	*Dislike*	*All*	*Like*	*Dislike*	*All*
Frontal	3.01 (0.32)	2.81 (0.30)	3.28 (0.34)	−1.07 (0.36)	−0.97 (0.35)	−0.37 (0.33)	2.63 (0.44)	3.22 (0.52)	2.96 (0.54)
Central	3.75 (0.30)	3.03 (0.29)	3.79 (0.31)	1.45 (0.35)	0.73 (0.30)	1.65 (0.29)	3.08 (0.34)	2.89 (0.34)	3.02 (0.36)
Parietal	3.89 (0.29)	3.05 (0.28)	3.63 (0.29)	4.23 (0.33)	3.10 (0.27)	4.00 (0.25)	2.50 (0.28)	2.34 (0.26)	2.42 (0.27)
Occipital	1.92 (0.35)	1.80 (0.33)	1.55 (0.35)	6.02 (0.33)	5.38 (0.32)	5.57 (0.30)	0.57 (0.21)	0.69 (0.23)	0.63 (0.20)

Data are collapsed across the three electrodes within each scalp location, and are shown as a function of poststimulus onset time window. Standard errors are in parentheses.

to make direct pairwise comparisons between each logo-type pairing). For all reported statistics, mean amplitude measures were taken relative to a −200 to 0 msec prestimulus baseline.

150–200 msec poststimulus. Data in this time window (Figure 1, left gray shaded bars) were consistent with an effect of L/D manifest in the central/parietal P1 component, an effect specifically associated with logos that were disliked. In particular, no significant main effect of L/D was found [$F(2, 62) = 1.88, p = .16$], but L/D interacted with scalp location [$F(2, 62) = 2.95, p = .009$]. Planned ANOVAs examining the interaction between L/D and scalp location revealed significant main effects of L/D at the central [$F(2, 62) = 3.67, p = .031$] and parietal [$F(2, 62) = 3.60, p = .033$] sites, but not at the occipital [$F(2, 62) = 0.94, p = .394$] or frontal sites [$F(2, 62) = 1.06, p = .352$]. Subsequent planned ANOVAs within the central and parietal sites examining the main effects of L/D revealed that whereas liked_logos and all_logos did not significantly differ at either central [$F(1, 31) = 0.01, p = .906$] or parietal [$F(1, 31) = 0.84, p = .366$] scalp locations, disliked_logos consistently differed from both liked_logos [central: $F(1, 31) = 4.75, p = .007$; parietal: $F(1, 31) = 4.97, p = .033$] and all_logos [central: $F(1, 31) = 8.27, p = .037$; parietal: $F(1, 31) = 4.01, p = .054$].

200–400 msec poststimulus. Data in this time window (Figure 1, middle gray shaded bars) were consistent with an effect of L/D manifest in the parietal/occipital P2 and the central N2 components, effects again strongly associated with logos that were disliked. Specifically, we found a main effect of L/D [$F(2, 62) = 3.60, p = .033$] that also interacted with scalp location [$F(6, 186) = 5.14, p = .0001$]. Planned ANOVAs examining the interaction between L/D and scalp location revealed significant main effects of L/D at the central [$F(2, 62) = 4.30, p = .018$], parietal [$F(2, 62) = 6.35, p = .003$], and occipital [$F(2, 62) = 3.52, p = .036$] sites, but not at the frontal sites [$F(2, 62) = 2.58, p = .084$]. Subsequent planned ANOVAs examining the main effects of L/D revealed that liked_logos and all_logos did not significantly differ at central [$F(1, 31) = 0.32, p = .57$], parietal [$F(1, 31) = 0.64, p = .429$], or occipital [$F(1, 31) = 2.98, p = .094$] scalp locations. However, disliked_logos differed from liked_logos at parietal [$F(1, 31) = 6.67, p = .015$] and occipital [$F(1, 31) = 4.03, p = .053$] electrode sites, and differed from all_logos at central [$F(1, 31) = 19.29, p = .0001$] and parietal [$F(1, 31) = 12.86, p = .001$] sites. There were no significant differences between disliked_logos and liked_logos at central sites [$F(1, 31) = 3.35, p = .076$], or between disliked_logos and all_logos at occipital sites [$F(1, 31) = 2.68, p = .112$].

400–600 msec window. Data in this time window (Figure 1, right gray shaded bars) were consistent with no effect of L/D on the LPP: No main effect of L/D was found [$F(2, 62) = 0.04, p = .959$], nor did it interact with scalp location [$F(6, 186) = 1.11, p = .360$].

Discussion

To summarize, we found significant effects of hedonic evaluation on the central/parietal P1 (150–200 msec window), and the parietal/occipital P2 and central N2 components (200–400 msec time window), modulations on component amplitudes that appeared to be primarily driven by disliked_logos. These effects were observed despite the absence of any explicit instructions to think about or evaluate the logos. As such, our data suggest that we do, in fact, evaluate everyday images at a hedonic level, and further, that the effect these evaluations have on visuocortical processing is extremely rapid-emerging within the first 200 msec of observing a stimulus. However, our results also raised several questions of interest we wanted to explore further.

For one, our effects resembled emotion-related evaluative judgments in at least two fundamental ways. First, they were fast and arose despite an absence of explicit evaluative instructions, as has been reported for valence-normed, emotion-related attitude objects (e.g., Codispoti et al., 2006; Herbert et al., 2006; Duckworth et al., 2002). Second, the hedonic effect was associated with disliked logos, a response akin to the negativity bias frequently reported for attitude objects with a negative emotional valence (e.g., Herr & Page, 2006; Dijksterhuis & Aarts, 2003; Ito & Caccippo, 2000; Ito et al., 1998). Yet our results also differed from emotion-related evaluative judgments in at least one critical way: Whereas implicit emotional judgments have reliably produced modulations in the LPP (e.g., Codispoti et al., 2006; Herbert et al., 2006; Cuthbert et al., 2000; Ito & Caccippo, 2000; Ito et al., 1998; Cacioppo et al., 1996, 1997; Crites et al., 1995; Cacioppo & Berntson, 1994), no such effects of hedonic evaluation were observed in the LPP here (400–600 msec time window).

There are at least two competing possibilities to explain this absence of an LPP effect in our data. One is that implicit hedonic evaluations may simply not extend to or include those evaluative processes indexed by the LPP. Given that the LPP has been associated with higher-level, contemplative analysis and categorization of attitude objects (e.g., Crites et al., 1995; Cacioppo & Berntson, 1994), it would not necessarily be surprising to find a null result here. For example, LPP amplitudes are reduced for emotional stimuli that have lesser versus greater affective intensity (e.g., Cuthbert et al., 2000). In short, although people may certainly be able to report on whether or not they like a logo, the images themselves are relatively benign at an emotional level and may not drive ''deeper'' implicit reflection as manifest in the LPP. The other possibility, however, is that with a fairly small number of logos to choose from (25 in

Experiment 1), we may have undersampled the poles of the hedonic spectrum. In other words, although our measures of liking and disliking may have been sufficient to drive differences in pre-LPP evaluative processes, comparable effects in the LPP time range may only emerge when the attitude objects reflect stronger exemplars of the ''liked'' and ''disliked'' categories. This suggested that with more variety (or logos to choose from), it would increase the likelihood that participants would be able to select more strongly liked and disliked logos—and represent a stronger test of LPP involvement in implicit hedonic responses.

A second issue to clarify concerned the nature of the effects we observed in the pre-LPP time range. In particular, implicit evaluative responses in this time range are often construed as reflecting initial, perceptual-level evaluative responses to attitude objects (e.g., Näätänen, 1992), such as ''feature impression'' (Höfel & Jacobsen, 2007a, 2007b). If so, we wanted to address two follow-up questions with regard to these ''perceptual'' or ''early'' hedonic effects. First, how do they change over time, as one becomes more familiar with an attitude object? For example, are hedonic responses present the first time an object is viewed, or do they only emerge with repeated exposure to it? Second, given that perceptual-level visual processing is strongly sensitive to the physical attributes of a stimulus (e.g., luminance, color contrast, symmetry, complexity), to what extent could we identify or dissociate more stimulus-bound aspects of the hedonic response from more individual-bound aspects of the response, which should transcend the particular physical features of the given attitude object?

Given this collective set of issues and questions, we thus designed a second experiment that modified Experiment 1 in three key ways. First, in order to better-sample the poles of the hedonic continuum, we increased our stimulus set size from 25 to 232 logos. Second, to examine how hedonic effects vary or change with repeated exposure, each block of trials included presenting each of the 232 logos exactly once, thereby allowing us to include exposure history as a factor in our analyses. Finally, on the logic that stimulus-bound hedonic effects would be stronger or more prominent in the more popularly selected logos, we planned additional analyses that factored in group-wide logo L/D rates in order dissociate more stimulus-bound versus more individual-bound aspects of the hedonic responses.

EXPERIMENT 2

Methods

Participants

Eighteen right-handed adult volunteers (7 men, 11 women) were paid $20 to participate. All had normal or corrected-to-normal vision, and reported no neurological abnormalities. None had participated in Experiment 1.

Stimuli and Procedures

All stimuli and procedures were identical to Experiment 1, with the following exceptions. First, 232 nontarget logos were used as the primary stimulus set, the 25 original logos from Experiment 1 and an additional 207 new ones; the new logos were again drawn from sources publicly available on the Internet. In selecting these new logos, we applied the same inclusion criteria as outlined in Experiment 1, and the logos themselves can be viewed and downloaded at the website cited above. Importantly, postexperiment debriefing confirmed that none of the participants were previously familiar with any of the 232 logos. Second, each nontarget logo was presented once in each trial block. As a result, each trial block was slightly over twice as long as the trial blocks in Experiment 1; each participant viewed eight trial blocks in total, and thus, saw each logo eight times in total over the course of the ERP testing session (i.e., once per each block of trials). Third, due to the large size of the stimulus set, we did not ask participants to rate each logo for L/D after ERP recording. Rather, participants were instructed to examine all the logos and then to identify the 15 they liked the most and the 15 they disliked the most. Finally, all ERP recording and data averaging procedures were identical to Experiment 1, with the following exception: The waveforms for liked_logos and disliked_logos were based on 15 logos each, as per described above. Given our goal of more tightly sampling the poles of the hedonic continuum relative to Experiment 1, this reduced the ratio for liked_logos/all_logos and disliked_logos/all_logos almost in half, from 0.12 (3/25) in Experiment 1 to 0.065 (15/232) here.

Results

Behavior

The number of times each logo was selected as ''liked'' or ''disliked'' across all 18 participants is reported in Table 3. Mean reaction time to the targets was 427 msec (*SD* = 64.1 msec), and the mean target detection rate was 0.985 (*SD* = 0.025).

ERPs: Analysis Goals

The goals for ERP analysis in Experiment 2 were threefold: First, determine if we replicated the hedonic effects observed in Experiment 1. Second, determine to what extent, if any, these effects varied over time, in terms of repeated exposure to each logo. And finally, determine whether these effects varied between more-frequently selected versus less-frequently selected logos. Goals 1 and 2 were addressed by including trial block—or run—as a factor in our omnibus ANOVAs. Goal 3 was addressed by separately analyzing two subsets of the data: liked_ and disliked_logos selected three or fewer times

Table 3. Logo Ratings for Experiment 2

#	L	D	#	L	D	#	L	D	#	L	D
1	1	–	40	–	1	79	–	2	118	1	–
2	–	–	41	–	1	80	–	2	119	–	1
3	3	1	42	–	3	81	2	–	120	–	1
4	–	–	43	1	–	82	4	–	121	1	1
5	–	–	44	2	–	83	2	2	122	–	1
6	5	–	45	–	–	84	1	–	123	2	1
7	–	1	46	–	–	85	2	1	124	–	–
8	1	3	47	–	2	86	5	2	125	–	–
9	2	–	48	1	2	87	1	1	126	–	4
10	1	–	49	1	1	88	–	5	127	–	1
11	–	4	50	2	1	89	–	3	128	1	3
12	–	3	51	–	–	90	2	2	129	1	5
13	–	3	52	1	–	91	1	1	130	–	3
14	2	2	53	2	–	92	3	–	131	1	1
15	1	2	54	4	–	93	–	3	132	1	–
16	–	2	55	–	1	94	1	–	133	–	–
17	–	1	56	2	1	95	2	1	134	3	–
18	1	–	57	2	–	96	3	–	135	–	1
19	4	1	58	1	1	97	–	2	136	1	1
20	3	1	59	–	1	98	–	2	137	1	1
21	4	–	60	4	1	99	1	–	138	2	1
22	2	1	61	5	1	100	–	2	139	–	1
23	1	–	62	–	–	101	–	1	140	–	–
24	–	3	63	1	1	102	2	1	141	–	2
25	–	2	64	1	3	103	–	–	142	–	–
26	1	2	65	–	1	104	–	–	143	4	3
27	–	1	66	2	–	105	–	2	144	1	2
28	–	1	67	2	–	106	4	–	145	2	1
29	1	1	68	–	–	107	1	–	146	1	–
30	–	3	69	1	–	108	1	–	147	4	3
31	–	4	70	–	–	109	–	4	148	1	2
32	4	2	71	2	–	110	–	1	149	–	–
33	–	–	72	1	–	111	1	1	150	2	1
34	1	1	73	1	4	112	–	1	151	–	2
35	–	3	74	–	1	113	1	1	152	1	1
36	–	1	75	1	3	114	4	3	153	–	2
37	6	1	76	1	–	115	5	2	154	–	–
38	–	–	77	–	–	116	4	2	155	–	2
39	–	1	78	4	–	117	3	–	156	2	2

Table 3. (*continued*)

#	L	D	#	L	D	#	L	D	#	L	D
157	2	2	176	–	2	195	–	–	214	–	1
158	–	–	177	–	–	196	–	–	215	–	4
159	–	–	178	1	–	197	–	2	216	2	1
160	5	–	179	1	2	198	–	1	217	3	–
161	2	1	180	2	3	199	1	2	218	2	1
162	–	1	181	–	1	200	2	1	219	–	–
163	6	2	182	4	1	201	1	–	220	–	2
164	5	1	183	1	–	202	–	2	221	–	–
165	1	2	184	3	–	203	1	2	222	5	2
166	1	3	185	–	4	204	6	1	223	–	–
167	1	1	186	–	2	205	–	3	224	–	2
168	–	1	187	–	2	206	–	1	225	6	1
169	–	–	188	–	–	207	–	–	226	–	1
170	3	1	189	3	1	208	–	4	227	1	–
171	–	–	190	–	3	209	–	1	228	1	–
172	1	–	191	1	2	210	1	3	229	2	1
173	–	3	192	–	–	211	–	–	230	1	2
174	2	1	193	–	–	212	2	1	231	1	–
175	1	1	194	–	–	213	1	–	232	1	2

Shown are how many times each logo was rated ''most liked'' and ''most disliked,'' across participants. # = logo number; L = liked; and D = disliked.

across participants, and liked_ and disliked_logos selected four or more times across participants.

ERPs: Omnibus Analyses

The ERP data from one participant were excluded from all group analyses due to excessive residual noise in his waveforms. Grand-averaged ERP waveforms from the remaining 17 participants for liked_logos, disliked_logos, and all_logos are shown in Figure 2 and mean amplitudes across scalp locations and conditions are reported in Table 4. As in Experiment 1, we ran separate omnibus repeated measures ANOVAs on mean amplitude measures from three time windows of data: 150–200 msec, 200–400 msec, and 400–600 msec. Each ANOVA included factors of L/D (liked vs. disliked vs. all), run (with 8 levels, one for each trial block), and scalp location (frontal vs. central vs. parietal vs. occipital).

150–200 msec poststimulus. Data in this time window (Figure 2, left gray shaded bars) replicated the dislike bias that we observed in the central/parietal P1 component in Experiment 1. The initial omnibus ANOVA

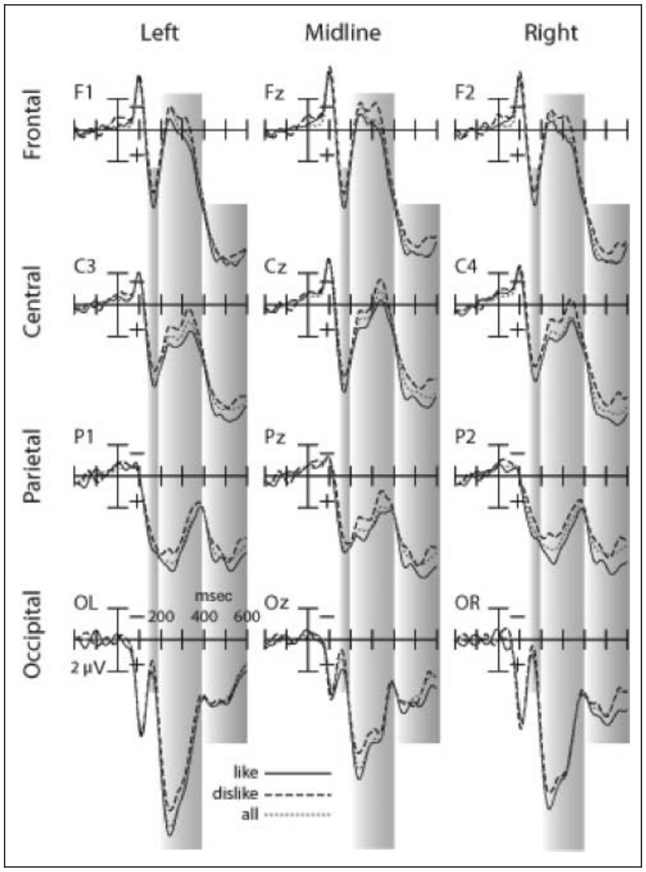

Figure 2. ERP responses to nontarget logos from Experiment 2. Data are shown as a function of hedonic evaluation of logos (liked vs. disliked), along with the response across all logos. In the 150–200 msec (left gray shaded bars) and 200–400 msec (middle gray shaded bars) time windows, there were significant modulations in ERP amplitude for disliked_logos across all scalp locations. In the 400–600 msec time window (right gray shaded bars), there was a significant increase in N2 amplitude for disliked_logos at central locations and a significant decrease for disliked_logos at parietal and occipital locations. An effect of hedonic evaluation only approached significance (p = .056) in the LPP time range (400–600 msec window, shaded blue).

revealed a main effect of run [$F(7, 112) = 2.48, p = .021$] and L/D [$F(2, 32) = 3.60, p = .039$]. There was no interaction between these two factors [$F(14, 224) = 1.34, p = .187$], nor was there an interaction between L/D and scalp location [$F(6, 96) = 0.05, p = .999$]. We confirmed via planned ANOVAs that the main effect of L/D was driven by a specific bias for disliking, where the difference between disliked_logos and all_logos was significant [$F(1, 16) = 8.41, p = .010$] and the difference between disliked_logos and liked_logos approached significance [$F(1, 16) = 4.22, p = .057$]. In contrast, there was no significant difference between liked_logos and all_logos [$F(1, 16) = 0.32, p = .581$].

200–400 msec poststimulus. Data in this time window (Figure 2, middle gray shaded bars) also replicated the dislike bias that we observed in the parietal/occipital P2 and central N2 components in Experiment 1. The initial omnibus ANOVA revealed a main effect of run [$F(7, 112) = 2.99, p = .007$] and L/D [$F(2, 32) = 6.93, p = .003$]. There was no interaction between these two factors [$F(14, 224) = 1.12, p = .343$], nor was there an interaction between L/D and scalp location [$F(6, 96) = 0.38, p = .889$]. We confirmed via planned ANOVAs that the main effect of L/D was driven by a specific bias for disliking, where the difference between disliked_logos and all_logos was significant [$F(1, 16) = 5.74, p = .029$], as was the difference between disliked_logos and liked_logos approached significance [$F(1, 16) = 12.68, p = .003$]. In contrast, there was no significant difference between liked_logos and all_logos [$F(1, 16) = 1.71, p = .209$].

400–600 msec poststimulus. Data in this time window (Figure 2, right gray shaded bars) manifest a trend toward an effect of L/D on the LPP, a trend in the LPP not observed in Experiment 1. The initial omnibus ANOVA revealed no main effect of run [$F(7, 112) = 1.82, p = .091$], but the main effect of L/D did approach significance [$F(2, 32) = 3.15, p = .056$]. There was no interaction between these two factors [$F(14, 224) = 0.52, p = .922$], nor was there an interaction between

Table 4. Mean Amplitude (µV) of Group-averaged ERPs for Liked, Disliked, and All Logos from Experiment 2

	Time Window								
	150–200 msec			*200–400 msec*			*400–600 msec*		
Scalp Location	*Like*	*Dislike*	*All*	*Like*	*Dislike*	*All*	*Like*	*Dislike*	*All*
Frontal	3.87 (0.49)	3.04 (0.49)	3.66 (0.50)	2.36 (0.71)	1.48 (0.67)	1.99 (0.75)	6.75 (1.18)	5.99 (1.23)	6.38 (1.15)
Central	3.98 (0.58)	3.23 (0.59)	3.89 (0.58)	4.03 (0.76)	3.23 (0.78)	3.82 (0.79)	5.75 (0.89)	4.84 (0.84)	5.21 (0.82)
Parietal	3.60 (0.49)	2.88 (0.48)	3.43 (0.49)	2.29 (0.62)	1.42 (0.61)	1.91 (0.66)	5.75 (0.97)	4.86 (0.98)	5.29 (0.95)
Occipital	3.79 (0.55)	3.02 (0.55)	3.56 (0.55)	5.23 (0.76)	4.34 (0.78)	4.94 (0.80)	4.17 (0.68)	3.57 (0.65)	3.79 (0.61)

Data are collapsed across all runs and across the three electrodes within each scalp location, and are shown as a function of poststimulus onset time window. Standard errors are in parentheses.

L/D and scalp location [$F(6, 96) = 1.17$, $p = .327$]. Given that the main effect of L/D approached significance, we made direct comparisons between each of the three L/D conditions. This analysis confirmed that disliked_logos significantly differed from liked_logos [$F(1, 16) = 4.78$, $p = .044$], but not from all_logos [$F(1, 16) = 1.31$, $p = .269$]; liked_logos and all_logos also did not significantly differ [$F(1, 16) = 1.71$, $p = .209$].

ERPs: Repeated Stimulus Exposure

Toward understanding the main effect of run found in each time window, we plotted the waveforms for all_logos as a function of each block of trials (Figure 3). Visual examination of these data suggested that the first trial block was contributing a disproportionately large percentage of run-related variance, at least in the 150–200 (Figure 3, left gray shaded bars) and 200–400 msec time windows (Figure 3, middle gray shaded bars). To confirm this interpretation and explore what may have been unique to Run 1, we thus conducted two subanalyses of our data: Repeating the above ANOVAs with the data from Run 1 excluded from analysis (i.e., ''run'' was a factor with 7 levels rather than 8), and analyzing the data from Run 1 only.

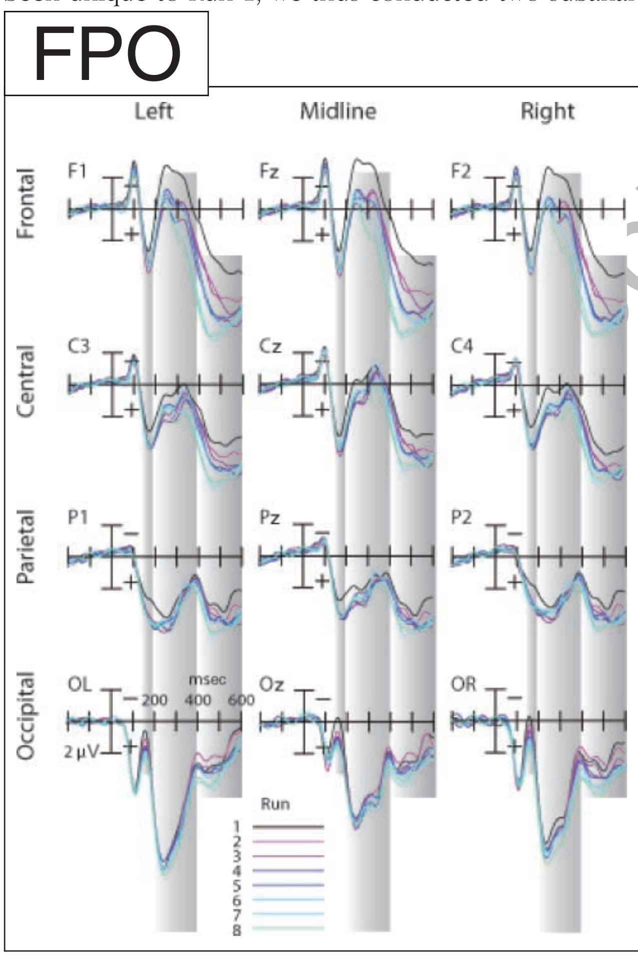

Figure 3. ERP responses to all_logos in Experiment 2 as a function of run. In the 150–200 and 200–400 msec time windows (left and middle gray shaded bars, respectively), there was a uniquely differing amplitude of response for Run 1, relative to Runs 2 to 8. Effects of run in the LPP time range (400–600 msec window, right gray shaded bars) were nonsignificant.

Run 1 excluded. In the 150–200 msec time window, dropping Run 1 from the dataset eliminated the main effect of run [$F(6, 96) = 1.38$, $p = .230$] while the main effect of L/D was preserved [$F(2, 32) = 5.10$, $p = .012$]. As well, no interaction between run and L/D was observed [$F(12, 192) = 1.28$, $p = .235$]. In the 200–400 msec time window, dropping Run 1 also eliminated the main effect of run [$F(6, 96) = 1.64$, $p = .144$] while preserving the main effect of L/D [$F(2, 32) = 8.01$, $p = .002$]. Again, there was also no interaction between run and L/D [$F(12, 192) = 1.10$, $p = .364$]. In the 400–600 msec time window, there was no main effect of run [$F(6, 96) = 0.93$, $p = .479$], L/D [$F(2, 32) = 2.00$, $p = .152$], or interaction between run and L/D [$F(12, 192) = 0.60$, $p = .840$].

Run 1 only. In the 150–200 msec time window, there was no main effect of L/D [$F(2, 32) = 0.22$, $p = .805$], nor was there an interaction between L/D and scalp location [$F(4, 64) = 1.28$, $p = .235$]. In the 200–400 msec time window, there was also no main effect of L/D [$F(2, 32) = 0.47$, $p = .628$], nor was there an interaction between L/D and scalp location [$F(4, 64) = 0.78$, $p = .589$]. In the 400–600 msec time window, although there again was no main effect of L/D [$F(2, 32) = 0.51$, $p = .603$], there was a significant interaction between L/D and scalp location [$F(4, 64) = 2.46$, $p = .029$]. Within this time window, however, separate ANOVAs within each of the four scalp locations revealed no main effect of L/D within any location [all Fs $(2, 32) < 2.13$; all ps $> .136$].

ERPs: Selection Frequency Analysis

To help dissociate between stimulus-bound and individual-bound influences on implicit hedonic responses, we split our data based on whether each liked_logo and disliked_logo had been selected by either one to three versus four to six participants (based on a maximum of 6 participants selecting a particular logo in either category; see Table 3). That is, while we continued to account for individual variability of hedonic responses by only analyzing for each participant those logos he or she selected as L/D, this splitting of the data allowed us to compare L/D effects as a function of normative popularity within our participant sample. We thus repeated the above ANOVAS for each of these two subgroups of data. Our rationale was that more-frequently selected logos would have stronger stimulus-bound attributes normative to liking and disliking, relative to the less-frequently selected logos. Although we included run as a factor in our analyses, it never interacted with L/D, and thus, for brevity, we do not report main effects of run here.

Less-frequently selected logos. The ERP waveforms for the less-frequently selected logos are shown in Figure 4, and mean amplitudes across scalp locations are reported in Table 5. These data were suggestive of an effect of L/D that was restricted to the 200–400 msec time window, an interpretation that was confirmed statistically. In the 150–200 msec window, we found neither a main effect of L/D [$F(2, 32) = 1.31$, $p = .283$] nor an interaction between L/D and scalp location [$F(6, 96) = 0.13$, $p = .993$]. In the 200–400 msec window, we found both a main effect of L/D [$F(2, 32) = 4.17$, $p = .025$] and an interaction between L/D and scalp location [$F(6, 96) = 2.34$, $p = .037$]. Separate ANOVAs within each scalp location in this time window revealed a main effect of L/D at frontal [$F(2, 32) = 5.27$, $p = .011$] and central sites [$F(2, 32) = 3.87$, $p = .031$], but not at parietal [$F(2, 32) = 2.13$, $p = .136$] or occipital locations [$F(2, 32) = 1.55$, $p = .229$]. Finally, in the 400–600 msec window, we found neither a main effect of L/D [$F(2, 32) = 0.69$, $p = .508$] nor an interaction between L/D and scalp location [$F(6, 96) = 1.65$, $p = .142$].

More-frequently selected logos. The ERP waveforms for the more-frequently selected logos are shown in Figure 5, and mean amplitudes across scalp locations are reported in Table 6. These data appeared to manifest an effect of L/D that was present only in the LPP time range. Analyses within each time window confirmed this interpretation. In the 150–200 msec window, we found no main effect of L/D [$F(2, 32) = 2.71$, $p = .082$], but the interaction between L/D and scalp location was significant [$F(6, 96) = 3.56$, $p = .003$]. However, separate ANOVAs within each scalp location indicated that there were no main effects of L/D within any location: frontal [$F(2, 32) = 0.95$, $p = .398$], central [$F(2, 32) = 0.36$, $p = .702$], parietal [$F(2, 32) = 0.55$, $p = .581$], or occipital [$F(2, 32) = 1.42$, $p = .256$]. Rather, the interaction between L/D and scalp location indicated that the direction of the L/D effect in the occipital N1 (disliked_logos > liked_logos) differed relative to the direction of the effect in the frontal/central/parietal P1 (liked_logos > disliked_logos). In the 200–400 msec window, we found neither a main effect of L/D [$F(2, 32) = 2.79$, $p = .077$] nor an interaction between L/D and scalp location [$F(6, 96) = 0.58$, $p = .749$]. In the 400–600 msec window, however, we found a main effect of L/D [$F(2, 32) = 5.57$, $p = .008$] but no interaction between L/D and scalp location [$F(6, 96) = 0.33$, $p = .917$].

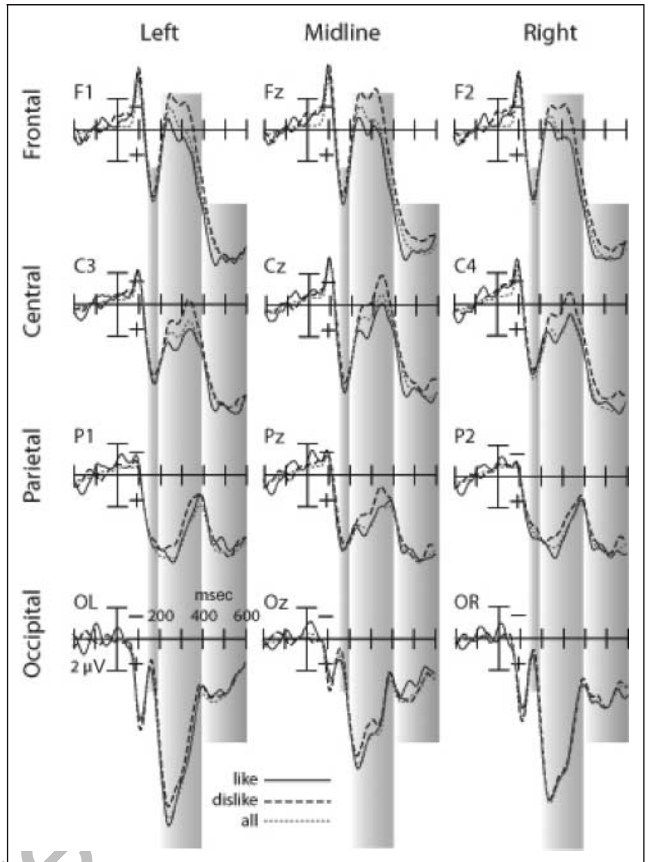

Figure 4. ERP responses to less-frequently selected logos from Experiment 2. Data are shown as a function of hedonic evaluation of logos (liked vs. disliked), along with the response across all logos. There was a main effect of liking/disliking in the frontal/central N2 component (200–400 msec time window, middle gray shaded bars).

Table 5. Mean Amplitude (μV) of Group-averaged ERPs for Less-frequently Selected Liked, Disliked, and All Logos from Experiment 2

	Time Window								
	150–200 msec			*200–400 msec*			*400–600 msec*		
Scalp Location	*Like*	*Dislike*	*All*	*Like*	*Dislike*	*All*	*Like*	*Dislike*	*All*
Frontal	2.96 (0.28)	2.61 (0.24)	2.96 (0.15)	0.86 (0.39)	−0.48 (0.31)	0.48 (0.26)	5.98 (0.51)	5.29 (0.48)	5.77 (0.40)
Central	3.50 (0.26)	3.21 (0.23)	3.49 (0.16)	1.43 (0.31)	0.48 (0.25)	1.21 (0.20)	4.55 (0.37)	3.98 (0.33)	4.39 (0.27)
Parietal	3.34 (0.24)	3.03 (0.21)	3.32 (0.15)	2.63 (0.24)	2.11 (0.19)	2.67 (0.13)	3.44 (0.26)	3.30 (0.23)	3.49 (0.16)
Occipital	2.45 (0.25)	1.94 (0.23)	2.32 (0.16)	5.58 (0.27)	5.02 (0.26)	5.64 (0.21)	2.46 (0.25)	2.53 (0.22)	2.64 (0.13)

Data are collapsed across all runs and across the three electrodes within each scalp location, and are shown as a function of poststimulus onset time window. Standard errors are in parentheses.

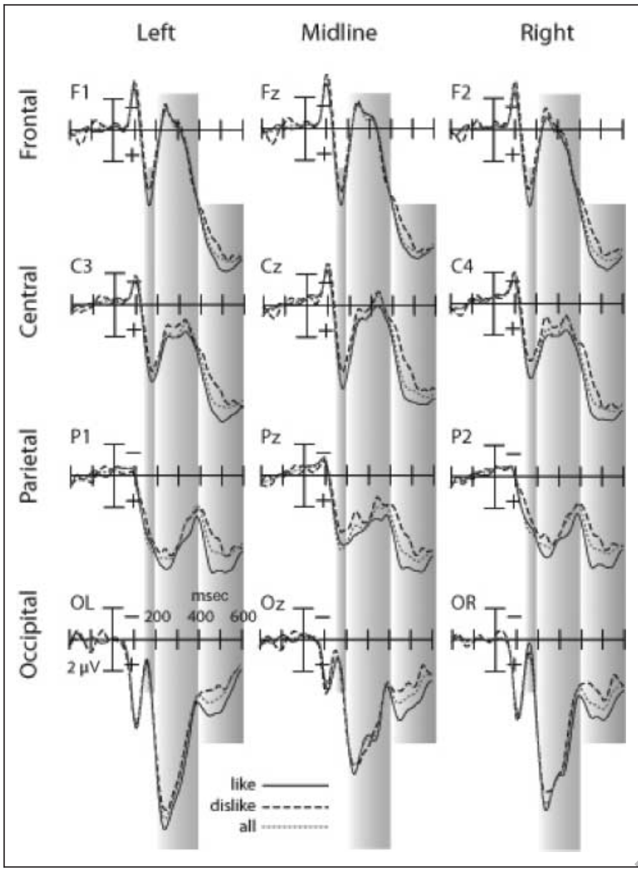

Figure 5. ERP responses to more-frequently selected logos from Experiment 2. Data are shown as a function of hedonic evaluation of logos (liked vs. disliked), along with the response across all logos. There was a main effect of liking/disliking in the LPP (400–600 msec time window, right gray shaded bars).

Discussion

Our analysis goals in Experiment 2 were three-fold. First, we wanted to replicate the rapid, implicit hedonic effects we found in Experiment 1, and in particular, the bias for disliked_logos observed in the central/parietal P1 component (150–200 msec window), and the parietal/occipital P2 and central N2 components (200–400 msec window). Importantly, this same pattern of effects was indeed found in Experiment 2, suggesting that they are both reliable and valid. Moreover, the effects of L/D observed in Experiment 2 were more spatially broad (i.e., extended to more scalp locations) in the 150–200 msec and 200–400 msec time windows, relative to Experiment 1. In particular, unlike in Experiment 1, the L/D effects extended to the frontal P1/occipital N1 (150–200 msec window) and the frontal N2 components (200–400 msec window). This indicates a more extensive influence of hedonic evaluative processing within both time windows relative to Experiment 1. Notably, not only does this increase in the spatial breadth of the hedonic effects suggest that our increase in stimulus set size was indeed successful in more tightly sampling the poles of the hedonic continuum, but the involvement of the occipital N1, in particular, indicates that hedonic effects can bias the initial stages of discriminative processing in visual cortex (e.g., Vogel & Luck, 2000).

The second goal of our analysis was to determine the extent to which these effects would be sensitive to—or vary with—repeated stimulus exposure. In this regard, we observed no significant interactions between hedonic evaluations and run in any of our three time windows of analysis. Instead, we found that there was a significant effect of run in each time window that was specifically driven by the first block of trials. Further, this effect in each ERP component was analogous to the overall bias observed for disliked_logos: decreased frontal/central/parietal P1 and increased N1 amplitude in the 150–200 msec window, increased frontal/central N2 and decreased parietal/occipital P2 amplitude in the 200–400 msec window, and increased LPP amplitude in the 400–600 msec window. Of interest here is that in the ERP components sensitive to hedonic evaluation, there were also strong novelty effects, a finding consistent with evidence indicating that novel stimuli—defined as stimuli not seen before—undergo a deeper level of neurocognitive analysis, relative to stimuli previously observed (e.g., Habib & Lepage, 1999). Consistent with a dominance

Table 6. Mean Amplitude (µV) of Group-averaged ERPs for More-frequently Selected Liked, Disliked, and All Logos from Experiment 2

	Time Window								
	150–200 msec			*200–400 msec*			*400–600 msec*		
Scalp Location	*Like*	*Dislike*	*All*	*Like*	*Dislike*	*All*	*Like*	*Dislike*	*All*
Frontal	3.05 (0.19)	2.37 (0.22)	2.96 (0.15)	0.59 (0.28)	0.45 (0.33)	0.48 (0.26)	6.09 (0.45)	5.38 (0.47)	5.77 (0.40)
Central	3.50 (0.18)	2.76 (0.22)	3.49 (0.16)	1.50 (0.21)	0.97 (0.25)	1.21 (0.20)	4.90 (0.31)	3.85 (0.33)	4.39 (0.27)
Parietal	3.09 (0.17)	2.60 (0.20)	3.32 (0.15)	3.07 (0.16)	2.45 (0.20)	2.67 (0.13)	4.18 (0.21)	3.03 (0.23)	3.49 (0.16)
Occipital	1.97 (0.18)	2.16 (0.21)	2.32 (0.16)	5.90 (0.23)	5.51 (0.26)	5.64 (0.21)	3.22 (0.18)	2.22 (0.20)	2.64 (0.13)

Data are collapsed across all runs and across the three electrodes within each scalp location, and are shown as a function of poststimulus onset time window. Standard errors are in parentheses.

of this novelty response in the first run, analyzing data within this run only showed no significant hedonic effects.

Finally, on the logic that stimulus-bound hedonic effects would be stronger or more prominent in the more-frequently selected logos, we wanted to separately examine ERPs derived for liked_ and disliked_logos selected three or fewer times across participants, and liked_ and disliked_logos selected four or more times across participants. These analyses revealed an interesting dissociation, in that for logos selected less than three times, hedonic effects disappeared in the 150–200 msec time window, whereas for logos selected more than three times, hedonic effects not only disappeared in both the 150–200 and 200–400 msec time windows but also emerged in the LPP (or 400–600 msec time window). Comparatively speaking, this pair of results suggests a stronger role of stimulus-bound factors in the hedonic responses manifest in the LPP component, and a stronger role for individual-bound factors in the hedonic responses manifest in the parietal/occipital P2 and central N2 components.

GENERAL DISCUSSION

Our data are consistent with the hypothesis that participants rapidly and implicitly evaluated logos at a hedonic level. In Experiment 1, using a paradigm designed to capture individual variability in hedonic responses, we found a bias in visuocortical processing for disliked logos that emerged within the first 200 msec of viewing the offending image. In Experiment 2, we replicated this effect while dissociating influences associated with a stimulus' novelty and physical attributes. Notably, this pattern of data was obtained despite using images that were not normatively selected for having strong positive or negative emotional intensity, and arose despite no explicit evaluative instructions. As such, our findings suggest that even the most innocuous and fleeting of commercial visual images—images such as one would find adorning the corner of a browsed web page or embedded within a piece of junk e-mail—are subject to a rapid and implicit evaluative analysis during the initial stages of visual processing. In this concluding section of the article, we consider some of the key questions and issues arising from our data and interpretations.

Are the Hedonic Effects Emotion-related?

People rapidly and implicitly evaluate visual images having a strong positive or negative emotional content (e.g., Herr & Page, 2004; Duckworth et al., 2002; Giner-Sorolla et al., 1999; Hermans et al., 1994), evaluations that bias visuocortical processing in a manner analogous to what we report here (e.g., Codispoti et al., 2006; Herbert et al., 2006; Cuthbert et al., 2000; Ito & Caccippo, 2000; Ito et al., 1998; Cacioppo et al., 1996, 1997; Crites et al., 1995; Cacioppo & Berntson, 1994). Given this sensitivity of visual processing to emotion-related influences, and given the hypothesis that aesthetic responses to art are inextricably linked to emotional responses (e.g., Silvia, 2005; Berlyne, 1971), to what extent might the effects we label here as ''hedonic'' be construed as ''emotional''?

In this regard, our results have at least two characteristics in common with implicit evaluative judgments of more emotionally valenced attitude objects: They were rapid (e.g., Codispoti et al., 2006; Herbert et al., 2006; Duckworth et al., 2002), and manifest a bias towards disliked logos akin to emotional negativity biases (e.g., Herr & Page, 2006; Dijksterhuis & Aarts, 2003; Ito & Caccippo, 2000; Ito et al., 1998). However, although implicit emotional judgments have also been reliably associated with modulations in the LPP (e.g., Codispoti et al., 2006; Herbert et al., 2006; Cuthbert et al., 2000; Ito & Caccippo, 2000; Ito et al., 1998; Cacioppo et al., 1996, 1997; Crites et al., 1995; Cacioppo & Berntson, 1994), we only found hedonic effects on the LPP when examining the ERP responses to more-frequently selected logos—that is, logos that more closely approximated normative metrics of L/D. Given that the LPP indexes comparatively later and deeper levels of evaluative analysis, this difference in LPP responses between emotional and hedonic evaluative situations would certainly be consistent with quantitative differences in the emotional intensity of the attitude objects involved. That is, the stronger the emotional valence of the object, the more likely it might be expected to implicitly drive the deeper levels of evaluative analysis manifest in the LPP via the arousing nature of the stimuli themselves. If so, our data showing LPP effects for the most popular logos would suggest that although most hedonic evaluations of everyday visual images such as logos may not typically engage emotional arousal, there may be some more normatively popular images that do have some facility in this regard.

Construed from an emotional perspective, our findings are also consistent with appraisal-based models of visual aesthetic judgments. In particular, although emotional responses to art have long been explained at the psychobiological level in relation to interest-driven changes in general arousal (e.g., Berlyne, 1971), only recently has it been suggested that these emotional responses can be multifactorial in nature, including not just arousal but emotions such as happiness, disgust, anger, frustration, curiosity, and the like (Silvia, 2005). In this view, an evaluative aesthetic judgment follows from how the attitude object is appraised regardless of both the physical features of the object itself and what constellation of different emotional factors may be influencing that appraisal. Normative-based methodologies have not been able to inform on the validity of this model due to the linking of evaluative responses to specific stimuli. Although we cannot speak to the specific emotions (or lack thereof) that may have been driving the evaluations of our observers, our data are, nevertheless, consistent with the prediction of appraisal models that a common evaluative response should emerge across observers when individual evaluative responses are decoupled from specific attitude objects.

What Do Our Results Say about Hedonic Analysis?

Beyond providing electrophysiological evidence suggesting that hedonic evaluations of everyday images can be rapid and implicit, our findings also provide insight into the structure and functional nature of these hedonic evaluations. First, that hedonic effects were present in multiple ERP components spanning multiple time windows suggests that hedonic evaluations are nonmonolithic. Rather, the data support the hypothesis that they reflect a sequential process manifest across several distinct stages or steps. For example, it has been proposed that aesthetic judgments of beauty can be decomposed into at least two distinct stages: an initial formation of one's impression of the attitude object at a featural or perceptual level, followed by a categorization of the object based on that analysis (e.g., Höfel & Jacobsen, 2007a, 2007b). Our data here indicate that hedonic-related evaluations may operate in an analogous manner.

Second, despite the emphasis we have placed on individual variability in evaluative responding, we nevertheless found evidence indicating that there are normative trends in hedonic analysis. Metaphorically speaking, although one person's treasure may be another person's trash at a hedonic level, when one samples across a population, there are some objects that will be seen more often as "treasure" and some objects seen more often as "trash." For example, people tend to prefer objects and images that are prototypical of the given category (Rhodes & Halberstadt, 2003; Halberstadt & Rhodes, 2000), and likewise, certain feature configurations of faces are universally viewed as being more attractive than other feature configurations (e.g., Olson & Marshuetz, 2005). Of interest here is that when we examined the ERP responses to more-frequently selected logos in Experiment 2, we found significant modulations in the LPP modulations that were not present for less-frequently selected logos (Experiment 2) and when data were averaged across all logos (Experiments 1 and 2). What this raises is the question of whether prosaic attitude objects that show a high commonality of hedonic evaluation across a population are somehow more thought-provoking or resonate more deeply with individuals.

Third, one point of debate in our data is whether the absence of significant effects for liked_logos in the P2 and N2 components in the 200–400 msec time window might reflect an insensitivity in these components to hedonic processes associated with liking, rather than a true negativity bias. Specifically, positive versus negative evaluative spaces are dissociable rather than necessarily representing two ends of a continuum (e.g., Cacioppo et al., 1997; Cacioppo & Berntson, 1994). This raises the possibility that the processes associated with the parietal/occipital P2 and frontal/central N2 may only capture negative valence judgments. However, recent ERP studies investigating the processing of emotionally arousing versus neutral stimuli via normative methods have shown increased P2/N2 amplitudes for both positively and negatively valenced stimuli relative to a neutral-valence baseline (e.g., Herbert et al., 2006), even under conditions such as those used here, where visual objects are repeatedly presented with no explicit evaluative goals as part of the task (Codispoti et al., 2006). In light of our own results, this suggests a dissociation in the P2/N2 response to negatively versus positively evaluated attitude objects, where the former emerges in these ERP components for less intensely valenced objects relative to the latter. Given the emotionally arousing nature of the stimuli used by Codispoti et al. (2006) and Herbert et al. (2006), we may simply find disliked images to be more arousing than disliked images—at least for more benign, everyday images such as logos. Why? Like the greater sensitivity we have to financial losses versus gains of equal monetary value (e.g., Kahneman & Tversky, 1979), we may show a similarly greater sensitivity for negative versus positive hedonic evaluations of equal subjective magnitude, at least at the P2/N2 level.

Finally, if our ERP data are indeed indicative of a negativity bias in visual cortical processing, what does this reveal about the cognitive nature of these automatic responses? Modulations in the P2/N2 ERP components typically reflect how much we pay attention to or notice a stimulus, especially one that deviates in some way from the prevailing situational context (e.g., Näätänen, 1992). From this perspective, our results suggest that disliked images have the capacity for quickly catching our attention at an implicit level. But why should disliked images stand out to us rather than images we report to like? Over 35 years ago, Berlyne (1971) predicted that we should specifically dislike visual objects that violate our individual sense of aesthetic norms. Not only do our data support this long-standing proposal by showing that liked images generate a response indistinguishable from a hedonically neutral baseline but they also confirm that even the most fleeting of everyday images are subject to a rapid and automatic analysis of their aesthetic merit.

Are Our Effects Truly Implicit?

Our discussion thus far is predicated on the assumption that the rapid evaluative effects we report are, in fact, implicit. The assumption logically follows from the task and instructions given to the participant, which focused exclusively on target detection (i.e., there were no explicit instructions to think about and/or evaluate the nontarget logos). Moreover, our findings parallel those previously reported for emotion-related implicit evaluations, in that they were rapid (e.g., Codispoti et al., 2006; Herbert et al., 2006; Duckworth et al., 2002) and manifest a negativity bias (e.g., Herr & Page, 2006; Dijksterhuis & Aarts, 2003; Ito & Caccippo, 2000; Ito et al., 1998). However, given that we did not ask participants *after* testing to report on any conscious evaluative analyses that may have occurred *during* ERP testing, it remains possible that some percentage of participants may have engaged in explicit evaluative analysis of their own accord. For example, visual processing in the time range of the occipital N1 component is highly sensitive to conscious attentional strategies (e.g., Handy & Mangun, 2000), and thus, if participants were paying more attention to disliked images this may have had some impact on the processing of these images. That said, the interesting implication here is that if participants were, in fact, engaging in some form of explicit evaluative analysis, it would suggest that the drive to form hedonic judgments of affectively benign stimuli is sufficiently strong as to transcend the engagement of purely implicit, nonvolitional processes. This possibility points toward the value of future research specifically aimed at examining possible explicit evaluative contributions to the effects we are interpreting here as implicit in origin.

What Are the Practical Implications?

In conclusion, there are at least two points to consider regarding the more practical implications of our findings. First, from a marketing/branding perspective, although logos may be specifically designed to engender a positive hedonic evaluative response (e.g., Wheeler, 2006), what our findings suggest is that it is the images we *dislike* that appear to stand out to us at a neurocognitive level. How this might impact behavior, and consumer behavior in particular, is of course a question that remains to be addressed. For example, if this dislike bias has something functionally in-common with novelty responses afforded to unfamiliar stimuli as described above, might comparable memory facilitation effects be found—where we're better able to remember encounters with novel stimuli (e.g., Habib & Lepage, 1999)? Consistent with this possibility, irritating jingles from television and radio ads often have a frustrating way of getting stuck in our heads. What our data here raise is the question of whether there may be a visual analog to this auditory effect.

Second, cognitive researchers typically assume that as long as the emotional affect of our stimuli are neutral there is no need for concern over evaluative effects entering into our data. But what our data here suggest is that even emotionally benign stimuli may, in fact, be subject to implicit hedonic analysis, thereby introducing potential sources of noise and systematic biases in our data. For example, there are well-known visual attention biases toward the right relative to left visual field (e.g., Handy, Grafton, Shroff, Ketay, & Gazzaniga, 2003; Mangun et al., 1994). Given that we also appear to have liking preferences for objects to our right versus left (e.g., Nisbett & Wilson, 1977), might there be a relation between these attentional and liking biases? Likewise, the novelty effects we found in Experiment 2 highlight the need to take seriously the possibility of accounting for evaluative responses in our data regardless of what kind of stimuli we may be using. Indeed, at the most general level, our findings stress the apparent omnipresent nature of human hedonic responses, and the practical value of understanding these responses for experimenters and marketers alike.

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